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Research Progress Report

1955

Research Section

Western Weed Control Conference

Boise, Idaho
March 22, 23

PREFACE

The 1955 Research Progress Report is a concise summary of research findings of the past field season, plus reported results of long-term studies as well. The material contained herein should be considered tentative and provisional, and is not for publication. Much of the research reported here will eventually find its way into such professional publications as Agronomy Journal, Weeds, Journal of Range Management, Botanical Gazette, and others. The Progress Report is intended primarily to be a "workbook", correlating the findings of many researchers, providing new leads, and keeping all workers informed of the general aspects of weed control under a wide range of climatic conditions.

Grateful acknowledgement is extended to each of the Project Leaders for his part in making this publication a representative sampling of current fundamental and applied weed control research.

Appreciation is extended to Dr. Jess L. Fults for the providing of clerical assistance through the Department of Botany and Plant Pathology, Colorado A & M College, and for his assistance in the preparation of the manuscript.

It has been a real pleasure to serve as Research Section Chairman this year, and I have been aided and encouraged by many individuals throughout the western region. It would be impossible to name them all here, but I do want to express my warm appreciation for their cooperative efforts.

Roger M. Blouch

PROJECT INDEX

Note.--No reports were received for Projects 8, 9, and 11.

AUTHOR INDEX (Continued)

AUTHOR INDEX

PROJECT 1. PERENNIAL HERBACEOUS WEEDS

F. L. Timmons, Project Leader

SUMMARY

A total of 17 reports were received from 10 investigators in 7 different states. Results with various herbicides and cropping systems were reported on 12 different weeds.

Broad-Leaved Perennials

Canada thistle (Cirsium arvense (L.) Scop.). In Montana heavy infestations of Canada thistle growing in small grains on 8 different farms reduced crop yields 40 to 70 percent. Barley yields were reduced more than were those of winter wheat, spring wheat, or oats. Of 16 cultural and combination chemical-cultural methods being tested in Montana several reduced Canada thistle stands 86 to 99.6 percent the first year. Intensive cultivation, cropping to perennial grass or to spring wheat, plus spraying with 2,4-D at 3/4 pound per acre, and cropping to alfalfa were the most effective in that order. In Wyoming 2,4-D amine and ester applied in early spring as a spray at rates of 40 to 120 pounds acid per acre reduced the stands of Canada thistle 90 percent or more.

Canaigre (Rumex hymenosepalus). In Arizona 2,4-D amine and ester formulations at rates of 2 to 6 pounds acid per acre and maleic hydrazide at 12 pounds per acre applied March 5 gave 90 to 100 percent control of 6-month old canaigre plants. CMU at rates of 4 to 16 pounds per acre proved disappointing despite early indications of good results.

Horsetail rush (Equisetum arvense L.). In Oregon amino triazole at rates of 3 and 9 pounds per acre and MCP and 3,4-dichlorophenoxyacetic acid at 3 pounds per acre applied in July gave excellent top kills and apparently good root kills. Ammate at 2 and 4 pounds per square rod was somewhat less effective. Several other chemicals including Alanap, benzoic acid derivatives, chloro-IPC, Dalapon, 2,4-D, and 2,4,5-T had little or no effect at the rates tested.

Leafy spurge (Euphorbia esula L.). Results of experiments conducted in Montana since 1948 showed that 3 pounds of 2,4-D and 60 pounds of ammonium sulfamate per acre in 2 successive years gave 95 percent kills of leafy spurge. This combination consistently gave better control than either chemical alone. Fifteen to 25 pounds of 2,4-D acid per acre in an emulsifiable oil suspension gave kills as high as 98 percent when applications were made in the fall. Reinfestation from spurge seedlings occurred rapidly after all treatments were discontinued.

Russian knapweed (Centaurea repens L.). In Wyoming stands of Russian knapweed were reduced 90 percent or more by 2,4-D amine and ester formulations applied in early spring as a spray at rates of 40 to 120 pounds per acre. The 2,4-D was completely dissipated from the surface 3 inches of soil within 65 days after the applications.

Tansy ragwort (Senecio jacobea L.). An experiment in Oregon showed the butoxyethanol ester of 2,4-D to be definitely more effective than were MCP, 3,4-D, 4-chlorophenoxyacetic acid, or 2,4,5-T. Applications of 2,4-D in rosette and bolt stages gave a complete kill but treatments in the bloom stage failed to prevent seed set. A second experiment in Oregon showed that amino triazole at rates of 2 and 4 pounds per acre in rosette, bolt, and bloom stages gave good top kills of tansy ragwort but that extensive regrowth developed from the crown regions. Treatments in bolt and bloom stages prevented seed production, which may be important since the weed is a biennial.

Perennial Grasses and Sedges

Johnson grass (Holcus halepensis L.). In Arizona, Johnson grass growing along an irrigation canal was eradicated by Dalapon treatments made in August at rates of 20, 30, and 40 pounds per acre and repeated at the same rates in mid-October. Where Johnson grass growing in cotton was spot-treated with solutions containing ¼ and ½ pound of Dalapon per gallon of water, good control resulted with no obvious effects on seedling cotton plants.

Nutgrass (Cyperus spp). Exploratory tests in Oregon indicated that Karmex DW and other substituted urea compounds at rates of 40 and 80 pounds per acre applied in early March gave good control of yellow nutgrass (C. esculentus) throughout 1954. Satisfactory control was not obtained with TCA, sodium chlorate, or chloro-IPC, each applied at heavy rates. Post-emergence applications of amino triazole, Dalapon, and 2,4-D at high rates gave good top kills. Benzoic acids were not effective. In New Mexico preliminary results on nutgrass (C. rotundus) appeared promising for foliage applications of Dalapon and a combination of amino triazole and 2,4-D amine. 2,4-D alone was less effective. Soil applications of the same chemicals were less effective while IPC and CIPC had no effect.

Quackgrass (Agropyron repens (L.) Beauv.). Amizol (3-amino-1, 2,4-triazole) was tested in Montana at 5 pounds per acre, in Oregon at 4, 8, and 16 pounds per acre, and in Utah at 5, 10, and 20 pounds per acre. Results showed a loss of chlorophyll at the lower rates and a complete top-kill at the higher rates. Regrowth occurred in 3 or 4 months at all rates in each state, with reduction in stand and albinism of surviving plants in Oregon.

Dalapon was tested on quackgrass in Montana at 10, 20, 40, and 60 pounds per acre, in Oregon at 8, 16, and 32 pounds per acre, and in Utah at 5, 10, 20, and 40 pounds per acre. Good top kills resulted from all rates in Montana and Oregon and from the higher rates in Utah. All rates suppressed regrowth several months, the period of time being longer for higher rates. The higher rates gave considerable stand reduction in all states but rapid recovery eventually occurred in Montana and Utah despite repeated applications in Utah. In Oregon, where the treatments followed plowing and working down one month prior to application, practically no regrowth developed the first season.

In Montana, sodium TCA at 100 pounds per acre and CMU at 30 pounds per acre were about as effective on quackgrass as Dalapon at 20 and 40 pounds per acre, respectively. 2, 3, 6-trichlorobenzoic acid at rates of 2 to 25 pounds per acre had no effect.

In Montana, quackgrass rhizomes were dug, cleaned, and exposed to air for varying periods of time and then replanted in moist soil. The percentages of rhizome buds producing new shoots after 0, 2, 3, 5, 7, 9, and 12 days exposure were 48.1, 4.4, 3.5, 0.7, 0.5, 0, and 0, respectively.

Reed canary (Phalaris arundinacea L.). In Utah, high rates of CMU, sodium chlorate, and Polybor-chlorate applied in December 1953 and March 1954 gave much less satisfactory control of reed canary grass growing along an irrigation canal than the same treatments applied in December 1952 and March 1953. Subnormal precipitation in the winter and spring were believed responsible for the poor results in 1954.

Saltgrass (Distichlis stricta (L.) Greene). In Nevada, Dalapon at 16 and 32 pounds per acre in June reduced saltgrass cover about 50 percent. Other treatments with Dalapon and TCA on three different dates resulted in little or no control.

The individual reports are arranged alphabetically by names of weeds in two groups: A. Broad-leaved Perennials and B. Perennial Grasses and Sedges, and are arranged alphabetically by author under each weed.

A. Broad-leaved Perennials

Canada thistle and Russian knapweed control with heavy rates of 2,4-D. Bohmont, Dale W. Replicated rod square plots were established in 1953 on old stands of Canada thistle and Russian knapweed at two locations. 2,4-D ester and amine were applied in early spring at rates of 40 to 120 pounds acid per acre with final plant counts for evaluation being taken 13 months later. The chemicals were applied as a spray and by a carbon bisulfide injector, making possible a comparison of two application methods. The chemical was diluted with an equal volume of water for spraying, and soil injections were made at 12-, 15-, and 18-inch intervals.

The 12-month period following chemical application was exceptionally dry; however, all rates of 2,4-D applied as a spray controlled 90 percent or more of the established perennial weeds. There appeared to be little difference between the chemical formulations under the conditions tested. The chemical was completely dissipated out of the upper soil strata (1 and 3 inches) in all treatments within 65 days after application. This was determined by interval plantings of beans and barley in the greenhouse. The 80 pounds of acid per acre completely eradicated all thistle and knapweed; however, established native grasses growing in the plots survived the treatments. Spray application was about twice as effective for a given rate of 2,4-D as the soil injection method. The heaviest rates of 2,4-D injection (120 pounds per acre) controlled about 80 percent of the established weed stand compared to the 60-pound spray treatment which controlled over 90 percent of both weeds. Tests are being continued to determine influence of moisture and soil type upon control results. (Wyoming Agricultural Experiment Station)

The influence of Canada thistle stand on yield of small grains. Hodgson, Jesse M. Yield samples were obtained in different fields of small grain infested with Canada thistle to study the effect of different levels of Canada thistle infestation on yields as compared to thistle-free samples.

The sampling (from 2 x 8 plots) was done in farmers' fields where the required levels of thistle populations could be found and where the farmers' cooperation was obtained. The different levels of infestation sampled consisted of areas with 0 thistle shoots. The 0 sample was taken just outside the thistle patch. Each succeeding sample of heavier infestation was taken on the same drill rows toward the center of the thistle patch where the desired level of infestation occurred. A level of 45 to 55 thistle shoots per 2 x 8 foot plot (3-4 thistles per square foot) was usually as heavy an infestation as could be found in the thistle patch.

Small grain & field*	Average yield in bushels per acre at 4 levels of Canada thistle infestation			
	0 shoots	3-8 shoots	20-30 shoots	45-55 shoots
1. Winter wheat P.B.	64	55.3	46.4	35.2
Percent	100	86.3	72.4	54.9
2. Winter wheat J.S.	51.7	45.6	35.2	31.4
Percent	100	88.2	68.1	60.7
3. Spring wheat X.H.	31.7	27.6	23.0	18.0
Percent	100	87.0	72.5	56.7
4. Spring wheat A.T.	15.9	13.8	10.6	7.1
Percent	100	91.7	70.0	47.1
5. Barley J.S.	63.5	51.4	44.5	23.4
Percent	100	80.9	70.0	36.8
6. Barley A.H.	58.3		43.4	26.6
Percent	100		74.4	45.6
7. Barley P.B.	72.5	56.2	36.5	23.1
Percent	100	77.5	50.3	30.3
8. Oats M.L.	61.4	54.2	37.8	33.7
Percent	100	88.3	61.6	54.9

* Fields 1, 3, 5, and 8 are averages of 4 replications; others are averages of 2 replications.

All fields sampled exhibited a consistently decreasing yield as Canada thistle infestation increased, although there was considerable variation from field to field. Yields of winter wheat were reduced least by the heaviest levels of Canada thistle infestation, while barley yields showed the greatest yield reductions from Canada thistle infestations. (Field Crops Research Branch, ARS, USDA, and Montana Agricultural Experiment Station, Bozeman, cooperating)

Canada thistle control with cropping, and with cultural and chemical treatments. Hodgson, Jesse M. In an attempt to develop more efficient means for control and eradication of Canada thistle (*Cirsium arvense* (L.) Scop.) several combined treatments of cropping, spraying, and cultivation were begun in May, 1953. Sixteen different treatments were randomized and replicated 4 times on land infested with Canada thistle at the Montana Experiment Station, Bozeman. The original infestation of Canada thistle on each plot was determined by counting the number of thistle shoots on 10-square yard quadrats through the center of the plot before any treatments were made. Annual follow-up counts were made on the same locations as the original counts. This test was planned to extend for a 5-year period; however, some treatments have given outstanding control after one season. Only a few representative treatments are referred to in this abstract.

One treatment program consisted of normal seedbed preparation and cropping to spring wheat. Nitrogen fertilizer was applied at 50 pounds per acre prior to seeding wheat each year. These plots were plowed immediately following harvest. Heavy ester or amine 2,4-D was applied at 3/4 pound when the Canada thistle was in the early bud stage. The thistle stand was reduced by 90 percent after one season of this combined treatment. Mean wheat yields were 60 bushels per acre on these plots.

A second control program was spring wheat cropping with 50 pounds of nitrogen fertilizer per acre but no 2,4-D. The number of shoots have increased 28 percent under this treatment after 1 year and yields were 47.8 bushels per acre, which was 20 percent less than spring wheat on plots infested with Canada thistle that were treated with 3/4 pound of 2,4-D.

A third control program of alfalfa cropping and mowing has decreased the thistle stand 86 percent according to thistle shoot counts in 1954. These thistles and alfalfa were mowed twice in 1953 and twice in 1954. A very heavy, vigorous stand of alfalfa was present on these plots.

A fourth control program consisted of a seeded grass pasture which was sprayed annually with 3/4 pound of 2,4-D per acre. The reduction of thistle stand on these plots was 94 percent after one season. The grass and weeds on this plot were clipped and hay yields taken three times during the growing season.

One season of cultivation on a series of plots in this test reduced the stand of Canada thistle 99.6 percent. The cultivation consisted of a plowing May 5, followed by duckfoot cultivation every 21 days. A total of 6 cultivations were made during the growing season.

Plots that had no treatments of cropping, spraying, or cultivation increased 48 percent in stand or number of shoots during the same period that the noted decreases of stand occurred in the above treatments. (Field Crops Research Branch, USDA, and Montana Agricultural Experiment Station, Bozeman, cooperating)

<u>The control of canaigre with several chemicals.</u> Arle, H. Fred. The production of canaigre (<u>Rumex hymenosepalus</u>) as a potential source of tannin is being investigated in this area. The plant also exhibits some characteristics which indicate that it could present a weed problem. The control of this plant is therefore being studied.

Plots were sprayed on March 5, 1954, at which time the seedling plants were 6 months old and averaged 12 inches in height. There were also a scattered number of plants which had originated from established rootstocks. These were in the heading stage. The following treatments were included: CMU at 4, 8, 12, and 16 pounds

PROJECT 2. HERBACEOUS RANGE WEEDS

L. L. Jansen, Project Leader

SUMMARY

Twelve individual reports of research progress on herbaceous range weeds were received. Eight of these dealt with halogeton and 2 with Medusa-head rye. Following the practice of previous years the reports have been arranged for discussion and presentation as follows:

Weedy Grasses

Preliminary ecological studies of Medusa-head rye (Elymus caput-medusae), a recent invader of cheatgrass ranges in southwestern Idaho, indicate that this grass is as well-adapted to these disturbed rangelands as cheatgrass, and that certain characteristics give it a slight advantage over cheatgrass. It now occupies about 150,000 acres and seems destined to remain as a characteristic range annual. Competition through restoration of a perennial cover is suggested as the best means of control. Fall applications of CMU completely eradicated the plant at rates of 40 pounds per acre or higher.

Nonpoisonous Forbs

In a report on the ecology and control of Mediterranean sage (Salvia aethiopis) information is presented on population densities, growth habits, germination, and competition of this weedy biennial, and on its potential for several soil types. Measures for successful control with 2,4-D, diesel oil, and cultivation are given, and the problem of ultimate control is discussed.

Poisonous Forbs

Biological control of Klamath weed (Hypericum perforatum) by Chrysolina beetles is now relatively assured in areas of northern Idaho. Marked reduction in Hypericum occurred during the 3rd and 4th years following release of the beetles. Associated with the reduction in Hypericum, ecological changes in other vegetation have been found. Studies on rehabilitation of these ranges have also been started.

Four of the reports submitted concern chemical control measures for halogeton, 2 with CMU and 2 with 2,4-D. Results from 3 seasons of work with CMU in Idaho and Utah are reported which demonstrate that rates of 40 pounds per acre or greater are necessary to sterilize the soil against halogeton. Perennial forage species, however, have been severely damaged or killed, usually by much lower rates. It appears to this project leader that the use of CMU for the control of halogeton should be limited to areas where total sterilization is desirable, such as gravel stock piles, road shoulders, and railroad embankments.

Two years of coordinated experiments have limited the period for most successful spraying of halogeton with 2,4-D in northern Utah and southern Idaho to 2 stages of growth--the cruciform stage and the early part of the elongation-branching stage. The optimal rate of 2,4-D appears to be between 1½ and 2 pounds per acre. Treatments at earlier stages than the cruciform were less successful because of post-treatment germination. Plants became resistant to 2,4-D in the last part of the elongation-branching stage, and rates up to 8 pounds per acre were necessary to obtain kills at the later stages. Results of an additional experiment conducted in Idaho confirm those of the coordinated work and it seems likely that the findings have general application to all regions. Development of resistance to 2,4-D was found to be correlated with physiological age of the plants and was independent of their chronological ages.

Basic studies on the physiology and ecology of halogeton have continued to progress. Recent findings are contained in 4 reports, received from personnel in Idaho, Nevada, and Utah. In one study in Idaho a number of growth and development processes were found to be correlated with supplemental water applied to field plots of halogeton. Plants also responded to a slight extent to added nitrogen. Susceptibility to 2,4-D was greater at the higher moisture levels. Results from life-history and ecological studies by Idaho workers have shown that 50 percent germination of brown seeds can be obtained after 1 to 2 years of burial. It seems probable that some observed field germination can be attributed to brown seeds carried over in the soil for 3 years. In Idaho foliage cover indices of 20 percent for native shrubs appear to be critical in competitive control of halogeton; in Nevada, critical shrub densities from 12-27 percent have been determined. Nursery experiments and field observations indicate that halogeton will not grow on sand in northern Nevada. In Utah continued studies of the flowering responses of halogeton indicate that the initiation of reproductive growth is probably correlated with a period of warm nights.

practical solutions. Fortunately there is more perennial grass on the annual ranges than might be expected, and results so far indicate possibilities of fairly rapid recovery of perennials with improved management. Artificial reseeding is feasible over much of the lower areas covered with Medusa-head, and offers a speedy means of restoring a highly desirable perennial cover. Due to its high degree of adaptation and wide spread, Medusa-head seems certain to remain as a characteristic range annual of the region. (Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow)

Toxicity of CMU to Medusa-head rye. Morton, H. L. The rapid spread of Medusa-head rye, (Elymus caput-medusae) has caused considerable concern in the range areas of southwestern Idaho. Since many of the new Medusa-head rye infestations in Idaho are relatively small in area, it would appear that a practical means of eradicating these infestations is through the use of a soil sterilant. CMU (3-(p-chlorophenyl)-1, 1-dimethylurea) has shown a high degree of toxicity to many annual grasses, and effective control of weedy annual grasses has been obtained with this compound at rates as low as 3 pounds per acre.

In the fall of 1952 and 1953, CMU was applied to Medusa-head rye on arid range lands at rates ranging from 1 pound per acre to 80 pounds per acre. No appreciable Medusa-head rye control was obtained with CMU rates of less than 10 pounds per acre. Complete eradication of Medusa-head rye in both years was possible only with the 40- and 80-pound per acre rates. Less than 10 Medusa-head rye plants occurred on each square-rod plot treated at the 20-pound per acre rate; however, these plants grew to maturity and produced viable seed. (University of Idaho Agricultural Experiment Station)

Ecology and control of Mediterranean sage (Salvia aethiopis). Poulton, Charles E. Mediterranean sage, Salvia aethiopis, is an important range weed in south-central Oregon and adjacent California. The weed is native to the Mediterranean area where it grows in competition with fescues (Festuca spp.), needle-grasses (Stipa spp.) and other perennials. In spite of a biennial habit, the plant is a relatively strong competitor and may maintain a seed source on fairly good ranges. It has been observed in Oregon to complete its life cycle in a heavy sod of dryland sedge (Carex spp.) and to mature 22 plants per 100 square feet in an area where beardless wildrye (Elymus triticoides) averaged 37 culms per square foot. It is an abundant seed producer, develops a large rosette of basal leaves, and is an aggressive competitor on deteriorated range lands. In one area of particularly bad infestation near Lakeview, Oregon, Mediterranean sage produced 34 rosettes per square foot in 1954. It is estimated that the infestation is currently spreading over more than 100,000 acres in Lake County.

The plant is not eaten by livestock, much of the infested area cannot be worked with machinery, and the range itself lacks the cover of perennial grass necessary to hold the weed in check. It therefore presents a serious threat to range feed production on

REPORTS OF INDIVIDUAL CONTRIBUTORS

A study of the Medusa-head problem in Idaho. Hironaka, M., Tisdale, E. W., and Sharp, L. A. A range problem of considerable potential has been created on cheatgrass (Bromus tectorum) ranges of southwestern Idaho by the recent and rapid spread of Medusa-head (Elymus caput-medusae), an annual wild rye grass. The estimated area of infestation is now about 150,000 acres, located mainly in Gem, Washington and Payette counties. This invasion of cheatgrass ranges by Medusa-head has appreciably lowered the grazing capacity of the infested areas, and threatens to spread onto additional large areas of this type of range.

Preliminary studies of this plant made over the past 4 years have revealed something of its ecology and the nature of the problem. Until 1954, however, this work was done on a very small scale, without the support of an organized project. Beginning in 1954, a more comprehensive study was begun. The work will involve a survey type study of the infested area, with emphasis on the management practices and site conditions which appear to have favored the spread of the plant. Studies are under way on the ecology of Medusa-head, its competitive ability and the feasibility of its control by perennial species. Control by artificial reseeding is included in this program.

Results of the studies made to date indicate that Medusa-head is well-adapted to invade annual grass ranges in southwestern Idaho. It is the only annual species which has replaced cheatgrass on any large scale in this area. The growth cycle is much the same as for cheatgrass, but Medusa-head reaches maturity about 2 weeks later. Dense stands are formed, with as many as 1,000 plants per square foot. Yields are as high or higher than those of cheatgrass, but grazing capacity is considerably lower due to low palatability. While the stiff awns render the plant unattractive and even dangerous in the flower and seed stages, it is grazed to some extent earlier in the season. Seed production is abundant and there is some carry-over of viable seed in the field for at least one year after it has matured.

The Medusa-head problem, like most range weed problems, appears to be primarily the result of poor range conditions. The areas it has invaded were originally dominated by sagebrush and perennial grasses. Their conversion to annual grass range was accomplished by grazing out most of the perennial grass and killing the sagebrush by fire. Cheatgrass invaded these areas and remained the dominant until the arrival of Medusa-head. While the use of direct control methods such as fire and herbicides are being studied, it does not appear that these will provide the answer to the Medusa-head problem. The real problem is lack of perennial forage cover, and the studies aimed at restoration of perennials either by management or by artificial reseeding appear most likely to provide areas where annual grass species and/or unpalatable brush predominate. Work by W. A. Sawyer of the Squaw Butte Station and by others in the problem areas, has demonstrated easy control of Mediterranean sage by one pound per acre (acid-equivalent) of 2,4-D butyl ester applied in late spring after germination is complete. The species is also easily controlled by diesel oil spray and cultivation or grubbing where feasible. Thus methods are available for control, but merely killing the plants does not solve the problem. Effective control requires replacing Mediterranean sage by desirable perennial forage.

The Oregon Agricultural Experiment Station initiated a preliminary study to determine the germination and growth characteristics of the species on ten typical range soils of Oregon. This work has pointed up the following interesting facts: Seed purity, 77 percent; germination percent, 92.5 in the light and 45.0 in the dark; seed weight, 173,200 seeds per pound. Greenhouse germination on typical range soils varied from none on an alkali soil of a saltgrass (Distichlis stricta) area, to 70 percent on a Winchester sand. This preliminary work suggests that Mediterranean sage may be a potential problem on more Oregon soils than it now occupies. A more critical field analysis of the problem is contemplated for the summer of 1955. This may lead to formalization of a project on this problem weed. (Oregon Agricultural Experiment Station)

Ecology and control of Hypericum perforatum. Tisdale, E. W., Hironaka, M., and Harshman, E. P. Since 1951 studies of certain phases of the ecology of Hypericum and its control by biological means have been conducted in northern Idaho. During the past year the reduction of Hypericum continued on sites where Chrysolina beetles had been released previously.

