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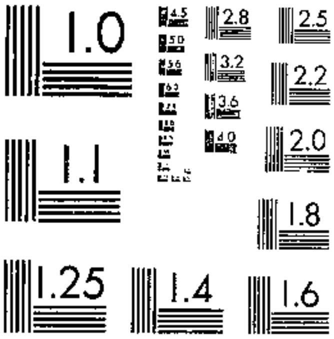

MICROCOPY RESOLUTION TEST CHART
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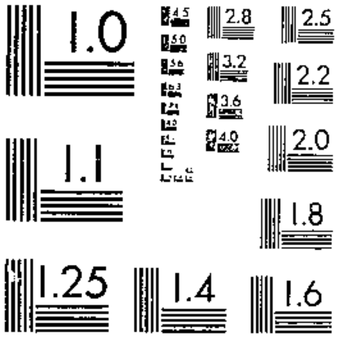

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RESPONSE OF SEVERAL CROPS TO SIX HERBICIDES IN IRRIGATION WATER

Technical Bulletin No. 1461

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
In cooperation with
Washington, Montana, and Arizona
Agricultural Experiment Stations

PREFACE

The investigations reported herein were conducted during 1962 through 1966 in Washington, Montana, and Arizona. The results of these investigations are still applicable and pertinent in 1972. They are published as a contribution toward the safe use of herbicides within an associated environment, for use as background information for future investigations of a similar nature, and as an accession to the literature of agricultural science.

Inasmuch as the investigations were conducted in three States under varying soil and climatic conditions and cultural practices, the results are applicable to many of the irrigated areas of the West.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

PROTECT
Use Pesticides Safely
FOLLOW THE LABEL

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RESPONSE OF SEVERAL CROPS TO SIX HERBICIDES IN IRRIGATION WATER

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INTRODUCTION

Efforts to develop additional herbicides for control of aquatic and ditchbank weeds in and along irrigation channels, drains, lakes, and reservoirs increased considerably after the successful introduction of (2,4-dichlorophenoxy)acetic acid (2,4-D) and aromatic solvents in the mid and late 1940's (*17, 20, 23*).[2] The response of crops irrigated with water that contains such herbicides is an important phase of the development process to insure safe usage. The objective of the investigations reported herein was to gain information on the response of certain crops to sodium salt of (2,3,6-trichlorophenyl)acetic acid (fenac); 2,6-dichlorobenzonitrile (dichlobenil) ; disodium salt of 7-oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid (endothall); mono (*N, N*-dimethylalkylamine) salt of endothall (monoamine salt of endothall) ; potassium salt of 4-amino-3,5,6-trichloropicolinic acid (picloram); and dimethylamine salt of 3,6-dichloro-o-anisic acid (dicamba) when applied in irrigation water under different soil and climatic conditions and irrigation methods in Washington, Montana, and Arizona.

PREVIOUS INVESTIGATIONS

During the two decades before 1966, the tolerance of certain crops to a number of herbicides in irrigation water was reported by investigators from Washington, Montana, Arizona, and other States. Some of the more common herbicides included in such reports were aromatic solvent (*1, 8, 9, 13, 14, 16, 22, 23*), acrylaldehyde (acrolein) (*2, 3, 5, 8, 9, 10, 14, 21, 23, 24*), 6,7-dihydrodipyrido [1,2-*a*:2′,1′-*c*]pyrazinediium ion (diquat) and certain other quaternary ammonium compounds (*8, 9, 14, 15, 22*), orthodichlorobenzene (*12*), 2,4-D (*6, 7, 11, 19*), 3-amino-s-triazole (amitrole) (*12*),

[1] The authors conducted the research at the following locations: V. F. Bruns at Prosser, Wash.; J. M. Hodgson at Bozeman, Mont.; and H. F. Arle near Tolleson, Ariz.

[2] Italic numbers in parentheses refer to Literature Cited, p. 28.

the sodium salt of 2,2-dichloropropionic acid (dalapon) (*12*), and disodium salt of endothall (*4, 8, 9, 14*).

INVESTIGATIONS IN WASHINGTON

The response of soybeans (Ottawa Mandarin) and field corn (P.A.G. 234) to the sodium salt of fenac and to dichlobenil in irrigation water was studied in field experiments at the Irrigated Agriculture Research and Extension Center, Prosser, Wash., during 1962. In 1963, the studies were repeated, using soybeans, corn, and in addition, a root crop, sugarbeets (U & I Monogerm Hyb. R/B). In 1964, the response of the same varieties of soybeans, corn, and sugarbeets to monoamine salt of endothall in irrigation water was studied.

Methods and Materials

The experiments were conducted on Warden very fine sandy loam, which was low in organic matter (about 1.5 percent) and about 5 feet deep over bedrock.

After the seedbeds had been fertilized and prepared, plots 10 by 20 feet were laid out on contour with a zero grade within each of three blocks (*6, 11*) (fig. 1). Alleyways between blocks were 8 to

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FIGURE 1.—Panoramic view of experimental area, plot arrangement, and tanks.

10 feet wide, and those between plots were 2 to 4 feet wide. The plots were grouped by crop within each block. In a split-plot design (plots divided in half transversely), four rows of the test crops, 10 feet long and 2 feet apart, were planted on one-half of each plot (corn and soybeans on May 14, 1962, May 14, 1963, and May 11, 1964; sugarbeets on May 9, 1963, and March 4, 1964). Poultry netting on 6-inch board frames was placed over the plots in the 1963 and 1964 experiments to protect crop seed and seedlings from pheasants.

After the seedlings were well-developed, soybeans, sugarbeets, and corn were thinned to average one plant per 3, 10, and 14 inches of row, respectively. Within 1 week after irrigation with the herbicide-treated water, the other half of each plot was retilled, leveled, packed, and planted to the test crops. Thus, one irrigation with herbicide-treated water served to test both a preplanting and a postemergence treatment.

As described in previous publications (*6, 7, 11*), 600-gallon tanks mounted on sleds and equipped with valves, hoses, and boom attachments were used in applying the herbicide-treated irrigation water. The plots were cultivated and irrigated normally before and after the herbicide treatments. The untreated irrigation water from a pipeline was applied by hoses and booms and regulated and measured by flowmeters. The irrigation furrows were dammed at each end of the plots to facilitate uniform application and wetting and to eliminate effluent during irrigations. The water flow from the tanks was regulated by valves to maintain a proper level of water in the irrigation furrows.

The herbicide treatments were made to each crop at random within each block. Data on time and rate of application for each chemical in each experiment and related information are given in table 1.

