STATION BULLETIN 403 FEBRUARY 1942

Selective Sprays for Weed Control in Crops

L. E. HARRIS
G. R. HYSLOP

Oregon State System of Higher Education
Agricultural Experiment Station
Oregon State College
Corvallis

FOREWORD

A broad experimental program on eradication of weeds was started by the Oregon Agricultural Experiment Station immediately after appropriation of funds for this purpose by the 1937 session of the Oregon Legislature. Subsequent appropriations were made by the sessions of 1939 and 1941.

This bulletin records results of a part of the research program initiated and continued as a result of these appropriations. The use of selective chemical sprays has been found sufficiently positive in result to be recommended under certain conditions as herein set forth. Other methods directed toward a solution of weed problems are under investigation by members of the Experiment Station staff.

Weeds cause one of the most serious of the preventable losses to agriculture. The use of the methods discussed in this publication are of special importance at this time because of the increasing emphasis upon increased crop production. It is apparent that larger and more profitable production may be obtained of such much-needed crops as the cereals, grass seed crops, peas, and fiber flax.

Wm. A. Schoenfeld
Dean and Director

Illustration on cover—

Field of fiber flax sprayed (left) with Sinox, 5 pounds, and ammonium sulphate, 5 pounds per acre. Unsprayed check strip (right) showing wild turnip in bloom.

Selective Sprays for Weed Control in Crops

By

L. E. HARRIS, Associate Agronomist, and G. R. HYSLOP, Agronomist,*
Oregon Agricultural Experiment Station

INTRODUCTION

ALMOST complete control of many of the annual and some perennial weeds found growing with certain crops has been demonstrated to be possible by a new selective spray method that is the outgrowth of 4 years of research work. This method is effective in weed control and can be applied at costs that often make its use profitable. The yield and quality of crop may be materially increased, and foreign material and dockage are both reduced in the harvested product.

Combinations of the chemical, sodium dinitro-ortho-cresylate, (a commercial form is known as Sinox) with the common fertilizer, ammonium sulphate, used as a selective spray have produced phenomenal results in weed control. These combinations of chemicals are effective mainly in killing common broad-leaved weeds found growing with certain crops such as small grains, grasses, flax for fiber or seed, peas and some other specialty crops. On the other hand, the broad-leaved potato and vetch plants are effectively killed by the spray. Possibilities for weed killing in many other crops have not been explored thus far. The effective destruction of many weeds with little or no injury to the crop is the reason that these spray combinations are termed selective. Both the chemicals entering into the solution contain nitrogen and this frequently has a pronounced effect in fertilizing the crop plants. Removal of weed competition also results in more moisture and plant food to support crop growth.

Reduction of crop returns by annual weeds constitutes one of the major losses to agriculture. The numerous annual weed species, some of which are found on nearly every acre under cultivation, are potential enemies of all crops. They reduce both yield and quality and increase production costs. While perennial weeds are a serious menace in the much more limited acreages they occupy, the annuals cause greater losses in Oregon crops because of their general presence and competition with the crops in nearly all fields. Good farming operations, including rotation, tillage, good seedbed preparation, and clean seed, will always be basic factors in the control of weeds. Even with good operation, however, conditions may arise whereby the infestation of annual weeds becomes so excessive that crop production is substantially reduced.

Most weeds are prolific seeders and easily become widely disseminated. A great many have "hard" or dormant seeds that live in the soil for long periods and may germinate at varying intervals through several years, even after careful seedbed preparation. Some crop plants such as Hairy Vetch may become weeds in other crops because of the long life of "hard" seeds in the

* Acknowledgment is made to the growers who cooperated in this work and to the county agents in Oregon who assisted in locating and establishing many of the test plots and collecting the data. Valuable assistance also has been received from Dr. D. D. Hill, Agronomist, Oregon Experiment Station, through advice and suggestions concerning a number of problems in connection with the field work and in preparation of the typescript.

soil. The longer soils are in production without rotation the greater will be the tendency toward weed infestation.

When the farmer is confronted with serious infestation of weeds in any crop, a method of eradicating those weeds without injury to the crop is of great economic advantage.

CHEMICALS USED AS SELECTIVE SPRAYS

The use of selective chemical treatments for weeds is not new. Copper sulphate, iron sulphate, sodium nitrate, ammonium sulphate, and sulphuric acid as sprays, and cyanamid as a dust, are some of the chemicals that have been used with varying degrees of success. Spraying with these materials, however, has not generally been so successful that farmers have continued to use them.

Sinox, demonstrated in France to have weed-killing qualities, was introduced in 1938 into the United States where it was first used as a selective spray in Oregon and California. It was found superior to other chemicals used for this purpose. Ammonium sulphate, because of its combined weed-killing and fertilizing properties, was fairly effective. The combination of the two has been far more effective than Sinox alone or any other chemical or combination of chemicals tried in these experiments.

Sinox, a coal-tar derivative, is a paste-like compound, yellow-orange in color. It is readily soluble in water, is noncorrosive and noninflammable unless allowed to become dry. In concentrated form it is poisonous but in the dilutions used for field sprays there appears to be no hazard to livestock. The first use of the Sinox-ammonium sulphate combination was at the Oregon Agricultural Experiment Station in 1939.

Figure 1. Field of winter barley at Granger Experimental farm showing removal of vetch and weeds when sprayed (left) with 8 pounds of Sinox and 30 pounds of ammonium sulphate per acre. Unsprayed check at right.

FACTORS INFLUENCING SELECTIVITY

The power of certain chemicals to kill or to injure some plants while under the same conditions affecting other plants very little, if at all, is due to certain structural differences that influence the susceptibility of plants to the spray.

Character and extent of the leaf surface generally determines the effectiveness of the spray materials. While all phases of this problem have not been solved in detail, it is apparent that the degree of adherence of the spray to the leaf is of great importance. It is possible that thickness of cuticle, or a protective covering like a waxy surface, protects the leaves against the effect of the spray.

On some plants the spray does not adhere to or thoroughly wet the surface of the leaves and is therefore ineffective on them. The narrow and parallel veined structure of the surface of grass leaves is such that much of the spray gathers in drops and rolls off the plant. Pubescence or hairiness of the surface will interfere with wetting of leaves and stems. Waxy leaves retain less of the spray materials. Plants having any of these leaf surfaces are unlikely to be injured by the spray. Plants such as grasses, that have protected growing points, are less susceptible than many rapidly growing plants with more exposed growing points. Young plants are more susceptible to spray injury than the more mature ones. Plants with broad leaf surfaces and of such a nature as to retain considerable amounts of spray are most susceptible. Crops that are less susceptible to the effects of a selective chemical than are the weeds growing with them may be successfully sprayed.

Weed species that may be successfully controlled. Experimental trials have not covered all weeds but it is known that many species can be controlled by the Sinox-ammonium sulphate spray combination. Among annual weeds most susceptible are many of the mustards; black mustard, *Brassica nigra;* field mustard, *Brassica arvense;* wild turnip, *Brassica campestris;* tansy mustard, *Sisymbrium* spp.; fanweed or pennycress, *Thlaspi arvense* and *Thlaspi perfoliatum;* smartweed, *Polygonum* spp.; wild buckwheat, *Polygonum convolvulus;* Russian thistle, *Salsola pestifer;* corn cockle, *Agrostemma githago;* vetches, *Vicia* spp., including cultivated and many wild forms; Chinese or prickly lettuce, *Lactuca scariola;* hunger weed, *Ranunculus arvensis,* and other broad-leaved succulent forms.

Among perennials found in grass crops, common or ripple seed plantain, *Plantago major;* mouse-ear chickweed, *Cerastium vulgatum,* and some other shallow-rooted broad-leaved species may be controlled.

Weeds that are less susceptible include a number that must be sprayed when they are somewhat younger than the group listed above. In a number of trials, many plants in this group, although not completely killed, were often stunted, which reduced competition and weed seed production. These weeds include such annuals as tarweed or fireweed, *Amsinckia* spp.; wild radish, *Raphanus sativus;* nightshade, *Solanum* spp.; French pink or bachelor button, *Centaurea cyanaus;* star thistles, *Centaurea* spp.; lambsquarter, *Chenopodium album;* pigweed, *Amaranthus* spp.; and dogfennel, *Anthemis cotula.*

Buckhorn plantain, *Plantago lanceolata;* Cat's-ear, *Hypochaeris radicata,* and others are killed as seedlings. Established plants are more resistant and a more highly concentrated solution is necessary.

Weeds that are not killed include deep-rooted perennials and those annual weeds such as knotweed, *Polygonum aviculare;* and wild oats, *Avena* spp. Such weeds have leaves that are not easily wet with a spray solution or have some other means of protection.

SCOPE OF INVESTIGATION AND MATERIALS AND METHODS USED

Experiments were established under a wide range of conditions in a number of counties in both western and eastern Oregon. Numerous trial plots were established in which applications were made with power equipment or occasionally with a hand knapsack sprayer. Two types of power sprayers were used. One with a pump capacity of 10 gallons per minute and a tank volume of 100 gallons was mounted on a two-wheeled trailer; this sprayer was used to cover most locations as it was easily transported. The other sprayer, which was mounted on a four-wheeled trailer, had a pump capacity of 15 gallons per minute and a tank volume of 300 gallons.