Results from intensive study of some 25 sites representing a variety of site conditions and type of plant cover have shown the following trends:

(a) Marked reductions of Hypericum have occurred on most sites in the 3rd and 4th years following beetle release.
(b) The first vegetational response has been a marked increase in annuals, both grasses and forbs.
(c) There has been slower but appreciable increase in perennial forbs.
(d) On most sites there has been little increase in perennial grass. This has been due to lack of sizeable remnants of parent plants and in some cases to grazing pressure.
(e) Hypericum, after being virtually eliminated on many sites after the 4th year, has reappeared in some cases in the form of numerous seedlings. The fate of these young plants will be revealed in future studies.

Now that the control of Hypericum by beetles is relatively assured over much of the area, it is becoming obvious that this is merely the first step in the rehabilitation of these ranges. So far the principal change has been a replacement of Hypericum by annuals, some of which are as undesirable as the former species. Studies of means of increasing perennial cover by management or artificial reseeding are needed and are being started as part of this project. (Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow)

Sterilization of highway right-of-way and gravel stock piles with CMU for halogeton control. Cronin, E. H. Results of experiments started in November of 1952 and reported in the 1954 Research Progress Report showed that CMU, 3-(p-chlorophenyl)-1, 1-dimethylurea), at 4 and 8 pounds per acre gave some control of halogeton, but also killed many of the native shrubs. At that time data for the 8-pound rate indicated that 100 percent of big sage (Artemisia tridentata) and shadscale (Atriplex confertifolia) and 58 percent of the black sage (Artemisia nova) had been killed. The 4-pound rate had killed 81 percent of the big sage brush and black sage and 73 percent of the shadscale.

The permanent transects were inspected again in June of 1954 and the following analyses of the perennial vegetation were obtained:

Rate of application of CMU	Percent loss of big sage (Artemisia tridentata)	Percent loss of black sage (Artemisia nova)	Percent loss of shadscale (Atriplex confertifolia)	Percent loss of bud sage (Artemisia spinescens)
4 lbs/A	87.0	84.0	73.0	77.7
8 lbs/A	93.3	96.3	100.0	100.0

Although the original vegetation was largely killed, especially at the higher rates of application, the halogeton was retarded only for a year. As stated in the earlier report it appeared that a number of plots were free of halogeton. However, the June, 1954 inspection revealed that halogeton was present on all 45 treated plots.

Rabbit brush (Chrysothamnus viscidiflorus subsp. stenophyllus) is spreading into the plots replacing the dead black sage and shadscale plants.

Two additional plots were located on the top of a gravel stock pile near Park Valley, Utah, on Highway #70. They were sprayed with 60 and 8 pounds of CMU per acre, respectively, on March 7, 1953. The 60-pound application effectively controlled all plants in both the 1953 and 1954 seasons. The 8-pound application appeared completely effective in 1953 but the 1954 inspection disclosed the presence of numerous halogeton plants. (Field Crops Research Branch, ARS, USDA, and Utah Agricultural Experiment Station, cooperating)

Toxicity of CMU to halogeton and some desirable range plants. Morton, Howard L., and Haas, Robert H. Soil sterilants have been suggested, and in some instances used, as a means of eradicating small spot infestations of halogeton (Halogeton glomeratus). To determine the toxicity of CMU to halogeton, and the length of time this toxicity persists, treatments were made in 1951, 1952, and 1953.

In October, 1951, CMU was applied to halogeton in an area devoid of all perennial vegetation at rates of 20, 40, and 80 pounds per acre. Both the 40- and 80-pound rates have given complete sterilization against halogeton growth during the 1952, 1953, and

1954 growing seasons. In April, 1952, CMU was applied to a mixed stand of halogeton and crested wheatgrass at rates of 2½, 5, 10, 20, and 40 pounds per acre. During the 1952 growing season the CMU was ineffective in preventing halogeton growth on all of the treated plots. Apparently the root systems of the halogeton seedlings present on the plots at the time of application were developed to depths sufficient to insure their escaping the toxic influence of CMU. By the end of the 1953 growing season all crested wheatgrass plants on the CMU-treated plots were dead. The plots treated with 2½, 5, and 10 pounds of CMU per acre have supported normal-appearing halogeton stands during the 1953 and 1954 growing seasons. The 20-pound rate reduced halogeton stands by approximately 75 percent during the 1953 and 1954 growing seasons, and the 40-pound rate was effective in preventing all halogeton growth during the 1953 and 1954 growing seasons.

In September, 1953, rod square plots in an area supporting a mixed stand of halogeton and saltsage (Atriplex nuttallii) were treated with CMU at rates of 2½, 5, 10, 20, 40, and 80 pounds per acre. On September 28, 1954, estimates of halogeton and saltsage kills were made on each of the treated plots. Halogeton kills for each treatment averaged 33, 60, 80, 93, 100, and 100 percent for the 2½-, 5-, 10-, 20-, 40-, and 80-pound per acre rates, respectively. The average saltsage kills were 13, 40, 56, 90, 83, and 100 percent for the 2½-, 5-, 10-, 20-, 40-, and 80-pound per acre rates respectively. Halogeton and saltsage kills were not considered to be 100 percent unless all of the plants of the species on the plot were dead. For this reason the 20-pound rate produced an average halogeton kill of only 93 percent, although very few plants were present on some of the plots treated at this rate. It is apparent from the high saltsage mortality that there is little CMU selectivity between halogeton, an annual, and saltsage, a perennial.

The minimum rate necessary for complete kills of halogeton in 1951, 1952, and 1953 applications of CMU was 40 pounds per acre. This rate of CMU application is also effective in preventing growth of most other range plants. The soil sterility produced by 40-pound per acre rates of CMU has been effective for at least three years. (University of Idaho Agricultural Experiment Station and Field Crops Research Branch, ARS, USDA, cooperating)

Results of two years' cooperative research on herbicidal control of halogeton. Morton, Howard L., Cronin, Eugene H., and Haas, Robert H. During the 1953 and 1954 field seasons an attempt was made to conduct a coordinated experiment on the herbicidal control of halogeton in the various western states concerned. Prior to this time much of the information concerning the herbicidal control of halogeton was obtained as a result of observations gleaned from field-scale operations, unreplicated experiments conducted in one area, or research conducted with one herbicidal material in one part of the region and another herbicidal material in another part. Valuable as these sources of information have proven to be, they have resulted in some contradictions about herbicidal control of halogeton. This experiment was designed to provide uniform replication of herbicidal applications in different areas. Specific objectives of the experiment were: (1) Determine the stage of growth at which halogeton is most susceptible to 2,4-D, (2) Determine the most effective 2,4-D rate to be applied at each stage of growth, and (3) Determine the dates at which the different stages of growth occur in different sections of the western United States and what variability exists in the date of occurrence of these stages of growth as they relate to herbicidal susceptibility.

In 1953 an outline of experimental procedure was distributed to seven agencies whose personnel had expressed an interest in the project at the 1953 meeting of the Research Section of the WWCC. This outline called for the application of the propyleneglycol butyl ether ester of 2,4-D at rates of 1, 2, 4, and 8 pounds per acre each at the seedling, elongation-branching, early flowering, and early seed stages of halogeton growth. Only two agencies were able to apply the treatments in 1953, the applications being made in southern Idaho and northern Utah. In 1954 the outline was changed to include six stages of halogeton growth: seedling, cruciform, early elongation-branching, late elongation-branching, early flowering, and early seed. The rates of application of the propyleneglycol butyl ether ester of 2,4-D were 1, 1½, 2, 3, and 4 pounds per acre. The above treatments were applied in southern Idaho and the 1-, 1½-, and 2-pound per acre rates were applied at all but the early seed stages in northern Utah.

Treatments made at the seedling stage of growth were less effective than those treatments made at the cruciform and early elongation branching stage. This lessened effectiveness was due to germination on the plots after the treatments were made. The treatments applied in the cruciform stage were made only in 1954. Optimum kills were obtained at this stage of growth both in Utah and in Idaho. In Idaho the 1-pound rate gave an average of 99 percent kill and all rates above 1 pound per acre produced 100 percent halogeton kills. In Utah the halogeton kills varied from 96 to 99 percent for the three rates of application made at the cruciform stage of growth.

The treatments applied at the early elongation-branching stage of growth also produced excellent kills in Idaho and Utah. In Idaho, only the 1-pound rate failed to produce 100 percent halogeton kills during the 1953 and 1954 seasons. In Utah, the 1953 treatments resulted in kills of 64, 68, 96, and 97 percent for the 1-, 2-, 4-, and 8-pound rates respectively. In 1954 the 1-, 1½-, and 2-pound rates all resulted in 99 percent halogeton kills. The poor agreement in the percent halogeton kills produced in Idaho and Utah in 1953 may be due in part to the difference in dates of application, June 11 in Idaho and June 26 in Utah. The treatments applied at the late elongation stage of growth were relatively ineffective in both Idaho and Utah. Halogeton kills ranged from 20 percent to 76 percent in Idaho and from 22 percent to 55 percent in Utah. With the exception of the 8-pound rate, treatments were ineffective at both the early flowering and early seed stages in Idaho and Utah in both 1953 and 1954. Only the 8-pound rate produced an effective kill at the early flowering stage in 1953.

From the results of two years' cooperative work on the herbicidal control of halogeton, it is apparent that halogeton becomes resistant to 2,4-D during the elongation-branching stage of growth, and the most susceptible stages of growth are the seedling, cruciform and early elongation-branching. The seedling stage is an undesirable time to treat, however, because of late season germination. It was further shown that the rate of 2,4-D application necessary for optimum kill at the cruciform and early elongation-branching stages of growth was somewhere between the 1½- and 2-pound per acre rates. A rate of 8 pounds per acre is needed in the late elongation-branching and early flowering stages to produce halogeton kills equivalent to those obtained with the 2-pound per acre rate in the cruciform and early elongation-branching stages of growth. Because of the lack of regional replication in the experiment, it was not possible to determine the dates at which different stages of growth occur and the stages at which halogeton becomes resistant to 2,4-D in different sections of the western United States. (University of Idaho Agricultural Experiment Station, Field Crops Research Branch, ARS, USDA, and Utah Agricultural Experiment Station, cooperating)

<u>Interacting factors of germination date and spraying date and their influence on the susceptibility of halogeton to 2,4-D.</u> Haas, Robert H., and Morton, Howard L. Halogeton has been observed to germinate over a long period of time during the spring and summer months. An experiment was designed in 1954 to determine whether plants which germinate during early spring develop resistance to 2,4-D earlier than those plants which germinate in early summer. Included in this experiment were plants which had germinated in late March to early April, on May 1, June 1, and on July 1. Plants germinating at each of the above four dates were sprayed with the butoxyethanol ester of 2,4-D at a rate equivalent to 2 pounds per acre on July 17, July 27, August 6, August 16, and August 27. Percentage kills were determined on each of the plots from population counts made at the time of treatment and final counts on September 27. Each treatment was replicated four times in a 4 x 4 Latin square split-plot experiment.

On July 17 the plants which had germinated on April 1 and May 1 were in the elongation-branching stage of growth and were quite resistant to 2,4-D. However, the plants which had germinated on June 1 and July 1 were still susceptible to 2,4-D, being in the cruciform and rosette-cruciform stages of growth respectively. On July 27 the plants which had germinated on June 1 were in the elongation-branching stage of growth and had developed considerable resistance to 2,4-D. Plants treated on August 16 and 27 were even more resistant to 2,4-D as the percent kills obtained on these dates were considerably lower than those obtained on August 6.

It is evident from this experiment that resistance to 2,4-D in halogeton is independent of the chronological age of the plant and is dependent upon the physiological age of the plant. In this experiment, the resistance of the halogeton plants to 2,4-D was developed simultaneously with the advancement of the elongation-branching stage of growth. The halogeton plants which germinated early in the season became resistant to 2,4-D at an earlier date than the plants which germinated later in the growing season. The plants which germinated early in the growing season were chronologically older at the time they became resistant to 2,4-D than were the plants which germinated later in the growing season. (Field Crops Research Branch, ARS, USDA, and University of Idaho Agricultural Experiment Station, cooperating)

Some factors involved in the growth and development of halogeton. Haas, Robert H., and Morton, Howard L. An exploratory study of halogeton growth and development was initiated in 1954 to determine the plant's response to supplemental water and nitrogen. Five levels of nitrogen were established on an old halogeton stand by adding nitrogen at rates of 0, 12½, 25, 50, and 100 pounds per acre. Supplemental water was supplied to each of the nitrogen levels at rates of 2¼, 4½, and 7½ surface inches, over a 32-day period, to establish low, medium and high soil moisture, respectively. In order to check the susceptibility of the halogeton plants a portion of each plot was treated uniformly with 2 pounds butoxyethanol ester of 2,4-D on August 6 and August 27, 28 and 47 days, respectively, after the initiation of the experiment.

Plant height and density data were collected at regular intervals on each plot. After the plants had matured visual ratings were made on each treatment for percentage kills and seed production. At the same time five 2-inch stem sections were collected at random from each treatment and analyzed for the number of black and tan seeds produced.

Results from the check plots (plots not treated with 2,4-D) indicate that growth was stimulated in direct proportion to the amount of supplemental water applied. Seed production per plot was increased in a similar manner. A response was obtained from the addition of nitrogen, although growth and seed yield per plot was just as great when 12½ pounds of nitrogen was added as when 100 pounds was added. This would indicate that the supplemental nitrogen requirement for halogeton is quite low.

Although both herbicide treatments were applied after the plants had gained considerable resistance to 2,4-D, better kills were obtained at both dates of application on high soil moisture levels. With the first 2,4-D application, kills of 20, 30, 42, and 52 percent were obtained with no additional water, low, medium and high supplemental water rates, respectively. This can be accounted for, at least in part, by the fact that flowering was somewhat delayed on the higher moisture plots, indicating that maturity was being delayed. There were no observable effects of nitrogen on percentage kills obtained from 2,4-D.

A notable increase was obtained in total seeds produced per unit length of stem when some water was applied. As the water rate was increased, the percentage of black seeds (i.e. seeds without adherent bracts) was steadily decreased. The percentages of black seeds produced were 96.4, 73.6, 50.7, 38.8 for no additional water, low, medium, and high supplemental water, respectively. The number of seeds produced per unit length of stem was also increased when nitrogen was applied. However, it was not shown that the addition of nitrogen either increased or decreased the percentage of black seeds produced.

The 2,4-D treatment had a marked effect on the number of halogeton seeds produced per unit length of stem, with the first application being most effective in reducing seed set. As compared with the check, seed set reductions of 87.6 and 43.0 percent were obtained when 2,4-D was applied August 6 and August 27, respectively. It is also evident that the 2,4-D applications were effective in reducing the percentage of black seeds; the percentage black seed produced being 30.2, 40.3, and 54.4 for the August 6, August 27, and check treatments, respectively. In this experiment the effects of 2,4-D in reducing both total seed set and percentage black seed set was not influenced by either water or nitrogen supplementation. (Field Crops Research Branch, ARS, USDA, and University of Idaho Agricultural Experiment Station, cooperating)

Ecology and control of Halogeton glomeratus. Tisdale, E. W., Sharp, L. A., and Holl, R. G. Emphasis in this project is being placed on studies of the competition of native and reseeded species with halogeton, and the effect of different range management practices on the relationship between halogeton and other species. Work on the life-history of halogeton has been reduced to studies of a few critical points such as the longevity and viability of the 2 forms of seed under field conditions.

This shift of emphasis seems justified in view of the following:

(a) A working knowledge of the life history of the plant as it occurs in southern Idaho has been obtained by the studies made to date.

(b) Much work on the physiology and ecology of halogeton is currently being done by the weeds section, U. S. Agricultural Research Service.

(c) It is becoming increasingly evident that the permanent control of halogeton can be accomplished only by means of competing plant cover. For this reason, much more needs to be learned about these competitive relationships and the conditions which favor perennial species in the various site conditions occurring on the ranges.

Work during the past year added further information on the amounts of different kinds of perennial cover required to control halogeton and on the longevity of the 2 forms of seed. Results to date indicate that in southern Idaho, stands of native shrubs having a foliage cover index of 20 percent or more (as measured by the loop transect method) are relatively immune to invasion by halogeton. Further studies are needed to test this relationship.

Halogeton seed of the brown form, normally dormant, gave up to 50 percent germination after 1 to 2 years of field burial. Seedlings from seed carried over in the soil were obtained on areas where no seed crop had been produced for 3 years. Presumably this germination comes from the brown seed, since seed of the black form buried for more than 1 year showed no viability. (Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho)

<u>Soil and competitive vegetation factors in relation to presence of halogeton</u>. Robocker, W. C. Nursery plot and field studies were conducted during the summer of 1954 in an effort to relate the presence of halogeton to soil texture. The nursery studies indicated that soil classified as sand would not support the growth of halogeton, while a luxuriant growth, with other conditions being similar, was obtained on clay and soils with a high percentage of clay. These results coincided with field observations made across the northern part of the State of Nevada.

Coincident with the soil study, Parker loop transects were run on important vegetation types over the northern part of the State. Sites were selected on which approximately 1 percent of halogeton occurred in 1954, and permanent transects were laid out. The following critical densities of shrubs under 1954 weather conditions were indicated: Shadscale (<u>Atriplex confertifolia</u>), 27 percent; big sagebrush (<u>Artemisia tridentata</u>), 24 percent; whitesage (<u>Eurotia lanata</u>), 20 percent; greasewood (<u>Sarcobatus vermiculatus</u>) on mixed vegetation sites, 16 percent; shadscale-little greasewood (<u>Sarcobatus baileyi</u>), 12 percent. These studies, as well as the soil studies, will be carried into the southern region of the halogeton infestation in Nevada in 1955. (Field Crops Research Branch, ARS, USDA, and Nevada Agricultural Experiment Station, cooperating)

<u>Photoperiodic and temperature responses of halogeton under field conditions</u>. Jansen, L. L. Field photoperiod experiments, as conducted in 1953 (see Research Progress Report, 1954, p. 157), were repeated and expanded in 1954. Artificial night lengths of 14, 11 or 10 hours were given to 24 plants on each square-foot plot, starting June 14 -- natural night slightly less than 9 hours -- and continuing for one, two, three, or five consecutive nights. Also included was a treatment consisting of three 14-hour nights alternated with two natural nights. Unlike results of 1953, no marked acceleration of the appearance of black seeds occurred in 1954. Pronounced differences were found, however, in the rates of flower formation and development after treatment. Within 9 days after beginning of treatment a few anthers were visible an inch or two below the terminal buds of plants in the group which received five 14-hour nights. A week later these plants were at peak-flowering, with anthers visible all the way to the stem tips and progressive cluster developments at lower positions. At that time plants of other treatments could be arranged in graded series between the 14-hour groups and the untreated controls. In descending order of effectiveness on reproductive stimulation,

night-length treatments followed the expected trend 14-, 11-, 10-, and natural-night; and for any given night length, five, three, two, and one night(s). The three 14-hour-alternate night treatment elicited responses intermediate between those of three and five consecutive nights as in 1953. Plants of the one and two 10-hour night groups did not differ in any appreciable manner from the controls, indicating that 10 hours of darkness or a 14-hour-daylength is very close to the critical.

Maximum-minimum temperature records kept in 1953 showed that an abrupt increase in the daily minimum temperatures occurred approximately two weeks prior to the first floral primordia in untreated field plants. Except for one night, the period of June 11-18, 1953 was characterized by night temperatures above 50 degrees F. During both the week prior and the week after that period minima were below 43 degrees F. Flower primordia were present in 3 out of 4 plants examined on June 29. A thermograph record was maintained throughout the 1954 season. Night temperatures did not fall below a 50 degree F minimum on the nights of May 9 and June 3 but fluctuated between freezing and 44 degrees F on all other nights. Beginning June 12, 1954, however, nights became considerably warmer. In the next 3-weeks period the minima were above 48 degrees F except for two nights when it fell to about 42 degrees. Flower primordia were first found by bud dissection on June 21.

In consideration of the growth rates and time element involved, the growing conditions in the natural environment, and certain data gathered under controlled conditions, initiation of reproductive growth in halogeton seems to be best correlated with a period of warm nights, during which the temperature remains above 50 degrees F minimum. Short days during the period of induction, then, would seem to increase the magnitude of the response. Differences observed in responses to 1953 and 1954 treatments may possibly have resulted from differences in the physiological status of the plants at time of treatment. (Field Crops Research Branch, ARS, USDA, and Utah Agricultural Experiment Station, cooperating)

PROJECT 3. UNDESIRABLE WOODY PLANTS ON IRRIGATION SYSTEMS, FOREST AND RANGE LANDS

O. A. Leonard, Project Leader

SUMMARY

The most obvious change in the abstracts this year are those related to the use of chemicals for brush control along rights-of-way. Chemicals are used because of economic considerations and some interesting cost figures are presented in a few of the reports. It is clear that the use of chemicals for rights-of-way is here to stay and that the use of chemicals will spread into other areas.

Brush control along irrigation systems is becoming more popular, but insufficient research is being conducted along with the actual use of chemicals. This leads to unnecessary expense, due to application failures or only partial kills. Hence, research data are gathered through use -- which is possible -- but this is a slow and expensive method for obtaining information. Studies on willow control are urgently needed, since our understanding of species response at different seasons of the year and to different soil moisture conditions is fragmentary at best. Salt-cedar continues to be difficult to control and wild rose is still a problem.

Information that has been gathered on forest lands represents some of the best research that has been obtained on the chemical control of woody plants. In ribes control work, complete control is an objective and this has influenced the research that has been done. The data obtained are quite valuable, because the factors found to be necessary for a high degree of control also apply to other woody plants. It is encouraging to see research on the use of chemicals in connection with reforestation and timber improvement. Scotch broom is spreading in the Sierra Nevada and it grows in such dense stands as to limit pine reproduction. Even though this plant is sensitive to 2,4-D, the problem of control is still with us, because of difficulties in making applications and because of seedlings.

Only five reports were obtained on the control of woody plants on range lands and three of these involved the control of big sagebrush. It is clear that this plant is sensitive to both 2,4-D and 2,4,5-T and that good control can be obtained with either chemical. The cost factor is the major consideration and obviously favors the use of 2,4-D, or combinations of 2,4-D and 2,4,5-T when mixtures of certain types of vegetation are involved. Local recommendations may be influenced by factors not existing in other areas, but efforts should be continued towards a better understanding of factors influencing successful control.

Phragmites is a large reed that is a problem along certain drainage areas of the Imperial Valley. This plant has been found to be sufficiently susceptible to Dalapon to be satisfactorily controlled with this chemical.

Chemical control of woody plants. Wetsch, A. F. The Bonneville Power Administration has employed chemicals in brush control on its transmission line rights-of-way for the past three years with highly satisfactory results. The annual program has been in excess of 2000 acres and for the most part encompasses the region lying west of the Cascade Mountains in the States of Oregon and Washington. The methods of chemical brush control consist of stump treatment, basal treatment and foliage treatment. In mixed stands a combination of these methods has proven the most effective and economical.

All the stumps with the exception of conifer stumps are treated immediately following a brush cutting operation to obtain best results. If stumps are not treated immediately following cutting, treatment is postponed until resprouting has occurred, at which time a basal mixture is applied to the new sprouts and the original stump. Results of stump treatment approximate 80 percent kill on most species with the exception of alder which is nearer 100 percent.

Basal treatment is generally employed on species resistant to foliage treatment such as maple, oak, cherry and others, although cottonwood and willow are also highly susceptible to this treatment as well as to the foliage treatment. The degree of kill is proportionate to the thoroughness of coverage and on species other than alder upwards of 80 percent kill has been obtained. Alder, especially that in tall dense groves, appears to be resistant to the common basal treatment, although alder treated as long as two years ago still show effects. Summer basal appears to give somewhat better results than dormant basal on alder, although there does not seem to be any marked difference in respect to other species.

Foliage spray mixtures consist of 2 quarts of the low volatile ester brush killer (2 pounds each 2,4-D and 2,4,5-T) in 100 gallons of water. Basal and stump treatment mixtures consist of 4 to 5 gallons of the low volatile ester brush killer (2 pounds parent acid each of 2,4-D and 2,4,5-T) in 94 to 95 gallons Diesel oil.

Cost comparisons are rather meaningless since so many variables are present. However, in general it requires twice as much labor and ten times more basic chemical per acre for basal treatment than for foliage treatment. Cutting, disposal and stump treatment roughly requires five to ten times more labor than basal treatment, with the amount of chemical about the same as for basal treatment. Brush control measures have been confined to an initial treatment with no follow-up because of the large backlog, although future programs envisage such follow-up treatment. Thus, control measures have been confined to brush ranging between 12 to 30 feet tall. Brush control has also been on a selective basis, that is treating only the brush that is a potential hazard to the line and saving the low-growing varieties to deter undesirable brush and weed growth and to prevent soil erosion. (Bonneville Power Administration)

Brush control as practiced by a utility company. Rowse, R. Larry. One of the prime responsibilities of any electric utility company, private or public, is continuous uninterrupted service to all customers. Brush and trees beneath power lines is a constant threat to this obligation. The incredibly high cost of pruning and hand removing has inevitably led many utilities to apply the accepted practices of chemical brush control.