Seedling emergence, foliage injury, plant mortality, yield, and quality were observed or determined during the course of the experiments. On the halves of plots that were treated with herbicide before planting, the seedlings were cut at ground level and weighed 4 to 6 weeks after their first emergence. On the halves of plots treated when the plants were young and growing vigorously, soybeans were cut on September 12 to 19 and threshed about 3 weeks later, sugarbeets were harvested the first or second week in October, and corn usually was harvested during the last week in October and shelled after the ears had been air-dried for about 2 weeks. At harvesttime in 1963, 2- to 3-pound foliage and seed samples were collected at random from each check plot and also from each plot

TABLE 1.—*Data for tests of herbicides applied in irrigation water to soybeans, corn, and sugarbeets at Prosser, Wash., from 1962 through 1964*

Chemical, date applied, and maximum air temperature	Crop		Quantity applied	
	Kind	Growth stage	P.p.m.w.[1]	Lb./acre
Fenac, sodium salt:				
June 18, 1962 (84° F.)	Soybeans	2–4 trifoliate leaf	0 0.1 1.0 10.0	0 0.045 0.45 4.5
June 18, 1962 (84° F.)	Corn	6–8 leaf	0 0.1 1.0 10.0	0 0.045 0.45 4.5
June 12, 1962 (85° F.)	Sugarbeets	3–5 leaf	0 0.1 1.0	0 0.045 0.45
June 13, 1963 (87° F.)	Soybeans	2–4 trifoliate leaf	0 0.1 1.0	0 0.045 0.45
June 14, 1963 (93° F.)	Corn	5–7 leaf	0 0.1 1.0	0 0.045 0.45
Dichlobenil:				
June 19, 1962 (88° F.)	Soybeans	2–4 trifoliate leaf	0 0.1 1.0 10.0	0 0.045 0.45 4.5
June 19, 1962 (88° F.)	Corn	6–8 leaf	0 0.1 1.0 10.0	0 0.045 0.45 4.5
June 12, 1963 (85° F.)	Sugarbeets	3–5 leaf	0 0.1 1.0	0 0.045 0.45
June 13, 1963 (87° F.)	Soybeans	2–4 trifoliate leaf	0 0.1 1.0	0 0.045 0.45
June 14, 1963 (93° F.)	Corn	5–7 leaf	0 0.1 1.0	0 0.045 0.45
Endothall, monoamine salt:				
May 28, 1964 (74° F.)	Sugarbeets	5–10 leaf	0 1 25	0 0.45 11.25

See footnote at end of table.

TABLE 1.—*Data for tests of herbicides applied in irrigation water to soybeans, corn, and sugarbeets at Prosser, Wash., from 1962 through 1964*—Continued

Chemical, date applied, and maximum air temperature	Crop		Quantity applied	
	Kind	Growth stage	P.p.m.w.[1]	Lb./acre
Endothall, monoamine salt—Cont.				
			0	0
June 15, 1964 (75° F.)	Soybeans	3–4 trifoliate leaf	1	0.45
			25	11.25
			0	0
June 16, 1964 (69° F.)	Corn	6–8 leaf	1	0.45
			25	11.25

[1] Parts per million by weight in equivalent of 2 acre-inches of irrigation water.

treated with postemergence applications of dichlobenil. The samples were stored at 0° F. for residue analysis. The analysis for residues of dichlobenil and its possible metabolite, 2,6-dichlorobenzoic acid (2,6-DCBA), were completed in 1967.[3] The analytical method was based on electron-capture gas chromatography, as described by Meulemans and Upton (*18*).

Results and Discussion

Postemergence treatment

Fenac. *Soybeans.*—Within 10 days after treatment, soybeans on plots treated with fenac at 1.0 or 10.0 p.p.m.w. were stunted, wilted, and shrivelled. The youngest trifoliate leaves failed to open and develop properly (fig. 2). Drastic, inward curling of such leaves was characteristic of fenac injury. However, leaves that were expanded at the time of treatment appeared uninjured. No definite or distinct discoloration in the foliage was apparent within the first 10 days.

As the season advanced, stunting, malformation, and desiccation became progressively more severe. Within 30 days after treatment, 5 to 10 percent of the plants had been killed on plots treated at 1.0 p.p.m.w., and nearly 100 percent on plots treated at 10.0 p.p.m.w.

By harvesttime, all soybeans were dead on plots treated at 10.0

[3] Edwin T. Upton, Thompson-Hayward Chemical Company, Kansas City, Kans., performed the residue analysis and provided the residue data.

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FIGURE 2.—Soybean foliage. *Top:* Untreated. *Bottom:* Various degrees of injury 30 days after treatment with fenac at 1.0 or 10.0 p.p.m.w. in 2 acre-inches of irrigation water (0.45 or 4.5 lb./acre).

p.p.m.w. A few plants survived the treatment at 1.0 p.p.m.w., but yields were nil (table 2). Few, if any, marketable seeds were produced.

Fenac at 0.1 p.p.m.w. also injured soybeans, but to a lesser degree than at 1.0 p.p.m.w. After mid-July, recovery of the soybeans was remarkable. Yields in bushels-per-acre were not reduced significantly by the treatment, but the quality of the seed was decreased. The reduction in weight per 100 seeds was significant at the 5-percent level of probability in the 1962 experiment. Soybeans are very sensitive to fenac when applied to the soil in irrigation water.

Corn.—In general, corn was more tolerant than soybeans to fenac. It apparently was uninjured by treatments at 0.1 or 1.0 p.p.m.w. The postemergence treatments at the highest concentration (10.0 p.p.m.w.) injured corn only slightly, and the plants recovered. None of the treatments reduced the quality or yield of shelled corn (table 2).

Sugarbeets.—Within 10 days after treatment with fenac at 1.0

TABLE 2.—*Effect on yields of soybeans, field corn, and sugarbeets of applying sodium salt of fenac in irrigation water in Washington*

Date and fenac concentration[1]	Soybeans[2]			Field corn seed yield per acre[2]	Sugarbeets[2]	
	Seed yield per acre	Weight per 100 seeds	Seed quality		Roots per acre	Root yield per acre
	Bushels	*Grams*		*Bushels*	*Number*	*Tons*
June 18–19, 1962:						
No chemical (check)	39.1a	15.2a	Good	100.2a		
0.1 p.p.m.w. (0.045 lb./acre)	38.8a	13.5 b	Fair	111.8a		
1.0 p.p.m.w. (0.45 lb./acre)	.9 b	11.3 c	Poor	107.6a		
10.0 p.p.m.w. (4.5 lb./acre)	0 b	0. d		124.3a		
June 12–14, 1963:						
No chemical (check)	37.3a		Good	177.5a	28,520a	30.4a
0.1 p.p.m.w. (0.045 lb./acre)	36.8a		Fair	201.9a	29,070a	27.1a
1.0 p.p.m.w. (0.45 lb./acre)	4.2 b		Poor	183.4a	27,070a	22.5a

[1] Applied in 2 acre-inches of water by furrow irrigation at Prosser, Wash., during 1962 and 1963. See table 1 for stage of growth of various crops on given dates.

[2] Any 2 figures in the same column and year that are not followed by the same letter are significantly different at the 5-percent level of probability, as determined by Duncan's multiple-range test.

p.p.m.w., sugarbeets were malformed, chlorotic, wilted, and somewhat desiccated (fig. 3). Visible symptoms of injury persisted throughout the season. Yield reductions were observed but were not significant at the 5-percent level of probability (table 2). Fenac at 0.1 p.p.m.w. did not appreciably injure sugarbeets or significantly reduce yields.

Dichlobenil. *Soybeans.*—Soybeans were noticeably stunted and malformed within 10 days after treatment with dichlobenil, particularly at concentrations of 1.0 or 10.0 p.p.m.w. The concentration of 0.1 p.p.m.w. injured soybeans visibly in the 1962 experiment but not in the 1963 experiment. Actually, such treatments appeared to stimulate the foliar growth of soybeans in 1963.

