THE EFFECT OF 4-(2,4-DICHLOROPHENOXY) BUTYRIC ACID ON ALFALFA, COWPEAS, GUAR, MUNGBEANS, PEANUTS, SAFFLOWER AND SESAME

By

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INTRODUCTION

Weed control is no longer accomplished by the costly process of hoeing. With the introduction of a new selective herbicide, 2,4-D (2,4-dichlorophenoxy acetic acid), over a decade ago a new field in agriculture was opened and many new herbicides are becoming available.

However each new chemical must be carefully tested not only in its ability to control weeds but also in its effect upon the various crops. Members of the same botanical family may vary in tolerance to a chemical from almost complete resistance to almost complete susceptibility.

The present government acreage allotments on wheat, cotton, peanuts and corn have put increased emphasis on other crops that can be grown in this climate. Many herbicides are available for use on wheat, cotton and corn, but very few have been found to be useful as post emergence sprays on alfalfa, Medicago sativa; mungbeans, Phaseolus aureus; cowpeas, Vigna sinensis; guar, Cyamopsis tetragonoloba; peanuts, Arachis hypogaea; sesame, Sesamum indicum; and safflower, Carthamus tinctorius.

A new herbicide, 4-(2,4-dichlorophenoxy) butyric acid, has recently been released and has been tested on several weed species

and some crops in an effort to find its potential as an herbicide.

The purpose of this study was to determine if 4-(2,4-DB) could be safely applied as a post-emergence spray on those crops mentioned above and the rate of application the crop could withstand without significant reduction in yield.

REVIEW OF LITERATURE

While 4-(2,4-DB) has only been recently introduced as an herbicide it was tested by Synerholm (16) [1] as early as 1947 as a plant growth regulator on tomato, Lycopersicon esculentum, and found to be somewhat active in producing growth.

The discovery of 4-(2,4-DB) as a selective weed killer resulted from research at the Agricultural College of Wye, England, in 1954 by Wain (23). This research was started primarily with the object of showing that a basic chemical process called beta-oxydation known to occur in the living animal also occurs within plant tissues. Beta-oxydation is the process accomplished by specific enzymes whereby acid molecules are progressively broken with a loss at each stage of a fragment containing two carbon atoms. Results from various tests showed that different plants varied in their reaction to certain chemicals indicating that species which did not possess the enzyme system to break down the chemical would remain unharmed. Chemically 4-(2,4-DB) is related with 2,4-D and the tests indicated that 4-(2,4-DB) owed its weed-killing properties to the fact that susceptible plants possess the appropriate enzymes to convert it to 2,4-D. However, the beta-oxydation theory presented does not account for all the facts and

[1] Figures in parenthesis refer to Literature Cited.

further research in the physiology of the treated plants is needed.

Work done by Brown (1) indicates that 4-(2,4-DB) may be used satisfactorily for control of broadleaf weeds in alfalfa and white sweetclover, Melilotus alba. The highest rate used was $\frac{1}{2}$ pound per acre. In comparison with other herbicides 4-(2,4-DB) gave the least damage to the alfalfa and sweetclover but required a higher rate per acre to be effective on the weeds. In general the degree of weed kill paralleled the degree of injury to the legumes. Weeds controlled were lambsquarters, Chenopodium album; pigweed, Amaranthus retroflexus; peppergrass, Lepidium densiflorum; and shepherd's purse, Capsella bursa-pastoris.

Dowler and Willard (2) reported satisfactory results in weed control in birdsfoot trefoil, Lotus corniculatus, using up to 4 pounds of 4-(2,4-DB) per acre. The ester formulations affected both the weeds and trefoil more than the amines. Weeds controlled were lambsquarters; Pennsylvania smartweed, Polygonum pensylvanicum; and ladysthumb, Polygonum persicaria. Many of the tops of Canada thistle, Cirsium arvense, were killed, but the effect on the roots was not known.