During 1953, accurate records were kept on labor, materials, equipment depreciation and miscellaneous expenditures to determine actual costs of hand-clearing rural distribution rights-of-way. Using trained crews with complete, modern equipment, it was found that clearing costs ranged from $1,000 to $1,500 per mile, depending upon the density of the brush. Even under ideal conditions this method offers only temporary relief because within 3 to 5 years the brush has responded "beautifully" to the severe pruning and is ready to harvest again.

Periodic evaluations of chemical spraying have indicated that the degree of control obtained is dependent upon a trained and conscientious crew, suitable equipment and proper mixtures in relation to seasonal weather variations. Foliage spraying is started in early spring as soon as the leaves have reached the full development stage. Applications made immediately following bud break, when the terminal growth is developing rapidly, have not proved successful. Presumably, these immature leaves are not producing excess carbohydrates for stem and root storage, therefore there is a minimum of translocation to the root zone. Most species of brush common to the Pacific Northwest can be controlled with 2,4-D and 2,4,5-T mixtures. Extensive comparative trials have been conducted using the 50-50, or 2 pounds each of 2,4-D and 2,4,5-T, and 2-2/3 pounds 2,4-D and 1-1/3 pounds 2,4,5-T. The results of these trials indicate no difference in ultimate kill. The so-called low volatile esters are used and mixed at the rate of 3 pounds of the combined parent acid (2-2/3 pounds 2,4-D and 1-1/3 pounds 2,4,5-T) per 100 gallons of water. The addition of wetting agents has been found extremely advantageous. As the spray season progresses to the hot, dry months, 2½ to 5 percent Diesel oil is added to the above mixture to aid penetration. It is generally agreed that thorough wetting of the stem is essential in foliage applications. However, on large scale rights-of-way operations it has been found most feasible to keep the truck or unit moving at a speed sufficient to allow the operator to achieve an 80 percent or better coverage. Stops and starts are extravagant of time and material and not in proportion to the slight percentage improvement in ultimate kill. Weather conditions and adjacent crops permitting, "fogging on" the diluted mixtures has proved most successful. Excessive drenching of the foliage is avoided.

Average costs in 1953 for first-time foliage applications to right-of-way distribution lines totaled $29.53 per mile with an 80 percent kill. Touch-up applications completed within the second or third year can be made at a fraction of the initial cost.

Winter basal spraying is considered an integral part of the entire program for a number of reasons quite apart from the fact that it allows for almost a year-round operation. The degree of kill, too, is considerably higher than with foliage sprays. Basal spraying is started after the first freezing weather, usually in early December. In the basal mixture, 16 pounds of combined parent acid (2-2/3 pounds 2,4-D plus 1-1/3 pounds of 2,4,5-T) is mixed per 100 gallons of oil. Repeated trials on several hundred miles of right-of-way have indicated that the use of heavier oils (General Petroleum #10) increased the effectiveness considerably. Basal applications are made from the ground line to a height of 36 inches. It is essential that the entire stem or trunk be saturated to this height.

Average costs in 1952 for first-time basal applications to distribution lines averaged $52.47 per mile with a 95 percent kill. 1954 basal applications averaged $71.78 per mile. All cost figures include labor, equipment depreciation, supplies and materials. (Portland General Electric Company)

Chemical brush control by The Pacific Telephone and Telegraph Company in northern California. Anonymous. In 1949 we started to use chemicals on a trial plot basis. Five miles were treated in 1950, 20 miles in 1951, 20 miles in 1952, 30 miles in 1953, and 50 miles in 1954. All of this right-of-way was foliage, basal or stump sprayed with esters of 2,4-D, 2,4,5-T or combinations of both chemicals. Most of the work is performed by outside parties on a contract basis for each individual job. We are now trying a new system with a 5-year "kill and control" contract on the Los Gatos-Santa Cruz-Watsonville toll line. The contractor decides what chemicals to use, the method of application, and when and where to apply; thus, we are concerned only with the results.

We have tried spraying CMU (Telvar) on the ground around brush and small trees, and also of injecting CMU into the ground around larger trees. The results appear promising, but more trials are needed. In 1954 we tried red "O" mixed in a 1-10 Diesel oil solution to assist in obtaining good coverage. It seemed to work well, except where manzanita was present.

In northern California along Eel River, the broad leaf maple is a difficult species. This is a heavy rainfall area (70-80 inches) with cool and foggy summers, and the maples grow very fast. Six miles of a 20-foot right-of-way were treated in June 1951 with 2 quarts of 2,4-D and 3 quarts of 2,4,5-T in 100 gallons of water. This area was re-treated in May 1952 with the same mixture plus 12 ounces of multi-film spreader sticker. The first treatment resulted in defoliation and stunting of the maples, but an 80 percent kill was obtained with the second application. No treatment was made in 1953 or 1954. It is now regarded that the maples should have been sprayed in 1953, and it will be necessary to start all over again in 1955. However, the results have been much better and cheaper than would have been obtained by brushing out by hand.

We have also been trying to kill suckers around redwood stumps by both foliage and basal sprays using a 1-10 ratio of 2,4,5-T in Diesel oil; follow-ups are necessary with this method. (The Pacific Telephone and Telegraph Company, San Francisco, California)

Chemical brush control by The Pacific Telephone and Telegraph Company in Oregon. Hoff, W. S. Two methods were used -- foliage sprays and stump treatments. Foliage sprays were applied in Western Oregon on bushy growth of salmonberry, blackberry, huckleberry and digitalis. Regrowth developed on these species. Complete kills of red alder up to 14 feet tall, scotchbroom, and willow were obtained. Salal has not been killed.

The solution used contained 1500 parts per million each of 2,4-D and 2,4,5-T applied in water, using power equipment.

In eastern Oregon a section of scrub oak (Oregon white oak) was slashed to 12 inches and treated with 1.5-2.0 percent each of 2,4-D and 2,4,5-T in kerosene, with good results. When completely sprayed, some regrowth came from roots 8-10 inches from the stumps, but most regrowth came from stumps one inch or less in diameter, indicating poor coverage. Knapsack sprayers were used in making the stump applications. (Pacific Telephone and Telegraph Company, Portland, Oregon)

Salt cedar control investigations. Lowry, Orlan J. The Bureau of Reclamation has made annual reports regarding salt cedar control for several years to the Western Weed Control Conference in the form of progress reports. The chemical formulations, methods of application, and seasonal results have been reported in the 1952, 1953 and 1954 progress reports. Thus, to prevent repetition, this paper will deal primarily with the work during 1954.

Approximately 8,000 acres of mixed phreatophytes were sprayed on the Middle Rio Grande Project in June 1954, financed by the Bureau, and 4,500 acres were sprayed, financed by the State of New Mexico. In addition, 1,800 acres were sprayed by the Bureau near the upper end of Caballo Reservoir in May. This is at least the second application on all the above areas, and in most cases it is the third. Observations made in October on the 1,800 acres sprayed on Caballo in October 1951, June 1952, and May 1954 indicated about 50 percent top-kill with secondary die-back occurring on the tip of all regrowth branches. This area was sprayed with 2 pounds 2,4-D amine salt in emulsion at the rate of 5 gallons per acre. In an area of 725 acres on the Middle Rio Grande Project, sprayed with the above formulations, observations in October indicated nearly 100 percent kill of Baccharis, 80 percent kill of cottonwood, and 80 percent top-kill and 50 percent plant-kill of salt cedar, following two applications in 1953 and one in 1954. In an area sprayed once in 1953 and once in 1954 with the low volatile esters (Iso-octyl) of 2,4-D and 2,4,5-T at 2 pounds per acre, nearly 100 percent top-kill of willows was apparent, and about 50 percent top-kill of salt cedar. However, regrowth occurred from 90 percent of the salt cedars and 25 percent of the willows. Similar results were observed in a tract of 1,140 acres which were sprayed twice in 1953 and once in 1954 with the low volatile esters of 2,4-D. Beginning in 1951, a 250-acre tract of mixed phreatophytes was sprayed five times (June 1951, October 1951, August 1952, July 1953, and September 1953) with 2 pounds 2,4-D amine salt in emulsion. The top-kill on all plants, except the extremely large cottonwood trees, appeared nearly complete after each application, but regrowth developed rapidly after each spraying. An inspection in June 1954, indicated an almost complete top-kill and a high percentage of plant-kill. However, by October a vigorous bottom regrowth had developed from more than 50 percent of the salt cedar and almost as high a percentage of willow and cottonwood.

Thus, the results on all airplane-sprayed tracts of mature phreatophytes are quite similar. Two or three repeated spray treatments failed to give more than 50 percent kill and as soon as repeated sprayingsare discontinued, the phreatophyte growth soon recovers to the original stand and density. With the present formulations being used, annual spraying appearsnecessary to control mixed mature phreatophytes.

Low volatile esters of 2,4-D and 2,4,5-T at over 4 pounds per acre applied to adult salt cedars in the early bud stage indicate promising effects. The amines were almost completely ineffective in this test. Continued applications during this stage of growth to ascertain the actual effectiveness are necessary.

Repeated annual spraying of 2 pounds or more of 2,4-D in 10 gallons or more of solution applied with a ground spray rig will control most salt cedar seedlings and regrowth along canals, laterals and drains. There are indications that continued resprayings (plant starvation) rather than the rate of application may be a prime factor in controlling seedling and regrowth phreatophytes. (Contributed by Bureau of Reclamation Region 5)

Effect of type and amount of carrier on the action of three rates of 2,4-D applied as basal sprays on dormant salt cedar (*Tamarix pentandra*). Whitworth, J. W. Basal sprays of 2,4-D in an oil carrier applied to dormant salt cedar have proved to be an effective but impractical method of killing the dense and extensive infestations of salt cedar in New Mexico. This method of treating salt cedar has proved useful as a means of studying the factors that affect the response of salt cedar to herbicides.

Treatments were made on March 9, 1954, to determine the amount of 2,4-D required to kill salt cedar and the type and amount of carrier necessary to introduce 2,4-D into the system of the plant.

Two carriers, water and a No. 2 fuel oil, were compared at rates of 1/16, 1/2, and 1 pint per plant. Three rates of 2,4-D (propylene-glycol butyl ether ester), 5 ml (1.44 grams acid), 10 ml and 20 ml per tree, were included in both carriers at the different volumes. The straight oil was used as a check. Each treatment was applied as a basal spray to six salt cedar trees 12 to 14 feet tall, with 4 to 8 trunks 1 inch in diameter.

On July 8, 1954, five months after treating, preliminary readings were made. Table 1 is a summary of this data. Oil proved much superior as a carrier and penetrant. When oil was used as a carrier, the amount of 2,4-D and carrier was not an important factor. Many investigators working with other woody species have indicated that volume of carrier was very important, and effective treatments required enough volume to permit the solution to run down the trunk to the basal root area. This observation did not prove valid in this test with either the water or the oil carrier. Oil alone was very low in toxicity even at volumes of 1 pint per tree.

Water was much less effective than oil as a carrier. Increasing the rate of 2,4-D increased the effectiveness of the treatments applied with water, but even the highest rate in water was less effective than the lowest rate in oil. (New Mexico Agricultural Experiment Station, State College, New Mexico)

Table 1. Average degree of injury on salt cedar (Tamarix pentandra) 8 July 1954 following dormant, basal treatments made 9 March 1954.1/

Type of carrier	Amount of 2,4-D In ml per tree				Amount of carrier in pints per tree		
	0	5	10	20	1/16	1/2	1
No. 2 fuel oil	7	92	96	99	93	97	97
Water	-	18	53	73	53	40	52

1/ Injury key:
100 - plant entirely dead; 90 - plant nearly dead; 80 - severe injury, leaves drying up and dying; 70 - severe injury with some live leaf tissue; 60 - leaves showing severe burn and malformations; 50 - leaves showing moderate to severe burn and malformations; 40 - leaves showing moderate burn and malformations; 30 - leaves showing light burn and malformations; 20-leaves showing very light burn and malformations; 10 - leaves showing trace of burn and malformations; 0 - plant apparently normal.
(New Mexico State Agricultural Experiment Station)

Control of wild rose (Rosa woodsii) by basal dormant applications of growth regulators. Lee, W. O. and Timmons, F. L. Several experiments on the use of basal dormant spray applications to control wild rose were conducted in Utah prior to 1953. Results of these tests were disappointing. An experiment was started November 11, 1953, to determine whether it is possible to apply enough chemical to kill wild rose by basal dormant application. The propylene-glycol butyl ether ester of 2,4,5-T and a 50-50 mixture of the propyleneglycol butyl ether esters of 2,4-D and 2,4,5-T were compared at concentrations of 2 and 8 percent (20,000 and 80,000 ppm) applied in Diesel oil. Treatments were applied to the lower 15 inches of the plant with sufficient material being used to wet completely this portion of the plant. All treatments were replicated twice on wild rose growing in a fence row.

Effect of basal dormant treatments on wild rose.

Chemical	Concentration % by weight	Gallons, spray per acre	Pounds acid per acre	Percent regrowth 9-15-54 Top	Bottom	Total
50-50 mixture	2	190	31.6	85	0	85
50-50 mixture	8	166	110.4	25	3	28
2,4,5-T	2	164	27.3	53	5	58
2,4,5-T	8	176	117.1	8	Tr.	8

As shown in the table, these two materials, when used at the lower concentration but at rates as high as 31 pounds per acre, did not give satisfactory kills of wild rose. Even the higher concentration which gave rates as high as 117 pounds per acre did not result in 100 percent kill of all wild rose present. However, control was good enough with the straight 2,4,5-T treatment so that it might not be too difficult to complete the kill of the wild rose by follow-up treatment. The absence of regrowth from the roots probably indicates that a root-kill as well as a top-kill was achieved on most plants and that the small remaining top growth may have been due to insufficient coverage of all rose canes. (Field Crops Research Branch, ARS, USDA, and Utah Agricultural Experiment Station, cooperating)

<u>Relation of stage of growth to effectiveness of 2,4,5-T spray applications on wild rose</u>. Timmons, F. L. and Lee, W. O. Experiments conducted in Utah in past years have shown that straight 2,4,5-T gives better control of wild rose than does 2,4-D alone or combinations of 2,4-D and 2,4,5-T at equivalent rates. An experiment was started in the spring of 1953 to determine the best stage of growth for applying 2,4,5-T. Treatments were made at six stages of growth: pre-leaf (spring dormant), full-leaf, bud, bloom, post-bloom, and after leaf-drop (fall dormant). In the initial application all foliage-stage plots were treated uniformly with spray containing 1500 ppm of 2,4,5-T in 160 gallons of water per acre which gave 2 pounds acid equivalent per acre. At spring and fall dormant stages two concentrations were compared, 3,000 and 12,000 ppm in 80 gallons per acre of a 1 to 7 oil-water emulsion which gave 2 and 8 pounds per acre, respectively. All treatments were replicated three times. The spring dormant and all foliage stage plots except the post-bloom stage were re-treated in the summer of 1953 with a uniform concentration of 1500 ppm in sufficient volume to give coverage of all regrowth.

Effect of 2,4,5-T on wild rose at different stages of growth

Stage of growth	Original treatment date 1953	Rate, lbs/acre, 1953 Original treatment	Retreatment	Total	Percent regrowth 6-7-54
Pre-leaf (dormant)	3-6	2.0	3.3	5.3	88
Pre-leaf (dormant)	3-6	8.0	3.3	11.3	56
Full leaf (foliage)	5-25	2.0	1.7	3.7	22
Bud (foliage)	6-22	2.0	1.8	3.8	62
Full bloom (foliage)	7-8	2.0	1.0	3.0	50
Post-bloom (foliage)	8-13	2.0	none	2.0	88
After leaf-drop (dormant)	11-30	2.0	none	2.0	27
After leaf-drop (dormant)	11-30	8.0	none	8.0	25

As shown in the table, regrowth in June 1954 was considerably less from applications made originally at the full-leaf stage and at the fall dormant stage than at other stages of growth. There appeared to be little advantage for the heavy rate at either the spring or fall dormant stage. The relatively poor results from applications made at bud and bloom stages are somewhat surprising since applications at those stages have given relatively good results in previous experiments. All plots were given foliage re-treatments in 1954 and observations of regrowth will be made in 1955. (Field Crops Research Branch, ARS, USDA, and Utah Agricultural Experiment Station, cooperating)

Control of Phragmites with Dalapon. Swezey, A. W. and Day, B. E. *Phragmites communis* is a serious weed along ditch banks and drainage areas of California's Imperial Valley. It grows in thick stands to the virtual exclusion of other plant growth. Past practice has been to suppress its growth by burning mature stands, followed by frequent spraying with aromatic oil throughout the growing season.

Dalapon was applied to a series of test plots throughout the 1954 growing season to determine the effect of season, stage of growth, and rate of application on the degree of control obtained with this chemical. Initial plots were bulldozed to remove old growth in September, 1953 and were treated with 20, 40, and 60 pounds of Dalapon (acid equivalent basis) both with and without wetting agent (Triton X-100) on December 29, 1953. These exploratory plots were not replicated. Five additional series of test plots were treated during 1954. These tests were made in areas that had been burned to remove old growth. Dalapon was sprayed on

Condition of Phragmites Plots on December 21, 1954

Date burned	Date sprayed	Volume of water (gallons per acre)	Height when sprayed (feet)	Rate (pounds per acre)	Regrowth (percent control)	Height of regrowth (feet)	Regrowth malformed (percent)
September 29* 1953	December 29 1953	300	2-3	20**	27	5	5
				20	30	5	5
				40	8	4	25
				60	7	2	37
February 3 1954	April 26 1954	265	3	15	3	5	10
				30	3	5	30
				45	2	5	15
February 3 1954	June 16 1954	420	6-8	15	1	2	60
				30	1	2	70
				45	0.5	2	80
April 30 1954	June 16 1954	420	3-5	15	2	4	60
				30	2	4	55
				45	2	4	60
April 30 1954	August 12 1954	500	6-10	15	2	4	60
				30	1	2	75
				45	2	2	80
August 13 1954	October 13 1954	265	3	15	none	-	--
				30	none	-	--
				45	none	-	--

* Old growth removed by bulldozing instead of burning.

**Triton X-100 added at 8 oz./100 gallons of spray.

the foliage at rates of 15, 30, and 45 pounds per acre in sufficient water to wet. Plots were 20 by 25 feet in size and each treatment was replicated four times. The entire top growth of Phragmites was killed back to the ground in all cases. On December 21, 1954 the number of stalks of regrowth in each plot was counted. The regrowth, calculated as percent of adjacent controls, along with height of regrowth, and percent of stalks malformed (with symptoms of Dalapon injury), is given in the table on page 39.

After the first plots were bulldozed, only a partial stand of regrowth had developed at the time of spraying in December. This might account for the poorer results obtained from the December treatments. Rhizomes dug in October from plots treated in April, June, and August appeared to be alive. Roots from the nodes of the rhizomes were dead and partially decomposed. Segments of the rhizomes were found to produce new shoots when planted on moist blotters in a seed germinator. (Dow Chemical Company and University of California Citrus Experiment Station)

Results of experiments to control manzanita (Arctostaphylos parryana var. pintorum) and snowbrush (Ceanothus velutinus) on central Oregon forest land. Dahms, W. G. Manzanita and snowbrush often form extensive brushfields in old burns, or occupy small openings and understocked portions of ponderosa pine stands. Experiments with herbicides are aimed at controlling brush in the large fields as a first step in seeding or planting operations, and in releasing young tree seedlings that are usually growing underneath the brush in small openings.

The following facts and conclusions were drawn from small plot hand sprayer tests with herbicides made in 1953 and 1954:

1. Manzanita (a nonsprouter) can be completely killed very easily.

2. The aerial parts of snowbrush can be easily killed during the main growing season. A very limited amount of late-season spraying indicates that a kill of aerial parts is much less certain, but sprouting is greatly reduced. This indicates that it may be possible to completely kill snowbrush by late-season spraying.

3. Low volatile ester 2,4-D (propyleneglycol butyl ether esters) are just as effective as the same ester of 2,4,5-T and much more effective than the butyl ester of 2,4-D or low volatile ester of 2,4,5-TP.

4. Manzanita is most easily killed from the time snowbrush starts twig growth until it quits blossoming.

5. The brush shields young pine trees growing under it from spray to a large degree. On plots treated with either 2,4-D or 2,4,5-T at the rate of 3 pounds per acre all exposed trees were either killed or severely damaged, but 55 percent of trees growing under brush were unharmed, and only 12 percent killed when the carrier was water. Much more damage was done to trees with a Diesel oil carrier.

Application of low volatile ester 2,4-D (propyleneglycol butyl ether ester) with a fixed wing plane was tried July 7, 1954.

Application was at the rate of 1, 2, and 3 pounds of acid per acre. Emulsions and straight Diesel oil carriers were both used. Summer oil at the rate of 1 gallon per acre was tried on 3-, 5-, and 10-gallon per acre emulsion sprays and Diesel oil at the rate of 2/3 gallon per acre in a 6-1/2 gallon emulsion spray. Straight Diesel oil was used in 3- and 5-gallon per acre spray volumes.

The following facts and conclusions emerged from the test:

1. Manzanita was 100 percent killed by all of the combinations tried.

2. Only 48 percent of the snowbrush plants had their aerial parts completely killed. Most of the partially-killed plants were in an understory position where manzanita plants shielded them from the spray.

3. Kind or volume of carrier did not significantly affect results on snowbrush.

4. The aerial parts of a significantly smaller number of snowbrush plants were killed by the 1-pound dosage than with the 2- and 3-pound dosages.

5. Heavy damage including frequent loss of terminal bud on the leader, was done to all exposed trees covered by 2- or 3-pound dosages. Only superficial damage was done to many fully exposed trees covered with the 1-pound dosage, but many twigs lost their terminal buds on the exposed side of some trees and the terminal bud on the leader appeared to be dead in some cases. (Contributed by USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon)

Possible use of herbicides for thinning lodgepole and ponderosa pine. Dahms, W. G. Pole-sized lodgepole and ponderosa pine trees have been killed cheaply by the cut surface method at Pringle Falls Experimental Forest. Hack marks covering about half of the circumference of the tree are cut through the bark and into the wood with a hatchet. About 4 cc of undiluted commercial amine 2,4-D (4 pounds acid equivalent per gallon) was squirted into each hack mark. Trees treated during the growing season died in from 1 to 2 months. Minimum dosage and number of hacks required have not yet been determined. (Contributed by USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon)

Chemical brush control on cutover forest land on the Oregon coast. Ruth, R. H. Foliage applications were tried on a salmonberry (*Rubus spectabilis*) and associated species to kill or control brush competition long enough for natural conifer reproduction or planted trees to become established. Small 20- x 20-foot plots were sprayed with propyleneglycol butyl esters of 2,4,5-T and a 50-50 mixture of 2,4-D and 2,4,5-T in water. Concentration was 4375 ppm, with chemicals applied in sufficient volume to give thorough wetting of the foliage. Treatments were made on May 25, June 23, and July 17, 1953. All treatments were replicated twice.

Results with the 50-50 mixture of 2,4-D and 2,4,5-T were about the same as with 2,4,5-T alone: 90 percent defoliation of salmonberry with a few scattered sprouts from the root crowns of the plants the same year and more vigorous sprouting the next spring. The mid-season treatments were slightly less effective than the May or July treatments. Treatments with butoxyethanol esters were added to the experiment at the July application. Early results were about the same as with the propyleneglycol butyl esters. (Contributed by USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon)

Scotch broom control with 2,4-D. Leonard, O. A., Pryor, M., Mobley, L. and Randall, G. Mature Scotch broom (*Cytisus scoparius*) was treated with 1 and 2 pounds of 2,4-D (butoxyethanol ester) per 100 gallons of water on June 24, 1953. The flowering period was nearly over, the seeds were 1 to 2 mm in diameter, and there was ample soil moisture for growth.

One-half of the treatments contained water as the only diluent of the ester formulations, while the other treatments received 1 quart of Shell Tank Mix No. 1 (UR 90 percent and viscosity 61) containing 10 percent Tenlo 70 emulsifier. The results as observed on August 25, 1954 indicated the following: (1) 1 pound of 2,4-D in water gave a 90 percent kill of the plants close to the road and did not kill plants very far back away from the road, (2) 1 pound of 2,4-D in water plus 1 quart of the oil-emulsifier mixture resulted in 100 percent of the plants next to the road being killed and many plants behind these plants were also killed. The 2-pound rate of application gave a complete kill, with or without the addition of the oil.

The small cost of the oil and the increased chance for a good kill obviously suggests that the sprays should not be applied without using it. (University of California and the California State Department of Agriculture)

Continuing use of hormone-type herbicides on ribes in California. Quick, C. R., and Burrill, W. S. Development of chemical control of ribes in California continues as an aid to the control of white pine blister rust in sugar pine stands. During 1954 some 235 small plots were initiated, and 175 plots initiated in 1953 were checked. Major emphasis in 1954 was on *Ribes roezli Regel* (Sierra Nevada gooseberry), but *Ribes nevadense* Kell., *Ribes cereum* Dougl., and *Ribes montigenum* McCl. were also included in tests.