Within 30 days after treatment with dichlobenil at 10.0 p.p.m.w., there was an increase in stunting, malformation, and desiccation, and 2 percent of the plants were dead. At comparable rates of application, dichlobenil injury to soybeans was similar in nature to fenac injury but less severe (fig. 4).

By harvesttime, the soybeans had recovered markedly, especially

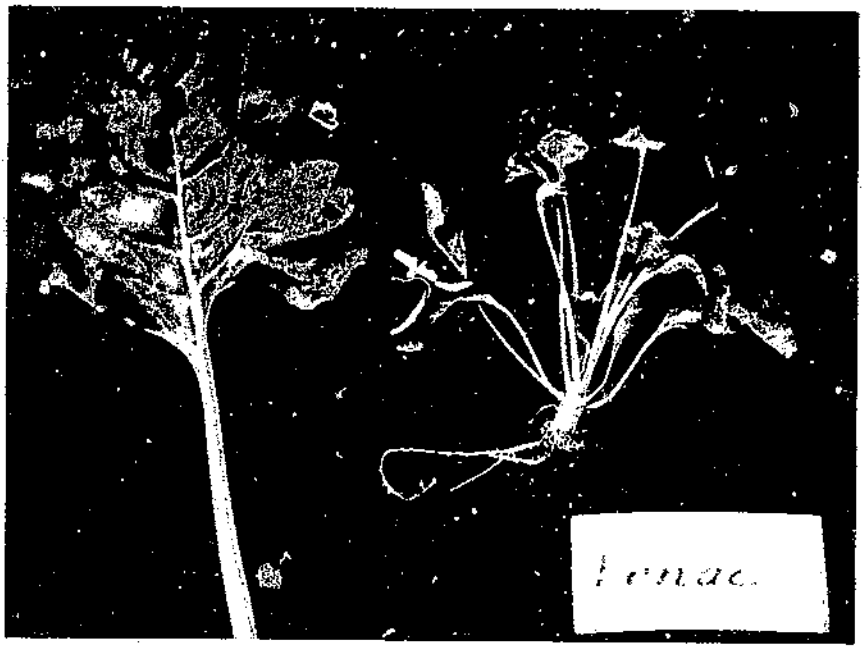

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FIGURE 3.—Sugarbeets. *Left:* Leaf from untreated plant. *Right:* Plant 30 days after treatment with fenac at 1.0 p.p.m.w. in 2 acre-inches of irrigation water (0.45 lb./acre).

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FIGURE 4.—Soybean foliage. *Top:* Untreated. *Bottom:* Various degrees of injury 30 days after treatment with dichlobenil at 1.0 or 10.0 p.p.m.w. in 2 acre-inches of irrigation water (0.45 or 4.5 lb./acre).

on plots treated with dichlobenil at 0.1 or 1.0 p.p.m.w Treatments at 0.1 or 1.0 p.p.m.w. did not reduce yields in terms of bushels per acre or weight per 100 seeds (table 3). However, maturity was delayed somewhat by such treatments in 1962, and some seeds were wrinkled and discolored. Treatments at 10.0 p.p.m.w. significantly reduced both the yield and quality of soybeans.

Corn.—Corn apparently was more tolerant than soybeans to dichlobenil. Generally, treatments at 1.0 or 10.0 p.p.m.w. caused only slight stunting of corn. A few plants, scattered throughout the plots, were more severely injured. Such injury was characterized by a pronounced crimpling of the leaf blades, a discoloration (yellow to dark blue or purple), a curling or rolling of the leaf apices at the onset of desiccation, or twisting of the leaves into rather compact rolls and rapid desiccation similar to symptoms of dalapon injury *(12)*. No plants were killed, and injured plants recovered rapidly. None of the treatments reduced the quality or yield of shelled corn (table 3).

Sugarbeets.—Dichlobenil at 0.1 or 1.0 p.p.m.w. did not visibly injure sugarbeets nor reduce yields (table 3).

TABLE 3.—*Effect on yields of soybeans, field corn, and sugarbeets of applying dichlobenil in irrigation water in Washington*

Date and dichlobenil concentration [1]	Soybeans [2]			Field corn	Sugarbeets [2]	
	Seed yield per acre	Weight per 100 seeds	Seed quality	Seed yield per acre [2]	Roots per acre	Root yield per acre
	Bushels	*Grams*		*Bushels*	*Number*	*Tons*
June 18–19, 1962:						
No chemical (check)	39.1ab	15.2a	Good	100.2a	—	—
0.1 p.p.m.w. (0.045 lb./acre)	45.9a	14.6ab	Fair	96.8a	—	—
1.0 p.p.m.w. (0.45 lb./acre)	37.4ab	15.5a	Fair	86.0a	—	—
10.0 p.p.m.w. (4.5 lb./acre)	29.1 b	13.5 b	Fair	100.6a	—	—
June 12–14, 1963:						
No chemical (check)	37.3a	—	Good	177.5a	28,520a	30.4a
0.1 p.p.m.w. (0.045 lb./acre)	37.8a	—	Good	201.9a	27,430a	30.8a
1.0 p.p.m.w. (0.45 lb./acre)	33.3a	—	Good	171.5a	25,980a	27.8a

[1] Applied in 2 acre-inches of water by furrow irrigation at Prosser, Wash., during 1962 and 1963. See table 1 for stage of growth of various crops on given dates.

[2] Any 2 figures in the same column and year that are not followed by the same letter are significantly different at the 5-percent level of probability, as determined by Duncan's multiple-range test.

Monoamine salt of endothall. *Soybeans.*—Within 3 or 4 days after treatment, the monoamine salt of endothall at 25 p.p.m.w. severely wilted soybean plants. Treatments at 1.0 p.p.m.w. caused some drooping of the leaves and petioles.

After 7 days, 42 percent of the plants on plots treated at 25 p.p.m.w. were severely wilted, stunted, and necrotic, and about half of those were almost completely desiccated (fig. 5). Growth on plots treated at 1.0 p.p.m.w. was somewhat retarded.

One month after treatment at 25 p.p.m.w., 9 percent of the plants were dead. Root systems had been injured extensively. Plants that were not injured fatally had recovered or were recovering rapidly. At the time of observation, injury symptoms were no longer apparent on plots treated at 1.0 p.p.m.w.

Despite the early-season injury, seed yields, especially on plots treated at 25 p.p.m.w., were not significantly reduced (table 4).

Corn.—Within 1 week after treatment with the monoamine salt of endothall at 25 p.p.m.w., some of the corn plants, particularly the smaller ones, were slightly stunted, retarded, shrivelled, or partly desiccated. Symptoms characteristic of moisture stress (blu-

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FIGURE 5.—Soybean foliage. *Left:* Untreated. *Right:* Various degrees of injury 7 days after treatment with monoamine salt of endothall at 25 p.p.m.w. in 2 acre-inches of irrigation water (11.25 lb./acre).

ish discoloration to partial chlorosis) were also present. However, recovery was rapid, and yields were not reduced (table 4). No injury symptoms were apparent on plots treated at 1.0 p.p.m.w.

Sugarbeets.—The monoamine salt of endothall at 1 or 25 p.p.m.w. did not visibly injure the foliage nor reduce the stand or yield of sugarbeets (table 4).