Kerkin and Peters (6) received good results using up to 3 pounds per acre of 4-(2,4-DB) on alfalfa and birdsfoot trefoil. The 2,4-D was toxic to alfalfa but no more toxic than 4-(2,4-DB) on the trefoil. The 4-(2,4-DB) was only 1/3 as effective as comparable rates of 2,4-D on mustard and ragweed. However both herbicides were equally effective on lambsquarters.

Freeman and Taylor (5) found that 2 pounds per acre of 4-(2,4-DB) gave better results than 2,4-D on red clover, Trifolium pratense. The 4-(2,4-DB) was less toxic to the seedling plants although the vigor of the red clover was reduced somewhat.

Alsike clover, Trifolium hybridum, sprayed with 2 pounds per acre of 4-(2,4-DB) when in the 5 per cent bloom stage gave only a negligible reduction in seed yield as reported by Yeo and Dunham (25). The viability of the seed was not affected but 2½ pounds of 4-(2,4-DB) caused sweetclover blossoms to "strip off". The one pound per acre rate gave a good top kill on Canada thistle growing in the plots.

Variety number 39 canning peas were unaffected by ½ pound per acre of 4-(2,4-DB) as shown by Nylund and Nelson (11) although the one pound per acre of 4-(2,4-DB) tended to delay flowering slightly. The experiment was designed to test control of annual grasses on which 4-(2,4-DB) had very little effect.

Switzer (15) sprayed Perfection canning peas with ½ pound per acre 4-(2,4-DB) and reported no effect on the crop and poor weed control. Rates which had no effect on crops also gave poor weed control.

Molberg (8) found that ½ pound per acre of 4-(2,4-DB) on Selkirk wheat when the crop was in the two-leaf stage gave no reduction of seed yield.

Andrew oats, Avena sativa, were shown by Robinson, Jordan and Dunham (13) to be unaffected by 3/4 pound per acre of

4-(2,4-DB) when sprayed after one or two spikelets had emerged from the boot. All treatments controlled lambsquarters 100 per cent but the 4-(2,4-DB) worked more slowly than 2,4-D or MCP.

Noll (10) has shown that 2 pounds of 4-(2,4-DB) per acre as a pre-emergence spray in Fordhook 242 lima beans gave good weed control and increased the yield as compared to the untreated check plot. However the same experiment conducted on beets, Beta vulgaris, resulted in a significant reduction in yield.

Robinson, Jordan and Dunham (12) reported that Marine flax, Linum usitatissimum, sprayed when 6 inches tall with 3/8 pound per acre of 4-(2,4-DB) (amine form) resulted in a decreased straw yield. This was essentially the same as resulted from 2,4-D (amine form) at the same rate.

Sexsmith (14) in studying the effect of 4-(2,4-DB) on several crops found that severe injury resulted to table and sugar beets, and moderate injury occurred on potatoes, Solanum tuberosum; green beans and dry beans, Phaseolus vulgaris; and carrots, Daucus carota. The following crops were unharmed by the rate of one pound per acre of 4-(2,4-DB): cumcumber, Cucumis sativus; canning pea, Pisum sativum; commercial yellow mustard, Brassica juncea; flax, Linum usitatissimum; barley, Hordeum sativum; wheat, Triticum vulgare; and corn, Zea mays.

The following list of weeds have been reported by the various workers (1, 2, 3, 8, 17, 19, 22, 24) as being satisfactorily controlled with 1 to 2 pounds per acre of 4-(2,4-DB):

Canada thistle	Cirsium arvensis
Cocklebur	Xanthium spp.
Kochia	Kochia scoparia
Ladysthumb	Polygonum persicaria
Lambsquarters	Chenopodium album
Marsh elder	Iva xanthifolia
Mouse-ear povertyweed	Eva axillaris
Pennsylvania smartweed	Polygonum pensylvanicum
Peppergrass	Lepidium densiflorum
Rough pigweed	Amaranthus retroflexus
Russian knapweed	Centaurea picris
Shepherd's purse	Capsella bursa-pastoris
Wild mustard	Brassica kaber

As the weed grows older it rapidly develops a tolerance to the herbicide and it was generally agreed that a young weed plant, 2-4 inches, is more susceptible to the chemical than an older one.