In a series of large-scale replicated tests put on the Stanislaus National Forest, on old-age decadent gooseberry plants, the best sodium-salt treatment of 2,4-D averaged 83 percent bush kill at 500 ppm, and 70 percent at 250 ppm, whereas the isopropyl ester of 2,4-D averaged 53 percent kill at 500 ppm, and 67 percent kill at 250 ppm. Other tests of the sodium salt and esters of 2,4-D confirm this reaction on old-age *R. roezli* in the central Sierra Nevada. It is believed that many liquid formulations of 2,4-D contain potent penetrants and detergents which actually reduce percentage of bush-kill of this very susceptible gooseberry.

In a series of small-plot tests on 4- to 8-year-old gooseberry bushes on the Stanislaus, the isooctyl ester of 2,4-D and the polyethyleneglycol 600 mono ester of 2,4-D killed all bushes at 125, 250, and 500 ppm acid equivalent. Variable types and distributions of ribes obscured the probability that a high-emulsant formulation of butoxyethanol ester of 2,4-D and a commercial formulation of butoxyethanol ester of 2,4-D were equally effective. In small-plot tests on 4- to 8-year-old plants, several forms of 2,4-D (methyl ester emulsifiable acid, isopropyl ester, and triethanolamine salt) gave 100 percent bush-kill at 125, 250, and 500 ppm acid equivalent.

The addition of propyleneglycol, or summer spray oil, or both, to sodium and ammonium salt formulations of 2,4-D did not enhance kill of R. roezli in small-plot tests on the Stanislaus. All formulations without additions killed all bushes (4- to 8-year-old) at 125, 250, and 500 ppm of 2,4-D acid equivalent. The formulations included in the tests were: (1) 2,4-D acid plus baking soda, (2) 2,4-D sodium salt, (3) 2,4-D sodium salt monohydrate, and 2,4-D ammonium salt. The 2,4-D acid dissolved with baking soda, at 125, 250, and 500 ppm, with or without additions of propyleneglycol and/or summer oil, killed all bushes to which it was applied. The triethanolamine salt of MCP in two tests at 500 and 1000 ppm, killed all gooseberry plants (6-8 years old) to which it was applied. The butoxyethanol ester of MCP also was effective at both concentrations. The sodium salt of MCP gave complete kill at 1000 ppm, but not at 500 ppm.

Simulated aircraft spray of water-miscible materials (by mist application of concentrated solutions of polyethyleneglycol 600 mono ester of 2,4-D plus polyethylene glycol and water to old-age and decadent R. roezli and R. nevadense) resulted in very considerable livestem reduction (90 to 92 percent), but low bush-kill (10 to 13 percent).

Treatments of aqueous-suspension sprays of two herbicidal derivatives of dimethylurea at the rate of 4 ounces per 1000 feet of ribes live stem, on Ribes roezli in the Sequoia National Park and on Ribes montigenum on the Toiyabe National Forest continue to show promising results. Reduction of ribes livestem in 1954 from treatments made in 1953 run as high as 90 percent on R. roezli, and 96 percent on R. montigenum. Due to the slow action of the dimethylurea derivatives, final results cannot be determined until 1955. The same two materials, as wettable powder and as pellets, were applied to clumps of Ribes cereum on the Lassen National Forest and in Sequoia National Park, and to R. montigenum on the Toiyabe. The materials were scattered on the crowns and immediately adjacent areas at the rate of 2½ and 5 grams per 100 feet of ribes livestem. These treatments appear slightly less promising than wettable powder sprays.

To simulate airplane application, broadcast and basal-area treatments with 2,4-D and 2,4,5-T methyl ester pellets were continued on R. roezli. Up to 90 percent of small gooseberry bushes have been killed by two such treatments. (Forest Service, USDA, Berkeley)

Progress in developing improved chemical methods of ribes suppression in the western white pine forests of Washington, Idaho, and Montana. Moss, V. D. Results of 1953 tests and the scope of work undertaken during 1954 in the development and improvement of chemical methods of ribes suppression for the control of white pine blister rust (Cronartium ribicola Fischer) are summarized.

From about mid-May to early September, the approximate period of active plant growth, ribes are killed with an aqueous spray of 2,4,5-T at dosages of 1,500 to 2,000 ppm of acid equivalent. The volume of spray applied per acre to forest lands ranges between 100 and 250 gallons depending upon the age and density of ribes and associated vegetation. Since this conventional aqueous spray is not effective on ribes after the first killing frost in September, about two months of favorable weather for spray work in the late fall have been lost.

In 1953, tests were made amending the aqueous spray of 2,4,5-T with 10 percent stove oil for late season treatments. Ribes were killed with this amended spray in late season as satisfactorily as they have been during the summer months with the conventional aqueous solution of 2,4,5-T. In late season when plants are undergoing natural defoliation, a spray must wet all winter buds and stems. As a drench it must thoroughly dampen porous soils or puddle heavier soils around root crowns of ribes without exposing roots. An improved method of emulsifying oil and water in 1954 made it possible to reduce the volume of stove oil in water to 5 percent and still retain the characteristic oil-like spray. This was accomplished by attaching an "injector" to the pressure line of the truck-mounted power sprayers. The mixture of stove oil and 2,4,5-T is broken into small particle size as it passes through the injector to a stream of water entering the tank.

While spraying until early November of 1954 in the Coeur d'Alene National Forest, hose lines and fittings froze during the night. This was remedied by pumping into the lines each evening an antifreeze (Zerone), dyed red so it could be recovered each morning without waste.

Other chemicals tested on ribes in 1953 included: PMU, CMU, IPC, MH, 2,5-D, and 3,4-D. All of these except CMU were applied in aqueous solution as foliage spray. PMU applied as spray and in powder form killed less than 50 percent of the ribes. Chloro-IPC at the rate of 20 pounds per acre in combination with 2,4,5-T at a dosage of 2,000 ppm of acid equivalent resulted in satisfactorily killing of both ribes and grass in aqueous spray treatments after September 1. MH was incompatible with 2,4,5-T in a combination spray applied to Ribes lacustre. No ribes were killed with aqueous sprays of 2,5-D and 3,4-D, or with CMU applied in pellet form. From May through October of 1954, 2(2,4,5-trichlorophenoxy) propionic acid was tested on ribes over a range of dosages, spray volumes, and methods of spray application. Foliage sprays alone were compared with foliage sprays plus soil drenching around root crown centers (without exposing roots) throughout the series of treatments.

Duplicate tests were made with 2,4,5-T. At present, ribes 1 foot or more in height growth are not killed with 2,4,5-T unless the root crown centers are drenched. Smaller ribes are killed by a broadcast spraying of an area.

Research was continued in the development and improvement of sprays and methods of spray application for late season work. Also, new formulations of 2,4,5-T were tested both in the laboratory and field on ribes and other brush species growing in the western white pine region. (Blister Rust Control, U. S. Forest Service, Region One)

Woody plant studies in Arizona. Turner, R. M. An area heavily infested with several species of *Opuntia* (predominantly *O. fulgida*) was sprayed with the PGBE esters of 2,4-D and 2,4,5-T. These were applied at the rates of 1 to 3 pounds per acre. The volume of the spray mixture varied from 10 to 40 gallons per acre. A carrier of a 4:1 Diesel oil emulsion was used throughout, duplicating a study made the previous year. Three and one-half months after treatment, kills as high as 35 percent were obtained, equal to the best kill obtained from the studies conducted during the previous year. Both chemicals were apparently equally effective, but the greatest kill was not obtained with the same rate and volume of application. Work next year will be directed towards (1) methods of enhancing penetration and translocation and (2) determination of the season of meristematic activity in the roots of *O. fulgida*.

Preliminary work on a means of controlling *O. fulgida* by a combination of mechanical and chemical treatments is in progress. Detached joints, in three sizes, are sprayed with various concentrations of MH and CIPC or left untreated. These groups of joints are replicated and each replication placed under different conditions of moisture and temperature. Control is obtainable by mechanical means provided the plants are knocked down at the proper season. CIPC kills the joints and MH inhibits sprouting but roots will develop under some conditions.

Tarbrush (*Flourensia cernua*), white thorn (*Acacia constricta* var. *vernicosa*), and creosote bush (*Larrea tridentata*) are found over a large area in southeastern Arizona. These species have been sprayed at fortnightly intervals using a 4:1 water:Diesel oil emulsion containing 2 and 4 percent 2,4,5-T. The effect of some other chemicals and treatments are also being conducted. Chaparral has been sprayed by aircraft for the second consecutive year using 2,4-D and 2,4,5-T and combinations. The chaparral is composed of chiefly *Quercus turbinella*, *Rhus trilobata*, *Forestiera neomexicana*, and *Arctostaphylos pugens*. The oak, which is the most prevalent plant, is the most resistant and low rates of kill were obtained. A root growth study of *Q. turbinella* will be undertaken next spring. In June, a large stand of chaparral is to be burned; one year later, the oak sprouts will be hand-sprayed with the herbicides. The exact details will be worked out as more information is accumulated. (Arizona Agricultural Experiment Station, Tucson)

Control of big sagebrush with 2,4-D. Hervey, Donald F. The primary objective of these tests was to determine the comparative effectiveness of low volatile forms of 2,4-D with the more volatile ones in the control of big sagebrush (Artemisia tridentata). Spray applications were made during the last week of May 1953, on the Great Divide Experimental Range northwest of Craig, Colorado. One-acre plots were treated with a tractor-mounted boom-type sprayer. Herbicides were applied in a water solution and 10 gallons of the solution were applied per acre. Emulsifier was added in all cases.

In June, 1954, the following results were indicated:

Formulation	% Sagebrush plants completely killed: 1½ lbs. 2,4-D acid equivalent	% Sagebrush plants completely killed: 2 lbs. 2,4-D acid equivalent per acre
Esteron Ten-Ten (Propylene-glycol butyl ether ester)	69.2	66.1
Estercide D-4 (Tetrahydrofurfuryl ester)	39.4	33.2
Esteron 76E (Isopropyl and butyl esters)	57.8	68.8
Estercide D-2 (Isopropyl ester)	64.5	68.4

The above results would indicate that the low volatile Estercide D-4 is not particularly effective in controlling sagebrush if applied in a water solution. However, a nearby area was sprayed aerially with Diesel as the solvent, and here the Estercide D-4 gave an 84-percent kill of big sagebrush, and Esteron-76 a 92-percent kill, when applied at the rate of 1½ pounds acid equivalent per acre.

In evaluating the ground-spray plots, data as to sagebrush kill were segregated into two classes: (1) kill of plants which exceeded 6 inches in height, and (2) kill of plants which were less than 6 inches in height. The average kill on all plots was 67.9 percent for the larger plants, and only 20.6 percent for the plants under 6 inches in height. The smaller plants were out in the open and were not an understory to the larger plants. (Colorado Agricultural Experiment Station)

Sagebrush (Artemisia tridentata) spraying in Oregon. Hyder, Donald N. Spraying trials on big sagebrush were continued in 1952, 1953, and 1954 with a complete factorial (6 x 3 x 2 x 2 x 3) involving times of spraying, materials, acid equivalent rates, solution volumes, and solvents. The work also included pertinent supplementary projects. Important main effects are summarized below.

Spraying was sufficiently effective throughout the season beginning with Sandberg bluegrass (Poa secunda) in "head" and ending with it showing "green color about one-half gone." The time and length of the intervening spray season is not the same each year.

In general, 2,4,5-T killed more sagebrush than 2,4-D, but relative effectiveness varied with time of spraying. The average differences between growth regulators in favor of 2,4,5-T were 14, 11, 7, 6, 1, and -5 percent mortality respectively by dates of spraying in chronological order. Propyleneglycol butyl ether ester 2,4-D and butyl ester 2,4-D were equally effective at all times.

One pound acid equivalent (average of all materials) per acre killed an average of 78 percent, and 2 pounds killed 87 percent of individual sagebrush plants. Three gallons of total spray solution killed an average of 77 percent, and 6 gallons killed 87 percent of the big sagebrush plants. Under the conditions of this study, solution volume was as important as the amount of acid. Differences in mortality among solvents of water, Diesel oil and Diesel oil emulsion were extremely small and not significant. In supplementary trials there were no significant differences among 14 different solvents. Thus, it appears that thoroughness in spray distribution and coverage is far more important to mortality than material "creep" and penetration when ester formulations are used in the foregoing solvents at the stated volumes.

The data from airplane spraying emphasized the difficulty of using airplane applications in research trials, but provided assurance in the conclusions drawn from other trials.

Continued research in the ecological responses to sagebrush control indicate a sustained higher level of forage production with some fading of Sitanion hystrix and continued strengthening of more dominant species. The appearance and growth performance of the grasses indicates that their major release comes through nitrate rather than moisture. Soil nitrate and soil moisture trends lend support to the observations. It is possible that some of the grass response may be due to other than competitive release. Following ammonium nitrate fertilization, 2,4-D symptoms on big sagebrush were much slower in appearing but final results appeared stronger. On fertilized plants leaf abscission did not occur.

Simultaneous control of big sagebrush and low larkspur (Delphinium megacarpum -- also classified as D. menziesii) seems reasonably practical, although the best times for spraying do not coincide. Excellent larkspur kills were obtained as Poa secunda reached late boot, but kills dropped markedly each succeeding two weeks. Mortality was zero as larkspur plants began flowering. Kills were much better with 2,4-D than with 2,4,5-T (esters). At this early period sagebrush is better killed with 2,4,5-T; therefore, a 1:1 mix at the total acid equivalent rate of 1½ to 2 pounds is indicated. (Squaw Butte-Harney Branch Experiment Station, Burns, Oregon)

Brush control in Nevada. Cords, H. P. and Robertson, J. H. In the spring of 1953 an experiment was initiated near Elko, Nevada, comparing the effectiveness of three spray materials at three application dates (April 18, May 18, and June18). Chemical treatments were as follows: (1) check, no treatment. (2) 2 lb. 2,4-D low volatile ester in 3 gallons Diesel oil per acre. (3) 1 lb. 2,4,5-T isopropyl ester in 3 gallons Diesel oil per acre. (4) Shale oil at 50 gallons per acre. In addition to the above treatments which were applied at all dates, shale oil was substituted for Diesel oil as a carrier of 2,4-D and 2,4,5-T and these additional treatments were made on May 18.

Treatments were made at two locations, one with a mature sagebrush stand, the other on an area that had been plowed in 1944 and seeded to Crested Wheatgrass. Both areas had an understory of rabbitbrush (Chrysothamnus viscidiflorus).

The plots were evaluated August 7 and 8, 1954. Evaluations of large sagebrush (taller than 4 inches) and rabbitbrush were based on actual numbers of live plants per plot, whereas sagebrush seedlings were estimated by counting the number in three equally-spaced 10-square foot areas within the plot. Total plot size was 1/100 acre.

In the mature sagebrush area, control of the larger plants was effectively achieved by 2,4,5-T treatment April 18 and May 18 and by 2,4-D treatment May 18. 2,4-D treatment April 18 and 2,4,5-T treatment June 18 appeared to be ineffective and only a fair degree of control was achieved with 2,4-D treatment June 18. Shale oil treatment appeared to be ineffective at all dates. Substitution of shale oil for Diesel oil as a carrier resulted in much poorer kills on this area. In the younger sagebrush stand, kills with 2,4-D and 2,4,5-T treatment were better and more consistent than on the mature sage site, and these treatments resulted in effective control at all dates. 2,4,5-T appeared to be slightly superior to 2,4-D, and the two earlier dates seemed to be a little better than June 18 for these applications. Shale oil alone was ineffective. As a carrier it appeared to be equal to Diesel oil.

Too few sagebrush seedlings were present on the plowed area for evaluation of the treatments. On the mature sage area, however, 2,4-D was more effective than 2,4,5-T in seedling control. 2,4-D applied May 18 appeared to be the most effective treatment, but reasonable control was achieved with this chemical at all dates. 2,4,5-T gave control only when applied April 18. Control from applications of shale oil alone was unsatisfactory.

2,4-D appeared to be more effective than 2,4,5-T at all dates for the control of rabbitbrush, but this species was more resistant to these chemicals than was sagebrush. 2,4-D in either carrier applied May 18 gave the best results. Results were similar on both the undisturbed and plowed area. (Nevada Agricultural Experiment Station)

Factors influencing the kill of blue oak using the cut-surface method of application. Leonard, O. A. Tests conducted in 1951 were aimed at a better understanding of factors influencing the successful use of the cut-surface method for killing trees. The treatments are sufficiently old now for us to be certain that the conclusions listed below are valid for blue oak (Quercus douglasii).

Spacing of the cuts around the bases of the trunks influenced kill, with a frill or a close spacing being the most dependable. Height of cut above the ground was a factor that had slight influence on top-kill, but a marked influence on sprout development around the bases of the trunks. Interestingly enough, all of the sprouts died, so that this was not an important factor with this species. However, this is a consideration on some of the more vigorous sprouting species. Depth of application was a factor, the results indicating that good kills cannot be obtained unless the chemical is introduced into the sapwood. An actual depth of 1 inch appeared to be satisfactory. The effectiveness of esters and amines of 2,4-D and 2,4,5-T were compared in all of the above tests and in some others, too. The amines were always considerably better than the esters, being as much as four times as effective in some tests. Dilution of the amines with water served no useful purpose and did greatly increase the time necessary to introduce the required quantity of 2,4-D amine into cuts. The straight undiluted formulations containing 4 pounds of acid equivalent per gallon were used in all tests, except in the dilution studies. Seasonal changes in the sensitivity of blue oak to 2,4-D and 2,4,5-T amines were evident. The trees were least sensitive in the summer, and became slightly more sensitive in October to very sensitive in November and continued this way until mid-spring. Resistance increased with the approach of summer. This cycle in sensitivity is related to seasonal changes in soil moisture and temperature. It is possible to kill trees at any time of the year by observing all of the factors that influence kill. However, we consider it best to suggest to the average user that the treatment be used from November until mid-spring. The kill is influenced by the quantity of chemical applied to the cuts, but 1 ml of 2,4-D amine (4 pounds acid equivalent per gallon) is adequate when properly applied; higher rates are necessary when the cuts are put rather far apart, with chances of a satisfactory kill uncertain. (University of California, Davis)

PROJECT 4. ANNUAL WEEDS IN CEREALS AND FORAGE CROPS

James L. Krall, Project Leader

SUMMARY

Eight reports were received from three cooperating institutions. Of these, four reports were concerned with cereal grains and four concerned forage crops.

Cereal Grains

Chilcote and Furtick tested 16 substituted phenoxyacetic acids and their various formulations at Oregon on Hannchen barley at 1 pound per acre at two stages of growth. Pigweeds and lambsquarter were equally sensitive to all compounds. Some of the chemicals caused barley injury, but 2,4,5-trichlorophenoxypropionic acid was the only formulation that adversely affected the yields. Seed germination was not affected through the use of any of the herbicides.

Warden reported on the influence of 2,4-D to near-headed spring wheat over a 5-year period in Montana. There was a consistent pattern each year. Maximum injury was obtained during blossom stage, 3 to 5 days after heading. By the 9th day yields were back to normal. The response obtained during a 5-day period before heading was variable.

The value of CMU and Dalapon for chemical fallow in Central Montana was reported by Krall. In one trial, residual Dalapon effects were observed on spring wheat grown on chemical fallow plots where rates above 5 pounds per acre were used. In another trial encouraging results were obtained with CMU. Rates of 2 and 4 pounds per acre gave satisfactory weed control and increases in yield and protein content.

Grass

The effects of Dalapon on perennial grasses in central Montana were reported by Dubbs. Species differences were observed from applications made in 1953. However, no differences were obtained from slightly lower rates applied at an earlier date in 1954.

Legumes

Lee and Timmons in Utah found CMU effective for the control of annual weeds in wide-spaced alfalfa. In 1953 CMU gave 99 percent control while DNBP-TCA combinations were only 15 percent effective. Except for Russian thistle, excellent control was still obtained in 1954. No effect of CMU on the alfalfa was detected.

Dalapon was applied at 4, 8, and 16 pounds per acre to four species of legumes infested with ryegrass and quackgrass at Oregon by Furtick and Chilcote. Their results indicated that the rates used gave satisfactory control of the grass, and that legume species varied in Dalapon tolerance. Lotus corniculatus was only slightly injured at 16 pounds per acre.

Further testing of C-IPC for the control of small-seeded dodder was reported by Lee and Timmons. Applications made during dormancy were not as effective as applications made just after the alfalfa was beginning to grow. The treatments generally increased alfalfa seed production. The higher rates of C-IPC gave better dodder control. No distinct trend for rates was obtained in alfalfa seed production.

REPORTS OF INDIVIDUAL CONTRIBUTORS

<u>The effect of various substituted phenoxyacetic acids and their various formulations on Hannchen malting barley at two stages of application</u>. Chilcote, D. O. and Furtick, W. R. Several substituted phenoxyacetic acids and their various formulations were used in an experiment on Hannchen malting barley at the single rate of 1 pound per acre, applied to the barley in the late-boot stage and at the 6- to 12-inch stage. The purpose was to determine the comparative weed control and the damage, if any, to the barley. The materials used were as follows: 2,4-D amine, 2,4-D iso-propyl ester, 2,4-D experimental California Spray Corporation miscible ester, 2,4-D butoxyethanol ester, 2,4-D Kathon L-4 capryl ester of Rohm and Haas Company, 2,4-D ethoxy ethoxy propyl ester, 2,4-D ethoxy butoxy propyl ester, 3,4-dichlorophenoxyacetic acid iso-octyl ester, 3,4-dichlorophenoxyacetic acid amine, 4-chlorophenoxyacetic acid amine, 4-chlorophenoxyacetic acid butoxyethanol ester, MCP amine, MCP butoxyethanol ester, 2,4,5-trichlorophenoxypropionic acid, propyleneglycol butyl ether ester, 2,4,5-trichlorophenoxypropionic acid amine. The principal weeds found in both trials were pigweed and lambsquarter. These two weeds appeared to be equally sensitive to the compounds in the trial. It was noted that the low volatile esters gave considerable apparent injury to the barley when compared to the amine formulations. This was especially true of the California Spray Corporation experimental ester and the 2,4,5-trichlorophenoxypropionic acid ester. The 2,4-D butoxyethanol esters also gave considerable injury. The yield data indicated that the injury took the form of shortened straw, and that final yield was not affected. The only material that adversely affected the yield was the ester formulation of 2,4,5-trichlorophenoxypropionic acid, which reduced the yield both at the boot and at the 6- to 8-inch stage of growth. Germination tests indicated no effect on seed viability through use of any of the herbicides. (Oregon Agricultural Experiment Station, Corvallis)

<u>Residual effects of Dalapon to spring wheat</u>. Krall, J. L. Some residual Dalapon effect to spring wheat was noted from applications made in 1953 to summer fallow for cheat control. Due to hail no yield data were obtained. The average estimated percent damage and plant height recorded from duplicate plots are given below:

Rate of Dalapon	Percent damage	Plant height
2½ pounds/acre	2.5	30.5
5 " "	10.0	37.5
10 " "	45.0	21.0
15 " "	67.5	18.5
Check	0.0	31.0

As indicated by the plant height above, most of the damage occurred in form of dwarfing of the plants. Affected plants had thicker culms, deformed heads, and a brown appearance. As a result it appears that rates above 5 pounds per acre would be hazardous for chemical fallow purposes. In a separate trial lower rates of Dalapon (2 and 4 pounds per acre) applied to emergent cheat were effective for chemical fallow purposes. However, tests of residual effects are still forthcoming. (Contributed by Montana Agricultural Experiment Station, Central Montana Branch Station, Moccasin, Montana)

CMU for chemical fallow. Krall, J. L. CMU was applied for chemical fallow purposes on triplicate 6 x 40-foot plots at rates of 0, 1, 2, and 4 pounds per acre on April 24, 1953. Observations made during the summer of 1953 indicated that 2 and 4 pounds would give adequate vegetative control. To test what effect these treatments would have on the ensuing crop, two 9-foot drill widths of winter and spring wheat were sown across the plots in the fall and spring. A summary of the results is given below:

Rates of CMU	Bushels/acre	Test weight	Percent protein
Winter wheat			
0	13.4	59.5	12.8
1	13.2	58.0	14.0
2	19.7	58.0	15.0
4	21.0	58.5	14.9
Spring wheat			
0	9.6	57.5	15.0
1	13.8	58.0	15.7
2	14.1	58.5	15.9
4	13.8	58.0	16.5

L.S.D. 5.8
(percent) C.V. 12.8

The percent weed control within the grain was 0, 63, 85, and 90 percent for the 0-, 1-, 2-, and 4-pound rates, respectively. Russian thistle was the principal weed not controlled. Although the yield increases are encouraging, the primary interest is the substantial increase in protein content. This increase resembles protein responses obtained from nitrogen fertilization in this area. (Contributed by Montana Agricultural Experiment Station, Central Montana Branch Station, Moccasin, Montana)

The effects of Dalapon on established stands of perennial forage grasses. Dubbs, Arthur L. This trial was conducted to determine the degree of tolerance of 30 perennial grasses when sprayed with 5 pounds per acre of Dalapon. These grasses were planted October 24, 1950 in rows spaced 2 feet apart. Application of the chemical was made on June 1, 1953 and consisted of one 4-foot spray width across the grass rows. All top growth died back shortly after spraying. Readings were taken in August 1954 to determine the percent of kill. Sixteen of the grasses were completely killed, while the others ranged from 99 to 0 percent. Two grasses, Hopkins timothy and hard fescue, recovered completely. Those showing a high degree of tolerance were standard crested wheatgrass, intermediate wheatgrass, Siberian wheatgrass, M24-3 crested wheatgrass and commercial timothy. Those grasses not completely killed by the chemical were stunted in growth (except Hopkins timothy and hard fescue) when compared to the unsprayed grasses.