Preplanting treatments

Fenac and dichlobenil. *Soybeans*.—After the preplanting treatments in 1962, pheasants severely damaged the soybean seedlings by feeding on the cotyledons at or just before emergence. To determine the effect of the treatments on the stand, the surface soil in the rows was removed by hand, and the remnants of emerging seedlings were counted. Within the reliability of this index, the preplanting treatments of fenac at 1.0 p.p.m.w. and dichlobenil at 10.0 p.p.m.w. reduced the initial stands by about 50 percent. Fenac at 10.0 p.p.m.w. reduced the initial stand about 90 percent.

In 1963, fenac at 0.1 or 1.0 p.p.m.w. or dichlobenil at 1.0 p.p.m.w. delayed emergence of seedlings. Either chemical at 1.0 p.p.m.w. reduced the stand and fresh weight of soybeans (table 5). At 0.1 p.p.m.w., dichlobenil did not reduce the stand or the fresh weight. Fenac reduced the fresh weight significantly, and the reduction in stand approached significance at the 5-percent level of probability.

After emergence, stunting and malformation were prevalent on plots treated with fenac at 1.0 p.p.m.w., and numerous plants died. Stunting and malformation were less prevalent on plots treated at 0.1 p.p.m.w., and none of these plants died within the 4-week period after emergence.

TABLE 4.—*Effect on yields of soybeans, field corn, and sugarbeets of applying monoamine salt of endothall in irrigation water in Washington*

Monoamine salt of endothall concentration [1]	Yields per acre [2]				
	Soybean seed	Field corn		Sugarbeet roots	
		Ears	Seed		
	Bushels	*Number*	*Bushels*	*Number*	*Tons*
No chemical (check)	33.4	34,120	169	27,950	32.5
1 p.p.m.w. (0.45 lb./acre)	34.6	33,760	165	27,950	32.0
25 p.p.m.w. (11.25 lb./acre)	32.9	33,580	162	28,500	34.1

[1] Applied in 2 acre-inches of water by furrow irrigation at Prosser, Wash., in 1964. See table 1 for stage of growth of various crops on given dates.

[2] Yield differences were not significant at the 5-percent level of probability.

TABLE 5.—*Effects on stand and growth of soybeans, field corn, and sugarbeets of applying dichlobenil or sodium salt of fenac in irrigation water before crop planting in Washington*

Chemical and concentration [1]	Yield per acre 4 weeks after seedling emergence [2]					
	Soybeans		Field corn		Sugarbeets	
	Plants	Fresh weight	Plants	Fresh weight	Plants	Fresh weight
	Number	*Ton*	*Number*	*Tons*	*Number*	*Ton*
No chemical (check)	38,660a	0.253a	41,380a	2.844ab	10,350ab	0.063a
Fenac:						
0.1 p.p.m.w. (0.045 lb./acre)	29,400a	.138 b	37,570a	2.529 bc	9,260ab	.042abc
1.0 p.p.m.w. (0.45 lb./acre)	4,360 b	.010 c	38,660a	1.968 cd	4,360 bc	.004 c
Dichlobenil:						
0.1 p.p.m.w. (0.045 lb./acre)	34,850a	.214ab	39,200a	3.370a	10,890a	.050ab
1.0 p.p.m.w. (0.45 lb./acre)	15,250 b	.057 c	34,850a	1.895 d	2,180 c	.013 bc

[1] Applied in 2 acre-inches of water by furrow irrigation at Prosser, Wash., on June 12–14, 1963, before the crops were planted.

[2] Any 2 figures in the same column that are not followed by the same letter are significantly different at the 5-percent level of probability, as determined by Duncan's multiple-range test.

Corn.—Pheasants ate or destroyed most of the corn seeds or seedlings in 1962. However, based upon general observations and inspections, dichlobenil at 10.0 p.p.m.w. would probably have reduced the initial stands appreciably. Some of the few seedlings after such treatments began to die soon after emergence, whereas the others appeared normal.

The initial stands probably would not have been reduced by the preplanting treatments with fenac. However, the leaves of some of the seedlings not destroyed by pheasants failed to unfold, and a number of seedlings began to shrivel and die soon after emergence on plots treated at 10.0 p.p.m.w. Considerable root damage was observed.

In 1963, dichlobenil at 1.0 p.p.m.w. caused some delay of seedling emergence, but none of the treatments reduced the stands of corn significantly (table 5). Fresh weights of corn, as determined 4 weeks after first emergence of seedlings, were lower from plots treated with fenac or dichlobenil at 1.0 p.p.m.w. than from untreated check plots.

At comparable rates, dichlobenil appeared somewhat more injurious to corn than fenac. A few seedlings died after emergence on plots treated with dichlobenil at 1.0 p.p.m.w. Others appeared somewhat wilted or retarded. Seedlings on plots treated with fenac at 1.0 p.p.m.w. were somewhat retarded, weak, or subject to bending or lodging.

Sugarbeets.—Fenac or dichlobenil at 1.0 p.p.m.w. delayed emergence and reduced the stands of sugarbeets. Both decreased the fresh weight of plants, based on samples taken 4 weeks after first emergence of the seedlings (table 5). At 0.1 p.p.m.w., both fenac and dichlobenil delayed the emergence of seedlings slightly, but neither reduced the stands. Reductions in fresh weight were not significant at the 5-percent level of probability.

After emergence, a number of plants on plots treated with fenac at 1.0 p.p.m.w. were stunted and malformed. For the most part, plant growth on all other plots appeared normal.

Monoamine salt of endothall. *Soybeans.*—The monoamine salt of endothall at 1.0 or 25 p.p.m.w. had not reduced the stand and fresh weight of soybean plants at 6 weeks after emergence of the seedlings (table 6). In comparison, the disodium salt of endothall at 1.0 p.p.m.w., which was applied to field beans in 1961 at the 4- to 6-trifoliate leaf stage, caused severe injury and reduced yields (*14*).

Corn.—The monoamine salt of endothall at 1.0 or 25 p.p.m.w.

TABLE 6.—*Effect on stand and growth of soybeans, field corn, and sugarbeets of applying monoamine salt of endothall in irrigation water before crop planting in Washington*

Monoamine salt of endothall concentration [1]	Yield per acre 8 to 10 weeks after treatment [2]					
	Soybeans		Field corn		Sugarbeets	
	Plants	Fresh weight	Plants	Fresh weight	Plants	Fresh weight
	Number	*Tons*	*Number*	*Tons*	*Number*	*Tons*
No chemical (Check)	25,590a	2.8a	40,840a	22.9a	20,690a	16.9a
1 p.p.m.w. (0.45 lb./acre)	19,600a	2.1a	39,200a	23.6a	22,870a	16.9a
25 p.p.m.w. (11.25 lb./acre)	24,500a	2.5a	40,840a	23.9a	17,970 b	14.7 b

[1] Applied in 2 acre-inches of water by furrow irrigation at Prosser, Wash., on May 28 or June 15, 1964, before the crops were planted.

[2] Any 2 figures in the same column that are followed by the same letter are significantly different at the 5-percent level of probability, except those for fresh weights of sugarbeets, which are significantly different at the 10-percent level, as determined by Duncan's multiple-range test.

did not decrease the stand or fresh weight of 6-week-old corn plants (table 6).