Plots established in growing crops were laid out in strips, usually with a minimum width of 30 feet, and from 200 to 1,000 feet or more in length. Most plots were either duplicated or triplicated. The effectiveness of the spray, as measured by percentage of plants killed, was determined by quadrat counts over multiple locations within the plot. Yield data were based on representative samples over the plot with at least five replications harvested. Each sample harvested was taken from one drill row 16 feet long for the wheat samples and 20 feet long for barley samples. Fiber flax yields were taken from quadrats 36 inches by 39.5 inches and 10 samples were harvested for each treatment.

COMPARISON OF CHEMICALS USED AS SELECTIVE SPRAYS

Results of five different chemicals applied to a range of cereal varietal plots on the Granger Experiment Station in 1938 are shown in Table 1. Most of the weed population in these plots consisted of narrow-leaved and other vetches. The infestation of volunteer vetch in these plots was so heavy that the trials would have been worthless for grain yields if the vetch had been allowed to grow and mature. Had this been a commercial grain field, the infestation of vetches would have caused serious losses because of increased harvest and cleaning costs as well as yield reduction and lower quality. While cultivated species of vetch are usually classed as crops, in grain fields they are troublesome weeds.

Sinox was very effective for the control of vetch in this trial. From 93 to 97 per cent was killed in the four plots that were treated. Its effectiveness was further emphasized by the good control when applied on different dates, approximately 1 month apart. The plants were from 2 to 3 inches in height on those plots sprayed on February 28, and they had reached a height of 7 to 10 inches on those sprayed April 12.

The percentage control of French pink for the first date of spraying, and wild carrot for both dates sprayed, was good. It was found that on the early dates 100 per cent control was obtained, whereas the control on plots sprayed 1 month later was 85 and 87 per cent. The French pink plants were considerably larger at time of the second application and the spray was less effective.

The results from other chemicals used are variable and on the average were not satisfactory, particularly when compared with Sinox. On some weed species, sulphuric acid and sodium thiocyanate showed a high degree of kill,

Table 1. Effect of Various Selective Sprays in Winter Grain for Annual Weed Control

Granger—1938

Plot and treatment	Chemical in 100 gallons of water per acre	Average number of weed plants to each 3 square feet and percentage of control: Vetches		Field chickweed		French pink		Wild carrot		
		Before treatment	Control	Before treatment	Control	Before treatment	Control	Before treatment	Control	Control all species
	Pounds	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Per cent*
1* Sulphuric acid										
First application	17	24	70	41	62	4	75	3	75	72
Second application	25.5									
2 Sulphuric acid	42.5	27	79	44	67	5	78	3	79	76†
3* Sodium thiocyanate										
First application	17									
Second application	42.5	28	93	39	87	4	100	3	100	95†
4 Sodium thiocyanate	25.5	25	80	38	90	3	90	4	88	87
5 Sinox	12.0	24	96	40	76	4	100	3	100	93
6 Sinox	15.0	25	97	41	79	5	100	2	100	94
7 Sinox	12.0	28	93	37	76	5	85	2	100	89
8 Sinox	15.0	26	97	38	72	4	87	3	100	89
9 Ammonium sulphate	170.0	23	69	43	58	5	50	6	75	63
10 Powdered cyanamid	125.0‡	24	58	41	83	4	25	3	50	54

* Two applications 3 days apart: first on February 25, 1938; second, February 28, 1938; Plots 1-6 applied February 25, 1938; Plots 7-10 applied April 2, 1938.

† 50 per cent injury to crop plants.

‡ Dry.

but those sprays also severely injured the crop plants. Two regular applications 3 days apart were made on one each of the sulphuric acid and sodium thriocyanate treated plots. The percentage injury to crops was considerably greater with the greater amount of spray in the two applications than with smaller amounts in the single applications.

Sodium thiocyanate showed the greatest injury as approximately 50 per cent of the crop plants were killed with this spray. Plots treated with 170 pounds of ammonium sulphate per acre as a spray and others dusted with powdered cyanamid at 125 pounds per acre resulted in only incomplete weed control, but the nitrogen fertilizer did exert a beneficial effect on crop growth in each case. The percentage control of different weeds varied from 50 to 75 per cent for ammonium sulphate while the cyanamid dust showed a control of from 25 to 83 per cent. Ammonium sulphate was approximately 70 per cent as effective as Sinox, and cyanamid dust was approximately 60 per cent as effective. Comparative values of Sinox and sulphuric acid (Table 2) are emphasized further by the differences in wheat yields from plots that were sprayed with these chemicals. Of the nine varieties of wheat in this trial, the average yield of all but one variety was substantially higher where Sinox was used. The average increase in yield from the Sinox plots for the nine varieties was 13.6 bushels per acre.

Although sulphuric acid applications were made under favorable weather conditions and at proper stage of growth, it produced a severe "burning" and permanent injury to the grain and also failed to make a satisfactory weed kill. Sinox produced very little if any injurious effect on the wheat plants, and in all respects has been significantly superior in weed control and crop yield to the sulphuric acid. The trials summarized in Table 2 show the average control of vetch was 96 per cent with Sinox and 74 per cent with sulphuric acid. The removal of the vetch and weed plants also reduced competition with the grain, and resulted in an increased crop growth. It was not possible to obtain yields of the checks or unsprayed plots as the infestation of vetch was so heavy that the field was harvested in the hay stage before the vetch could mature seed.

Additional yield data from plots of winter wheat sprayed with Sinox at different concentrations are presented in Table 3. The principal infestations in this field were vetches and field peas. There was also a small percentage of corn cockle and wild vetch. All plots showed a high degree of control for all weed plants present, but the sprays had less effect on field peas than on any other foreign plant in this trial. Although peas have a broad leaf surface, they do not wet readily with the spray solution, and consequently a higher concentration of chemical is necessary to kill the peas than is required for some other types of vegetation. The increased yield of wheat from these plots is based on a weed-free basis as determined after threshing. Significant yield increases over the untreated checks were found for all treated plots. The minimum increase was 7.3 bushels and the maximum was 14.5 bushels, with an average increase for all plots of 10.7 bushels.

In addition to increased yields, better quality with less foreign material and dockage resulted from the use of the spray. The average weed seed content in the grain from the sprayed plots was 1.61 per cent whereas there was 34.1 per cent weed seeds or foreign material in the grain from the unsprayed plots.

Table 2. Comparison of Yields of Several Varieties of Wheat Following Sulphuric Acid and Sinox Sprays for Control of Vetches

Granger—1938

Plot and variety		Yields per acre								Increase from Sinox
		Sulphuric acid			Sinox			Average		
		1	2	3	1	2	3	Sulphuric acid	Sinox	
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
48	32,4915	26.2	21.4	23.8	22.2	32.0	26.4	23.8	26.8	3.0
49	White Winter	20.6	26.4	21.8	33.6	27.6	38.2	23.0	33.2	10.2
50	32,5044	28.6	31.6	22.6	28.0	24.4	30.0	27.6	27.4	0.0
51	32,289-13	16.4	22.8	16.4	40.4	30.0	33.2	18.6	34.8	16.2
52	32,5023	17.2	18.6	20.0	22.8	48.8	48.4	18.6	40.0	21.4
53	32,4909	26.0	19.2	26.2	42.0	38.6	48.6	23.8	43.0	19.2
54	32,4957	21.6	20.4	22.2	53.8	43.4	49.8	21.4	49.0	27.6
55	White Winter	20.6	17.0	13.0	23.0	20.0	32.6	16.8	25.8	9.0
58	32,3070	14.4	15.0	21.0	33.4	29.4	33.8	16.8	32.2	15.4
Average		21.2	21.4	20.8	35.6	32.8	37.8	21.1	34.7	13.6

Average percentage vetch plants controlled with sulphuric acid=74.
Average percentage vetch plants controlled with Sinox=96.

Table 3. Yield of Fall Planted Wheat from Plots Sprayed with Different Amounts of Sinox for Control of Weeds
Linn County—1939

Sinox per acre	Volume per acre	Yield per acre by plots					Average yield per acre	Weed and other seeds*	Yield per acre on weed-free basis	Increase over check
		1	2	3	4	5				
Pounds	*Gallons*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Per cent*	*Bushels*	*Bushels*
8.00	100	28.4	27.2	30.0	25.4	30.6	28.3	3.20	27.4	9.1
12.0	100	20.0	31.4	23.4	28.8	26.4	26.0	1.57	25.6	7.3
15.0	100	28.4	41.0	22.4	24.4	48.2	32.9	0.35	32.8	14.5
8.0	120	26.2	30.2	35.6	20.4	44.0	31.3	1.17	30.9	12.6
12.0	120	23.0	28.0	32.0	23.2	35.8	28.4	1.77	28.0	9.7
Average	......	25.2	31.5	28.9	24.4	37.0	29.4	1.61	29.0	10.7
Check	......	29.0	25.0	33.0	28.0	22.4	27.5	†34.1	18.3	......

