SOME EFFECTS OF ACTIVATED CHARCOAL ON SELECTED HERBICIDES

by

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INTRODUCTION

The adsorption of herbicides by activated charcoal has been known for many years. As early as 1947 and 1948 (Arle et al. 4 and Lucas et al. 10), inactivation of 2,4-D was achieved. At that time 2,4-D was the principle herbicide in use, but with the herbicides today that are highly persistent, it has become necessary to find methods to nullify these residues in specific cases. Herbicide residues can be deactivated with the high absorptive capacity of activated charcoal.

Activated charcoal is formed by heating the raw material to 1800 degrees Fahrenheit, then treating it with steam and air. A teaspoon of activated charcoal may have an adsorptive surface of approximately 20,000 square feet depending on the porosity of the charcoal. The high external and internal adsorptive areas of charcoal provide the mechanism by which activated charcoal adsorbs herbicide residue.

The area to be treated with activated charcoal is limited due to the expense. Activated charcoal costs from 15 to 20 cents a pound. To treat a given area the cost would be between 75 cents and 3 dollars a 1000 square feet. Because of the expense, generally only high value crops would be treated when necessary. Some areas that would fall into this catagory would be vegetable and fruit crops, turf, greenhouse and nursery areas. Expense of charcoal also depends on the method of application. Plant dips and band applications reduce the area to be treated.

In the last ten years there has been an increased interest in deactivation of herbicides. Studies have been made on specific herbicides, types of adsorbents, and methods of application. This study was designed to compare the amount of activated charcoal needed to deactivate different herbicides and the herbicide rates that these herbicides were applied.

REVIEW OF LITERATURE

Coffey and Warren (5) reported activated carbon was far superior to other adsorbents in the adsorption of most of the herbicides. Activated carbon had the highest inactivation capacity.

Jagschitz (6) reported satisfactory turf stands were obtained when 200 lb/A of activated charcoal was used in the seedbed 7 weeks after the application of Bandane, Bensulide, DCPA, H-9573, and SD-11831. Also activated charcoal at 200 lb/A eliminated harmful effects of 2,4-D, dicamba, mecoprop, picloram, and silvex when applied 6 days before planting.

Andersen (3) reported a marked reduction in injury on oats from simazine and linuron where charcoal was incorporated in the soil.

Aherns (2) reported activated carbon 100 to 400 times greater than applied amounts of simazine protected seeded oats and tomato plants from residues in the soil. Soil treated with atrazine or simazine at rates of 1 lb/A, a ratio of 200 parts of carbon to 1 part herbicide protected beans, tobacco, and cabbage from herbicide damage.

Locascio (9) reported dichlobenil was effectively inactivated by activated charcoal during germination and early growth of seeded crops and native grasses. Little difference in effectiveness of the 200 and 400 lb/A rates of activated charcoal was found in early stages, but later growth and yield of tomatoes and cucumbers were reduced at all rates of dichlobenil and activated charcoal.

Linscott and Hagin (8) reported that protection of alfalfa seedings from triazines could be achieved by a banded area of activated charcoal, at the rate of 175 lb/A of activated charcoal.

Leopold, Schaik, and Neal (7) reported the adsorption of various phenoxyacetic acids onto activated charcoal. Serial dilutions of radioactive 2,4-D were exposed to the carbon for five hours in a slurry solution and the radioactivity was measured.

Lucus and Hamner (10) observed that mixing 2,4-D at 1000 ppm of the active principle with 1 per cent activated charcoal prevented injury to 10 day old bean plants.

Ahrens (1) also observed that a pre-planting root dip in activated carbon protected strawberry, cabbage, privet and forsythia but not euonymus against low rates of simazine.

Schubert (11) reported that a root dip in activated charcoal protected strawberry plants from herbicide residues.

Arle, Leonard, and Harris (4) reported that dusting wetted sprouts of sweet potatoes with activated charcoal (1 lb/1000 sprouts) increased plant survival from 2,4-D injury when applied as a pre-emergence herbicide.