Sugarbeets.—No symptoms of injury were noted in the foliage of the sugarbeet seedlings. However, the treatments at 25 p.p.m.w. decreased the stand and the fresh weights of the 6-week-old plants significantly at the 5- and 10-percent levels of probability, respectively (table 6).

Residues of dichlobenil

Difficulties were encountered in attempting to analyze the soybean samples. Modifications to eliminate some interference from the extractives were unsuccessful, and no reliable residue data for soybeans were obtained. The limit of detectability of the analytical method was 0.05 p.p.m. Within the limits of detection, no dichlobenil or 2,6-DCBA residues were found in any of the corn or sugarbeet samples from the treated and untreated plots.

INVESTIGATIONS IN MONTANA

The effects of the sodium salt of fenac, dichlobenil, and the disodium salt of endothall in irrigation water on sugarbeets (Great Western Monogerm) and alfalfa (Ranger) were studied in field experiments at the Montana State Agricultural Experiment Station, Bozeman, during 1963. Alfalfa yields were determined again in 1964 to check on possible residual effects.

Methods and Materials

The experiments were conducted on Huffine silt loam. The dark brown topsoil (10 to 18 inches thick) overlies a brown, sticky, silty clay or clay loam subsoil, which in turn overlies a distinct gravelly layer (2 to 4 feet below the surface). The surface 8 inches contains 31 percent sand, 43 percent silt, and 26 percent clay. It has a pH of 6.4.

Two areas, each approximately 48 by 120 feet, were laid out adjacently in a nearly level field (fig. 6). Sugarbeets were planted in rows in one area, and alfalfa was seeded (broadcast) in the other. Each area was divided into four blocks (replicates) with a 20-foot alleyway between areas and about 13-foot alleyways between blocks. The plots within each block were 6 feet wide and 20 feet long. Thus, a sugarbeet plot contained 4 rows 1.5 feet apart and 20 feet long.

On July 12, 1963, when the number of leaves averaged eight per

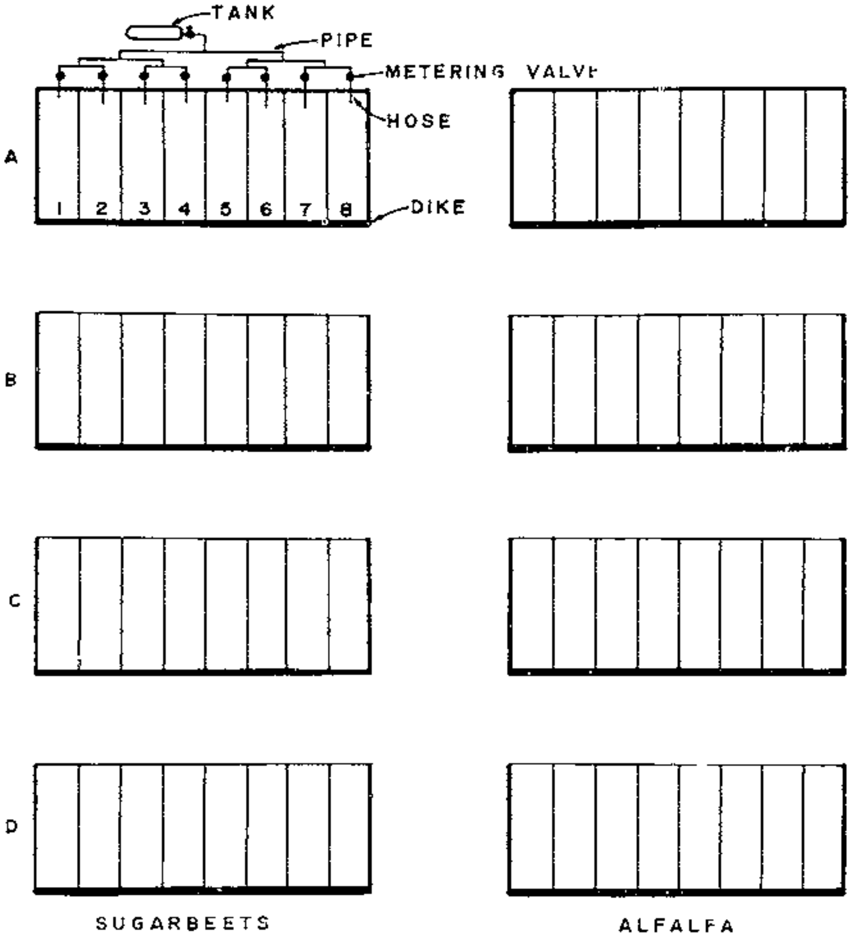

FIGURE 6.—A diagram of the field layout and of the manifold arrangement for applying the treated water.

plant, herbicides were applied to sugarbeets in 1.79 acre-inches of water by furrow irrigation and at random within each block as follows: No chemical, fenac or dichlobenil at 0.1, 1.0, or 10.0 p.p.m.w. (0.04, 0.45, or 4.56 lb./acre, respectively), and endothall at 10.0 p.p.m.w. Identical treatments were made to alfalfa on July 15, at which time the plants averaged 8 inches in height.

An 800-gallon tank and a manifold arrangement of 2.5 and 1-inch plastic pipe and ¾-inch hose was used to deliver water. Treatments were made to all plots in a block simultaneously. Appropriate amounts of chemical were premixed with 1 liter of water in the laboratory. The solutions were then metered at the prescribed rates into the ¾-inch lines just before the irrigation water entered the plots. All water was retained on each plot by diking the lower ends of the furrows and regulating the flow from the tank. All plots were irrigated twice with untreated water during the remainder of the season.

The two center rows in each sugarbeet plot were harvested for yield determination 12 weeks after treatment. Alfalfa yields were determined by harvesting 60 square feet from each plot on August 20, 1963, and on August 3, 1964.

Results and Discussion

Fenac.—Fenac at 0.1 p.p.m.w. in 1.79 acre-inches of irrigation water tended to increase the yield of sugarbeets, whereas 1.0 p.p.m.w. decreased yields (table 7). At 10.0 p.p.m.w., fenac severely injured the sugarbeets and reduced the yields markedly. The leaves and petioles were crinkled and distorted, and the crowns or leaf-bud zones were somewhat enlarged.

Alfalfa apparently was less tolerant than sugarbeets to fenac. In 1963, yields of alfalfa from plots treated at 0.1 p.p.m.w. were about equal to those from untreated checks (table 8). Fenac at 1.0 or 10.0 p.p.m.w. decreased yields significantly. In 1964, yields were

TABLE 7.—*Effect on yields of sugarbeets of applying sodium salt of fenac, dichlobenil, or disodum salt of endothall in irrigation water in Montana*

Chemical [1]	Application data		Yield of sugarbeets per acre [2]
	Concentration	rate per acre	
	P.p.m.w.	*Pounds*	*Tons*
None			13.1ab
Fenac	0.1	0.04	14.9a
Do	1.0	0.45	11.9 cd
Do	10.0	4.56	10.6 cd
Dichlobenil	0.1	0.04	13.5ab
Do	1.0	0.45	12.5 bc
Do	10.0	4.56	11.7 cd
Endohtall	10.0	4.56	13.8ab

[1] Applied in 1.79 acre-inches of water by furrow irrigation at Bozeman, Mont., on July 12, 1963, when plants averaged 8 leaves each.