* Weeds seeds found in threshed samples.
† Weed and other seeds in unsprayed checks at time of harvest:
Field peas 10.2 per cent
Hairy vetch 19.6 per cent
Corn cockle 2.3 per cent
Wild vetch 2.0 per cent

Figure 2. Field of grass (chewings fescue) in Union County sprayed (right) with Sinox-ammonium sulphate for control of yellow trefoil, *Medicago lupulina* and fanweed, *Thlaspi arvense* when grass was in seedling stage; unsprayed check (left). Note more vigorous growth of grass in sprayed portion. Photograph taken one year after application.

Table 4. EFFECT OF SINOX ALONE AND IN COMBINATION WITH OTHER CHEMICAL SPRAYS FOR CONTROL OF WEEDS IN COMMON RYEGRASS FOR SEED

Linn County—1939

Chemical per acre			Total yield per acre*	Clean seed	Yield per acre clean ryegrass	Weed seeds
Sinox	Ammonium sulphate	Calcium cyanamid				
Pounds	*Pounds*	*Pounds*	*Pounds*	*Per cent*	*Pounds*	*Per cent*
7	100	None	930	98.3	914	1.4
8	100	None	890	97.4	867	2.3
9	100	None	940	98.5	926	0.8
10	100	None	994	98.5	977	1.2
Average			933	98.2	921	1.4
7	None	100	1,005	95.3	958	3.9
8	None	100	852	96.6	823	2.7
9	None	100	896	94.9	850	4.0
10	None	100	908	95.0	863	3.7
Average			918	95.4	873	3.8
7	None	None	759	78.2	594	21.0
8	None	None	724	85.3	617	14.7
9	None	None	691	88.2	509	11.6
10	None	None	710	93.7	665	6.2
Average			721	86.3	614	13.4
None	100	None	862	36.8	316	58.0
None	None	100	905	39.0	352	57.5
Check			926	17.4	161	75.5

* Thresher run.

SINOX-AMMONIUM SULPHATE COMBINATION AS A SELECTIVE SPRAY

Since certain nitrogen carrying compounds showed merit as weed control agents and also as crop fertilizers, it seemed advisable to determine the effect of other chemicals when mixed with Sinox and used as selective sprays.

The outstanding combination for weed control proved to be ammonium sulphate and Sinox. This combination was much more effective not only in weed control but also as a crop-stimulating agent than either chemical used alone.

Spraying grass seed crops. One of the first trials with Sinox and ammonium sulphate was on a crop of common ryegrass in which there was an extremely heavy infestation of weeds consisting of two cultivated and two wild varieties of vetches. There was also a small population of miscellaneous weeds, mostly corn cockle. Sprays used were combinations of ammonium sulphate and Sinox, calcium cyanamid and Sinox, and each of the chemicals

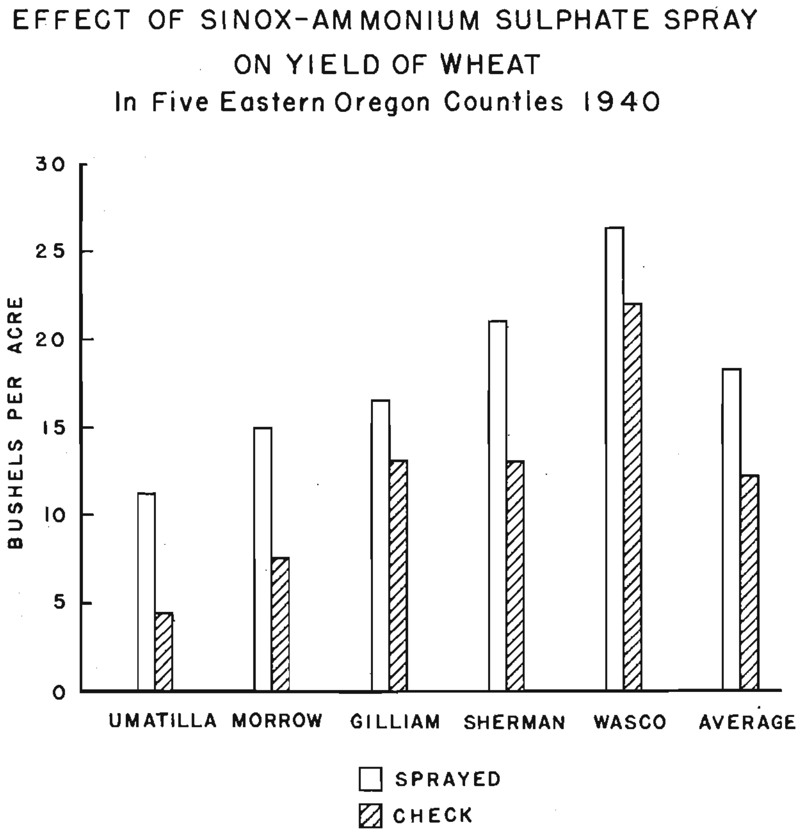

Figure 3.

used alone. The results of this trial are presented in Table 4. The ammonium sulphate-Sinox spray was superior to others used as shown by the percentage of weeds controlled and the yield of clean ryegrass seed. The average yield of clean ryegrass seed from all plots that were sprayed with Sinox-ammonium sulphate was 921 pounds per acre. From all plots sprayed with calcium cyanamid-Sinox the average was 873 pounds per acre, and for all plots where Sinox was used alone the average was 614 pounds per acre. The yield of all plots sprayed with ammonium sulphate was 316 pounds per acre; the yield of all plots sprayed with calcium cyanamid was 352 pounds per acre. The untreated check showed an average yield of clean ryegrass seed on a weed-free basis of only 161 pounds per acre.

The lower solubility of calcium cyanamid made that chemical less effective in a spray combination with Sinox. It proved to be difficult to spray evenly over the leaf surfaces and results were not satisfactory. The addition of wetting agents has increased the solubility of this combination but its effectiveness with Sinox has been less than the combination of ammonium sulphate with Sinox.

The beneficial effects of the combination of Sinox and ammonium sulphate are shown by comparing the results in per cent of weed seed and yield of grass seed, from plots treated with Sinox or ammonium sulphate alone with those from plots treated with the combination spray. The weed seed content of the crop from the plots sprayed with Sinox alone was 13.4 per cent; from the plots sprayed with ammonium sulphate alone, 57.5 per cent. When the two were

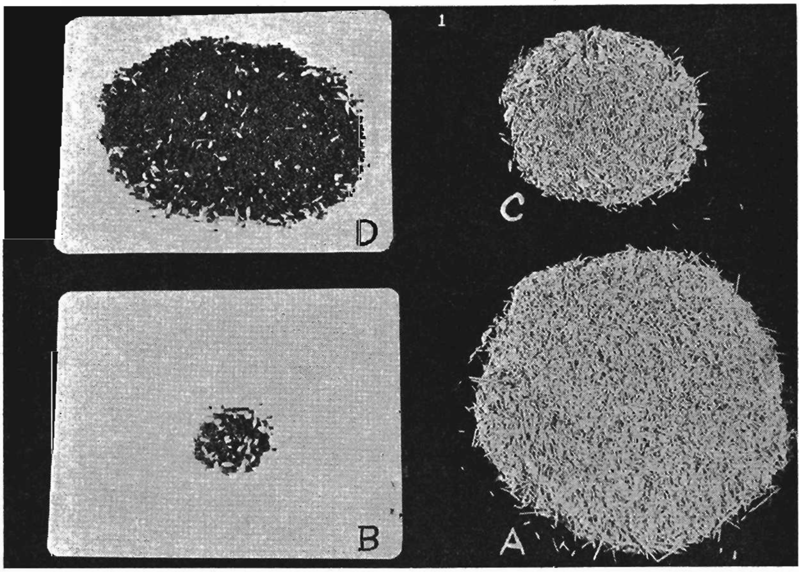

Figure 4. Comparative amounts of common ryegrass seed and weed seed from plots sprayed (A and B) with Sinox-ammonium sulphate and unsprayed check plots (C and D). Note small percentage of weed seeds (B) from sprayed plots and high percentage of weed seeds (D) from unsprayed plots at time of threshing.