MATERIALS AND METHODS

This experiment was conducted in the fall of 1968 as a growth chamber study at Kansas State University. A randomized block design was used for the experiment with three observations per cell. Six herbicides at three rates of application and four rates of activated charcoal were used in the treatments.

A three to one mixture of sandy loam soil and horticulture grade peat moss was used in 4 by 5½ inch containers, two inches deep. The charcoal was applied as a slurry and mixed into the top inch of the soil after the herbicide treatment.

Charcoal was applied at the rates of 0, 5, 10, and 20 pounds per 1000 square feet. The six herbicides and rates are as follows:

1.	DCPA	12, 24, 36 lb/A
2.	Bensulide	15, 25, 35 lb/A
3.	Dichlobenil	10, 15, 20 lb/A
4.	Terbutol	12, 18, 24 lb/A
5.	Simazine	3, 9, 18 lb/A
6.	Dalapon	3, 6, 10 lb/A

All the experimental herbicides used in this study are listed in Table 1.

Missouri Oats 0-205 was used as the indicator plant in this study. The seeds (50 per pot) were planted two days after the charcoal and herbicide treatments. The plants were fertilized with a 4 per cent water soluble nitrogen fertilizer every seven days.

At five day intervals a count of per cent live plants was taken for each container. At the end of the 30 day period the plants were cut at ground level and randomly measured to determine height. The plants were then oven dried at 65 degrees Centigrade for 48 hours and dry weight was taken for each individual plot. Visual observations were taken on root inhibition by breaking up the soil after cutting the oats.

All data were analyzed statistically according to Snedecor (12). A three-way statistical design was used to compare charcoal, herbicides and blocks and their interactions.

Table 1. The experimental herbicides used in this study.

Common Name	Trade Name	Chemical Name
Bensulide	Betasan	S-(O-O-diisopropyl phosphorodithicate) of N-(2-mercapoethyl) benzene sulfonamide
Dalapon	Dowpon	2,2-dichloropropionic acid
DCPA	Dacthal	Dimethyl 2,3,5,6-tetrachloroterephthalate
Dichlobenil	Casoron	2,6-dichlorobenzonitrile
Terbutol	Azak	2,6-tert-butyl-p-toyl methyl carbamate
Simazine	Princep	2-chloro-4,6-bis(ethylamino)-S-triazine

EXPERIMENTAL RESULTS

Characteristics studied were: germination, per cent live plants, height, and dry weight of plants.

The analysis of variance (Table 9) for germination five days after planting indicated the main significant factor was the charcoal effect. There was a herbicide and interaction effect, but these were small compared to the charcoal effect. The overall effect (Table 2) on plots treated with charcoal showed that the 5, 10, and 20 lb/1000 square feet rates were significant in comparison with plots not treated with charcoal. The only herbicide that showed a definite pattern was dichlobenil. With each increase in rate of dichlobenil, a corresponding increase in charcoal rate was needed to nullify the herbicide effect on germination.

The analysis of variance (Table 10) for germination of oats 10 days after planting indicated the main significant factor was the charcoal effect. The increase in the F value of the herbicide effect is due to the lower plant population in pots receiving the different herbicides. An increased F value of the charcoal effect, 10 days after planting compared to 5 days after planting, is due to the increased germination at the higher levels of charcoal. There was a definite trend in the overall means (Table 3) of charcoal rates. The higher the rate of charcoal, the more significant the charcoal effect on germination. Dichlobenil continued to be the only herbicide that showed with each increase in rate of dichlobenil, a corresponding increase in charcoal rate was needed to deactivate the herbicide effect on germination.

The analysis of variance (Table 11) for germination 15 days after planting indicated the main significant factor also was the charcoal effect. There was an increase in the F values of the charcoal and herbicide effect 15 days after planting compared to 10 days after planting. Also there was an increase in the interaction of the two. There was a definite trend in the overall means (Table 4) of charcoal rates: the higher the rate of charcoal the more significant the charcoal effect on germination. Dichlobenil continued to be the only herbicide that showed with each increase in rate of dichlobenil a corresponding increase in charcoal rate was needed to deactivate the herbicide effect on germination.