[2] Any two figures that are not followed by the same letter are significantly different at the 5-percent level of probability, as determined by Duncan's multiple-range test.

TABLE 8.—*Effect on yields of alfalfa of applying sodium salt of fenac, dichlobenil, or disodium salt of endothall in irrigation water in Montana*

Chemical [1]	Application data		Yield of alfalfa per acre [2]	
	Concentration	Rate per acre	1963	1964
	P.p.m.w.	*Pounds*	*Tons*	*Tons*
None			1.82a	3.53a
Fenac	0.1	0.04	1.77a	3.68a
Do	1.0	0.45	1.55 b	3.27a
Do	10.0	4.56	.81 d	1.22 b
Dichlobenil	0.1	0.04	1.68ab	3.58a
Do	1.0	0.45	1.73ab	3.49a
Do	10.0	4.56	1.33 c	3.67a
Endothall	10.0	4.56	1.72ab	3.64a

[1] Applied in 1.79 acre-inches of water by furrow irrigation at Bozeman, Mont., on July 15, 1963, when plants averaged 8 inches in height.

[2] Any 2 figures in the same column that are not followed by the same letter are significantly different at the 5-percent level of probability, as determined by Duncan's multiple-range test.

reduced only on the plots that had been treated the previous year at 10.0 p.p.m.w.

Dichlobenil.—Dichlobenil at 0.1 or 1.0 p.p.m.w. did not cause visible injury to sugarbeets or reduce yields significantly (table 7). However, dichlobenil at 10.0 p.p.m.w. decreased the yields.

Again, alfalfa appeared less tolerant than sugarbeets to dichlobenil. Although dichlobenil at 0.1 or 1.0 p.p.m.w. did not reduce the yields of alfalfa, the treatment at 10.0 p.p.m.w. decreased yields considerably in 1963 (table 8). Alfalfa yields were normal on all plots in 1964.

Disodium salt of endothall.—Disodium salt of endothall at 10.0 p.p.m.w. in 1.79 acre-inches of irrigation water did not affect the yield of either sugarbeets or alfalfa (table 7 and 8).

INVESTIGATIONS IN ARIZONA

The tolerance of cotton (Acala 44) to the potassium salt of picloram in irrigation water was studied near Tolleson, Ariz., in 1963 through 1966. Other chemicals included in the experiments were the sodium salt of fenac in 1963 and 1964, the monoamine salt of endothall in 1965, and the dimethylamine salt of dicamba in 1965 and 1966. In these experiments, the chemicals were applied by flood irrigation, rather than by furrow irrigation as in Montana and Washington.

Methods and Materials

The soil, Cajon silty clay loam, was composed of 23 percent sand, 53 percent silt, and 24 percent clay.

Each plot contained 3 rows of cotton, 40 inches apart and 30 feet long (84 plants per plot). Data on time and rate of application for each chemical in each experiment and related information are presented in table 9. All treatments were made at random within each block and replicated three times.

The chemicals were first diluted with 1 or more quarts of water and then metered from a constant-head vessel into the irrigation water as it flowed onto each plot. Each plot was surrounded by small dikes to contain the water.

Cotton from the middle row of each plot usually was picked in September and again in November or early December. Yields were computed as pounds of seed cotton per acre.

Results and Discussion

Fenac.—Sodium salt of fenac, applied at 0.1 p.p.m.w. in 12 acre-inches of irrigation water 7 to 10 days before planting cotton, somewhat reduced seedling emergence and vigor of young plants. First-pick yields were reduced in the 1964 experiment but not in the 1963 experiment (table 10). When the second-pick yields were included, total yields from plots treated at 0.1 p.p.m.w. and from untreated check plots did not differ significantly in either experiment.

Similar treatments at 0.5 and 1.0 p.p.m.w. in 1963 and at 0.3 and 0.5 p.p.m.w. in 1964 reduced seedling emergence considerably and retarded the growth of surviving plants. First-pick yields were reduced significantly. However, plants recovered markedly after the first-pick. Only treatments of 1.0 p.p.m.w. significantly reduced second-pick yields. Only treatments at 0.5 p.p.m.w. or more reduced total yields in either 1963 or 1964.

Picloram.—Injury symptoms were noted in the foliage of cotton plants within about 4 days after the plots had been treated with picloram during the second or third irrigation. On plots treated at 0.04 p.p.m.w. (0.03 lb./acre), the foliage tended to droop or bend downward, the leaves were slightly malformed (cupped), and some chlorosis was observed. However, such symptoms were only

TABLE 9.—*Data for herbicides applied in irrigation water in experiments on cotton from 1963 to 1966 in Arizona*

Chemical	Time of application: Date	Time of application: Irrigation	Air temperature	Average height of crop	Quantity per acre: Chemical	Quantity per acre: Chemical	Quantity per acre: Water
			°F.	*Inches*	*P.p.m*	*Pounds*	*Inches*
Picloram [1]	6-14-63	2d	90	11	0.04	0.03	3
Do	6-14-63	2d	90	11	.09	.06	3
Do	6-14-63	2d	90	11	.18	.12	3
Do	6-28-64	3d	98	16	.04	.03	3
Do	6-28-64	3d	98	16	.09	.06	3
Do	6-28-64	3d	98	16	.18	.12	3
Do	7- 1-65	3d	100	12	.04	.03	3
Do	7- 1-65	3d	100	12	.09	.06	3
Do	7- 1-65	3d	100	12	.18	.12	3
Do	6-14-66	2d	105	12	.04	.03	3
Do	6-14-66	2d	105	12	.09	.06	3
Do	6-14-66	2d	105	12	.18	.12	3
Fenac [2]	3-29-63	Preplant [3]	74		.1	.27	12
Do	3-29-63	do [3]	74		.5	1.35	12
Do	3-29-63	do [3]	74		1.0	2.70	12
Do	3-25-64	do [3]	60		.1	.27	12
Do	3-25-64	do [3]	60		.3	.81	12
Do	3-25-64	do [3]	60		.5	1.35	12
Endothall [4]	5-28-65	1st	94	3			
Do	6-22-65	2d	98	7.5			
Do	7- 6-65	3d	103	13			
Do	7-19-65	4th	100	18	[5] 10.0	[5] 6.79	[5] 3
Do	8- 2-65	5th	102	24			
Do	8-16-65	6th	99	30			
Do	6-22-65	2d	98	7.5	3.0	2.04	3
Do	6-22-65	2d	98	7.5	10.0	6.79	3
Do	6-22-65	2d	98	7.5	[5] 3.0	[5] 2.04	[5] 3
Do	7-19-65	4th	100	18			
Do	6-22-65	2d	98	7.5	[5] 10.0	[5] 6.79	[5] 3
Do	7-19-65	4th	100	18			
Dicamba [6]	7- 1-65	3d	103	12	.04	.03	3
Do	7- 1-65	3d	103	12	.09	.06	3
Do	7- 1-65	3d	103	12	.18	.12	3
Do	6-14-66	2d	106	12	.18	.12	3
Do	6-14-66	2d	106	12	.33	.25	3
Do	6-14-66	2d	106	12	.66	.50	3

[1] Potassium salt of picloram.