Table 5. Effect of Sinox-Ammonium Sulphate Sprays on Control of Weeds and Yield of Barley

Millhollen Tract—1940

Rate of chemical at 100 gallons per acre			Average number of weed plants per square foot			Yields per acre				
Sinox	Ammonium sulphate	Weeds	Before treatment	After treatment	Control	1	2	3	Average	Increase over check
Pounds	*Pounds*				*Per cent*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
12	......	Wild turnip,* vetch	11	6	45	61.6	53.8	66.0	60.4	8.1
10	......	Wild turnip	10	5	50	58.4	60.0	61.4	59.9	7.6
8	......	Wild turnip	14	8	43	52.6	61.4	64.3	59.1	6.8
Average			12	6	50	57.5	58.4	63.9	59.8	7.5
8	100	Wild turnip	11	0	100	120.5	107.4	71.2	99.3†	47.0
8	80	Wild turnip	10	1	90	107.4	88.0	62.6	86.0†	33.7
8	60	Wild turnip, vetch	16	2	88	68.6	59.3	65.1	64.3	11.0
8	40	Vetch	11	2	82	50.7	57.5	48.6	52.3	0
8	20	Wild turnip	19	2	89	49.8	53.3	64.5	55.8	3.5
6	100	Wild turnip	18	3	83	82.6	85.0	101.2	89.6	37.3
6	80	Wild turnip	14	1	93	63.0	100.2	69.2	77.5	25.2
6	60	Wild turnip	11	1	91	61.6	59.9	66.6	62.7	10.4
6	40	Wild turnip	9	2	78	64.4	60.8	65.1	63.4	11.1
6	20	Wild turnip	13	3	77	53.3	59.1	67.3	59.1	7.6
Average....	60	....	13	2	87	72.1	73.0	68.1	71.0	18.6
Check	....	....	11	....	0	37.4	63.4	56.6	52.3	......

* Wild turnip plants beginning bloom at time of spraying.
† Badly lodged.

combined, the weed seed content was only 1.4 per cent, and the amount of clean ryegrass seed was increased 307 pounds per acre.

It should be kept in mind that these trials represented extreme conditions. The crop was very heavily infested with vetch and other weeds—much more so, in fact, than would be the case under average conditions throughout the growing area. The increased returns per acre, therefore, may be considered in excess of the average that might be found for fields in general.

Spraying grain fields. The value of spraying weed infested fields of wheat and other grain crops with ammonium sulphate and Sinox has been demonstrated. Applications at the right stage of weed growth, in both western and eastern Oregon, have been highly successful in controlling weeds and increasing yields.

Effectiveness of the ammonium sulphate combination is illustrated by the results shown in Table 5. These results were obtained from spraying a field of barley that was 10 to 12 inches in height and heavily infested with wild turnip just beginning to bloom, and with hairy vetch. The percentage of plants killed by all rates of the Sinox-ammonium sulphate combination was greater than where 12 pounds of Sinox (the heaviest rate) was used alone. Yield increases from the combination over Sinox alone were very pronounced.

The yields of wheat from plots that were sprayed with various concentrations of the two chemicals in five eastern Oregon counties are summarized in Tables 6 and 7. The principal weed found in these fields was the common

Table 6. TOTAL WEIGHT OF CROP AND YIELD PER ACRE OF WHEAT SPRAYED WITH SINOX-AMMONIUM SULPHATE COMBINATION FOR CONTROL OF WEEDS

Sherman County—1940

Amount of chemical at 100 gallons per acre	Yield per acre			Yield of grain per acre	Increase of grain per acre
	Grain	Straw	Total weight of crop		
	Pounds	*Pounds*	*Pounds*	*Bushels*	*Bushels*
Field No. 1					
20 pounds amm. sulphate	1,181	2,600	3,781	19.7	8.5
5 pounds Sinox	....	....	....	....	......
Check	671	1,411	2,082	11.2	......
*Field No. 2**					
5 pounds Sinox	....	....	....	....	......
20 pounds amm. sulphate	1,350	2,942	4,292	22.5	3.3
Check	1,151	2,476	3,627	19.2	......
Field No. 3					
6 pounds Sinox	....	....	....	....	8.3
20 pounds amm. sulphate	1,192	2,590	3,782	19.7	......
6 pounds Sinox	....	....	....	....	8.7
40 pounds amm. sulphate	1,206	2,604	3,810	20.1	......
6 pounds Sinox	....	....	....	....	11.7
50 pounds amm. sulphate	1,385	2,966	4,351	23.1	......
Check	686	1,440	2,126	11.4	......
Total average, all sprayed plots	1,263	2,721	4,003	21.0	7.7
Total average, all check plots	836	1,775	2,611	13.3	......

* Very few weeds in this field.

Table 7. SUMARY OF WHEAT YIELDS FROM PLOTS SPRAYED WITH SINOX-AMMONIUM SULPHATE FOR CONTROL OF WEEDS IN FIVE EASTERN OREGON COUNTIES—1940

County	Yield by plots					Average	Increase over check
	1	2	3	4	5		
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Morrow							
Sprayed	17.9	17.1	14.2	11.7	14.9	15.2	7.3
Check	9.9	5.6	8.5	10.1	5.6	7.9	....
Gilliam							
Sprayed	16.5	15.7	17.6	16.6	......	16.6	2.8
Check	13.1	14.3	14.9	12.8	......	13.8	....
Umatilla							
Sprayed	12.0	15.7	10.1	12.3	6.3	11.3	6.5
Check	2.0	4.1	6.0	6.7	5.1	4.8	....
Sherman							
Sprayed	18.4	24.1	22.0	16.3	24.2	21.0	7.7
Check	8.3	12.2	15.7	16.4	14.0	13.3	....
Wasco							
Sprayed	28.4	29.1	25.2	23.6	25.7	26.4	4.3
Check	25.2	20.7	20.7	19.8	24.3	22.1	....
Average Sprayed plots	18.6	20.3	17.8	16.1	17.8	18.1	5.8
All check ..	11.7	11.4	13.1	13.1	12.2	12.3	....

Table 8. EFFECT OF SINOX-AMMONIUM SULPHATE COMBINATION SPRAYS ON RUSSIAN THISTLE GROWING IN PEAS
Umatilla County—1940

Chemical at 100 gallons per acre			Average number of thistle plants per square foot			
Plot number	Sinox	Ammonium sulphate	Before treatment	After treatment	Control	Injury to peas
	Pounds	*Pounds*			*Per cent*	
1	5.0	None	7	7	0	None
2	10.0	None	10	10	0	None
3	12.0	None	6	5	16	Slight
4	15.0	None	11	4	63	Slight
5	5.0	None	34	33	0	None
6	10.0	None	10	10	0	None
7	12.0	None	9	6	33	None
8	15.0	None	15	7	53	Slight
9	5.0	5.0	8	1	87	None
10	10.0	10.0	9	0	100	None
11	12.0	12.0	13	0	100	Severe 20%
12	15.0	20.0	9	0	100	Severe 35%
13	5.0	5.0	13	2	84	None
14	10.0	10.0	9	1	89	None
15	12.0	12.0	10	0	100	Severe
16	15.0	20.0	12	0	100	Severe

fireweed or fiddleneck, also called tarweed, *Amsinckia intermedia,* the seed of which is poisonous to hogs, horses, and cattle. In some locations there were both common mustard, *Brassica arvensis,* and fireweed.

The amount of Sinox that was used in these combinations was approximately half that required when Sinox is used alone. Although there was not 100 per cent control for all weeds, they were usually very much stunted when not actually killed. This decreased their competition with the wheat crop. The dosage for fireweed, however, should be at least 8 to 10 pounds of Sinox and 8 to 10 pounds of ammonium sulphate per acre as subsequent trials show more effective control at this rate than where 5 to 6 pounds of Sinox were used.

Spraying peas. The control of Russian thistle in canning peas also proved feasible with the combination spray, as indicated in Table 8. This control is made possible by the protective waxy surface on the pea leaves and the tender succulent condition of the young Russian thistle plants. Peas, however, are injured much more readily than grain.

EFFECT OF SINOX-FERTILIZER SPRAYS ON CONTROL OF WEEDS AND YIELD OF RYE GRASS SEED

Linn County 1939

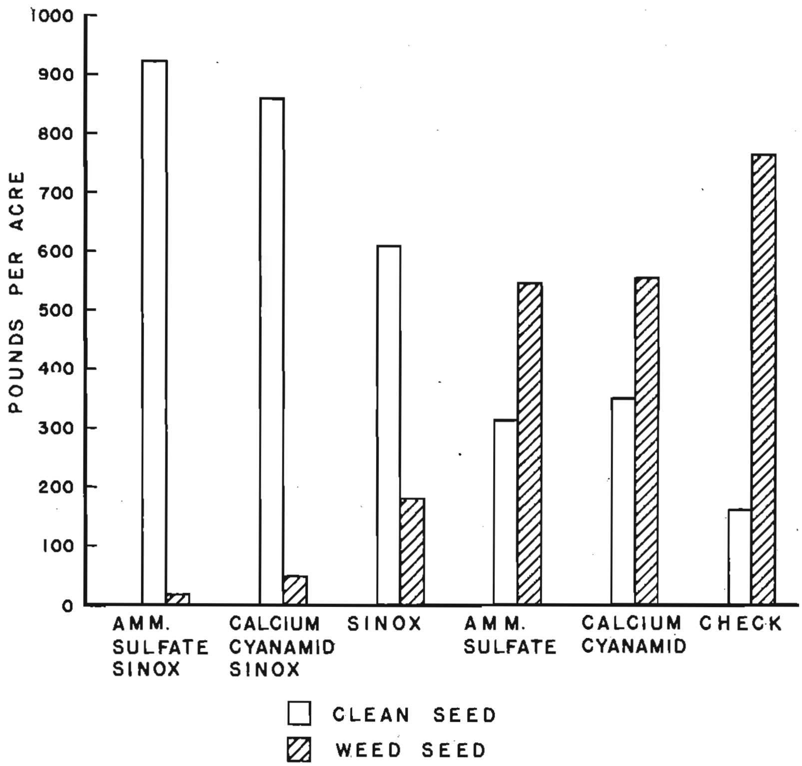

Figure 5.