The following weeds have been reported by workers (4, 7, 9, 18, 20, 21) as consistently giving poor results to applications of 2 pounds per acre or higher of 4-(2,4-DB):

Field bindweed	Convolvulus arvensis
Halogeton	Halogeton glomeratus
Leafy spurge	Euphorbia esula
Niggerhead	Rudbeckia occidentalis
Whitetop	Cardaria draba
Wild buckwheat	Polygonum convolvulus

MATERIALS AND METHODS

This study was conducted at the Oklahoma Agronomy Research Station, Stillwater, on a fairly uniform Norge loam soil with a 3 to 5 per cent slope. A good seedbed was prepared by plowing, disking and harrowing, and 250 pounds of 13-39-0 fertilizer were broadcast on the area just prior to planting on June 10.

Rainfall from June 1 to October 1 amounted to 20.17 inches and irrigation with a sprinkler system was applied when necessary for optimum growing conditions. The plots were kept free of weeds by hand hoeing from the time of emergence through harvest so that a reduction in yield would be due to variances in spray tolerance and not through weed competition.

The herbicides used in this experiment were 2,4-dichlorophenoxy acetic acid (amine form) and 4-(2,4-dichlorophenoxy) butyric acid. These herbicides contained 4 and 2 pounds of acid equivalent per gallon respectively. A knapsack sprayer equipped with a one foot boom, having two Teejet nozzels, number 65015, was used. The spray was applied at a rate of 40 gallons of water per acre with an air pressure of 30 pounds per square inch being maintained during the spraying process. Spraying was done when the wind was at a minimum so as to assure as uniform an application as possible. Observations

were made each day for 10 days following treatments.

The following varieties were used: alfalfa, Buffalo; cowpeas, Victor K-798; guar, Texsel; mungbeans, Purdue 2-2 Composite; peanuts, Argentine; safflower, N-10; and sesame, Dulce.

A completely randomized design was used for the alfalfa, cowpeas, guar, mungbeans, peanuts and sesame with five replications of each treatment. Each plot consisted of four rows 20 feet long and the data was collected from the two center rows thus allowing a row on each side for border effect and spray drift. The treatments were $\frac{1}{2}$, 1, $1\frac{1}{2}$ and 2 pounds per acre of 4-(2,4-DB), $\frac{1}{2}$ pound per acre of 2,4-D and the check which received no treatment. The forage yield of cowpeas, guar, mungbeans and peanuts was clipped with a Jari sickle type mower and the weights recorded in pounds at the time of harvest. A sample from each replication within a treatment was placed in a bag and weighed. This bag was then placed in a drying oven for three days, then weighed and the per cent dry matter of each treatment was calculated. The pounds of dry weight for each plot were then calculated using the per cent dry matter for each treatment.

The two clippings of alfalfa were handled in a similar manner as the other forage clippings except that the weights were recorded in grams and the entire length of the plot was harvested.

Seed yields in guar, peanuts and mungbeans were obtained by hand harvesting the plants and threshing with a nursery thresher after the plants had dried.

A poor stand of the safflower was obtained and to utilize it in the experiment a change was made from the original plan. A randomized block design was used with each plot having four rows 15 feet long. The treatments were $\frac{1}{2}$, 1 and $1\frac{1}{2}$ pounds per acre of 4-(2,4-DB), $\frac{1}{2}$ pound per acre of 2,4-D and the check which received no treatment. Four replications of each treatment were used.

RESULTS AND DISCUSSION

Alfalfa

The alfalfa was sprayed on July 8 when the plants were 7 to 8 inches tall and contained 6 to 7 leaves. The 2,4-D treatment rapidly wilted the plants and resulted in a severe reduction in stand, vigor and yield. The two pound rate of 4-(2,4-DB) displayed some wilting but much less than the 2,4-D, but 48 hours later they had fully recovered without damage to the yield.