[2] Sodium salt of fenac.

[3] Cottonseed was planted from 7 to 10 days after the irrigation with herbicide-treated water.

[4] Monoamine salt of endothall.

[5] The same treatments were made on the same plots at each irrigation.

[6] Dimethylamine salt of dicamba.

TABLE 10.—*Effect on yields of cotton of applying sodium salt of fenac in irrigation water in Arizona*

Date of treatment and fenac concentration [1]	Yield of seed cotton per acre [2]		
	First pick	Second pick	Total
	Pounds	*Pounds*	*Pounds*
March 29, 1963:			
No chemical (check)	1,080a	1,970a	3,050a
0.1 p.p.m.w. (0.27 lb./acre)	740a	1,890a	2,630a
0.5 p.p.m.w. (1.35 lb./acre)	130 b	1,060ab	1,190 b
1.0 p.p.m.w. (2.70 lb./acre)	70 b	490 b	550 b
March 25, 1964:			
No chemical (check)	1,170a	2,960a	4,130a
0.1 p.p.m.w. (0.27 lb./acre)	670 b	2,830a	3,490a
0.3 p.p.m.w. (0.81 lb./acre)	250 bc	2,530a	2,780ab
0.5 p.p.m.w. (1.35 lb./acre)	50 c	1,470a	1,520 b

[1] Applied in 12 acre-inches of water by flood irrigation near Tolleson, Ariz., late in March of 1963 and of 1964, from 7 to 10 days before the cotton crop was planted.

[2] Any 2 figures in the same column and year that are not followed by the same letter are significantly different at the 5-percent level of probability, except those under 2d pick for 1963, which are significantly different at the 10-percent level, as determined by Duncan's multiple-range test.

temporary, and the plants recovered rapidly. Maturity was not delayed, and seed cotton yields were not reduced significantly by such treatments in any of the experiments (table 11).

On plots treated at 0.09 or 0.18 p.p.m.w. (0.06 or 0.12 lb./acre), the injury symptoms were similar to those described in the preceding paragraph, but more pronounced and severe. In the 1963 experiment, when treatments were made during the second irrigation, some of the plants were killed and first-pick yields were reduced. However, recovery of the surviving plants was remarkable, and the differences in second-pick yields were not statistically significant. Only the treatment at 0.18 p.p.m.w. reduced total yield.

In the 1964 and 1965 experiments, when treatments were made during the third irrigation, only the treatment at 0.18 p.p.m.w. reduced first-pick yields. None of the treatments reduced second-pick or total yields. Actually, second-pick yields were increased significantly on plots treated at 0.09 or 0.18 p.p.m.w. in 1965.

In 1966, pink bollworm damaged the cotton during the latter part of the season. Thus, only the yields from the first-pick are presented (table 11). Yields tended to decrease as the rate of treatment increased. However, variability and two missing plot samples contributed to a large error factor, and any statistically significant difference in yields was masked, even at the 10-percent level of probability.

Monoamine salt of endothall.—Only treatments at 10 p.p.m.w. during the first irrigation (May 28) produced visible symptoms of injury in cotton plants 4 to 6 inches tall. The foliage of such plants was desiccated only if submerged in the treated water. Plant growth was not retarded, and seed cotton yields were not reduced, with as many as six treatments at 10 p.p.m.w. (total 40.73 lb./acre) during the season (table 12).

Dicamba.—Applications of dicamba at 0.04, 0.09, and 0.18 p.p.m.w. during the third irrigation (July 1) slightly malformed some leaves on a few cotton plants. However, seed cotton yields were not reduced by any of the treatments (table 13).

TABLE 11.—*Effect on yields of cotton of applying potassium salt of picloram in irrigation water in Arizona*

Date of treatment, irrigation number, and picloram concentration [1]	Yield of seed cotton per acre [2]		
	First pick	Second pick	Total
	Pounds	*Pounds*	*Pounds*
June 14, 1963, 2d irrigation:			
No chemical (check)	1,080a	1,970a	3,050a
0.04 p.p.m.w. (0.03 lb./acre)	980ab	2,100a	3,080a
0.09 p.p.m.w. (0.06 lb./acre)	620 b	1,930a	2,550a
0.18 p.p.m.w. (0.12 lb./acre)	120 c	1,360a	1,480 b
June 28, 1964, 3d irrigation:			
No chemical (check)	1,170a	2,960a	4,130a
0.04 p.p.m.w. (0.03 lb./acre)	920a	3,020a	3,940a
0.09 p.p.m.w. (0.06 lb./acre)	890a	2,960a	3,850a
0.18 p.p.m.w. (0.12 lb./acre)	300 b	3,260a	3,570a
July 1, 1965, 3d irrigation:			
No chemical (check)	1,750a	1,960a	3,700a
0.04 p.p.m.w. (0.03 lb./acre)	1,770a	2,180a	3,950a
0.09 p.p.m.w. (0.06 lb./acre)	1,400a	2,600 b	4,000a
0.18 p.p.m.w. (0.12 lb./acre)	550 b	2,840 b	3,380a
June 14, 1966, 2d irrigation:			
No chemical (check)	1,730a		
0.04 p.p.m.w. (0.03 lb./acre)	1,410a		
0.09 p.p.m.w. (0.06 lb./acre)	1,340a		
0.18 p.p.m.w. (0.12 lb./acre)	1,200a		

[1] Applied in 3 acre-inches of water during the 2d or 3d flood irrigation near Tolleson, Ariz., in 1963 through 1966. See table 9 for height of cotton plants on given dates.

[2] Any 2 figures in the same column and year that are not followed by the same letter differ significantly at the 5-percent level of probability, as determined by Duncan's multiple-range test.

TABLE 12.—*Effect on yields of cotton of applying monoamine salt of endothall in irrigation water in Arizona*

Treatment data: Date	Irrigation number	Endothall [1]: Per treatment	Endothall [1]: Total	Yield of seed cotton per acre [2]
		P.p.m.w.	*Lb./A.*	*Pounds*
		None (check)	0	3,290
May 28	1st	[3] 10	40.73	3,190
June 22	2d			
July 6	3d			
July 19	4th			
Aug. 2	5th			
Aug. 16	6th			
June 22	2d	3	2.04	2,880
June 22	2d	10	6.79	3,310
June 22	2d	[3] 3	4.08	3,300
July 19	4th			
June 22	2d	[3] 10	13.58	3,050
July 19	4th			

[1] Applied in 3 acre-inches of water during various flood irrigations near Tolleson, Ariz., in 1965. See table 9 for height of cotton plants on given dates.

[2] Yield differences were not significant at the 5-percent level of probability.

[3] The same treatments were made on the same plots at each irrigation.