From experimental data it now appears that solutions no stronger than 8 to 10 pounds each of Sinox and ammonium sulphate should be used. The superiority of the combination over Sinox for treatment of weeds is again demonstrated in this trial. Sinox alone was only partly effective, whereas 10 pounds per acre each of Sinox and ammonium sulphate gave 100 per cent control.

The combination spray also gave good control of vetch in field peas in western Oregon as shown in Table 9. The peas were approximately 3 to 4 inches high and the vetch about 2 inches. The sprays were applied in various concentrations with Sinox used alone and in combination with ammonium sulphate. At the concentration of 8 pounds per acre each of Sinox and ammonium sulphate, the vetch was readily killed with very little injury to the peas.

Table 9. EFFECT OF SINOX-AMMONIA SULPHATE SPRAY ON HAIRY VETCH GROWING IN FIELD PEAS

Granger—1940

Chemical at 100 gallons		Number of vetch plants each 2 square feet			
Sinox	Ammonium sulphate	Before treatment	After treatment	Vetch killed	Injury to peas
Pounds	*Pounds*			*Per cent*	
5.0	None	18	12	33	None
8.0	None	23	14	39	None
10.0	None	21	8	62	None
12.0	None	14	4	71	Slight
15.0	None	26	2	93	Severe
20.0	None	22	1	96	Severe
5.0	5.0	15	4	73	None
8.0	8.0	21	0	100	None
10.0	10.0	13	0	100	None
12.0	12.0	19	0	100	Severe
15.0	15.0	24	0	100	100%
20.0	20.0	17	0	100	100%

The Sinox-ammonium sulphate spray was also effective in the control of nightshade, *Solanum nigrum,* in canning peas. Trials reported in Tables 10 and 11 show that where Sinox was used alone the percentage kill of nightshade plants is negligible, even at rates as high as 18 pounds per acre. With the

Table 10. EFFECT OF SINOX-AMMONIUM SULPHATE SPRAY ON NIGHTSHADE, *Solanum nigrum,* GROWING IN CANNING PEAS

Umatilla County—1940

Chemical at 100 gallons per acre		Number nightshade plants per square foot			
Sinox	Ammonium sulphate	Before treatment	After treatment	Control	Injury to peas
Pounds	*Pounds*			*Per cent*	
5.0	None	8	8	None	None
8.0	None	10	9	10	None
10.0	None	11	9	18	None
15.0	None	17	15	11	Slight
18.0	None	20	15	25	Severe
5.0	5.0	9	2	77	None
8.0	8.0	23	1	96	None
10.0	10.0	19	0	100	None
15.0	15.0	13	0	100	Severe
15.0	25.0	17	0	100	Severe

combination spray, even small amounts of Sinox with very small amounts of ammonium sulphate produced significantly greater kills. A solution of 8.0 pounds per acre of each chemical was effective on nightshade plants. Ninety-six to 100 per cent of the plants growing in the plots were killed at this rate. Ten pounds per acre of each chemical gave 100 per cent kills. The peas were from 2 to 4 inches high and the nightshade was in the two-leaf to four-leaf stage.

Table 11. EFFECT OF RATES OF APPLICATION OF AMMONIUM SULPHATE WITH SINOX ON NIGHTSHADE PLANTS, *Solanum nigrum*, GROWING IN PEAS

Umatilla County—1940

Chemical at 100 gallons per acre		Average number of nightshade plants per square foot		
Sinox	Ammonium sulphate	Before treatment	After treatment	Kill
Pounds	*Pounds*			*Per cent*
5	None	10	10	0
5	1	17	15	11
5	2	14	9	35
6	3	10	4	60
5	4	19	7	63
5	5	14	5	64
5	10	13	3	76
8	None	9	8	11
8	1	22	13	41
8	2	15	4	73
8	3	17	5	70
8	5	21	4	80
8	8	19	0	100
S	10	13	1	92
10	None	11	9	18
10	1	26	19	27
10	3	18	3	83
10	5	11	0	100
10	7	31	2	93
10	10	17	0	100

Although the results so far indicate the possibility of using this solution for the control of nightshade plants growing in peas, additional information is necessary before the use can be recommended generally. The nightshade plants must be treated when they are very small for complete control. After plants are 2 to 3 inches in height, and have more than four to five leaves developed, even though the leaves are killed the plants have the ability to send out new growth.

Spraying flax. The use of Sinox-ammonium sulphate spray for the control of annual weeds in seed and fiber flax has been highly effective. Weeds growing in these crops are especially undesirable because flax plants are poor competitors with most weeds. They are particularly undesirable in flax grown for fiber not only because of yield reduction but also because of increased harvesting and processing costs. Weedy fiber flax is discounted at the retting plants and many weedy lots are rejected for fiber processing purposes. A high percentage of weed plants in the flax increases the cost of pulling, deseeding, storage, and scutching, and reduces the effectiveness of retting. The amount and quality of the line fiber may be reduced by excessive weeds in the straw and the tow, which contains most of the weed residue, is worthless.

Data on weed control in fiber flax fields that were sprayed with Sinox-ammonium sulphate are shown in Table 12. The fields varied in size from 10 to 50 acres, and entire fields were sprayed with the exception of check strips from 12 to 15 feet wide and extending the length of the field.

The principal weeds found in these fields were three wild mustards, *Brassica campestris*, *Brassica nigra*, and *Brassica arvensis;* wild buckwheat, *Polygonum convolvulus;* lambsquarter, *Chenopodium album;* and prickly lettuce, *Lactuca scariola*.

Figure 6. Control of wild turnip, *Brassica campestris*, in field of fiber flax, sprayed (right) with Sinox, 5 pounds, and ammonium sulphate, 8 pounds per acre, unsprayed check at left shows wild turnip in bloom.

As indicated by weights of flax and weed plants the spray was effective in eradicating the weeds, and it produced a substantial increase in flax tonnage. The average yield of fiber flax on a weed-free basis for all fields that were sprayed was 3.25 tons per acre as compared to the untreated check yields of 2.30 tons per acre, an increase of 0.95 ton per acre. The amount of weed plants was 0.23 ton per acre where flax was sprayed and 1.49 tons per acre in the unsprayed checks. The average weed plant content on a percentage basis was 6.6 and 39.4 respectively for sprayed and unsprayed portions of the fields.

In general, as indicated by these tests, the yield of fiber flax is decreased in direct proportion to the amount of weeds that are growing in the crop. If 1 ton of weeds on a dry-weight basis is produced in the crop, the yield of fiber flax will be decreased approximately 1 ton. In addition, harvesting costs on an acre basis will materially increase in weed-infested fields. As observed in practically every field this season, the weed-infested fields were badly lodged whereas there was little lodging in the clean or sprayed fields.

Five pounds of Sinox with 8 pounds of ammonium sulphate per 100 gallons per acre was the most satisfactory concentration for flax. At this rate the weeds were effectively killed with minimum injury to flax plants. The tolerance of flax to the spray is considerably less than that of grain or grass; consequently, it is necessary that applications be made at the proper stage of plant growth if this relatively low concentration of chemicals is to be effective. Flax should not be sprayed before the plants have developed from 3 to 4 pairs of leaves. The ideal stage is when the plants have from 3 to 8 pairs of leaves. Spraying may be done when the flax plants are larger than this if the weeds are small. The stage of weed growth at which this concentration of chemical is most effective is as follows: mustard, when plants have 2 to 6 leaves; lambsquarter, when plants have 2 to 4 leaves; wild buckwheat, when plants have 2 to 8 leaves.