On May 11, 1954 rates of 1, 2, and 4 pounds per acre of Dalapon were sprayed across these same grasses. No killing of the top growth was observed on any of the grasses. This indicates that rates of 5 pounds per acre or more are required to kill most grasses and on those showing a high degree of tolerance heavy rates, or more than one application, are necessary to obtain complete killing under Moccasin conditions. (Contributed by Montana Agricultural Experiment Station, Central Montana Branch Station, Moccasin, Montana)

Chemical control of annual weeds in wide-spaced alfalfa rows. Lee, W. O. and Timmons, F. L. Recent research work at the Utah Experiment Station indicates that alfalfa seed yields can be increased on dry land by planting alfalfa in rows 24 inches or more apart. Where these wide row-spacings are used, an annual weed problem develops from a lack of competition by the alfalfa.

An experiment started in April 1953 on 1-year-old alfalfa in rows spaced 48 inches apart compared CMU (3-(p-chlorophenyl)-1, 1-dimethylurea) at 2 pounds per acre with the alkanolamine salt of DNBP (dinitrobutyl phenol) at 6 pounds per acre followed by TCA (sodium trichloroacetate) at 8 pounds per acre. CMU and the alkanolamine salt of DNBP were applied April 3, when the alfalfa was just starting to grow. The TCA was applied to the DNBP plots May 11, when the alfalfa was 6 to 8 inches tall.

In 1953 CMU controlled 99 percent of the annual weeds, while the DNBP-TCA combination produced only about 15 percent control. The annual weeds present included prickly lettuce, rough pigweed, Russian thistle, green foxtail, and barnyard grass.

CMU showed no injury to the alfalfa at any time, while DNBP gave a temporary foliage burn and TCA caused a slight yellowing of the lower leaves. Alfalfa seed yields per acre were 586 pounds on the CMU plots, 551 pounds on the cultivated check, and 483 pounds on the plots receiving the DNBP-TCA treatment.

Observations made in 1954 showed excellent weed control on the plots treated with CMU in 1953. The only weed which developed was Russian thistle. Barley which was planted between the rows in the spring of 1954 started normally but soon began to show injury symptoms on the CMU plots and eventually died. This indicated that CMU was still present in the soil and was responsible for the good weed control observed in 1954. (Field Crops Research Branch, ARS, USDA, and Utah Agricultural Experiment Station, cooperating)

The use of Dalapon on established stands of alfalfa, Ladino clover, red clover, and Lotus corniculatus. Furtick, W. R. and Chilcote, D. O. March applications of Dalapon at the rates of 4, 8, and 16 pounds per acre were made on 1-year-old stands of Talent alfalfa, Ladino clover, Granger *Lotus corniculatus*, and Kenland red clover. The four legumes were heavily infested with ryegrass and quackgrass. Dalapon, at 4 pounds per acre, gave complete control of common ryegrass and suppressed any further growth of quackgrass through the first hay cutting in all four legumes. At the 4-pound rate only slight initial injury was noted on alfalfa and no injury was apparent on Lotus. Red clover was severely injured and injury to Ladino clover was moderate.

The 8-pound rate of Dalapon greatly retarded alfalfa but showed only slight injury on Lotus. Ladino clover was severely injured with only partial recovery during the summer. The Kenland red clover was killed by this treatment.

The 16-pound rate of Dalapon caused serious injury to alfalfa but produced only marginal chlorosis, without growth inhibition, on *Lotus corniculatus*. Both Ladino clover and red clover were almost completely killed at this rate of application. (Oregon Agricultural Experiment Station, Corvallis)

Use of C-IPC to control small-seeded dodder in alfalfa seed fields. Lee, W. O., and Timmons, F. L. Isopropyl N-(3-chlorophenyl) carbamate (or C-IPC) was applied at three rates on each of two dates, February 26 and April 7, 1954, in an alfalfa seed field heavily infested with small-seeded dodder (*Cuscuta spp.*). Two sets of treatments were made April 7, one on plots to be harvested for first crop seed and other on plots for second crop seed. All treatments were replicated six times in randomized blocks. Counts of dodder patches were made six places in each plot several times during the season.

Effect of C-IPC on dodder in alfalfa.

Pounds of C-IPC applied in 60 gals. of water per acre	No. of dodder[1/] patches per plot 5-24	6-8	7-26	Yields, pounds of seed per acre Alfalfa	Dodder
I. Treatments made February 26, 1954. Alfalfa dormant.					
A. Harvested for first crop seed.					
3.0	25	33	C.I.	113	668
4.5	22	26	C.I.	87	629
6.0	13	21	C.I.	132	662
Untreated check	29	35	C.I.	46	536
II. Treatments made April 7, 1954. Alfalfa just beginning to grow.					
A. Harvested for first crop seed.					
3.0	4	5	C.I.	255	598
4.5	6	9	C.I.	217	454
6.0	2	5	24	296	277
Untreated check	29	35	C.I.	46	536
B. Harvested for second crop seed.					
3.0	9	19	20	98	278
4.5	4	5	12	185	138
6.0	2	3	7	189	142
Untreated check	36	36	C.I.	53	676
L.S.D. (0.05)				77	208
L.S.D. (0.01)				102	276

1/(See next page)

1/ As the season advanced it became impossible to differentiate individual dodder patches. Thus, C.I. was used to denote complete infestations of dodder where counts were no longer possible.

The results summarized in the table appear to justify the following conclusions:

1. Applications of C-IPC made February 26 had only a slight temporary retarding effect on dodder. Increases in alfalfa seed yields over untreated check were significant only for the 6-pound rate.

2. C-IPC applied April 7 delayed the establishment of dodder patches, reduced the amount of dodder seed produced for most treatments, and increased alfalfa seed yields as much as 500 percent. The increases in alfalfa seed were highly significant for 5 of the 6 treatments.

3. The higher rates of C-IPC tended to give better dodder control but the difference was significant only for the 6-pound rate on plots harvested for first crop seed.

4. There was no distinct trend for rate of C-IPC in alfalfa seed yields. However, the 3-pound rate harvested for second crop seed was significantly lower in yield than higher rates.

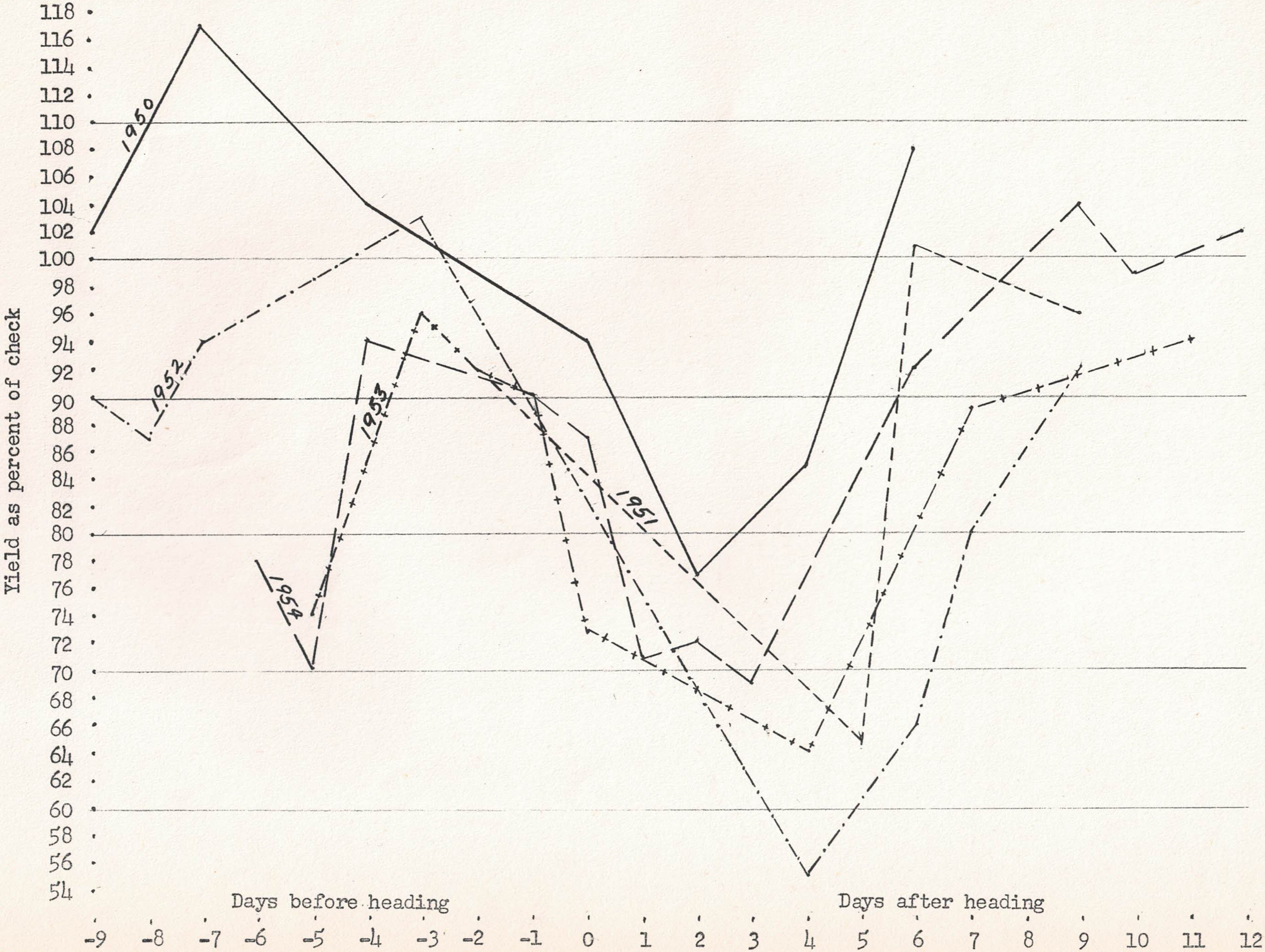
5. Dodder seed yields were significantly lower on C-IPC-treated plots harvested as second crop seed than on those harvested for first crop seed. However, alfalfa seed yields tended to be lower also, the differences being significant or highly significant for 2 of the 3 rates.

C-IPC applied early in April was much less effective in controlling dodder in 1954 than it was in a similar experiment conducted in 1953 and reported in the 1954 WWCC Research Report. Unseasonably high temperatures in April and May before the ground was shaded by the alfalfa and extreme drought conditions are believed to be responsible for the less satisfactory results in 1954. C-IPC applied April 7 did delay the development of dodder for a considerable period of time and gave the alfalfa a chance to get past the critical flowering stage before the infestation became heavy. Observations in the past have indicated that if the dodder infestation is heavy at the time of flowering, the flowers strip off and no seed is formed. If the dodder becomes established after seed pods are formed, alfalfa seed yields are not depressed so drastically. (Field Crops Research Branch, ARS, USDA, and Utah State Agricultural College, cooperating)

The influence of stages of growth near heading on the response of spring wheat to 2,4-D. Warden, Robert L. Thatcher, a hard red spring wheat, was treated at various stages of growth near heading over a 5-year period with 2,4-D ester at a rate of 1 pound per acre acid equivalent. The 5 trials were conducted with four replications in a randomized block design. All applications reported herein were made within a period of 9 days before heading and 12 days after heading. For purposes of the study the date of heading was defined as the first day when 90 percent of the heads were completely extruded from the boot. All trials were grown under irrigation and check yields ranged from 40 to 65 bushels per acre over the 5-year period.

Results (See Figure 1, following page) show a consistent pattern between years for the growth period extending from 4 days before treating to the end of the treatment period. The response for the period more than 5 days before heading is variable and should be studied further. There does seem to be a tolerant stage of growth just before heading. The degree of injury increases as heads begin to emerge and becomes greater as the wheat progresses to the flowering period. Maximum injury was sustained during the blossom stage 3 to 5 days after heading. By the 6th day after heading, yield curves in all years were ascending, and on the 9th day after heading yields were up to 90 percent of the unsprayed check, which is about the response expected from this 2,4-D rate at tolerant stages of growth. It is of interest that while the injury was expressed as a reduced number of normal seeds per spike the actual fertilization process was apparently completed since most of the so-called sterile florets did produce a seed coat and possibly a partially formed embryo. These did not contribute to yield because they were lost during the threshing process. (Contribution of the Agronomy and Soils Department, Montana Agricultural Experiment Station, Bozeman)

Figure 1.--Yields of Thatcher spring wheat as influenced by stages of growth near heading.



PROJECT 5. WEEDS IN FRUITS, VEGETABLES AND ROW CROPS

E. R. Laning Jr., Project Leader

SUMMARY

It is reported that CMU and DCMU (Karmex W and Karmex DW) appear very promising for use at low rates to maintain weed control in citrus orchards. Most orange and grapefruit trees withstood up to 20 pounds per acre of these herbicides without visible injury. The soil type apparently has considerable influence on both weed control and orchard injury.

Studies concerning pre-emergence weed control in vegetable crops indicate a tolerance of snap beans to the amine salt of DNOSBP, of red beets to TCA and Dalapon, and of peas to dinitro amine, KOCN, and low rates of 2,4-D. A new group of herbicides, chloroacetamides, are reported to appear very promising as pre-emergence treatments for snap beans, sweet corn, and onions. Longer periods of residual activity than are obtainable with present materials are claimed. Post-emergence treatments on onions resulted in good weed control with little or no injury to the crop.

Karmex DW appeared to be the most selective of the urea herbicides tested as pre-emergence sprays in cotton. It is believed that this selectivity is due to the lower solubility of the Karmex DW in relation to Karmex W or Karmex FW. The FW was also least effective in the control of grass infestation.

Post-emergence applications of many oils to cotton were less effective in the control of most weeds than was the older practice of flaming. Johnson grass, which was not controlled by flaming, appeared to be affected by repeat application of Dalapon or certain oils applied as spot treatments. It is proposed that heavy infestations would be too expensive to control in this manner.

Potatoes were found to be tolerant to various pre-emergence treatments including dinitro amine, 2,4-D, NaPCP, and TCA. Yield data indicated no differences among treatments.

Dalapon is reported to be promising for use in sugar beets as a post-emergence treatment for wild oats and volunteer grain. However, it appears that the beets should be sprayed early and with rates no higher than 10 pounds per acre.

Pre-emergence applications of the urea compounds gave good control of various weeds infesting peppermint without crop injury. Other materials were effective on either grasses or broadleaf type weeds for varying lengths of time. Dalapon and amino triazole post-emergence treatments resulted in lowered oil production as well as severe injury to the mint plants.

CMU and DCMU for control of annual weeds in citrus orchards. Day, B. E., and Russell, R. C. Under the widely used non-cultivation management system of citrus production, weeds are controlled under the trees by spraying with oil. Costs are higher during the first 2 to 4 years on non-cultivation and lower in subsequent years than the conventional disking and furrowing method. We have tested a number of soil-acting herbicides in search of materials which might selectively control annual weeds under citrus at lower cost. These tests have included most of the organic soil sterilants now available. The urea herbicides, CMU and DCMU, have been the most promising.

Results from 25 series of replicated test plots in southern California citrus districts, have shown that autumn applications of CMU and DCMU at rates of 1 to 4 pounds per acre control annual weed growth throughout the winter rainy season, without apparent injury to citrus. At these rates spring applications control annual weed growth until the onset of the autumn rains, except in the bottoms of the irrigation furrows where leaching is heavy. Two series of plots at rates up to 40 pounds per acre have shown that 20 or more pounds per acre of CMU must be applied to produce injury symptoms on orange and grapefruit trees. Orange trees tolerated 30 pounds of DCMU per acre without visible injury. Forty pounds per acre produced slight leaf discoloration.

Greenhouse tests with 26 citrus soils showed that the dose of CMU required to kill oat seedlings varied tenfold from the most sensitive to the least sensitive soil under non-leaching conditions. Soils varied more than fiftyfold in the amount of DCMU required to kill oat seedlings. In leaching tests both CMU and DCMU leached most readily in soils which required lesser amounts of the chemicals to produce sterility to oat growth. The factors of initial dosage required to produce sterility, and loss from the surface soil by leaching, thus tend to offset one another. This reduces the variability between soils in the amount of urea herbicides that must be applied to control annual weeds for a given period of time in the field. Soil surveys were found to be of little value in predicting the effectiveness of urea herbicides in the several citrus districts. (University of California, Citrus Experiment Station)

Tolerance of snapbeans to herbicides applied as pre-emergence sprays. Barnard, E. E. Tendergreen snap beans were planted in a silt loam soil on May 24, 1954, and on June 5 the following pre-emergence treatments were applied: DNOSBP (Premerge) at 4, 6, and 8 pounds per acre, 2,4-D amine at 1, $1\frac{1}{2}$, and 2 pounds per acre, C-IPC at 2, 4, and 6 pounds per acre, Alanap-1 at 4, 6, and 8 pounds per acre, and NaPCP at 15, 20, and 25 pounds per acre. All materials were applied in water at 50 gallons per acre replicated four times. All surviving weeds were suppressed throughout the test by mechanical cultivation. Good moisture conditions were maintained by sprinkler irrigation. Beans were harvested in three pickings, after which stand counts were made of the producing plants.

Stands were reduced significantly from the check by the 1½-pound rate of 2,4-D and the low rate of Alanap-1, and highly significantly by the 2-pound rate of 2,4-D and the higher rates of Alanap-1. Stands of all other plots approximated the check.

Yields were significantly reduced from the check by the 1½-pound rate of 2,4-D, and highly significantly by the 2-pound rate of 2,4-D and all rates of Alanap-1. The plots treated with the 8-pound rate of DNOSBP produced yields significantly greater than the check. Yields of all other treatments approximated the check. The plots treated with DNOSBP were the only ones which were consistently as good as or better than the check in both stands and yields. (Contribution of the Montana Agricultural Experiment Station)

The use of various herbicides for weed control in green beans and sweet corn. Chilcote, D. O., and Furtick, W. R. Dithiocarbamates were applied pre-emergence and chloroacetamides pre- and post-emergence to sweet corn and green beans. Dinitro amine was used as a standard for the pre-emergence applications, with 2,4-D amine as standard post-emergence treatment on the sweet corn. The beans were planted on May 25, and pre-emergence treatments applied May 26. The corn was planted on June 1, and sprayed pre-emergence on June 3. The soil was a sandy loam and was sprinkler irrigated. The first irrigation was applied on May 27 for the beans, and on June 4 for the corn. The area was infested with a variety of broadleaved species of weeds, and with quackgrass. Few annual grasses were present in the area. The rates of application were 4, 8, and 12 pounds per acre pre-emergence, and 5 and 10 pounds per acre post-emergence for the chloroacetamides. Dinitro amine was applied at 3 pounds per acre pre-emergence and the 2,4-D was applied at 3/4 pound per acre post-emergence. The post-emergence applications were made June 28. Of the new herbicides tested in this experiment the 2-chloroallyl diethyldithiocarbamate and 2-chloroallyl diisopropyldithiocarbamate produced by Monsanto Chemical Company showed promise for selective weed control when compared with the standard treatments. These two compounds gave excellent control of the annual weed species present throughout the summer months. Their soil life was much longer than DN amine which lasted only about 4 weeks. These compounds gave no apparent injury to the corn or beans. However, in some areas in which the soil was very sandy, a few deformed plants of corn were noted, but this was not serious. The compounds were most effective at the 8- and 12-pound per acre rates, the 4-pound per acre rate giving poorer control, with regrowth of weeds. Other trials indicated that these two compounds gave good annual broadleaf and annual grass control when applied pre-emergence. They are most effective on germinating seeds. The alpha-dichloro NN diallyl acetamide when applied pre-emergence did not compare favorably with the dithiocarbamates, but did rate well with the DN amine treatment.

The chloroacetamide lost its activity quite rapidly and allowed much regrowth to occur. Other trials have shown it to be more effective on heavier soils. The post-emergence application of this compound gave severe non-selective burn to the crop and weeds. (Oregon Agriculture Experiment Station, Corvallis)

Tolerance of red beets to herbicides applied as pre-emergence sprays. Barnard, E. E. Perfected Detroit red beets were planted in a silt loam soil on May 24, 1954, and on June 6 the following pre-emergence treatments were applied: IPC at 2, 4, and 6 pounds per acre, C-IPC at 2, 4, and 6 pounds per acre, Dalapon at 2, 5, and 8 pounds per acre, and TCA at 5, 10, and 15 pounds per acre. All materials were applied in water at 50 gallons per acre replicated four times. All surviving weeds were suppressed throughout the test by mechanical cultivation. Good moisture conditions were maintained by sprinkler irrigation. Beets were harvested as table beets on August 4.

Stands were not affected by any but the C-IPC treatments. All plots treated with C-IPC showed highly significant reductions in stand. At the 4- and 6-pound rates the beets were eliminated. Stands of all other treatments approximated the check.

Yields were adversely affected by the 6-pound rate of IPC, all rates of C-IPC, and the 8-pound rate of Dalapon. All plots treated with these materials showed highly significant reductions from the yields of the check. All other plots approximated the check. It is probable that the reductions in stands and yields were partially caused by the application of herbicides too near germination time. (Contribution of the Montana Agricultural Experiment Station)

The use of various herbicides for weed control in onions. Chilcote, D. O., and Furtick, W. R. Various herbicides were applied to onions at two locations on two different soil types to determine if selective weed control could be obtained. The first soil type was a labish peat and the second soil type was a highly organic clay soil. The compounds used in the experiment were Karmex DW (3(3-4 dichlorophenyl)1,1-dimethyl urea) at 3/4 and 1½ pounds per acre pre-emergence, 3-chloro IPC at 3 pounds per acre pre-emergence, potassium cyanate at 8 pounds per acre post-emergence, alpha chloro NN diallyl acetamide at 4, 8, and 12 pounds per acre pre-emergence and 5 and 10 pounds per acre post-emergence, plus other substituted acetamides. The onions on the clay soil were planted April 24, and on the peat soil April 23. The compounds were applied April 24, for the pre-emergence applications and June 3 for the post-emergence applications. At the clay soil location the onions were grown under irrigation and were irrigated up. There was no precipitation immediately following the application but a total of 3 inches of rain fell during the 30-day period after application. The weeds present at the clay soil location were annual bluegrass (*Poa annua*), purslane (*Portulaca oleracea*), prostrate spurge (*Euphorbia prostratea*), red root pigweed (*Amaranthus retroflexis*), groundsel (*Senecio vulgaris*), chickweed (*Stellaria media*), sow thistle (*Sonchus arvensis*), prickly lettuce (*Lactuca scariola*), and crabgrass (*Digitaria sanguinalis*). The peat soil contained very few weeds, with only crabgrass occurring occasionally in most plots, and for this reason it was impossible to obtain weed-control data. The experiment was rated on June 10, for the pre-emergence applications, and on June 23 for the post-emergence applications. Alpha chloro NN diallyl acetamide, pre-emergence, gave excellent weed control at the 8- and 12-pound per acre rates and was by far the most outstanding compound. The 4-pound per acre pre-emergence application was less effective and encroachment of weeds into these plots occurred more rapidly. The 8- and 12-pound per acre pre-emergence applications remained effective for a much longer period of time, giving nearly 100 percent control of the annual bluegrass and extreme suppression to the broadleaf plants. No injury to the onions was noted with the alpha chloro diallyl acetamide at any of the rates.

Post-emergence, the alpha chloro NN diallyl acetamide, at the rates of 5 and 10 pounds per acre, gave excellent suppression of annual bluegrass. Suppression of the broadleaved weeds present in the plots was apparent, especially at the 10-pound rate of application. In comparison, chloro-IPC, Karmex DW, and potassium cyanate were quite ineffective in their weed control. (Oregon Agricultural Experiment Station, Corvallis)

Tolerance of peas to herbicides applied as pre-emergence sprays. Barnard, E. E. Hyalite peas were planted in a silt loam soil on May 24, 1954, and on June 4 the following pre-emergence treatments were applied: DNOSBP (Premerge) at 2, 4, and 6 pounds per acre, 2,4-D amine at ½, 1, and 1½ pounds per acre, IPC at 2, 4, and 6 pounds per acre, KOCN at 8, 16, and 24 pounds per acre, and Alanap-1 at 4, 6, and 8 pounds per acre. All materials were applied in water at 50 gallons per acre replicated four times. All surviving weeds were suppressed throughout the test by mechanical cultivation. Good moisture conditions were maintained by sprinkler irrigation. Peas were harvested at the green pod stage in four pickings, after which stand counts of producing plants were made.