The analysis of variance (Table 12) for per cent live plants 20 days after planting indicated the main significant factor was the charcoal effect. At this time data was changed from per cent germination to per cent live plants because the herbicides started to decrease plant populations at low charcoal levels; this is the reason why the F value for charcoal increased

Table 2. Germination of oats as affected by different rates of activated charcoal and herbicides. Counts were made 5 days from planting date.

Herbicide	Active ingredient lb/A	Charcoal lb/1000 sq.ft.				Mean
		0	5	10	20	
Check	-	40.0	44.7	64.7	43.3	48.2
DCPA	12	16.0	39.3	42.7	74.0	43.0
DCPA	24	13.3	36.7	61.3	44.7	39.0
DCPA	36	22.0	44.7	36.7	41.3	36.2
Bensulide	15	24.7	54.7	50.7	67.3	49.3
Bensulide	25	13.3	48.0	36.7	70.0	42.0
Bensulide	35	6.0	42.7	53.3	39.3	35.3
Dichlobenil	10	0	37.3	39.3	63.3	35.0
Dichlobenil	15	0	13.3	38.0	33.3	21.2
Dichlobenil	20	0	0	15.3	34.7	12.5
Terbutol	12	25.3	48.7	34.7	52.0	40.2
Terbutol	18	31.3	35.3	56.0	58.0	45.2
Tèrbutol	24	39.3	36.0	44.0	57.3	44.2
Simazine	3	51.3	38.7	54.0	59.3	50.8
Simazine	9	24.7	58.7	42.0	45.3	42.7
Simazine	18	28.0	58.7	38.7	33.3	39.7
Dalapon	3	34.7	74.7	40.7	45.3	48.8
Dalapon	6	44.0	44.7	46.0	42.7	44.3
Dalapon	10	18.0	30.7	46.0	42.0	34.2
Mean		22.7	41.4	44.2	49.8	

L.S.D. .05 Herbicide 14.0 Charcoal 6.4 Herb x Char NS

Table 3. Germination of oats as affected by different rates of activated charcoal and herbicides. Counts were made 10 days from planting date.

Herbicide	Active ingredient lb/A	Charcoal lb/1000 sq.ft.				Mean
		0	5	10	20	
Check	-	64.7	79.3	95.3	84.7	81.0
DCPA	12	68.7	83.3	86.0	90.7	82.2
DCPA	24	39.3	83.3	94.7	84.7	75.5
DCPA	36	68.7	71.3	86.7	84.7	77.8
Bensulide	15	56.0	91.3	96.7	92.7	84.2
Bensulide	25	37.3	91.3	88.7	94.0	77.8
Bensulide	35	16.0	74.7	84.0	80.7	63.8
Dichlobenil	10	0	72.0	88.7	97.3	64.5
Dichlobenil	15	0	24.0	84.7	85.3	48.5
Dichlobenil	20	0	1.3	62.7	84.0	37.0
Terbutol	12	59.3	69.3	75.3	96.7	75.2
Terbutol	18	64.7	67.3	85.3	90.7	77.0
Terbutol	24	88.7	79.3	82.7	84.0	83.7
Simazine	3	88.0	67.3	96.0	96.7	87.0
Simazine	9	59.3	81.3	98.7	66.0	83.8
Simazine	18	68.0	82.0	76.0	90.0	79.0
Dalapon	3	78.0	96.0	91.3	88.7	88.5
Dalapon	6	93.3	96.7	85.3	86.0	90.3
Dalapon	10	80.0	92.7	86.0	86.0	86.2
Mean		54.2	73.9	86.6	89.1	

L.S.D. .05 Herbicide 12.9 Charcoal 5.9 Herb x Char 25.1

Table 4. Germination of oats as affected by different rates of activated charcoal and herbicides. Counts were made 15 days from planting date.