TABLE 13.—*Effect on yields of cotton of applying dimethylamine salt of dicamba in irrigation water in Arizona*

Date of treatment, irrigation number, and dicamba concentration [1]	Yield of seed cotton per acre [2]: First pick	Second pick	Total
	Pounds	*Pounds*	*Pounds*
July 1, 1965, 3d irrigation:			
No chemical (check)	1,750	1,960	3,700
0.04 p.p.m.w. (0.03 lb./acre)	1,850	1,870	3,720
0.09 p.p.m.w. (0.06 lb./acre)	1,900	1,880	3,780
0.18 p.p.m.w. (0.12 lb./acre)	1,880	2,170	4,040
June 14, 1966, 2d irrigation:			
No chemical (check)	1,780		
0.18 p.p.m.w. (0.12 lb./acre)	1,340		
0.33 p.p.m.w. (0.25 lb./acre)	1,440		
0.66 p.p.m.w. (0.50 lb./acre)	1,150		

[1] Applied in 3 acre-inches of water during the 2d or 3d flood irrigations near Tolleson, Ariz., in 1965 and 1966, when cotton plants averaged 12 inches in height.

[2] Yield differences were not significant at the 5-percent level of probability.

In 1966, applications at 0.18, 0.33, and 0.66 p.p.m.w. during the second irrigation (June 14) malformed foliage considerably, especially at the higher rates. Numerous squares became desiccated and were shed.

First-pick yields tended to decrease with the increase in treatment rate. However, the large error factor that resulted from missing plot samples and yield variability masked any statistical significance in yield differences. Pink bollworm destroyed the late-season bolls. Therefore, the cotton was picked only once.

SUMMARY AND CONCLUSIONS

The response of one or more crops to three or more herbicides in irrigation water was studied in field experiments at Prosser, Wash. (1962-64), Bozeman, Mont. (1963-64), and Tolleson, Ariz. (1963-66).

At Prosser and Bozeman, the crops were furrow-irrigated during early growth with various concentrations of the chemical in the equivalent of 2 and 1.79 acre-inches of water, respectively. By use of a split-plot design, the same irrigations also were tested as preplanting treatments at Prosser.

At Tolleson, cotton was flood-irrigated with several concentrations of the chemical in equivalents of 3 or 12 acre-inches of water. The number of applications ranged from one before planting to as many as six during the season after seedling emergence.

In Washington, applications of fenac at 0.1 p.p.m.w. (0.045 lb./acre) injured young soybeans and sugarbeets and reduced the quality of soybean seed, but did not reduce yields of either crop. At 1.0 p.p.m.w. (0.45 lb./acre), fenac severely injured or killed young soybeans, and few marketable seeds were produced. Similar treatments injured sugarbeets, but the yields were not reduced significantly. At 10.0 p.p.m.w. (4.5 lb./acre), all soybeans were killed, but corn was injured only temporarily and its yield was not reduced.

In Montana, fenac at 1.0 or 10.0 p.p.m.w. (0.45 or 4.56 lb./acre) injured the plants and reduced the yields of sugarbeets and alfalfa. At 0.1 p.p.m.w. (0.04 lb./acre), the yields were not reduced. In 1964, yields of alfalfa were reduced only on plots that had been treated the previous year with fenac at 10.0 p.p.m.w.

In Arizona, fenac applied before planting at 0.1 p.p.m.w. (0.27 lb./acre) in 12 acre-inches of water reduced first-pick yields of seed cotton in 1964, but not in 1963. Total yields were not reduced in either year by such treatments. Similar applications at 0.3, 0.5, or 1.0 p.p.m.w. (0.81, 1.35, or 2.70 lb./acre) reduced seedling emergence and first-pick yields in both years. The concentration of 1.0 p.p.m.w. reduced second-pick yields. Only treatments at 0.5 p.p.m.w. or more reduced total yields in either 1963 or 1964.

In Washington, applications of dichlobenil at 0.1 or 1.0 p.p.m.w. injured young soybeans and reduced seed quality in at least one experiment, but did not reduce seed yields in either experiment. Similar applications apparently did not affect sugarbeets or field corn. Dichlobenil at 10.0 p.p.m.w. killed 2 percent of the plants and reduced the yield of soybeans, but did not reduce the yield of corn.

Applications of fenac or dichlobenil in Washington at 0.1 p.p.m.w. before planting generally delayed emergence of sugarbeets and soybeans, but did not reduce the stands or fresh weights of 4-week-old sugarbeets or corn. At this concentration, dichlobenil did not delay emergence of soybeans, and neither chemical delayed emergence of corn. Fenac or dichlobenil at 1.0 p.p.m.w. delayed emergence, reduced stands, and decreased fresh weights of the sugarbeets and soybeans. Similar treatments did not reduce stands of corn, but decreased the fresh weights. Fenac or dichlobenil at 10.0 p.p.m.w. reduced the stands of soybeans about 90 and 50 percent, respectively.

Within the limits of detection (0.05 p.p.m.), no dichlobenil or 2,6-DCBA (possible metabolite of dichlobenil) residues were found in mature sugarbeets or corn after early-season treatments at 0.1 or 1.0 p.p.m.w. in 1963.

In Montana, dichlobenil decreased the yields of sugarbeets and alfalfa at 10.0 p.p.m.w., but not at 0.1 or 1.0 p.p.m.w. After the dichlobenil treatments in 1963, yields on all alfalfa plots were normal in 1964.

In Washington, young sugarbeets apparently were unaffected by applications of monoamine salt of endothall at 1.0 or 25 p.p.m.w. (0.45 and 11.25 lb./acre, respectively). At 25 p.p.m.w., corn was injured only slightly and temporarily, and yields were not reduced. Although treatments at 1.0 p.p.m.w. caused some temporary drooping, and treatments at 25 p.p.m.w. killed 9 percent of the soybean plants, seed yields were not significantly reduced.

In Washington, applications of monoamine salt of endothall at 1.0 or 25 p.p.m.w. before planting did not reduce stands or fresh weights of 6-week-old soybeans and corn. No symptoms of injury were noted in the foliage of sugarbeet seedlings. However, with treatments at 25 p.p.m.w., the stand and fresh weight of the young plants were decreased significantly at the 5- and 10-percent levels of probability, respectively.

Disodium salt of endothall at 10.0 p.p.m.w. did not affect the yields of sugarbeets or alfalfa in Montana.

In Arizona, leaves of young cotton were desiccated if submerged in water treated with the monoamine salt of endothall at 10.0 p.p.m.w. (6.79 lb./acre). However, plant growth was not retarded, and seed-cotton yields were not reduced by as many as six treatments applied at 10.0 p.p.m.w. (total 40.73 lb./acre) during the season.

Picloram applied at 0.04 p.p.m.w. (0.03 lb./acre) during the second or third flood irrigation injured cotton temporarily, but did not reduce yields in any of the experiments in Arizona. Treatments at rates of 0.09 or 0.18 p.p.m.w. (0.06 or 0.12 lb./acre) during the second irrigation killed some plants and reduced first-pick yields in 1963. Second-pick yields were not reduced significantly, and only the treatment at 0.18 p.p.m.w. reduced total yield. In 1964 and 1965, picloram applied at 0.18 p.p.m.w. during the third irrigation reduced first-pick yields. The same or lesser concentrations did not reduce second-pick or total yields.

In Arizona, dicamba applied at 0.04, 0.09, or 0.18 p.p.m.w. (0.03, 0.06, or 0.12 lb./acre) during the third irrigation caused slight malformation of a few cotton leaves but did not reduce seed cotton yields in 1965. In 1966, numerous squares became desiccated and were shed after treatments with concentrations as high as 0.66 p.p.m.w. (0.50 lb./acre) during the second irrigation. Pink bollworm damage and variability between plots probably masked any significance in the yield differences.

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