Stands were adversely affected by 2,4-D and Alanap-1. The plots treated with the low rates of 2,4-D and the low rate of Alanap-1 showed slight reductions, those treated with the high rate of 2,4-D and the middle rate of Alanap-1 showed significant reductions, and those treated with the high rate of Alanap-1 showed highly significant reductions in stands from the check. The plots treated with the high rate of KOCN showed a significant increase over the check. All other plots approximated the check.

Yields were adversely affected by 2,4-D, Alanap-1, IPC, and C-IPC. The plots treated with the higher rates of 2,4-D and the low rate of C-IPC showed significant reductions in yield, and the plots treated with all rates of IPC, all rates of Alanap-1, and the higher rates of C-IPC showed highly significant reductions in yield from the check. Only the plots treated with DNOSBP, the ½-pound rate of 2,4-D, or KOCN approximated the yields of the check plots. It is probable that the reductions in stand and yield were at least partially caused by application of herbicides too near germination time. (Contribution of the Montana Agricultural Experiment Station)

Use of several urea compounds for the control of annual weeds in cotton. Arle, H. Fred, and Houck, L. G. Studies involving substituted urea compounds for the control of morning glory and annual grasses in cotton were continued and expanded. One study was concerned with time of application of CMU (3-(p-chlorophenyl)-1,1-dimethylurea) in relation to effects on annual grasses and the tolerance of Pima S-1 cotton (long staple). CMU was applied as a spray covering the soil surface prior to (1) first irrigation, May 18, (2) second irrigation, May 27, (3) third irrigation, June 15, (4) fourth irrigation, June 30, and (5) prior to both the first and fourth irrigations. CMU was applied at the rate of 1.25 pounds per acre, except when used as a combination treatment prior to the first and fourth irrigations. In this (treatment) the chemical was applied prior to the first irrigation at a rate of 1¼ pounds per acre with an additional 1 pound per acre being applied prior to the fourth irrigation.

Plots receiving two applications of CMU (first and fourth irrigations) for a total application of 2¼ pounds per acre had better grass control than the plots receiving one application only. All plots receiving CMU had distinctly better grass control than untreated check plots. The lower cotton leaves which were directly sprayed with CMU turned chlorotic readily. However, this effect decreased in intensity as applications were made on progressively older plants. Yields of cotton are not available, but data collected thus far indicate that no significant differences between treatments are expected.

The tolerance of several cotton varieties, Pima S-1, Acala 44, and Acala 33 to several urea herbicides, and the effect of these herbicides on annual weeds were investigated in other experiments. Rates of 3/4, 1, 1½, and 2 pounds per acre of CMU; ½, 1, and 2 pounds per acre of DCMU (3-(3,4-dichlorophenyl)-1,1-dimethylurea) and PDU (3-phenyl-1,1-dimethylurea) were applied to cotton at "lay-by" time at several locations.

These experiments tended to indicate a slight difference in varietal response to the various chemicals, with Acala 44 appearing slightly more sensitive than either Acala 33 or Pima S-1. Incomplete yield data indicate no significant differences between most treatments. However, it appears that PDU will slightly reduce yields at the higher application rates. DCMU and CMU provided good control of annual grasses while PDU was much less effective. Broad-leaved weeds controlled by these materials included annual morning glory, pigweed and annual ground cherry. Control of these weeds prior to "lay-by" time was accomplished by cultivation. The use of CMU for the control of annual morning glory appears to be especially promising. Experiments are in progress to determine the residual effect of CMU, by planting wheat and barley on previously treated soils.

There was considerable variation in the effect of the three compounds on cotton. DCMU did not induce any visible symptoms. CMU was translocated to the shoot meristems, where scattered symptoms of foliage chlorosis became evident. A slight decrease in plant vigor occurred also. Both of these conditions were soon outgrown, and cotton plants appeared completely normal two months after treatment. PDU produced the most severe reaction in cotton plants, resulting initially in chlorotic spotting, and later in a general yellowing of the entire plant. Plant vigor also appeared to be temporarily retarded. The affected plants did, however, show a late season recovery. (Field Crops Research Branch, ARS, USDA, and Arizona Agricultural Experiment Station, cooperating)

The effect of various weed-control practices upon yields of cotton grown under conditions of heavy watergrass infestation. Foy, C. L., and Miller, J. H. Field experiments were conducted at three locations in 1954 to compare the effectiveness of weed control afforded by various combinations of post-emergence oils, flame cultivation, and conventional cultural practices.

The detailed test was located on clay loam soil heavily infested with watergrass (*Echinochloa crusgalli* L.). The following treatments were included: (1) a check (conventional cultivation to July 30); (2-11)* a non-selective weed oil, two selective carrot weed oils, a selective cotton weed oil, and a coal-tar derived hydrocarbon mixture at 5 and 7½ gallons per acre per application, each followed by flame cultivation; and (12) a flame-cultivated check (conventional cultivation until first flaming). Acala 4-42 cotton was planted and fertilized in early April. The first irrigation of plots was made about June 18, and then uniformly watered as needed. Three applications of post-emergence oils were made at 1-week intervals, beginning with cotton 3 inches tall (April 29). All plots, except check, were flame-cultivated four times, beginning with cotton 10 inches tall (June 8), and repeated as weed growth warranted. There were sufficient weeds present for valid comparisons following each oil application. (May 6, May 13, May 20) Of the total weeds, a relatively small percentage germinated during the period when oils were applied. By far the greatest populations existed after the first irrigation. A final weed count was taken on August 4.

All post-emergence materials, except the hydrocarbon mixture, controlled weeds which emerged prior to first irrigation (Table 1). Control by flame cultivation of heavy watergrass infestations following first irrigation was most outstanding. The non-selective weed oil proved too toxic to the cotton and was omitted after two applications. There was a definite trend for the weedy check to be lower-yielding than the flamed check. Conversely, there was a definite trend for all treated plots, except those treated with the non-selective weed oil, to yield more than the weedy check.

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*Non-selective weed oil - "Richfield A" (boiling range 400°to 760° F, aromatic content 70.2%, gravity API 20.8). Selective carrot weed oils - "Richfield Selective No. 1" (boiling range 318 to 380 degrees F, aromatic content 16%, gravity API 45), and "Shell Weed Killer No. 10" (boiling range 312 to 392 degrees F, aromatic content 19%, gravity API 43.8). Selective Cotton Weed Oil - "Coberly and Plumb End-Ho" (a blend of light aromatic domestic and foreign oils; exact specifications unknown). Coal-tar derived hydrocarbon mixture - "Hydrin" (exact specifications unknown).

Table 1. The effect of directed oil sprays followed by flame cultivation on cotton and weeds. Famoso, California. 1954.

Treatment	Rate in gallons per acre	Weeds per 20 feet of row: May 6	May 13	May 20	July 1	August 4	Cotton stands, percentage survival, May 28	Seed cotton-bales/acre 1st picking, October 10
1. Check	--	27.0	28.3	24.3	1200	195.0	96.1	2.03
2. Rich. Sel. #1	5.0	12.8	8.0	2.5			97.4	2.55
3. Rich. Sel. #1	7.5	18.8	3.5	2.5			88.9	2.40
4. C & P "End-Ho"	5.0	15.0	7.5	6.8			95.1	2.33
5. C & P "End-Ho"	7.5	12.0	3.3	2.3			97.0	2.46
6. Shell 10	5.0	26.0	8.5	6.0			97.4	2.53
7. Shell 10	7.5	5.5	0.8	0.5			94.7	2.19
8. Rich. A	5.0	18.5	2.3	4.0			70.0	2.02
9. Rich. A	7.5	8.8	0.3	0.5			46.0	1.71
10. Hydrin 10%	5.0	25.0	20.5	16.5			95.3	2.33
11. Hydrin 10%	10.0	29.5	13.3	13.5			96.7	2.46
12. Flamed Check*	--	31.0	34.0	30.8	1450	20.5	95.6	2.35
L.S.D. 5 percent level	Not		16.0	12.4			7.7	0.40
L.S.D. 1 percent level	sig.		21.5	16.7			10.2	0.54

*Normal cultivation until first flame cultivation on June 8.

In order to arrive at a more practical evaluation of experimental methods, treatments 1, 4, and 12 were compared with three levels of grower cultural management: (A) normal practice, plus hoeing after bolls were set, (B) normal practice (including one rotary hoe and four sweep cultivations to July 15), and (C) normal practice minus one cultivation.

For the various weed control practices listed in Table 2, weed infestations at time of picking were described as follows: (1) moderate infestation, but short and immature; (2 and 3) essentially weed free; and (4, 5, and 6) moderate, severe, and very severe infestations, respectively; all taller than the cotton and fully matured.

A comparison of cotton yields in Table 2 shows that plots treated with oil and flame or flame alone, yielded equally with the best grower practice "A" and greatly exceeded the normal "B" and poorest "C" practices in yield. In addition, where weed infestations were highest, picker efficiencies were reduced and trash percentages were increased.

Table 2. The effect of various weed control practices upon yields of cotton grown under conditions of heavy watergrass infestation.

Weed control practice	Date of final treatment	Seed cotton bales/acre 1st picking	Picker efficiency percentage 1st picking	Trash percentage 1st picking
1. Normal cultivation (check)	July 31	1.91	91.1	7.5
2. Oil & flame cultivation	July 31	2.21	92.2	3.7
3. Flame cultivation	July 31	2.22	91.7	4.2
4. Grower Management "A"	Late August	2.21	84.4	8.3
5. Grower Management "B"	July 15	1.76	83.7	9.4
6. Grower Management "C"	Early July	1.61	81.7	10.6
L.S.D. at 5% level		0.33	3.0	1.5
L.S.D. at 1% level		0.45	4.1	2.1

(Field Crops Research Branch, ARS, USDA, and University of California, Davis)

The use of spot treatments for control of Johnson grass in cotton. Miller, J. H. and Foy, C. L. Johnson grass is the most serious perennial weed in cotton in the San Joaquin Valley. Cotton growers have depended largely upon hoeing as a means of control, but this method has resulted in labor costs as high as $50 per acre, with little accomplished toward eradication of the weed. In 1954, two locations heavily infested with Johnson grass were treated with several materials in an attempt to find a method less expensive, less laborious, and more positive than hoeing. The treatments included a non-selective weed oil emulsified with water at a 1 to 3 ratio ("Richfield A"); two light aromatic carrot weed oils ("Richfield Weed Oil No. 1" and "Shell Weed Killer No. 10"); a light aromatic cotton weed oil (Coberly and Plub "End-Ho"); a coal-tar derivative used as 10 and 20 percent water emulsions ("Hydrin"); Diesel alone; Diesel fortified with ¼ pint hexachloroacetone (HCA) per gallon of spray; Diesel as a 10 percent emulsion with water fortified with: (1) ¼ pint hexachloroacetone, (2) 0.04 pounds of sodium pentachlorophenol (PCP), and (3) 9.46 cc of dinitro-ortho-secondary butyl phenol (DN) per gallon of spray; Dalapon at ¼ and ½ pound per gallon of water; and a hoed check.

The Johnson grass was treated when 4 to 6 inches tall, and re-treated as warranted by regrowth. A total of four applications was made. Johnson grass stand counts were made just prior to re-treatment and 1 month following the fourth application.

After two applications, "Hydrin" and oil-water emulsions, with one exception, did not satisfactorily control Johnson grass. Since these treatments required hoeing they were eliminated from the test. Table 1 shows the yield of seed cotton at one location and the response of Johnson grass following each application at both locations. The eight remaining spray treatments were more effective than hoeing for elimination of Johnson grass.

The modes of action were different for the oils and Dalapon. The oils caused a sharp contact burn followed by rapid collapse of injured tissues, whereas Dalapon caused a much slower contact injury with less rapid "knockdown" of plants and a systemic injury shown by the discoloration and decay of rootstocks along with inhibition of buds.

Following four applications, all eight spray materials were shown to be superior to hoeing for Johnson grass elimination. After one application, none of the sprays were more effective than hoeing. At one location after two applications, all sprays were more effective than hoeing; however, at the other locations none was better after two applications, and only Dalapon after three applications. This, coupled with the definite trend toward fewer plants in the plots at the close of the test, indicates that Dalapon was somewhat more rapid than oil sprays in eliminating Johnson grass.

A comparison of spray materials and hoeing with regard to time required for the applications showed a significant advantage for spray applications. The volume of material used indicated that material costs may become prohibitive with heavy Johnson grass infestations. This practice would, therefore, most likely find application in the more sparse infestations.

Table 1. Yield of seed cotton and response of Johnson grass as influenced by various materials used as spot treatments. 1954.

Treatment	Kings County Johnson grass after each application Percentage of original stand 1	2	3	4	Tulare County Johnson grass after each application Percentage of original stand 1	2	3	4	Seed cotton pounds per acre
Richfield Selective Oil No. 1	44.0	12.7	12.4	8.5	27.5	19.4	2.2	0.9	1797.1
Shell Weed Killer No. 10	38.7	9.9	11.1	3.6	12.2	37.5	3.5	0.4	1601.1
Coberly & Plumb Cotton Weed Oil	44.0	8.3	17.4	6.2	21.3	41.0	8.2	0.2	1638.8
Diesel oil	28.3	12.8	6.8	6.2	8.0	18.1	5.1	0.4	1781.4
Diesel with HCA	27.1	17.4	16.6	10.0	10.3	26.4	3.1	0.2	1535.7
Diesel-water emulsion with HCA	86.4	12.5	15.6	4.6	27.9	23.0	7.1	0.0	1487.4
Dalapon ¼ pound per gallon	110.3	5.9	5.9	0.8	39.1	15.0	0.4	0.0	1568.4
Dalapon ½ pound per gallon	45.4	3.9	5.9	0.5	13.6	11.8	0.8	0.0	1650.7
Hoed check	55.6 1/	53.6	58.3	31.7	15.1 1/	11.4	6.8	3.5	1454.7
L.S.D. at 0.05	44.5	11.0	14.7	7.5	10.9	14.0	4.9	1.2	N.S.
L.S.D. at 0.01	N.S.	14.9	20.0	10.2	14.9	19.0	6.7	1.7	

1/ Wide location difference caused by large numbers of rootstocks removed with first hoeing in Tulare County because of loose, dry soil.

(Field Crops Research Branch, ARS, USDA, and University of California, Davis)

Tolerance of potatoes to herbicides applied as pre-emergence sprays. Barnard, E. E. Netted Gem potatoes were planted in a silt loam soil on May 17, 1954, and on June 6 the following pre-emergence treatments were applied: DNOSBP (Premerge) at 3, 6, and 9 pounds per acre; 2,4-D at 1, 1½, and 2 pounds per acre; NaPCP at 15, 20 and 25 pounds per acre; and TCA at 5, 10, and 15 pounds per acre. All materials were applied in water at 50 gallons per acre replicated four times. All surviving weeds were suppressed throughout the test by mechanical cultivation. Good moisture conditions were maintained by sprinkler irrigation. Potatoes were dug on September 15, 1954.

Neither stands nor yields were affected by any of the treatments. All seed pieces planted germinated and grew to maturity. Yields in both numbers of tubers and total weight were equal or slightly higher for all treated plots than the yields of the check. However, no significant differences were present. (Contribution of the Montana Agricultural Experiment Station)

Effectiveness of Dalapon for grain control in sugar beets. Blouch, Roger M. Tests were conducted with Dalapon (sodium 2,2-dichloropropionate) on sugar beet land sowed to tame oats just prior to beet planting and rototilled in to simulate actual volunteer growth conditions. Rates used were 4, 6, and 10 pounds per acre, acid-equivalent. These rates were applied at 3 stages of growth of the beets -- cotyledonary, 2-leaf, and 4-leaf. Local moisture conditions were good throughout the season and beet yields averaged 19 tons on the test area.

The sole treatment showing real promise was the 10-pound rate at the cotyledonary stage of beet development, the oats being approximately 4 to 6 inches tall. When applied at this stage Dalapon stunted the oats back sufficiently to permit the beets to grow normally. At later stages Dalapon inhibited oat growth, but the beets did not recover due to the longer period of suppression by oat competition.

Further research appears profitable on the use of Dalapon as a foliage spray when the grain is just appearing above the surface. (Colorado Agricultural Experiment Station)

Effect of Dalapon on development and yield of sugar beets. Blouch, Roger M. Tests were conducted under weed-free conditions to determine what, if any, effects Dalapon (sodium 2,2-dichloropropionate) might have on the growth, yield, and sucrose content of commercial beets under northern Colorado conditions.

Rates of 4, 6, and 10 pounds per acre of acid-equivalent Dalapon were applied at the cotyledonary, 2-leaf, and 4-leaf stages. Six replications of each treatment were made, and 4-row plots were sprayed of which only the 2 center rows were used for data purposes.

At 2 weeks following treatment a small but consistent stunting effect was apparent at 6 and 10 pounds; however, this effect disappeared quickly and no visible difference was apparent at harvest.

Tolerance of potatoes to herbicides applied as pre-emergence sprays. Barnard, E. E. Netted Gem potatoes were planted in a silt loam soil on May 17, 1954, and on June 6 the following pre-emergence treatments were applied: DNOSBP (Premerge) at 3, 6, and 9 pounds per acre; 2,4-D at 1, 1½, and 2 pounds per acre; NaPCP at 15, 20 and 25 pounds per acre; and TCA at 5, 10, and 15 pounds per acre. All materials were applied in water at 50 gallons per acre replicated four times. All surviving weeds were suppressed throughout the test by mechanical cultivation. Good moisture conditions were maintained by sprinkler irrigation. Potatoes were dug on September 15, 1954.

Neither stands nor yields were affected by any of the treatments. All seed pieces planted germinated and grew to maturity. Yields in both numbers of tubers and total weight were equal or slightly higher for all treated plots than the yields of the check. However, no significant differences were present. (Contribution of the Montana Agricultural Experiment Station)

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The sole treatment showing real promise was the 10-pound rate at the cotyledonary stage of beet development, the oats being approximately 4 to 6 inches tall. When applied at this stage Dalapon stunted the oats back sufficiently to permit the beets to grow normally. At later stages Dalapon inhibited oat growth, but the beets did not recover due to the longer period of suppression by oat competition.

Further research appears profitable on the use of Dalapon as a foliage spray when the grain is just appearing above the surface. (Colorado Agricultural Experiment Station)

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Rates of 4, 6, and 10 pounds per acre of acid-equivalent Dalapon were applied at the cotyledonary, 2-leaf, and 4-leaf stages. Six replications of each treatment were made, and 4-row plots were sprayed of which only the 2 center rows were used for data purposes.

At 2 weeks following treatment a small but consistent stunting effect was apparent at 6 and 10 pounds; however, this effect disappeared quickly and no visible difference was apparent at harvest.

PROJECT 6. AQUATIC WEEDS; SUBMERSED AND EMERGENT

J. M. Hodgson, Project Leader

SUMMARY

The three abstracts submitted present results of experiments to control submersed aquatic weeds and the effect of two potential aquatic weed herbicides on two crops when applied by irrigation.

Trichlorobenzene (TCB) gave excellent control of submersed waterweeds including giant sago pondweed (Potamogeton pectinatus var. interruptis), horned pondweed (Zannichellia palustris), and water buttercup (Ranunculus sp.) in experiments at Logan, Utah. The trichlorobenzene at rates of 6 and 10 gallons per cfs gave better control of submersed waterweeds than either aromatic solvent or 1 to 2 mixture of trichlorobenzene and solvent did at 10 gallons per cfs.

Results of treatments with a mixture of 1 part TCB and 2 parts aromatic solvent to control submersed waterweeds in Arizona were also effective.

The yield of sugar beets was severely reduced and many plants were killed when irrigated for 30 minutes with water containing 880 ppm of TCB. No detrimental effect on field corn was found after irrigating with water containing 880 ppm of TCB. Rosine amine D acetate did not affect the appearance or yield of field corn or sugar beets when applied in irrigation water for 30 minutes at 1250 ppm.

REPORTS OF INDIVIDUAL CONTRIBUTORS

Control of submersed aquatic weeds with chemicals. Arle, H. Fred. During 1954 two applications of mixtures of TCB (trichlorobenzene) and an aromatic solvent were made for the control of submersed aquatic weeds. In each of the test applications 1 part TCB was mixed with 2 parts solvent. This combination resulted in a specific gravity slightly heavier than water. A nonionic emulsifier was added to the TCB-solvent mixture at 2 percent by volume.

In the first application, made on July 29, a small canal was treated at 10 gallons per cubic foot per second (740 ppm) for 30 minutes. Unfortunately the flow was slightly less than desirable and resulted in stream channeling and incomplete coverage of the weed growth. The material was introduced at a pressure of 65 psi immediately above a weir. The resulting emulsion appeared very adequate just below the point of introduction. However, the "blanket" gradually weakened and was no longer visible 3/4 mile below the point. Top growth of the weeds (*Potomageton pectinatus*) which was contacted by the treated water turned brown in several hours and disappeared several days later. Regrowth was rather rapid and approximately 4 weeks later weed growth equaled the infestation prior to treatment.

On August 25 the same mixture was used in retreating the canal. A total of 30 gallons was applied in 30 minutes. At the point of introduction, the flow was only 5/8 cfs and resulted in a concentration of 3555 ppm. Discoloration and disintegration of *P. pectinatus* and scattered *Heteranthera dubia* was rapid and complete. At a point ¼ mile below the point of introduction, additional water entered the canal, raising the flow to 3 cfs and lowering the concentration to 740 ppm. At this concentration satisfactory results were also obtained. Effective results were noted for a distance of 1 mile, at which point the lateral emptied into one of the main canals. Control of submersed weed growth was maintained for approximately 1 month. (Field Crops Research Branch, ARS, USDA, and Arizona Agricultural Experiment Station)

Control of submersed waterweeds in irrigation canals by use of an aromatic solvent, trichlorobenzene, and combinations of the two. Lee, W. O., and Timmons, F. L. During the summer of 1954 experiments were conducted in 12 irrigation canals to test the relative effectiveness of an aromatic solvent water weed killer at 10 gallons per cfs, TCB (trichlorobenzene) at 6 and 10 gallons per cfs and a 2 to 1 mixture of the two at 10 gallons per cfs. A nonionic emulsifier was added to the trichlorobenzene at 3 percent by weight. Commercial aquatic weed killer had emulsifier already incorporated.

The aromatic solvent used was a commercial aquatic weed killer made up chiefly of methylated benzenes. The trichlorobenzene was supplied by Ethyl Corporation, New York City, and was technical grade containing approximately 85 percent trichlorobenzenes and 15 percent di- and tetrachlorobenzenes.

The canals treated varied in length from 0.9 mile to 6 miles. The amount of flow varied from 2.7 cfs to 11 cfs. The velocity of flow varied from 0.30 foot per second to 1.25 feet per second. The applications were made with a small power sprayer at a pressure of 100 pounds per square inch. The treatment was applied at one station in each canal, during a period of 30 minutes.

The water weeds most frequently encountered were giant sago pondweed (Potamogeton pectinatus var. interruptis), horned pondweed (Zannichellia palustris), and water buttercup (Ranunculus sp.). In the canals treated, the water weed was more mature than is usually considered desirable for treatment with aromatic solvents. In most of the canals it had formed dense mats of vegetation which extended above the water surface and caused channeling of the stream, thus creating areas of still water which the chemical did not penetrate readily. In some instances the growth reduced velocity of flow below that usually considered optimum for best kills. The results of these tests are summarized as follows:

1. TCB at 6 and 10 gallons per cfs gave better control of submersed water weeds than either the aromatic solvent or the 1 to 2 mixture of TCB and solvent did at 10 gallons per cfs. The aromatic solvent used in these tests appeared to be less effective than other similar aquatic weed killers and also less effective than carried-over supplies of this brand from previous years.

2. TCB at 10 gallons per cfs gave excellent control of all types of water weed present for distances up to 6 miles.

3. TCB at 6 gallons per cfs gave excellent control of water buttercup and horned pondweed for distances up to 3 miles, but gave only temporary control of giant sago pondweed.

4. The action of TCB upon water weeds was more rapid than that of solvent or the mixture, with weeds turning brown and beginning to settle to the bottom within 15 minutes after first exposure to the chemical. The water level dropped as much as 14 inches within 24 hours after treatment.

5. TCB killed all weed growth to the bottom of the canals whereas the solvent and mixture killed only the upper portion, leaving the plants green at the base.

6. Water weeds began to show recovery in the canals treated with solvent and solvent-TCB mixture in from 1 to 3 weeks. Sago pondweed began to show recovery on the canals treated with 6 gallons of TCB in from 1 to 4 weeks. Horned pondweed and buttercup showed some recovery after 4 weeks. Where TCB was used at 10 gallons per cfs no recovery started from any species of waterweed in less than 4 to 6 weeks.

7. Retreatments were not necessary on any canals treated with TCB, whereas canals receiving the solvent and solvent-TCB mixture required retreatments in from 2 to 5 weeks. (Field Crops Research, ARS, USDA, and Utah Agricultural Experiment Station)

The effect of aquatic herbicide effluent of TCB and Rada on sugar beets and corn. Hodgson, Jesse M. Two chemicals that have given promising results in control of submersed aquatic weeds were tested for their effect on two crops. The chemicals tested were: TCB (trichlorobenzene), furnished by the Ethyl Corporation of New York, and Rosine Amine D Acetate (technical grade dehydroabietylamine acetate). The latter chemical was supplied by the Hercules Powder Company and has been referred to as Rada or Delrad.