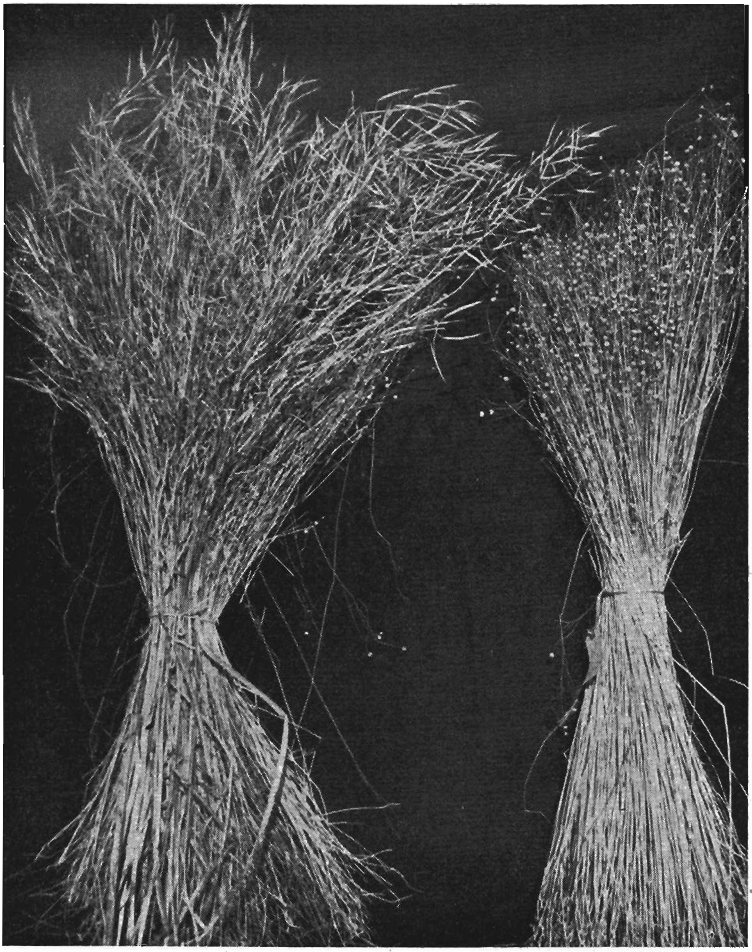

Figure 7. Representative samples of fiber flax harvested from unsprayed check (left) showing a high percentage of weeds and sprayed (right) showing very few weeds.

Table 12. SUMMARY OF THE EFFECT OF SINOX AND AMMONIUM SULPHATE SPRAY FOR CONTROL OF WEEDS IN FIBER FLAX AS SHOWN BY POUNDS PER ACRE OF FLAX AND WEEDS AND PER CENT OF WEED PLANTS ON FIVE WILLAMETTE VALLEY FARMS 1941

Farms	Total dry weight of plants per acre					
	Sprayed			Not sprayed		
	Flax	Weeds	Weeds	Flax	Weeds‖	Weeds
	Pounds	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*
Shaw	7,490	270*	3.4	5,430	1,448	21.0
Freeman	6,750	430†	5.9	4,860	2,700	35.7
Gilmour	5,150	950‡	15.4	4,140	4,270	50.7
Gilmour-Turnidge field No. 1	6,160	325§	5.0	4,280	3,050	48.6
Gilmour-Turnidge field No. 2	6,964	339§	4.6	4,299	3,508	44.9
Average pounds for all farms	6,503	463	6.6	4,602	2,995	39.4
Average tons for all farms	3.25	0.23	....	2.30	1.49	.....

Rate applied=Sinox 5 pounds, ammonium sulphate 8 pounds at 100 gallons per acre.
* Mostly horsetail rush.
† Ryegrass, lambsquarter.
‡ Mostly ryegrass.
§ Mostly ryegrass, some lambsquarter.
‖ Mustard, wild buckwheat, lambsquarter, some ryegrass and horsetail rush.

Other chemicals that have been used with Sinox. A number of tests have been made with other chemicals when combined with Sinox to determine their value for the control of annual weeds. Data are shown in Table 13 for trials where three different chemicals were used with Sinox and sprayed on hungerweed, *Ranunculus arvensis,* growing in a field of chewings fescue.

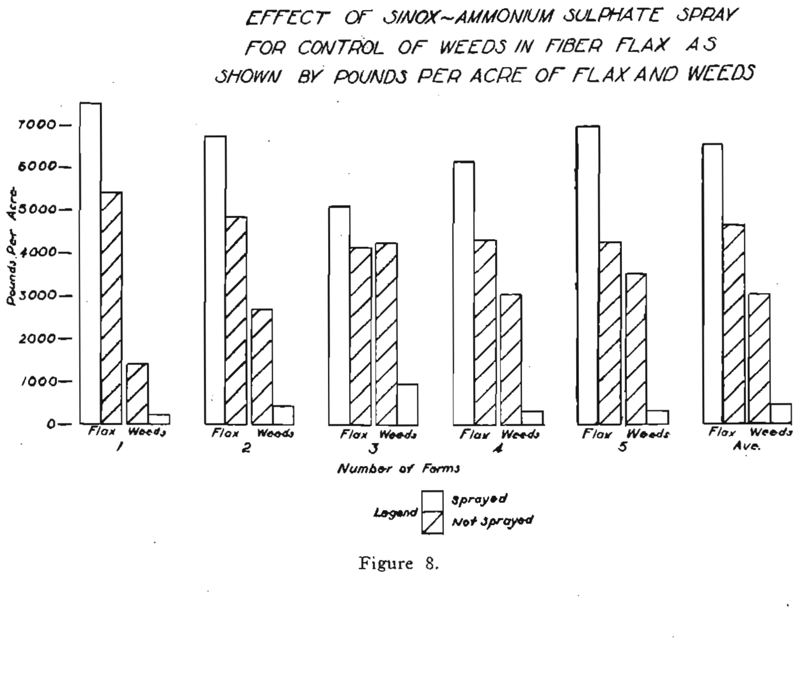

Figure 8.

Infestation was very dense and growth was exceptionally heavy. An average of 52 seedling plants prevailed per square foot. Seeding was made in the fall of 1939 and spray treatments were in the spring of 1940. The weeds were competing with the grass for moisture and soil nutrients, and were shading the young grass seedlings. Because of the wet condition of the field the sprays were not applied until the plants were well advanced. Approximately 60 per cent of the weeds were in bloom at the time of spraying. Concentrations of spray and amounts per acre used varied from low to relatively high.

Because of the size and condition of the weed plants at time of treatment, lower rates did not give satisfactory controls. The data listed in Table 13, therefore, are only from those plots where the effect of the treatment began to show results. The amount of Sinox in the combination required to kill the weed plants was high, as 20 pounds per acre were necessary. This heavy rate is not an economical one to use for most crops under general field conditions, but the size of the plant determines the amount of chemical required. This treatment shows the comparative toxicity of other chemicals, when combined with Sinox, as a selective spray. When Sinox was used alone, even in rather large quantities, there was no appreciable effect on the weed plants. Slight burning of the leaf tips was produced in some cases, but there was little plant kill. Ammonium sulphate and sodium bisulphate combined with Sinox were practically of equal value as weed killers. Increased killing effect was produced with either of these two chemicals added to Sinox even when relatively small amounts were used, but not until the sulphates were used at the rate of 45 pounds per acre did significant kills result. Sixty pounds and 80 pounds produced 100 per cent control of weed plants. Although the two chemicals with Sinox were similar in their effect on the weeds, the ammonium sulphate was superior to sodium bisulphate in its fertilizing effect on crop growth. The grass seedlings were more vigorous and with a better color in the ammonium sulphate plots than in the sodium bisulphate plots.

Table 13. COMPARISON OF CHEMICALS USED WITH SINOX AS A SELECTIVE SPRAY ON HUNGERWEED, *Ranunculus arvensis*, GROWING IN CHEWINGS FESCUE

Chemicals per acre				Weed plants killed, average per quadrat
Sinox	Ammonium sulphate	Sodium bisulphate	Sulphuric acid	
Pounds	*Pounds*	*Pounds*	*Per cent*	*Per cent*
20	....	....	....	0
20	15	....	....	15
20	25	....	....	56
20	45	....	....	88
20	60	....	....	100
20	80	....	....	100
....	80	....	....	0
20	....	....	....	0
20	....	15	....	12
20	....	25	....	58
20	....	45	....	98
20	....	60	....	100
20	....	80	....	100
....	....	80	....	0
20	....	....	4	0
20	....	....	5	0
20	....	....	6	0
20	....	....	8	30
20	....	....	10	47
....	....	....	10	0

Table 14. Comparative Effectiveness of Different Chemicals Combined with Sinox and Used as Selective Sprays

Chemical per acre in 100 gallons water				Number weed plants to each 2 square feet*				Control	
				Field chickweed		Fireweed			
Sinox	Ammonium sulphate	Sulphamic acid	Ammonium sulphamate	Before treatment	After treatment	Before treatment	After treatment	Field chickweed	Fireweed
Pounds	*Pounds*	*Pounds*	*Pounds*					*Per cent*	*Per cent*
4.5	......	......	......	123	101	97	88	37	9
10.2	......	......	......	212	96	151	77	55	49
......	10.2	......	......	439	438	126	126	0	0
......	......	10.2	......	130	71	110	96	45	13
......	......	......	10.2	175	173	102	100	0	0
4.5	4.5	......	......	163	27	151	33	83	78
6.8	6.8	......	......	352	......	163	0	100	100
10.2	10.2	......	......	400	0	121	0	100	100
4.5	......	4.5	......	326	2	97	20	99	79
6.8	......	6.8	......	133	1	145	7	99	95
10.2	......	10.2	......	156	1	139	1	99	99
4.5	......	......	4.5	227	8	127	11	97	91
6.8	......	......	6.8	110	5	130	8	96	94
10.2	......	......	10.2	350	0	149	7	100	95

* Plants were grown in flats in greenhouse.