Herbicide	Active ingredient lb/A	Charcoal lb/1000 sq.ft.				Mean
		0	5	10	20	
Check	-	98.0	97.3	96.7	94.7	96.7
DCPA	12	80.7	89.3	94.7	94.7	89.8
DCPA	24	60.7	88.7	98.7	92.0	85.0
DCPA	36	71.3	82.0	93.3	90.0	84.2
Bensulide	15	92.0	96.7	99.3	94.0	95.5
Bensulide	25	79.3	96.7	90.7	97.3	91.0
Bensulide	35	79.3	99.3	96.0	82.0	89.2
Dichlobenil	10	0	90.7	98.7	98.7	72.0
Dichlobenil	15	0	26.7	95.3	92.0	53.5
Dichlobenil	20	0	.6	78.7	92.0	42.8
Terbutol	12	82.0	92.7	92.0	97.3	91.0
Terbutol	18	79.3	94.7	98.7	98.7	92.8
Terbutol	24	92.0	96.0	99.3	96.0	95.8
Simazine	3	89.3	84.7	97.3	100.0	92.8
Simazine	9	90.7	93.3	100.0	100.0	96.0
Simazine	18	80.0	82.7	84.0	99.3	86.5
Dalapon	3	80.0	95.3	90.0	90.0	88.8
Dalapon	6	70.7	82.7	77.3	88.7	79.8
Dalapon	10	40.0	54.0	60.0	81.3	58.8
Mean		66.6	81.3	91.6	93.6	

L.S.D. .05 Herbicide 8.3 Charcoal 3.8 Herb x Char 16.7

from 80 to 156 in five days. Also at this date, the F values of herbicides, blocks, and herbicide-charcoal interaction became more significant. The trend of the overall means (Table 5) of charcoal became more pronounced at this date on per cent live plants. The decrease of plant population due to the death of oats on simazine plots is the principle reason for the more pronounced effect of charcoal on live plants. The herbicides that showed a definite pattern are dichlobenil and simazine. The higher the rates of dichlobenil and simazine, the higher the charcoal rates it took to nullify the herbicide effect on per cent live plants.

The analysis of variance (Table 13) for per cent live plants 30 days after planting indicated the main significant factor was the charcoal effect. The F value for charcoal increased from 155 to 227 because of the decreased plant populations. The overall means (Table 6) of charcoal rates were significant showing the higher the rate of charcoal the more pronounced the charcoal effect on live plants. Again, dichlobenil and simazine showed a definite trend in plant population; the higher the rate of charcoal, the higher the per cent of live plants.

The analysis of variance (Table 14) for plant height at cutting date indicated the main significant factor was the charcoal effect. The high F value of the charcoal is due to the great differences of height at the different levels of charcoal. Also, there is a high F value for herbicide effect which is due to the different herbicide effects on oats. The overall means (Table 7) of charcoal rates were significant indicating the higher the rate of charcoal the more noticeable the charcoal effect on plant height. Dichlobenil, simazine and terbutol showed a definite trend in that it took a higher rate of charcoal to deactivate the higher rate of herbicide. In bensulide and DCPA, the herbicide effect was nullified at the 5 lb/1000 square feet rate of charcoal. Charcoal did not have any noticeable effect of dalapon.

The analysis of variance (Table 15) for dry weight of oats at cutting date indicated the main significant factor was the charcoal effect. The high F value of the charcoal effect is due to the per cent live plants and to plant height. Also, there is a high F value for herbicide effect, but this is the result of the effect of herbicides on oats. The overall means (Table 8) of charcoal rates were significant indicating the higher the rate of charcoal, the more noticeable the charcoal effect on plant dry weight. Dichlobenil, terbutol and simazine showed definite trends in that a higher rate of charcoal was needed to nullify the higher rate of herbicide. In DCPA and bensulide the herbicide effect was generally nullified at the 5 lb/1000 square feet rate of charcoal. Charcoal did not have any noticeable effect on dalapon. There was an increase in weight on the check, but the reason for this is not known.