The first cutting was taken on August 5 and a second cutting was made on September 25 to ascertain that there were no delayed detrimental effects from the chemical. The mean of both forage yields is shown in Table I and revealed no significant difference between the mean of the check and the 4-(2,4-DB) treatments. The 2,4-D treatment was significantly lower than the check.

Guar

The guar was sprayed on July 5 when the plants were four inches tall and contained 5 to 8 leaves. Within 24 hours all treated plots had wilted but the 2,4-D plots were the most severely affected. The 4-(2,4-DB) recovered rapidly and four days later the only indication of a treatment was the somewhat darker green color of the check plots.

TABLE I

Multiple Range Test [X] of Mean Alfalfa Forage Yield in Pounds of Dry Weight Per Acre

Treatments	½ lb. 2,4-D	Check	½ lb. 4-(2,4-DB)	2 lbs. 4-(2,4-DB)	1½ lbs. 4-(2,4-DB)	1 lb. 4-(2,4-DB)
Means	349	1615	1629	1704	1712	1734
5% level						

TABLE II

Multiple Range Test [X] of Mean Guar Forage Yield in Pounds of Dry Weight Per Acre

Treatments	½ lb. 2,4-D	1 lb. 4-(2,4-DB)	2 lbs. 4-(2,4-DB)	½ lb. 4-(2,4-DB)	1½ lbs. 4-(2,4-DB)	Check
Means	1089	2156	2570	2592	2614	2875
5% level						

TABLE III

Multiple Range Test [X] of Mean Guar Seed Yield in Pounds Per Acre

Treatments	½ lb. 2,4-D	½ lb. 4-(2,4-DB)	Check	1 lb. 4-(2,4-DB)	1½ lbs. 4-(2,4-DB)	2 lbs. 4-(2,4-DB)
Means	922	1023	1306	1450	1493	1546
5% Level						

[X] Any two means underscored by the same line are not significantly different.

The 2,4-D treatment was much slower in recovering taking approximately 10 days to resume normal appearance and resulted in a stunted growth. The plants had wilted to the ground and then recovered. The base of the stems was much enlarged and throughout the rest of the season the plants were 5 to 6 inches shorter than the check and 4-(2,4-DB) treatments.

A forage yield was clipped on August 4 and the results are shown in Table II. The check gave the highest forage yield but the $\frac{1}{2}$, $1\frac{1}{2}$ and 2 pound per acre rates of 4-(2,4-DB) were not significantly different from the check. The seed yields revealed no significant difference between the check and the 4-(2,4-DB) treatments (Table III). The 2,4-D treatment was significantly lower than the check in both forage and seed yield.

Peanuts

On July 5 when the plants were five inches high and contained 3 to 6 leaves, the peanuts were sprayed. Only the 2,4-D and two pounds per acre of 4-(2,4-DB) affected the plants lightly and the other treatments displayed negligible evidence of being sprayed.

The entire lot was attacked by thrips and was sprayed on July 8 at the rate of four ounces of dieldrin per acre.

Within five days after the plots were treated with 4-(2,4-DB) the plants had fully recovered and eight days after the treatment the 2,4-D plots had recovered. The only visible evidence of damage was that the 2,4-D plots were slightly shorter in plant height.

The results of the forage clipping on August 5 are shown in Table IV. The 2,4-D treatment had the lowest yield but was not significantly different from the check.

The peanut seed yields were not analyzed because of severe Cotton rat damage to many of the plots.

Cowpeas

The cowpeas were treated on July 5 when the plants were 10 inches tall and contained 3 to 5 leaves. Within 12 hours all sprayed plots were severely affected as indicated by the flaccid drooping plants. Eight days after the application of the herbicides the 2,4-D and the $\frac{1}{2}$ pound per acre of 4-(2,4-DB) treatments were beginning to recover but were stunted too much to ever produce a satisfactory yield. The other treated plots were characterized by stiff, brittle leaves with a yellow and bronze coloring.

A damage characteristic to all treated plots was an enlarged stem at the base of the plant. The basal enlargement was 2 to 4 inches long and 2 to 3 times the normal stem diameter and was also woody and hard.