Sulphuric acid with Sinox did not cause any appreciable kill. The sulphuric acid was used at various percentages, and not until 8 per cent and 10 per cent were used was there a very definite sign of plant kill. Even at these rates, the percentage kill of weed plants was inferior to that in plots where either ammonium sulphate or sodium bisulphate was used.

Preliminary tests with two other chemicals, sulfamic acid and ammonium sulfamate, showed an increased killing effect when combined with Sinox as a spray on annual weeds. While results generally have not been equal to those of ammonium sulphate their prices under commercial production may make them worthwhile for some conditions. The results of experimental data on two different types of weeds are listed in Table 14.

DISCUSSION

There are many advantages when ammonium sulphate is combined with Sinox as a weed spray. The cost of the material for an effective spray program is materially reduced from that of the required amount of Sinox alone. At normal or average prices, approximately 10 pounds of ammonium sulphate are equal to 1 pound of Sinox in cost. Five to ten pounds of ammonium sulphate will replace at least 2 pounds of Sinox in the spray solution and in this proportion will give equal or better results in weed control. Under average conditions the price differences will be even more in favor of the Sinox-sulphate combination.

The reaction of the combination on vegetation is more rapid than when either chemical is used alone. This is an important factor when weather conditions are to be considered. When Sinox is used alone several hours to 2 or 3 or more days elapse before death of the weeds takes place. With the addition of ammonium sulphate the reaction is greatly accelerated and even a few hours after application the results are very noticeable. This is significant and important when rains and dews occur. With the combination spray, therefore, it is possible to have successful treatments with only a few hours' exposure. At the seasons of the year when spraying will be done, weather conditions are often unsettled, particularly in western Oregon.

Size of plant growth does not limit the use of this combination to the same degree as when Sinox is used alone. It is essential, however, to apply the spray when the weed plants are small. Reference has been made to the results when common mustard, *Brassica* spp., which was sprayed when the plants were partly in bloom (Table 5). The percentage of weed plants killed was significantly in favor of the combination. Even though later stages may not be as satisfactory, the spraying operations, therefore, can be conducted over a longer period of time and greater use can be made of spray equipment.

Another highly important factor is the fertilizing effect of ammonium sulphate on crop production. The amount of ammonium sulphate that can be used will depend on growing conditions, principally rainfall, and on the crop to be treated. It is not always possible to use large amounts of ammonium sulphate in areas of low rainfall, but usually some can be used to good advantage. In many localities, at least 50 pounds of ammonium sulphate per acre can be used. Application of 50 pounds per acre of a nitrogen fertilizer will produce sufficient response, under most conditions, more than to pay for the material. Even in areas of low rainfall it has been demonstrated that an addition of as little as 25 pounds will increase crop yields. It is not necessary, however, to add large amounts of ammonium sulphate to Sinox to produce maximum weed control. Small amounts, from 5 to 10 pounds per acre, can be added to like amounts of Sinox to produce the maximum weed-killing power of this solution. The amount of ammonium sulphate used in excess of the requirements for weed control will depend on growing conditions and crop requirement for nitrogen fertilizer.

The use of this combination has also made it possible to treat successfully a wider range or a greater number of weed species. There are some weeds that have shown a high degree of resistance to Sinox but are susceptible to the combination spray. For example, lambsquarter, *Chenopodium album*, field chickweed, *Stellaria media*, fireweed or fiddleneck, *Amsinckia* spp., and wild buttercup, *Ranunculus arvensis*, are a few of the plants that are not highly susceptible when treated with Sinox alone. The addition of small amounts of ammonium sulphate to the Sinox has given good control on most of these plants. Some species of weeds—for example, knotweed, *Polygonum aviculare*—are very difficult to control even with the sulphate-Sinox combination.

This method, used for the control of weeds and for increasing yields of grain and grass seed crops, has been satisfactory in trials that have been established. Oregon produces substantial amounts of various important seeds. Ryegrass, *Lolium* spp., both common and perennial, are very important seed crops. Both are usually grown on low or wet lands that are usually deficient in nitrogen, and in many areas infestation of annual weeds is a problem. Under such conditions a combination of chemicals that not only will kill weeds but will also fertilize the crop at the same time is very valuable.

The desirability of this combination spray for the control of weeds on most perennial grass seed crops is also apparent. Perennial grasses are generally slow in becoming established and it is often difficult to keep certain weeds from adversely affecting young grass seedlings during the first year. If high yields of seed are to be produced, it is necessary to destroy the weeds. This is true whether the grass is planted in rows, broadcast, or drilled in solid stands. Successful control of weeds in grasses that are planted in rows can be accomplished by spraying rows with a row sprayer and by cultivating between the rows. It is not always possible to keep the weed plants under control in a young grass planting by one application of the spray. The weed seedlings may be entirely killed by the spray but germination of weed seeds after the first application may occur. Another benefit to be considered in controlling weeds in grass seed crops with this combination is the effect of the weed seeds that are found in the grass seed after harvest. Many weed seeds are very difficult to clean out of grass seed because of similarity in size and shape. Destroying weed plants in the growing crop is of twofold value: (1) competition of the weed plants in the grass planting is decreased and yields of seed are therefore increased; (2) removal of weed plants before they mature seeds avoids the need for extra cleaning.

The value of this spray on flax, particularly fiber flax, has been well demonstrated. The application of approximately 5 pounds of Sinox and 8 pounds of ammonium sulphate has successfully controlled weeds. The removal of weeds in a crop of fiber flax is especially important. Yields are not only increased but a crop of fiber flax that has a relatively low percentage of weed plants at time of processing receives a higher price than a crop with high weed content.

FACTORS THAT INFLUENCE THE EFFECTIVENESS OF SELECTIVE SPRAYS

Stage of plant growth, conditions of growth that may influence succulence of plants, temperature, humidity, and sunshine are factors that determine the success or failure of selective sprays.

Stage of growth. The size of the weed plants is perhaps the first important factor for successful spraying. To obtain effective results, the weeds must be small at the time of treatment. They should have not more than three to eight leaves and be not more than 4 to 8 inches in height for best results. In general, all weeds should be sprayed while they are in the young or rosette stage and before they have developed stems. At this stage the plants are more tender and the penetration of chemicals applied in the form of spray is much greater. As the plants are more easily killed at this stage, the requirement for chemicals can be kept to a minimum. Mustard and other weeds have been controlled when a high percentage of the plants were beginning to bloom; vetch has been controlled when the plants were from 10 to 12 inches high. These, however, are exceptions. Fireweed or tarweed, particularly, should be sprayed when as young as possible as the plants develop resistance to the spray and in the more advanced stage the plant, even if killed down, will send up new shoots from the crown. Common buttercup or hungerweed, *Ranunculus arvensis,* has been controlled when a high percentage of the plants were in bloom but it required such rates of chemicals that the application would not be economical. Plants in a succulent condition regardless of size are more susceptible than those that are not.

An interesting observation of the effect of the combination spray on French pink, *Centaurea cyanus,* was made in 1941. A field of spring oats heavily infested with this weed was sprayed with 10 pounds of Sinox and 10 pounds of ammonium sulphate per acre. The weed plants ranged from seedlings to well developed plants in the bud stage. The seedling plants were generally killed, but some of the larger plants were not. Many plants, which apparently were not immediately injured, showed a cumulative effect of the spray over a period of several weeks. Although these plants were not killed as were the seedlings, growth was arrested, many plants were malformed, and seed production was generally cut down. In this case, although the spray was applied too late, the value was much greater than was indicated from a count of plants actually killed.

Weather conditions. Good results have been obtained when plants have been sprayed under a wide range of conditions of sunshine, temperature, and humidity. The optimum conditions prevail when there is bright sunshine, with temperatures from 60° to 80° F., and high relative humidity. Extremely dry, cool, or windy weather at the time of spraying adversely affects the degree of plant kill. Rainfall and other moisture conditions are important factors at the time of spraying and immediately after, as high moisture whether caused by fog, dews, or rain will dilute the solution or wash it off the leaves before killing action can take place. At least 1 or 2 days of clear weather is desirable after the spray has been applied. Good results have been obtained under ideal conditions within a few hours after spraying. Best results will not be obtained if heavy rains occur too soon after applications are made. In many cases, light showers within a few hours after spray has been applied have not shown adverse effects. It is also essential not to apply the spray too soon following rain or while the plants are wet with dew or fog as the chemicals are less effective under such conditions.

MIXING THE SPRAY SOLUTION

Clean water should be used at all times. Sinox is readily soluble in water but it should be washed into the spray tank through a deep strainer box as small particles may not dissolve and will clog nozzles if allowed to go into the tank. Ammonium sulphate should be added after the Sinox and it should also be dissolved or washed into the tank through the strainer box. Ammonium sulphate that is finely ground or powdered is preferable to use as this quality of sulphate dissolves more readily than the crystalline type. If heavy rates, 50 to 100 pounds or more, of ammonium sulphate are desired to produce fertilizer effects, considerable time is taken for refilling the spray tank if crystalline type is used unless it is already dissolved as this sulphate in those quantities is slow to go into solution.