Table 5. Percent live oats as affected by different rates of activated charcoal and herbicides. Counts were made 20 days from planting date.

Herbicide	Active ingredient lb/A	Charcoal lb/1000 sq.ft.				Mean
		0	5	10	20	
Check	-	98.0	98.7	99.3	96.0	98.0
DCPA	12	80.0	96.0	97.3	97.3	92.7
DCPA	24	54.7	92.0	98.7	94.7	85.0
DCPA	36	72.7	85.3	94.0	94.7	86.7
Bensulide	15	95.3	98.7	100.0	96.0	97.5
Bensulide	25	84.7	98.7	93.3	98.0	93.7
Bensulide	35	87.3	100.0	98.0	84.0	92.3
Dichlobenil	10	0	92.7	100.0	98.7	72.8
Dichlobenil	15	0	31.3	96.0	100.0	56.8
Dichlobenil	20	0	.7	78.7	95.3	43.7
Terbutol	12	80.7	92.0	94.7	98.0	91.3
Terbutol	18	77.3	90.7	98.7	98.7	91.3
Terbutol	24	93.3	95.3	99.3	96.7	96.2
Simazine	3	5.3	90.7	97.3	100.0	73.3
Simazine	9	18.7	34.7	100.0	100.0	63.3
Simazine	18	6.7	3.3	40.7	99.3	37.5
Dalapon	3	85.3	96.0	90.0	91.3	90.7
Dalapon	6	68.7	75.3	83.3	89.3	79.2
Dalapon	10	38.7	50.0	62.7	75.3	56.7
Mean		55.1	74.8	90.6	94.9	

L.S.D. .05 Herbicide 8.4 Charcoal 3.8 Herb x Char 17.6

Table 6. Per cent live oats as affected by different rates of activated charcoal and herbicides. Counts were made 30 days from planting date.

Herbicide	Active ingredient lb/A	Charcoal lb/1000 sq.ft.				Mean
		0	5	10	20	
Check	-	98.0	99.3	100.0	96.7	98.5
DCPA	12	79.3	98.0	100.0	99.3	94.2
DCPA	24	52.0	94.7	99.3	96.7	85.7
DCPA	36	69.3	86.7	97.3	96.7	87.5
Bensulide	15	98.7	100.0	100.0	98.7	99.3
Bensulide	25	90.0	100.0	98.7	98.7	96.8
Bensulide	35	89.3	100.0	100.0	85.3	93.7
Dichlobenil	10	0	92.7	100.0	100.0	73.2
Dichlobenil	15	0	32.0	97.3	100.0	57.3
Dichlobenil	20	0	0	84.7	100.0	46.2
Terbutol	12	78.0	88.0	95.3	100.0	90.3
Terbutol	18	70.7	86.7	98.7	100.0	89.0
Terbutol	24	92.0	90.0	99.3	97.3	94.7
Simazine	3	0	92.0	100.0	100.0	73.0
Simazine	9	0	0	100.0	100.0	50.0
Simazine	18	0	0	0	99.3	24.8
Dalapon	3	92.0	95.3	89.3	90.7	91.8
Dalapon	6	68.0	72.0	86.0	90.0	79.0
Dalapon	10	39.3	47.3	62.7	71.3	55.2
Mean		53.5	72.4	89.9	95.8	

L.S.D. .05 Herbicide 7.0 Charcoal 3.2 Herb x Char 15.4

Table 7. Height of oats as affected by different rates of activated charcoal and herbicides, expressed in centimeters at cutting date.