The sugar beets were planted with a field planter in rows 2 feet apart and 40 feet long. Normal field practices were followed. The beets were irrigated twice with regular irrigation water prior to treatment. The plants were 14 to 16 inches tall with roots 1 to 3 inches in diameter on July 14, 1954 when the treatments were made.

The field corn was planted in rows 3 feet apart and 40 feet long, and normal cultivation for corn cropping was also followed. Corn plants were 16 to 24 inches tall when treated with Rada and TCB in irrigation water.

The irrigation water was brought from a nearby canal in a head ditch and measured with a 90-degree V-notch weir. The chemicals were introduced into the water at this point. The treated water then flowed past the crop plots and was introduced onto the plots by 2-inch siphon tubes. The treated irrigation was continued for 30 minutes. The treatments and average yields are given in the following table.

Treatment	Yield in pounds per 33-foot row	
	Average of 3	Average of 4
	Corn silage	Sugar beets
1. 12 gallons TCB[1/] per 1 cfs, applied in 30 minutes, 880 ppm.	14.78	41.00
2. 4 gallons TCB plus 8 gallons Ortho Aquatic Weed Killer, applied in 30 minutes, 880 ppm.	14.42	73.70
3. 30 gallons 50% Rada[2/] per 1 cfs, applied in 30 minutes, 1250 ppm.	14.93	78.97
4. Control. Normal irrigation for 30 minutes.	14.69	76.01

1/ Trichlorobenzene. 2/ Rosine Amine D Acetate.

The TCB-treated water caused a severe reduction in yield of sugar beets at the rate tested (12 gallons per cfs). Many of the beets were killed on plots receiving this treatment. Corn silage yields were not affected by irrigation with the TCB-treated water. However, corn rows were 3 feet apart while sugar beet rows were only 2 feet apart. Some pigweeds and lambsquarters were observed to be killed in the irrigation furrows of the corn rows that were treated with TCB.

None of the other treatments caused any observable effect on the sugar beet or corn plants. (Field Crops Research Branch, ARS, USDA, and Montana Agricultural Experiment Station)

PROJECT 7. CHEMICAL AND PHYSIOLOGICAL STUDIES

B. E. Day, Project Leader

SUMMARY

In the field of chemical weed control, each year sees the gap widen between practical application and fundamental knowledge. New herbicides are turned out by the laboratories at a faster rate than our fund of basic knowledge can be built up to support programs for their use. Our chemical weed control development program, from screening laboratory to the user, is now largely on an empirical basis. Our deficiency in fundamental physiological and biochemical studies has never been more serious than it is at the present time.

The range of subjects covered in this year's reports are indicative of the multitude of problems needing solution. Electrophoretic studies of protein fractions of potato showed that treatments with 2,4-D increased protein synthesis and treatments with maleic hydrazide decreased protein synthesis. The character of the proteins produced was altered by each treatment. 2,4-D treatments were found to alter the content of phenolic substances in many plants. Phenolic substances were increased in some plants and decreased in others by 2,4-D. Seasonal trends in carbohydrate reserves in the leaves, stems, and roots of the velvet mesquite were measured in search of relationships with herbicide translocation.

Montgomery and Freed determined the relative growth-inhibiting action of several herbicides and interpreted the data as indicating a specific locus of action for each material tested. Chemical and physical properties of Dalapon and improved methods of analysis for 2,4-D and 2,4,5-T were reported. Studies by Stone and Rake established that sodium borates extend the effective life of 2,4-D in the soil by suppressing the action of soil microorganisms. Soil factors affecting the toxicity and longevity of urea herbicides have shown the relative toxicity of four of these compounds in soil and in nutrient culture. Steam sterilization extended the longevity of urea herbicides, the effect being most pronounced on PDU.

Field and laboratory experiments with 2,4-D, 2,4,5-T, and 2,4,5-TP evaluated the relative volatility of several formulations. Air contamination by low-volatile esters was shown to be appreciably greater under high temperature field conditions than was previously known. Late-season, directed basal sprays of Dalapon for grass control were found to be safe for use in cotton. Midseason applications injured cotton. Physiological and morphological effects of plant growth-regulators on cotton were reported.

REPORTS OF INDIVIDUAL CONTRIBUTORS

The effect of 2,4-D and maleic hydrazide on potato proteins as measured by paper electrophoresis. Yasuda, Grace, Payne, Merle G., and Fults, Jess L. Previous studies at this station have shown the effects of various growth-regulating chemicals on Red McClure potatoes. This report is concerned with relative quantitative and qualitative changes in potato tuber proteins due to plant spray treatments with 2,4-D and maleic hydrazide. Potatoes were grown during the 1953 season in the San Luis Valley. A Grassmann-Hannig type of electrophoretic instrument was used to produce zone electrophorograms. The relative amount of proteins in the tuber juice was measured by a Densichron, using the electrophorograms. Density curves were plotted for each treatment at harvest, and after 60 days of storage. The total area (proteins) under each curve was measured with a planimeter. The results are listed in the following table:

Treatment	Rate/acre	Total protein At harvest	Total protein After 60 days storage at 40° F
	Pounds	Square inches 3/	Square inches
1. Maleic hydrazide 1/	3.0	2.60	1.60
2. 2,4-D 2/	0.5	2.68	2.71
3. Maleic hydrazide plus 2,4-D	3.0 + 0.5	3.23	2.26
4. Control. No treatment	None	2.08	2.28

1/as MH(40)-the sodium salt, active ingredient basis.
2/as alkanolamine salt, active ingredient basis.
3/Planimeter measurements of areas under density curves. Each value is the mean of 6 different samples.

Quantitative differences. The total area (protein) as described in this table is a relative comparison of the total protein in the samples. At harvest the results indicated all three treatments increased the total protein as compared to the control. The greatest increase was in the combination treatment. After 60 days of storage the maleic hydrazide decreased and the 2,4-D increased the total protein as compared to the control. The combination treatment produced little change on the total protein. As indicated in earlier papers, this study has further substantiated our findings that 2,4-D treatment of Red McClure potato plants prior to harvest increases the protein content of the tubers. It is also in accord with the report of Steward and Caplin who found that 2,4-D stimulated protein synthesis of isolated potato tissue.

Qualitative differences. In the controls, six protein fractions appeared in the electrophorograms in samples taken at harvest. After 60 days storage, the main fraction (observed in the samples taken at harvest) was decidedly decreased and one of the secondary fractions increased in about the same amount. All treatments changed the character of the six protein fractions. 2,4-D treatment caused a shift in the main protein fraction at harvest similar to the shift observed in the controls after 60 days storage. Maleic hydrazide produced very little change in the samples at harvest but appeared to prevent the shift after storage seen in the controls. This failure to change in the maleic hydrazide samples may be associated with the basic reason why maleic hydrazide prevents sprouting of potato tubers, and 2,4-D (at $\frac{1}{2}$ pound per acre) does not. Combination treatments produced effects which resembled those of 2,4-D used alone. (Colorado Agricultural Experiment Station, Fort Collins)

Phenolic substances in plants and the herbicidal action of 2,4-dichlorophenoxyacetic acid. Dybing, C. Dean, Fults, Jess L., and Johnson, Gestur. Previous studies at this station showed that scopoletin (6-methoxy-7-hydroxy 1:2 benzopyrone) accumulated in tobacco, and some other plants following 2,4-D treatment. Studies elsewhere showed that scopoletin also accumulated in tobacco following invasion by tomato spotted-wilt virus and in potatoes following invasion by potato leaf-roll virus. These facts have been interpreted to mean that both 2,4-D and certain viruses interfere with normal metabolism of scopoletin in those plants in which scopoletin is a naturally-occurring metabolite. Since an intensive survey at this station of some 60 species of weeds and crop plants showed that only 7 naturally contain scopoletin, the scopoletin mechanism can hardly be considered universal. In an effort to broaden our horizon of comparisons a study to determine the total phenolic content of a wide range of weeds and crop plants is being made. This may lead to information for the interpretation of mechanisms involved in resistance and susceptibility to 2,4-D.

A study of the total phenolic content of 60 plant species has been nearly completed. Alcoholic extracts of dried plant material have been treated with Folin-Denis reagent and measured colorimetrically to determine total phenolic content. One indication from the study is that plants exhibit wide variation with respect to phenolic content. These variations showed no direct correlation between total phenolic content and resistance to 2,4-dichlorophenoxyacetic acid. Comparisons of plants sprayed with herbicidal dosages of 2,4-D with untreated control plants indicated changes in total phenolic content following treatment. With some species, an increase in phenolic content following treatment was observed; with others, the trend was one of decreasing phenolic content. Whether or not there are direct relationships is not yet clear. (Colorado Agricultural Experiment Station, Fort Collins)

Carbohydrate relations in naturally-growing velvet mesquite. Hull, Herbert M. The dependency of herbicidal translocation upon carbohydrate movement has suggested the importance of carbohydrate relations within the plant. To obtain this information in velvet mesquite (*Prosopis juliflora* var. *velutina*), small tissue samples were taken from the leaves and the phloem and xylem (3 mm adjacent to the cambium) of twigs, trunk, and taproot. This was done at pertinent intervals of phenological development over a 17-month period. The same trees were sampled throughout. Seedlings were also used, but had to be sacrificed at each sampling. Samples were individually analyzed for total starch and total soluble carbohydrates by colorimetric procedures, and for individual sugars by paper chromatography.

All carbohydrates of the twig phloem (and seedling stems) remained at a fairly constant level throughout the year, even during the winter dormant period. Starch and sucrose were present in about equivalent amounts, no sugar other than sucrose being found in the twig phloem. The soluble sugars in the phloem of trunk and root build up constantly between mid-April, when the new leaves are about half-expanded, and late fall just before defoliation in December. Thereafter, the sugars remain about constant, but fall rapidly between mid-February and mid-April. Sucrose is the predominant sugar with smaller amounts of glucose and fructose being present, except that no fructose was found in the phloem of seedling stems and roots at any time. Sugars of the trunk and root xylem follow essentially the same pattern. Sucrose is the only sugar present in root xylem the entire year, with the exception of summer when moderate amounts of fructose are present in both seedlings and trees. Starch, on the other hand, falls rapidly between mid-April and early July in all trunk and root tissues with the exception of the seedling root xylem. It is apparently hydrolyzed during this time to form sugars which become readily available for the spring and early summer growth. After July the starch is constantly replenished, up to the time of defoliation in December. The intensity of these annual fluctuations of starch in the trunk and root is considerably more marked in the xylem than in the phloem, but follows the same general pattern in both. Total sugars within the leaves remain about constant from the first leafing out until early July, after which they continuously increase until the time of defoliation. Starch content is fairly high in the new leaves, but drops by July and increases slightly thereafter up until time of defoliation.

Future studies will endeavor to establish whether the optimum critical period for herbicidal application is dependent primarily upon carbohydrate relations or more upon phenological development, e.g., cuticular and stomatal development at time of treatment. (Field Crops Research Branch, ARS and Forest Service, USDA, cooperating, Tucson, Arizona)

A study on the absorption and translocation of radioactive 3-(p-chlorophenyl)-1,1-dimethyl urea (CMU) by bean plants. Fang, S. C., and Freed, V. H. Bean plants (Phaseolus vulgaris var. Black Valentine) were grown in flats containing Chehalis sandy loam soil under greenhouse conditions. The plants were treated when the primary leaves were almost fully expanded and their terminal buds were still quite small. Radioactive 3-(p-chlorophenyl)-1,1-dimethyl urea, dissolved in ethyl alcohol solution containing 1 percent of Tween-20, was applied quantitatively to one primary leaf of each plant along the midrib. After harvesting, all plants were sectioned and homogenized with 80 percent alcohol.

Following is a summary of the results obtained:

1. Bean plants absorbed radioactive CMU very rapidly from the leaf and distributed it throughout the treated leaf.

2. Only a small amount was translocated to the other parts of the plant.

3. The maximum concentration of CMU in the stem and the untreated leaf was noted on the 4th day.

4. Approximately 4 percent of the applied radioactive CMU in the soil was absorbed in 24 hours.

5. Older seedlings appeared to absorb the chemical more rapidly. (Oregon Agricultural Experiment Station, Corvallis)

<u>The determination of the thermodynamic "activity" of chloroalkyl acids and amino triazole.</u> Montgomery, M. and Freed, V. H. It has been shown that thermodynamic "activity" of a compound is related to the mode of biological action. This "activity" is a function of maximum solubility and concentration at a given toxicity or biological activity level.

The "activity" of three related compounds (chloroalkyl acids and derivatives) and amino triazole was determined as part of a study to elicit the mode of action of these compounds. The procedure followed consisted of placing 10 seeds of gray winter oats in a petri dish on two filter papers. Five ml of solution of one of the four different concentrations was added to the dish. Each solution was prepared to contain the equivalent of 10^{-1}, 10^{-2}, 10^{-3}, or 10^{-4} molar concentration of its respective parent compound. After one week, the percentage germination and growth of the sprouts were determined. The following table summarizes the information thus obtained.

Material	Concentration (Moles/liter)	Percent germination	Length (cm)	"activity"
2,2-dichloro-propionic acid	0	90	4.6	$< 10^{-3}$
	0.1	0	-	
	0.01	0	-	
	0.001	80	2.9	
	0.0001	70	4.0	
Sodium dichloropropionate	0	70	2.7	$< 10^{-3}$
	0.1	0	-	
	0.01	30	1.1	
	0.001	80	3.2	
	0.0001	30	2.5	
Chloroacetic acid	0	90	4.6	$< 10^{-3}$
	0.1	0	-	
	0.01	60	1.1	
	0.001	70	3.2	
	0.0001	70	2.5	
N,N,diethyl-alpha-chloroacetamide	0	90	8.5	1.67×10^{-3}
	0.1	0	-	
	0.01	0	-	
	0.001	0	-	
	0.0001	7	11.2	
Amino triazole	0	80	5.5	3.00×10^{-3}
	0.1	0	-	
	0.01	10	0.7	
	0.001	80	3.6	
	0.0001	90	3.0	

Since any value for "activity" less than 10^{-2} is usually interpreted as indicating a physiologically specific reaction, it is apparent that all of the compounds studied affect specific sites or reactions. (Oregon Agricultural Experiment Station, Corvallis)

A study of 2,4-D with borate additives as affecting soil microorganisms. Stone, J. D., and Rake, D. W. Early laboratory studies showed that compounds such as 2,4-D are readily utilized as nutrients by microorganisms occurring naturally in the soil, and that growth of these organisms may actually be accelerated by additions of 2,4-D within certain limits. Standard potato nutrient agar media (to which 2,4-D was added at rates of 0.075 pounds, 0.15 pounds, and 0.3 pounds acid-equivalent per 100 square feet) was inoculated with a water infusion from fresh garden soil and incubated for 7 days. The growth of soil microorganisms was accelerated in proportion to the added increments of 2,4-D, the lowest rate used being approximately equivalent to 33 pounds of herbicide per acre.

Numerous tests were undertaken to determine the practicability of adding to the pesticidal compound, in formulation or application, an ingredient which could depress, limit, or prevent the growth and/or activity of microorganisms that feed on and decompose these organic pesticidal compounds. For practical field application, such an additive must be cheap, readily available, adaptable to water spray or dry application. It must also have chemical and physical characteristics compatible with the physical, chemical and end-use characteristic of a wide range of pesticides.

The sodium salt of 2,4-D was selected as a standard test material representing the organic pesticides, and among the additives tested as possible microorganism control agents were sodium or calcium borate salts. Initial tests with these materials indicated their effectiveness in reducing the activity of soil-borne organisms and at the same time illustrated economy from a possible use viewpoint. The sodium borates, having desirable herbicidal characteristics, were thoroughly investigated.

Agar plates were treated with 1 pound per 100 square feet equivalent and 2 pounds per 100 square feet equivalent of a 7½ percent 2,4-D-92½ percent sodium borate mixture. The culture media was inoculated with a soil water infusion and incubated for 7 days. Also included in this test were the equivalents of the individual constituents making up the complex along with representative check plates. Microbiological activity was completely inhibited on the cultures treated with the 2,4-D-borate complex, and with the borate additives alone.

Additional proof of the microbiological activity depression caused by this mixture of 2,4-D and sodium borate was obtained by determining the relative activity of soil organisms on the basis of CO_2 evolution. This was measured in mm of mercury by use of a simple manometer. Treatments of 0.15 pounds 2,4-D acid equivalent per 100 square feet showed micro-activity to be high and uniform throughout the 7-day incubation period, varying from 2.40 mm of mercury to 3.82 mm of mercury. The borate-2,4-D complex showed a range of 0.05 to 0.23 mm mercury pressure while the check ranged from 2.90 to 4.40 mm of mercury pressure. (Pacific Coast Borax Company, Los Angeles)

The chemical and physical properties of 2,2-dichloropropionic acid. Freed, V. H., McKennon, K., and Montgomery, M. The sodium salt of 2,2-dichloropropionic acid (Dalapon) has been introduced recently as a systemic herbicide for grass. Since properties of the parent compound may influence the biological behavior of the herbicide, it became of interest to examine some of these properties.

The degree of ionization (and pK_a) of acids has been shown to be related to the ease with which they are absorbed by the plant. This relationship is usually an inverse one except at the point where $pH \leqslant pK$. A sample of 2,2-dichloropropionic acid assaying 97 percent pure, plus 3 percent homologs and analogs, was used for the determination of ionization constant, boiling point and density. It is recognized that these values are not absolute because of the presence of impurities. Table 1 summarizes the information thus obtained.

Table 1.

pH (Dalapon 78 percent)			3.76
pH (2,2-dichloropropionic acid)			1.38
K_i	"	"	2.94×10^{-2}
pK_a	"	"	1.53
Boiling point	"	"	185° - 190°
Density	"	"	1.389
H_2O solubility	"	"	Very soluble
Molecular weight	"	"	142.98

This compound undergoes the typical reactions of an alkane carboxylic acid, such as salt formation, esterification, and acyl chloride formation. Of considerable interest are the two chlorine atoms on the second carbon. These can be removed by hydrolsis in the presence of alkali to yield pyruvic acid. Removal can also be affected by photohydrolysis which would indicate the inadvisability of long light exposure when the material is in solution. A third reaction involving the chlorine in 2,2-dichloropropionic acid is that with sulfhydryl groups of organic molecules. Preliminary experiments show this reaction to proceed at physiological pH. (Oregon Agricultural Experiment Station, Corvallis)

Quantitative determination of 2,4-D and 2,4,5-T. Freed, V. H., McKennon, K., and Montgomery, M. The increased use of these chemicals in recent years has made it desirable to perfect a method for the quantitative determination of the compounds. A method, based on the formation of a distinctive purple color when 1,8-dihydroxy napthalene 3,6-disulfonic acid (chromotropic acid) and 2,4-D are heated in sulfuric acid, has been developed. It was adapted successfully to a quantitative determination using a spectrophotometer. The procedure described below was carried out in an attempt to obtain standard curves for these compounds.

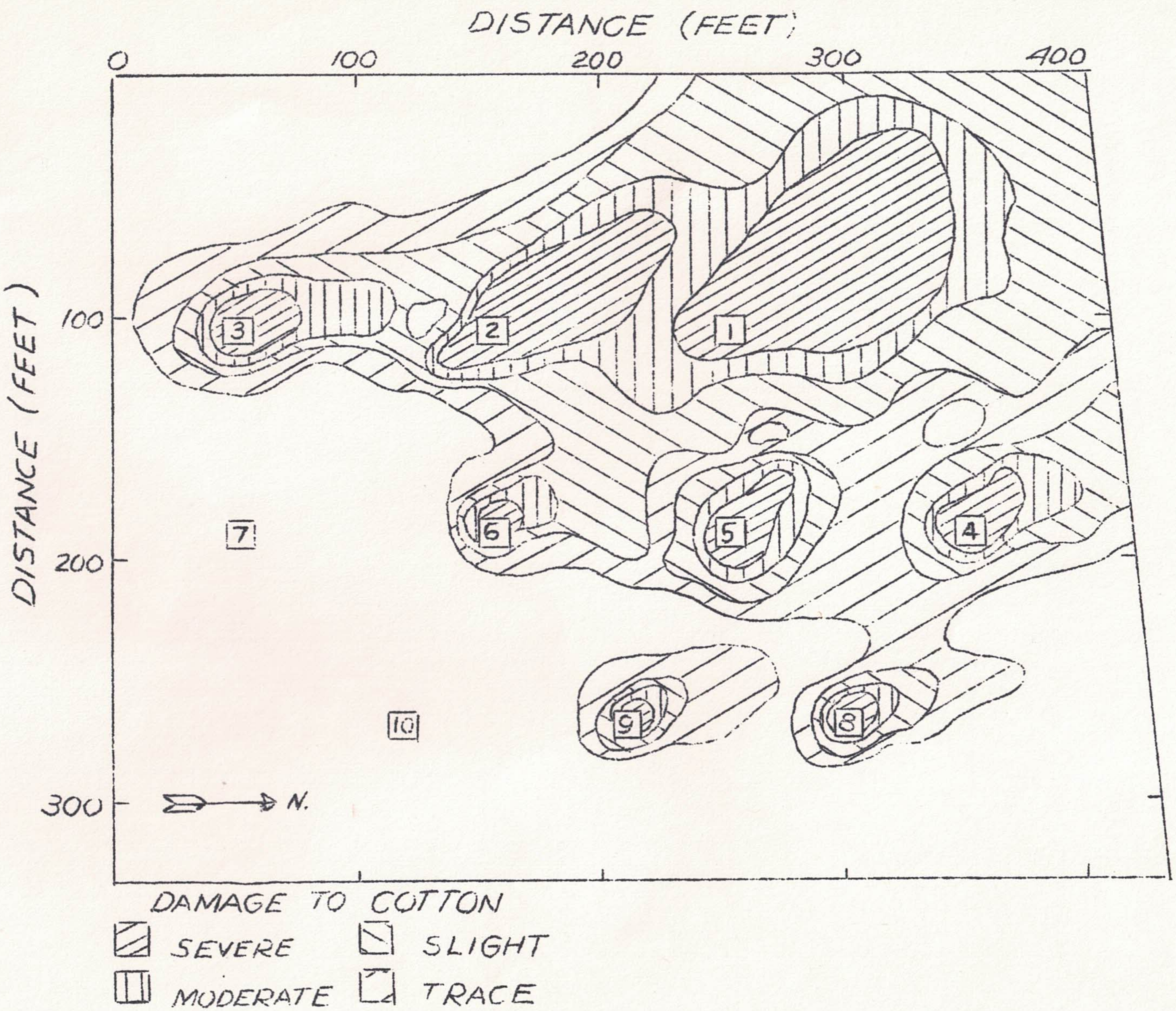
One ml of the solutions containing 10 gamma/ml, 20 gamma/ml, and 50 gamma/ml were put in 10 ml volumetric flasks equipped with ground glass stoppers. A chromotropic-sulfuric acid reagent was prepared by dissolving 400 mg of chromotropic acid in 200 ml of sulfuric acid. After evaporation of the flasks to dryness, 8 ml of the chromotropic reagent was added and the flasks were heated in a glycerine bath at 150 degrees C for 2 minutes. The flasks were cooled and the optical density of the solutions was read at 580 millimicrons on a Klett spectrophotometer using a blank of acid reagent carried through the heating process, as zero transmittance. The slopes of the lines of 2,4-D and 2,4,5-T were obtained by plotting Klett reading versus concentration, and were in good agreement with theory. The slopes of the lines were 5.2 for 2,4-D and 4.5 for 2,4,5-T. (Oregon Agricultural Experiment Station, Corvallis)

Volatility of herbicides under field conditions. Day, B. E., Johnson, E., and Dewlen, J. L. Volatility is recognized as one of the hazards of 2,4-D and similar compounds. The use of herbicidal preparations containing 2,4-D, 2,4,5-T, or MCP in the form of highly volatile liquids is now prohibited by law in California. The usual test to which a 2,4-D preparation is subjected to determine whether or not it is highly volatile is to expose it in a beaker within an enclosure in which susceptible plants are growing. The temperature under those conditions rarely exceeds 85 to 90 degrees F. When a herbicide is applied in the field it is deposited over a large surface exposed to the direct rays of the sun. A temperature of 160 degrees F for surfaces exposed to the summer sun in California desert valleys is not unusual.

To test the possible vaporization of several commercial formulations of 2,4-D, 10 plots, each 10 feet square, were treated in a cotton field in the Coachella Valley in the summer of 1954. Herbicides were mixed with water and applied at the rate of 100 gallons per acre with a knapsack sprayer. Plots were covered with a portable shelter at the time of spraying to prevent spray drift. Water was withheld from the furrows which ran through the plots in order to eliminate the possibility of carrying 2,4-D by that means. Treatments were applied on July 1, 1954, and the extent of cotton injury in the field was mapped on four occasions during the remainder of the growing season. The following table lists the materials and rates applied to the plots, and the accompanying map shows the distribution of cotton injury on August 6.