The means from the forage yield taken on August 4 are shown in Table V. The 2,4-D treatment yielded more than each of the 4-(2,4-DB) treatments but produced 44 per cent less than the check. The check plots grew vigorously and vined out over their adjacent plots. Seed yields were not obtained because it was difficult to distinguish between the entangled rows. A close examination revealed that the sprayed plots were stunted, lacked branching

TABLE IV

Multiple Range Test [X] of Mean Peanut Forage Yield in Pounds of Dry Weight Per Acre

Treatments	½ lb. 2,4-D	2 lbs. 4-(2,4-DB)	Check	½ lb. 4-(2,4-DB)	1½ lbs. 4-(2,4-DB)	1 lb. 4-(2,4-DB)
Means	1579	1794	1921	2131	2303	2304
5% Level						

TABLE V

Multiple Range Test [X] of Mean Cowpea Forage Yield in Pounds of Dry Weight Per Acre

Treatments	1½ lbs. 4-(2,4-DB)	2 lbs. 4-(2,4-DB)	1 lb. 4-(2,4-DB)	½ lb. 4-(2,4-DB)	½ lb. 2,4-D	Check
Means	305	331	545	1255	1955	3476
5% Level						

TABLE VI

Multiple Range Test [X] of Mean Mungbean Forage Yield in Pounds of Dry Weight Per Acre

Treatments	1½ lbs. 4-(2,4-DB)	2 lbs. 4-(2,4-DB)	1 lb. 4-(2,4-DB)	½ lb. 4-(2,4-DB)	Check	½ lb. 2,4-D
Means	1244	1306	1351	1970	2190	2234
5% Level						

[X] Any two means underscored by the same line are not significantly different.

and consequently had few seed pods.

Mungbeans

The mungbeans were sprayed on July 5 when the plants were 6 to 8 inches tall and contained 3 to 5 leaves. Within 24 hours all treated plots were severely wilted and six days later the leaves had begun to turn yellow and bronze. At this time a hard, wind driven rain carrying some hail struck resulting in defoliation of the brittle, yellow and bronze leaves. The root system was not killed and a new growth of foliage resulted from the treated plots.

The mean of the forage yield which was clipped on August 5 is shown in Table VI. A multiple range test revealed no significant difference between the means of the check, $\frac{1}{2}$ pound per acre of 4-(2,4-DB) and 2,4-D. The results of the 2,4-D treatment were surprising since it yielded more than the check however the quality of the forage was definitely lower. The enlarged basal portions of the stems undoubtedly played an important role in the high yield. The forage yield means for the 1, $1\frac{1}{2}$ and 2 pounds per acre rates of 4-(2,4-DB) were significantly lower than the check.

The mean seed yields shown in Table VII indicate a significant reduction compared with the check for all the treated plots. The check plots were picked on August 15, September 2 and September 24 to obtain the total yield as the pods matured. Spraying delayed the maturity 12 days for the $\frac{1}{2}$ pound per acre of 4-(2,4-DB) and the 2,4-D. These two treatments were hand

TABLE VII

Multiple Range Test of Mean Mungbean Seed Yield in Pounds Per Acre

Treatments	1 lb. 4-(2,4-DB)	2 lbs. 4-(2,4-DB)	1½ lbs. 4-(2,4-DB)	½ lb. 4-(2,4-DB)	½ lb. 2,4-D	Check
Means	418	456	533	634	879	1402
5% Level						

Any two means underscored by the same line are not significantly different.

TABLE VIII

Number of Sesame Plants Per Plot and the Treatment Means

	Check	½ lb. 2,4-D	½ lb. 4-(2,4-DB)	1 lb. 4-(2,4-DB)	1½ lbs. 4-(2,4-DB)	2 lbs. 4-(2,4-DB)
	234	13	34	24	20	8
	202	16	47	17	18	4
	235	9	33	28	30	14
	225	16	47	36	10	21
	243	9	34	17	26	16
Mean	224	13	39	24	21	13

picked on August 27 and September 24. The maturity of the 4-(2,4-DB) treatments at 1, 1½ and 2 pounds per acre was delayed two weeks and when harvested the plants did not continue to bloom and produce seed.