EQUIPMENT FOR APPLYING THE SOLUTION

Selection of spray equipment will depend on several conditions. Some of the factors to be considered are acreage to be sprayed, topography of field, and water supplies. The pump is the most important unit of equipment. A pump in general use is the plunger type and most of these operate at high pressure similar to those used for orchard and hop sprayers. It is not essential to use high pressure pumps as the low pressure types will meet most requirements and will be more economical to use. There are many orchard or hop sprayers available in a number of communities that may be economically fitted for field spraying. Some pumps can be operated by power take-off devices for use with

Figure 9. Power sprayer in operation in a field of Alta fescue infested with English daisy and vetch; note the boom attached to side of machine.

trucks or tractors. When this is done, it is necessary to make sure the engine turns over fast enough to develop the full capacity of the pump.

Length of the boom will depend on capacity of the pump. Where approximately 100 gallons of spray is applied per acre, allowance should be made for approximately ¾ gallon per minute for each nozzle. The boom should be of

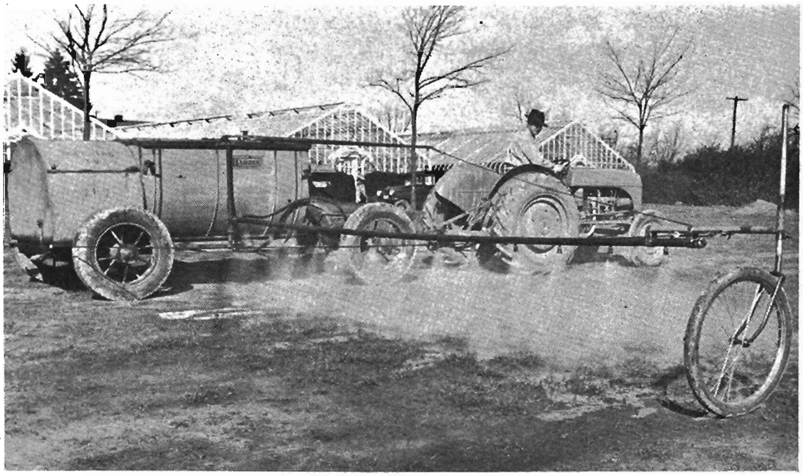

Figure 10. Power sprayer with boom attached to side of tank and opposite end supported by tiller wheel.

thick iron pipe at least 1¼ inches in diameter. For best results it should be attached ahead of the equipment as this gives better coverage of the weeds by the spray and decreases possibility of injury to crop by wheels of the machine if plants are sprayed ahead of rather than behind the equipment. The boom placed in front of tractor or truck is in a more advantageous position for direct observation and control of operator. If large machines are used, the boom can be attached to either side of the machine with a section in front of the tractor or truck to cover ahead of the wheel tracks. If properly braced the entire boom may be placed in front of the machine. Regardless of where the boom is attached it should be stabilized to prevent excessive end "whip" and to maintain the nozzles at a uniform height above the plants. For small acreages, however, one section placed in front or extending from the side of the outfit is sufficient.

In general the average length of sections of the boom will be about 15 feet. Provision should be made for raising or lowering the boom easily and quickly.

Spray nozzles and disks. The most efficient coverage of vegetation is made with a nozzle that discharges the spray in a fan shape. A nozzle with a conical spray does not produce the required angle of spread between nozzles and allows more skips or misses. For most conditions a disk that delivers a spray at an 80° angle with nozzles 1½ feet apart should be used. The spacing of the nozzles on the boom depends on angle of spread of the spray. The nozzles are attached to the boom with a ¼ inch nipple and tapped into the boom. When the boom is being tapped for nipples it is desirable to stagger the holes slightly on alternate sides of the center line. It is then possible to obtain maximum overlap of spray from each nozzle as the discharge will pass in front of or behind the discharge of adjacent nozzles. The nipples should extend into the inside of the pipe at least ¼ to ½ inch. This extension of the nipple inside the pipe allows for a greater portion of sediment and dirt particles to settle without going into the nozzles and clogging the disk. Ease of cleaning the inside of the boom is facilitated if a valve or cap is placed on the end of the pipe away from the inlet. Considerable time is saved if the boom can be rinsed out quickly to remove rust and other particles that may obstruct passage of the spray solution.

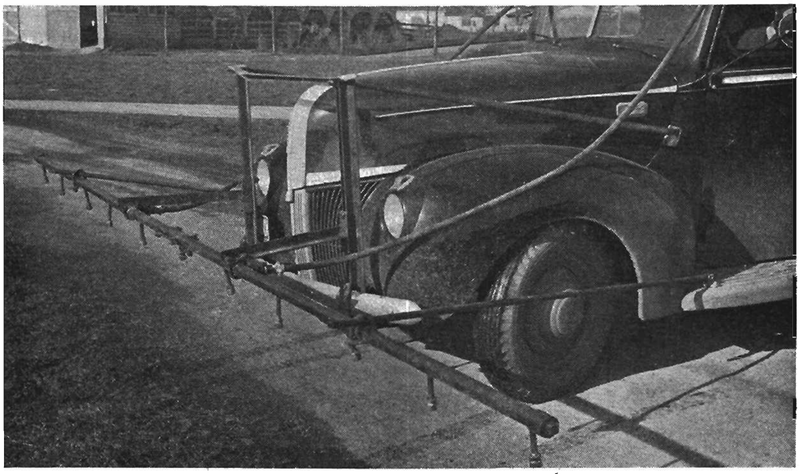

Figure 11. Power sprayer with boom attached to front of truck. Boom assembly should be rigidly braced to prevent end "whip." Note feed lines from tank that is mounted back of cab.

The size of disk opening or orifice will depend on volume, the pressure delivered, the speed of travel, and the spacing of nozzles on the boom. The rate of travel for general conditions will vary from 3 to 5 miles per hour. Speeds in excess of these rates may cause too much "shake" or "whip" of the boom end unless the surface of the field is smooth. The size of disk opening should therefore conform to the conditions and needs of the individual.

Screens. It is necessary that the water or spray solution be thoroughly strained through fine wire mesh before it goes into the spray tank. It is also essential that fine screens be used on the refill line and that a strainer box be used at all times when the tank is being refilled. Provision should also be made for screening the solution before it passes into the pump. This triple screening of the solution lessens the possibility of particles entering into the boom and stopping the nozzles.

Type and size of spray tank. The size of spray tank will depend on individual needs. Usually where moderately large acreages are sprayed, the most economical unit will be one having a capacity of at least 300 to 500 gallons. For very large acreages tank capacities should be larger. The tank may be made from either wood or steel. It is not necessary to use special equipment or metals in pump or tank but reasonable care should be exercised in keeping them washed and rinsed. The tank and pump should be washed out thoroughly after each day's operation and when the machine is not to be used for some time. Sinox is not corrosive, but the ammonium sulphate corrodes metal if in contact with it for any long period.

COSTS OF APPLYING THE SPRAY

The cost of applying the spray solution will depend on a number of factors. The cost of the material will average from $1.25 minimum to as high as $2.75 an acre, depending on crop to be treated and size of plants and weather conditions at time of application. In 1941 Sinox sold for approximately 20 cents per pound and ammonium sulphate for about 2½ cents per pound. Under ideal conditions and for a number of weeds, successful applications can be made when using an average of 6 pounds of Sinox and from 6 to 10 pounds of ammonium sulphate. For some weeds, such as fireweed or tarweed, the rates will necessarily be increased to as much as 8 to 10 pounds each of the two chemicals with the resulting increased cost of material applied. The cost of applying the solution will depend on the size of the unit and the acreage covered per day. It is estimated that an individual using his own machine will spray at a cost of approximately 50 cents per acre. The total cost will average from $1.75 to as much as $3.00 per acre.

SUMMARY

1. This bulletin presents the results of experiments with selective chemical sprays on weeds in growing crops as authorized by the legislative sessions of 1937, 1939, and 1941.

2. Various combinations of ammonium sulphate with sodium dinitro-orthocresylate, commercially known as Sinox, have been worked out as successful selective sprays for controlling many species of annual and some perennial weeds in grain, grass, pea, and flax crops.

3. Broad-leaved succulent weeds in early stages of growth are easily killed. Some plants having leaf surfaces that do not retain the coating of spray or that are resistant to it, are not seriously injured by the spray.

4. Substantial increases in yield and quality of crops have been obtained when weed-infested fields were sprayed. Grain yields increased from 3 to 45 bushels, common rye grass to as much as 300 pounds, and fiber flax 1 ton or more per acre. In addition, the percentage of weeds at time of harvest was relatively low.

5. Good equipment capable of complete and uniform coverage of weeds with spray applied under favorable weather conditions is necessary for good results.

6. Spraying of weedy fields of grains and other grasses, peas, seed, and fiber flax, is economically feasible.