Plot	Material applied	Rate (pounds/acre)
1	Butoxyethanol 2,4-D	16
2	"	8
3	"	4
6	"	2
8	"	1
4	Propyleneglycol butyl ether 2,4-D	4
5	Tetrahydrofurfuryl 2,4-D	4
7	Alkanolamine salts of 2,4-D	4
9	2,4-D acid emulsion	4
10	Propyleneglycol butyl ether 2,4,5-TP	4

The amine salt showed no symptoms outside the plot. The ester formulations of 2,4-D affected an area extending northwesterly from the plot in a fan-shaped pattern roughly proportional in extent to the concentration of the solution applied. No significant difference was noted between different formulations at the same concentration.



DISTANCE (FEET)
0
100
200
300
400
DISTANCE (FEET)
100
200
300
1
2
3
4
5
6
7
8
9
10
N.
DAMAGE TO COTTON
SEVERE
SLIGHT
MODERATE
TRACE

The patterns at once suggested the influence of wind. The general direction of airflow was from northwest to southeast during the night and from southeast to northwest during the day. It, therefore, appeared that the vapor generated from the treated plots in the daytime was sufficient to affect cotton plants, but not at night. The cotton plants around the 2,4,5-TP plot did not show symptoms of 2,4-D injury, but at the time of the first observation, 10 days after treatment, the petioles of the leaves were recurved throughout an area comparable in size, shape, and direction to the areas affected by 2,4-D ester formulations of the same concentration. Neither these nor any other abnormalities were detected on subsequent observations, although the plants within the plot died as quickly as those in any of the 2,4-D plots. The amine salt at first appeared not to have affected any of the plants outside the plot, but after 6 weeks, symptoms appeared for about three rows to the northwest. Possibly a more volatile product was formed by a change in the chemical composition of the residue. (University of California, Citrus Experiment Station, California Department of Agriculture, Riverside County Department of Agriculture)

<u>The steam volatility of phenoxyacetic acid compounds</u>. Freed, V. H., Montgomery, M., and McKennon, K. There has been an increasing awareness of the danger from vapors of the phenoxyacetic acid herbicides. The quantity of vapor arising from a chemical is a function of its vapor pressure and the exposed area. Since the amount of chemical carried over in steam distillation is a function of that chemical's vapor pressure, this method was selected as a means of investigating the volatility of certain formulations of 2,4-D and 2,4,5-T. Moreover, it is known that under certain conditions encountered in the field, vapor distillation of herbicides can occur.

A 2-gram sample (or 2 ml) was placed in a flask and steam-distilled. Forty ml of distillate were collected. One-half ml of this distillate was analyzed by the chromotropic acid method, where this was possible. One-tenth of 1 ml of the distillate was placed on the fully expanded primary leaf of bean plants in 8-inch pots. The treatment was replicated three times and the experiment was run twice. Observations were made at 4 and 20 hours to determine the effect. The isopropyl ester of 2,4-D was chosen as giving an effect of 100 and the others rated on this basis. The following table summarizes the information from these trials. Each figure is an average of three readings in each of two runs.

Material	Effect	Gamma/ml
2,4-D acid	10.0	12.6
2,4-D isopropyl ester	100.0	5010.0
2,4-D isooctyl ester	30.0	27.9
2,4-D THFA ester	100.0	
2,4-D butoxyethyl ester	95.0	
2,4-D amine (triethanol)	0.0	
2,4,5-T acid	0.0	
2,4,5-T isopropyl ester	57.5	
2,4,5-T amine (triethyl)	0.0	
2,4,5-TP isooctyl ester	5.0	

(Oregon Agricultural Experiment Station, Corvallis)

Soil studies with four substituted ureas. Sheets, T. J. Four of the substituted urea herbicides including CMU (3(p-chlorophenyl)-1,1-dimethylurea), DCMU (3(3,4-dichlorophenyl)-1,1-dimethylurea), PDU (3-phenyl-1,1-dimethylurea), and Dupont M (3(3,4-dichlorophenyl)-1-methylurea) were tested in the greenhouse with respect to their behavior in the soil. Each material was applied to steam-sterilized and non-sterilized Yolo clay loam soil at six concentrations ranging from 0 to 8 ppm based on the weight of air dry soil. Continuous cropping (therefore, continuous moisture) vs alternate cropping was also introduced as a variable. There were three replications.

Kanota oats were used as indicator plants. The oats were seeded every month or every other month according to treatment. The alternate-cropping system devised by Crafts for soil toxicity studies consists of alternate monthly crops of oats, separated by 1 month during which the soil remains dry. This drying period may prolong the toxicity of the herbicides.

Although the experiment has not been completed, certain trends in residual activity are apparent. By the end of the fourth month a difference between sterile and non-sterile soil was obtained with all materials. The length of time required for sterility of the soil to become measurably effective varied among the four herbicides included in the test. Thus, it appears at the end of the fourth month that the effect of soil sterility on residual toxicity is much more pronounced with PDU than with the other three chemicals. The order of toxicity in sterile soil was approximately the same as the first run (CMU about equal to PDU greater than DCMU greater than Dupont M). In non-sterile soil the toxicity of PDU had decreased to where it was least toxic of the four compounds whereas the relative order of the other three remained the same.

The only data to date which could be used to compare continuous and alternate cropping are those collected at the end of the third month. At that time the difference was significant at the 5 percent level with PDU. With the other three herbicides there was no difference between cropping systems.

In conjunction with this experiment a study was conducted to determine the critical level of the same ureas in nutrient culture. The order of toxicity follows: DCMU about equal to Dupont M greater than CMU greater than PDU. If the order of toxicity in nutrient culture is compared with order of toxicity in the soil the first run (cited above), it will be noted that the soil affects these materials differently. The toxicity of Dupont is reduced by the soil far more than the other three herbicides. (Field Crops Research Branch, ARS, USDA, and California Agricultural Experiment Station, cooperating)

The effect of directed basal sprays of Dalapon (2,2-dichloropropionic acid) on cotton. Foy, C. L., and Miller, J. H. The invasion of annual grasses after first irrigation, and throughout the remainder of the season, poses one of the most serious problems in California cotton production. Preliminary field trials, using

The patterns at once suggested the influence of wind. The general direction of airflow was from northwest to southeast during the night and from southeast to northwest during the day. It, therefore, appeared that the vapor generated from the treated plots in the daytime was sufficient to affect cotton plants, but not at night. The cotton plants around the 2,4,5-TP plot did not show symptoms of 2,4-D injury, but at the time of the first observation, 10 days after treatment, the petioles of the leaves were recurved throughout an area comparable in size, shape, and direction to the areas affected by 2,4-D ester formulations of the same concentration. Neither these nor any other abnormalities were detected on subsequent observations, although the plants within the plot died as quickly as those in any of the 2,4-D plots. The amine salt at first appeared not to have affected any of the plants outside the plot, but after 6 weeks, symptoms appeared for about three rows to the northwest. Possibly a more volatile product was formed by a change in the chemical composition of the residue. (University of California, Citrus Experiment Station, California Department of Agriculture, Riverside County Department of Agriculture)

<u>The steam volatility of phenoxyacetic acid compounds</u>. Freed, V. H., Montgomery, M., and McKennon, K. There has been an increasing awareness of the danger from vapors of the phenoxyacetic acid herbicides. The quantity of vapor arising from a chemical is a function of its vapor pressure and the exposed area. Since the amount of chemical carried over in steam distillation is a function of that chemical's vapor pressure, this method was selected as a means of investigating the volatility of certain formulations of 2,4-D and 2,4,5-T. Moreover, it is known that under certain conditions encountered in the field, vapor distillation of herbicides can occur.

A 2-gram sample (or 2 ml) was placed in a flask and steam-distilled. Forty ml of distillate were collected. One-half ml of this distillate was analyzed by the chromotropic acid method, where this was possible. One-tenth of 1 ml of the distillate was placed on the fully expanded primary leaf of bean plants in 8-inch pots. The treatment was replicated three times and the experiment was run twice. Observations were made at 4 and 20 hours to determine the effect. The isopropyl ester of 2,4-D was chosen as giving an effect of 100 and the others rated on this basis. The following table summarizes the information from these trials. Each figure is an average of three readings in each of two runs.

Material	Effect	Gamma/ml
2,4-D acid	10.0	12.6
2,4-D isopropyl ester	100.0	5010.0
2,4-D isooctyl ester	30.0	27.9
2,4-D THFA ester	100.0	
2,4-D butoxyethyl ester	95.0	
2,4-D amine (triethanol)	0.0	
2,4,5-T acid	0.0	
2,4,5-T isopropyl ester	57.5	
2,4,5-T amine (triethyl)	0.0	
2,4,5-TP isooctyl ester	5.0	

(Oregon Agricultural Experiment Station, Corvallis)

Dalapon as a directed basal spray in cotton, have indicated it to be effective for controlling several annual grass species. In some cases, however, delayed maturity and/or reduction in yield of cotton also has been reported. Since it seemed desirable to study further the economic responses of cotton to Dalapon, an experiment was conducted on a sandy loam soil to determine the effect of various rates applied at different periods upon the general vigor, yield, maturity, and seed and fiber qualities of cotton.

Under weed-free conditions, Acala 4-42 cotton was conventionally planted and fertilized on April 19. During the season, the crop was irrigated 11 times, 9 of which occurred after the mid-season application of Dalapon, and 4 after the "lay-by" application. The test included 7 treatments replicated 8 times. Two 40-inch rows, 130-feet long, comprised the individual plots. Dalapon was applied as a basal spray to 20-inch bands over the row at mid-season (June 14) and/or "lay-by" (August 4) by means of a shielded high-clearance tractor spray rig. The chemical, expressed in pounds acid equivalent per acre, was delivered in 50 gallons of water. Yield, maturity and picker efficiency data are summarized in the following table.

	Rate of Dalapon pounds/acre		Bolls per plant	Lint cotton pounds/acre		Percentage	Picker efficiency percentage	
	Midseason	lay-by	5 Sept.	1st picking 28 Sept.	Total	1st picking	1st picking	Final
1.	0	0	8.2	1116	1475	75.7	91.0	94.9
2.	3		8.5	969	1390	69.7	90.5	95.3
3.	3	3	8.9	988	1410	70.1	89.7	95.3
4.		3	8.7	1106	1470	75.3	92.0	95.0
5.	6		8.9	910	1365	66.7	89.6	95.1
6.	6	6	8.4	918	1350	68.0	90.6	95.6
7.		6	8.5	1096	1455	75.3	91.0	95.2
	L.S.D. at 5% level		N.S.	55	60	--	--	--
	L.S.D. at 1% level		N.S.	75	75	--	--	--

Throughout the season, all plots appeared normal and boll counts 3 weeks prior to picking indicated that yields would not be affected; however, both the 3- and the 6-pound rates of Dalapon per acre, applied at mid-season, significantly delayed maturity and reduced final cotton yields. Neither rate applied both at mid-season and at "lay-by" was any more injurious than an equal rate applied at mid-season only. In either case, the 6-pound rate was more injurious than the 3-pound rate. The "lay-by" applications alone, regardless of the rate of chemical, did not affect either yield or maturity. Although the pattern for yield and maturity was exactly reversed between first and second pickings (thus tending to equalize total yields), the losses caused by mid-season applications of Dalapon were not entirely recovered at second picking, as evidenced by significant reductions in total yields.

There was a tendency for picker efficiencies at first and second picking to vary directly with the amount of cotton to be picked at the time. However, final picker efficiency was unaffected. Complete seed and fiber analyses showed no significant differences between treatments for either picking, thus indicating that Dalapon had no deleterious effects upon seed or fiber qualities.

In summary, herbicidal rates of Dalapon were applied at "lay-by" with safety, but mid-season applications of Dalapon proved injurious, possibly for reasons related in some way to delayed maturity. (Field Crops Research Branch, ARS, USDA, and the University of California, Davis)

<u>The response of cotton (Acala 4-42) to various growth regulators.</u> Miller, J. H., and Foy, C. L. The use of 2,4-D and related compounds is restricted in the cotton growing areas of California. Recently a new group of related compounds, the chlorinated phenoxypropionic acid derivatives, has been developed. This study was undertaken to determine the comparative hazards of this group of compounds to cotton.

Four replications of Acala 4-42 cotton were treated at three stages of growth with three rates of five different herbicides. The cotton was treated in the early square (June 18), full bloom (July 23), and boll (August 18) stages of growth. The herbicides used were low volatile esters of 2,4-D, 2,4,5-T, 2,4-DP, 2,4,5-TP, and 2,4,5-TP amine. The rates of application were 0.1, 0.01, and 0.001 pound per acre. After one application the 0.1 pound per acre rate was discarded because of the high mortality of cotton, and the 0.0001 pound per acre substituted into the test. Applications at the various dates were made over the top of the plants using a volume of 165 gallons of spray per acre.

Following the first date of application, both groups of compounds caused epinastic responses in a matter of 2 to 3 hours. Both groups also caused an increase in red pigmentation. The latter was more pronounced in the case of the chlorinated phenoxypropionic compounds. Secondary growth responses were quite different. The chlorinated phenoxyacetic acid compounds caused the characteristic "strapping" of leaves in which it appeared that the development of the vascular system greatly exceeded that of the remainder of the leaf. With the chlorinated phenoxypropionic acid compounds, the reverse appeared to be true, resulting in a "cupping" of leaves rather than "strapping." Another characteristic of the latter group was a temporary shortening of internodes in the secondary growth. Both groups of compounds caused the plants to be extremely brittle for several weeks after treatment. Another secondary growth response in evidence was the formation of proliferated or gnarled callus tissue, sometimes 1½ inches in diameter in extreme cases, in the stem-root transitional and primary root regions. This phenomenon was most pronounced in the 2,4-D treated plots, considerably less in the 2,4,5-T treated plots, and infrequent or absent in all other plots. The treatments varied in their effect on defoliation of cotton. Plots treated with 2,4-D and 2,4,5-T, at all dates, were not defoliated as well as plots treated with the chlorinated phenoxypropionic acid derivatives.

After the second application, the same types of responses were noted, but in lesser degrees. After the third date, the responses were scarcely noticeable, probably because the cotton plants had approached vegetative maturity.

The following table shows the yield of seed cotton in pounds per 33 feet of row for the various treatments.

Yields of seed cotton as influenced by various growth regulators (pounds/33 feet of row), 1954.

Treatment	Rate pounds/ acre	Dates of application 6/18 Early square	7/23 Full bloom	8/19 Boll
2,4-D	0.1	0.00	--	--
	0.01	0.00	1.75	10.50
	0.001	0.00	5.75	9.38
	0.0001	--	8.25	10.63
2,4,5-T	0.1	0.00	--	--
	0.01	1.63	3.63	9.13
	0.001	6.13	6.33	9.63
	0.0001	--	7.63	10.13
2,4-DP	0.1	0.00	--	--
	0.01	1.00	2.13	8.38
	0.001	4.63	7.75	8.88
	0.0001	--	8.88	9.75
2,4,5-TP	0.1	0.00	--	--
	0.01	1.63	2.00	8.38
	0.001	6.38	6.75	9.75
	0.0001	--	7.75	9.50
2,4,5-TP amine	0.1	0.00	--	--
	0.01	1.25	3.00	9.13
	0.001	4.38	6.88	8.50
	0.0001	--	8.50	8.63
Untreated	--	8.75	9.50	9.63
L.S.D. at 0.05		0.86	2.97	N.S.
L.S.D. at 0.01		1.14	3.95	N.S.

At the early square stage, the 0.1 pound per acre rate killed all the cotton plants when the low-volatile esters were used. A few survived when the amine salt of 2,4,5-TP was used, but were stunted to the extent that no cotton was produced. The 0.01 pound per acre rate severely retarded growth, but killed very few plants. Of all the herbicides used, 2,4-D caused by far the most injury to the cotton plants, eliminating cotton production entirely. While the other four herbicides caused drastic yield reductions, no differences among these treatments could be observed. The 0.001 pound per acre application of 2,4-D again caused the greatest injury and no cotton was produced. Among the other four herbicides, all four caused highly significant reductions in cotton yields, but the ester of 2,4-DP and the amine salt of 2,4,5-TP caused a greater reduction than esters of 2,4,5-T and 2,4,5-TP.

At the full bloom stage, with the 0.01 pound per acre rate, the untreated plots yielded considerably more than treated plots. However, within the treated plots no differences were demonstrated. Of the treatments at 0.001 pound per acre only 2,4-D and 2,4,5-T caused yields to be significantly lower than the untreated plots. The other three herbicides caused a definite trend toward reduced yields, however. A difference between treated and untreated plots could not be shown when sprayed with the five herbicides at the 0.0001 pound per acre rate.

At the boll stage, the cotton plants were near vegetative maturity and none of the herbicides, at the rates used, caused a reduction in seed cotton yields. Twenty-five lock samples, representative of the bottom, middle, and top crops, were harvested to determine the effects of treatments upon seed and fiber qualities. Fiber analysis and seed viability data are not yet completed. The study will be continued next year. (Field Crops Research Branch, ARS, USDA, and the University of California, Davis)

PROJECT 10. ECONOMIC STUDIES OF WEED PROBLEMS AND CONTROL

D. C. Myrick, Project Leader

SUMMARY

Three reports on economic studies were received. These are the first to be reported in this project of the Research Section, and represent an important milestone of progress. These studies are based on experimental work still in progress, hence report very preliminary analysis.

In Oregon, analysis of the first year's results in a study of physical control and economic practicability of control of different levels of tarweed (Ansinkia intermedia) infestation in wheat has pointed up some difficulties in control of experimental conditions. In order to establish the different levels of infestation that will be essential to the economic study, tarweed was planted in a field in the fall of 1954.

After 2 years study of Canada thistle (Cirsium arvense) control in spring wheat on plots at the Montana Station, significant results were observed in comparing yields on unfertilized plots treated both years with 2,4-D and similar plots not treated. Gross return from the treated plots was about $10 per acre per year greater than that from the untreated plots. Cost of materials used in treatment averaged 75 cents a year.

In California, data show a definite cost advantage for certain control practices in cotton infested with water grass. Oiling and flaming, or flaming alone, have been found superior to other methods tested. Losses of $45 to $150 per acre are reported for various other cultural practices and control methods.

Economic studies of tarweed (Ansinkia intermedia) control in eastern Oregon. Bayer, David E., Furtick, W. R., and Mumford, D. Curtis. This trial was started in the fall of 1953 to determine the relative effectiveness of certain spray chemicals in controlling different degrees of tarweed infestation in wheat and to determine the economic practicability of controlling the different levels of infestation. Materials used in this trial were 2,4-D, MCP, 2,4,5-T, and mixtures of 2,4-D and 2,4,5-T. These materials were used at three rates, ½, 1, and 1½ pounds per acre applied at locations in three counties of the Columbia Basin region. The trials were on three different levels of tarweed infestation. Applications were all made at the same stage of tarweed and wheat growth as nearly as possible. The trial was set up using five replications. Rod-row yield was taken of the wheat in these experiments. No significant yield differences could be detected from these trials. 2,4-D and mixtures of 2,4-D and 2,4,5-T were found to be considerably more effective in controlling tarweed than either MCP or 2,4,5-T.

One of the difficulties encountered in this trial was keeping weed stage and stage of growth of the wheat comparable in such widely-separated phases of this trial. In order to overcome this difficulty, an attempt was made in the fall of 1954 to plant tarweed in a single field which did not have a history of tarweed using different planting rates. The rates used were 1, 3, 9, and 27 pounds of tarweed seed per acre. Excellent germination occurred at all rates but differences in infestation level could not be detected. This exploratory work on economic studies has indicated that a great deal of attention needs to be given to getting comparable trials at different levels of weed infestation. In order to detect differences small enough to be interpreted on a practical basis for farmer use, data from these preliminary trials would indicate a high number of replications will be required. (Oregon Agricultural Experiment Station,Corvallis)

Economic evaluation of alternative methods of control of Canada thistle in irrigated crops of the Gallatin Valley. Baker, C. B. Experiments with control methods began in 1953 by J. M. Hodgson of the Agricultural Research Service, USDA, in cooperation with the Department of Agronomy and Soils, Montana Experiment Station, on 64 plots infested with Canada thistle at the Bozeman Station, Montana Agricultural Experiment Station. This report is restricted to 20 of these plots on which the spring wheat was and is being grown.

Three methods were tried. In one, nitrogen was applied at 50 pounds per acre on each of eight randomized plots. On June 6, 1953, at the outset of the trials, a thistle count gave an average of 242 shoots per plot. The 1953 yield was 56.5 bushels per acre. On June 6, 1954, the thistle count was 567. While the thistle count more than doubled, the yield dropped only to 47.8 bushels per acre.

Variation in yield between plots was so great that the difference in average yield did not appear to be significant, between these 2 years. A scatter diagram of yield plotted against thistle count likewise did not appear to give a significant relationship for either year or for the 2 years combined.

A second method included nitrogen fertilizer (same rate) and 2,4-D applied at 3/4 pound per acre immediately after the thistle count on eight randomized plots. Finally, a third method included 2,4-D, as in the second method but excluded fertilizer. Yield between years or between methods in each year did not appear to differ significantly for methods two and three. However, both dropped the thistle count substantially. The 1953 count gave an average of 101 shoots per plot (yield: 54.9 bushels per acre); 1954, 32 shoots per plot (yield: 59.9 bushels per acre).

Assuming wheat to sell for $2 per bushel, two applications of 2,4-D over a 2-year period increased gross returns by about $10 per acre per year. Materials cost of 2,4-D, at about $1 per pound, amount to about $1.50 per acre for 2 years' application. This gives a return net of materials cost of about $18.50 per acre. This amount is then available for payment of labor and machinery cost involved in the spray application and profit from control. (Montana Agricultural Experiment Station)

Summary of results -- Canada thistle control methods in irrigated spring wheat, Gallatin Valley, Montana, 1953-1954.

Treatment		Thistle count 1/	Yield 2/	2-year mean yield 2/
No 2,4-D	1953	242	56.5	52.2
	1954	567	47.8	
Increase		325	- 8.7	
2,4-D at 3/4 pounds per acre	1953	101	54.9	57.4
	1954	32	59.9	
Increase		- 69	5.0	5.2

1/ Thistle shoots per plot, June 6. 2/ Bushels per acre.

The effect of weed control practices upon yield, grade, and returns per acre from machine-picked cotton infested with water grass. Foy, C. L., and Miller, J. H. Table 1 shows the actual yields obtained by mechanical harvester, official grades from U. S. Cotton Classing Office, and approximate returns and losses per acre as a result of given treatments for water grass control in cotton. The loss figures represent a composite of losses from three major sources and one minor source: (1) reduced yields, (2) reduced picker efficiencies, (3) reduced grades, and (4) voiding the possibility of premium prices for plus (+) grades, since the plus designation is not given if grass is present. Estimated net loss data show a definite cost advantage for the use of oiling and

Table 1. The effect of various weed control practices upon yield, grade, and returns per acre from machine-picked cotton grown under conditions of heavy water grass infestation.

Weed control practice	Yield[1] pounds per acre	Grade[2] 8 or 16 samples	Value $/acre Fresno spot market October 15	Value $/acre fixed Govt. loan 1954-1955	Loss $/acre due to weeds October 15 market	Estimated[3] $/acre net loss due to weeds
1. Normal cultivation (check)	919.9	1-M, 2-M*, 4-SLM*, 1-LM**	322.31	307.18	70.42	63.92
2. Oil and flame cultivation	1080.4	1-M+, 6-M, 1-M*	392.73	375.76	--	--
3. Flame cultivation	1076.5	4-M, 4-SLM**	381.89	366.07	10.84	6.34
4. Grower management A	982.6	4-M, 10-SLM*, 1-SLM, 1-LM**	343.21	328.27	49.52	45.72
5. Grower management B	779.0	2-M*, 6-SLM*, 4-SLM**, 4-LM**	267.83	253.85	124.90	116.10
6. Grower management C	696.8	2-SLM*, 6-SLM**, 8-LM**	235.00	219.88	157.73	147.78

1/ Lint yields computed on the basis of 37 percent lint. Value of the seed was considered adequate to cover ginning costs.

2/ Final grade is shown. Asterisk means sample was reduced 1 grade*, or 2 grades**, due to grass.

3/ Extra operation charges per acre estimated as follows: Cultivation - $1.15; Hoeing - $5.00; Oil - $1.50; Flame fuel - $0.50. (Equipment costs not included.)

flaming, or flaming alone, in comparison with other methods tested. There appeared to be only a slight advantage to using oil preceding flame cultivation. In cases of heavy infestations, however, it is believed that the weeds which escape cultivation during the period from emergence until flame cultivation necessitate the use of some supplemental method of weed control, whether it be oiling, one hand-weeding, or others.

At other locations, oiling and flaming were effective in the control of nutgrass and most annual weeds, but were not adequate to control Johnson grass. (Field Crops Research Branch, ARS, USDA, and the University of California, Davis)

RESEARCH PROGRESS REPORT

1955

Research Section

WESTERN WEED CONTROL CONF.

BOISE, IDAHO,

March 22, 23, 1955