Sesame

The sesame was sprayed on July 8 when the plants were 8 to 9 inches tall and contained 4 to 5 pairs of leaves. The 2,4-D treatment quickly affected the plants, characterized by drooping flaccid plants and eventually most of them died. The heavier rates of 4-(2,4-DB) quickly affected the plants and resulted in severe damage to the stand. The lighter rates of 4-(2,4-DB) gave a slower reaction but eventually killed many of the plants.

Table VIII contains a stand count taken of the mature plants. Since the few remaining plants in each plot were very productive because of the isolation effect with abundant moisture and fertility, a seed yield would have been misleading.

Safflower

The safflower was sprayed on July 8 and 12 hours later the 2,4-D treatment was definitely affected continuing to wilt until 10 days later it was completely dried up. The 4-(2,4-DB) treatments showed little sign of injury until three days after spraying when they eventually began to wilt. The 4-(2,4-DB) worked very slowly in the safflower but three weeks after the treatment all plants had died leaving only the check plots alive.

SUMMARY

The effect of 4-(2,4-DB) at rates up to two pounds per acre on various crops was studied in tests at the Oklahoma Agronomy Research Station, Stillwater, in 1958.

The treated plots of guar and alfalfa did not have a significant decrease in yield compared with the check plots although the guar did wilt immediately following the spraying. The yield results indicate that two pounds per acre of 4-(2,4-DB) can be used satisfactorily on guar and alfalfa. There is a strong possibility that 4-(2,4-DB) can be used with good results on peanuts since the forage yields displayed no significant decrease from the check. Unfortunately the seed yield was partially destroyed by rats and was too erratic for conclusive results.

The safflower was completely destroyed and the sesame suffered a major stand reduction with all rates of 4-(2,4-DB). Cowpeas and mungbeans were defoliated by each herbicidal treatment. The yields obtained from the treated plots were the results of a regrowth of foliage. Therefore the use of 4-(2,4-DB) as a post emergence spray for broadleaf weed control on safflower, sesame, cowpeas and mungbeans would be impractical.

The 2,4-D was used in this experiment as a check on the crop's reaction to 2,4-D as well as a comparison with 4-(2,4-DB) since 2,4-D is much less injurious to plants under certain climatic conditions. On the cowpeas and mungbeans the 4-(2,4-DB) was more injurious than 2,4-D. However on all other crops the 2,4-D was more destructive to the yield.

There was a variation in the crop's immediate reaction to the herbicide and the end result. Guar wilted rapidly but recovered quickly and suffered no significant reduction in yield. The sesame reacted somewhat slower than the guar and the safflower was very slow in reacting to 4-(2,4-DB) but both were severely injured.

One problem which was confronted throughout the experiment was with the weedy grasses. The 4-(2,4-DB) is effective only on broadleaf weeds and once these are removed the weedy grasses if present are likely to become a serious problem.

Wain (23) had postulated that the 4-(2,4-DB) owed its weed-killing properties to the fact that certain plants contain the enzyme to convert 4-(2,4-DB) to 2,4-D in a systematic breakdown in the plant. However the 4-(2,4-DB) in this experiment was more injurious to cowpeas and mungbeans than the 2,4-D.

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Personal data: Born August 3, 1934 at Lamont, Oklahoma, the son of John Paul and Ruth (deceased) McMurphy.

Education: Attended elementary school at Banner, District 94, near Lamont, Oklahoma, graduated from Lamont High School in 1952, received a Bachelor of Science degree from Oklahoma Agricultural and Mechanical College with a major in Agronomy in May, 1956, attended Graduate School at Oklahoma State University 1958 to 1959.

Experience: Reared on a farm, 2 years military service with a Commission in Infantry, Graduate Assistant in Agronomy Department at Oklahoma State University.