Herbicide	Active ingredient lb/A	Charcoal lb/1000 sq.ft. 0	5	10	20	Mean
Check	-	21.3	21.3	21.3	21.0	21.3
DCPA	12	16.7	23.0	24.0	24.7	22.1
DCPA	24	11.0	22.3	22.3	20.0	18.9
DCPA	36	13.7	23.7	21.3	20.3	19.8
Bensulide	15	19.7	22.0	20.3	24.0	21.5
Bensulide	25	12.0	23.7	23.0	23.3	20.5
Bensulide	35	10.3	23.3	24.0	21.7	19.8
Dichlobenil	10	0	21.3	21.7	19.0	15.5
Dichlobenil	15	0	11.3	19.0	17.7	12.0
Dichlobenil	20	0	0	18.7	19.7	9.6
Terbutol	12	5.0	17.0	18.7	18.7	14.8
Terbutol	18	5.0	4.7	16.3	18.7	11.2
Terbutol	24	4.7	5.3	12.7	18.7	10.3
Simazine	3	0	20.7	19.7	20.3	15.2
Simazine	9	0	0	18.3	19.7	9.5
Simazine	18	0	0	0	11.3	2.8
Dalapon	3	15.7	11.3	10.0	10.3	11.8
Dalapon	6	5.7	7.3	6.7	6.0	6.4
Dalapon	10	4.0	4.7	5.3	6.0	5.0
Mean		7.6	13.8	17.0	17.9	

L.S.D. .05 Herbicide 1.3 Charcoal 0.6 Herb x Char 2.7

Table 8. Dry weight of oats as affected by different rates of activated charcoal and herbicides, expressed in centimeters at cutting date.

Herbicide	Active ingredient lb/A	Charcoal lb/1000 sq.ft.				Mean
		0	5	10	20	
Check	–	1.47	2.37	2.28	2.26	2.10
DCPA	12	1.28	1.79	1.95	1.97	1.75
DCPA	24	.59	1.78	2.05	1.65	1.52
DCPA	36	.97	1.75	1.90	1.70	1.58
Bensulide	15	1.29	1.93	1.99	2.20	1.85
Bensulide	25	.79	1.79	1.69	2.14	1.60
Bensulide	35	.58	1.69	1.67	1.44	1.35
Dichlobenil	10	0	2.09	2.49	2.30	1.72
Dichlobenil	15	0	.62	2.04	1.98	1.16
Dichlobenil	20	0	0	1.59	2.16	.94
Terbutol	12	.31	1.75	2.25	2.34	1.66
Terbutol	18	.38	.48	2.06	2.13	1.26
Terbutol	24	.51	.47	1.35	2.81	1.28
Simazine	3	0	1.24	2.05	2.54	1.46
Simazine	9	0	0	.93	1.96	.72
Simazine	18	0	0	0	.72	.18
Dalapon	3	1.07	.85	.81	.92	.91
Dalapon	6	.28	.56	.45	.46	.45
Dalapon	10	.16	.24	.27	.30	.25
Mean		.51	1.13	1.57	1.79	

L.S.D. .05 Herbicide 0.24 Charcoal 0.11 Herb x Char 0.47

EXPLANATION OF PLATE 1

Measureable effects are on growth of oats. Such growth reflects herbicide and charcoal at different rate combinations. DCPA (Dacthal) was applied at the rates of 12, 24, and 36 pounds to the acre. In each picture, starting from the left, the charcoal treatments were 0, 5, 10, and 20 lb/1000 square feet. In general Dacthal was deactivated at 5 pounds and higher rates of charcoal treatments.

PLATE I

EXPLANATION OF PLATE II

Measureable effects are on growth of oats. Such growth reflects herbicide and charcoal at different rate combinations. Bensulide (Betasan) was applied at the rates of 15, 25, and 35 pounds to the acre. In each picture, starting from the left, the charcoal treatments were 0, 5, 10, and 20 lb/1000 square feet. Inhibition of growth was reduced at the 5 pound and higher rates of charcoal treatments on Betasan.

PLATE II

EXPLANATION OF PLATE III

Measureable effects are on growth of oats. Such growth reflects herbicide and charcoal at different rate combinations. Dichlobenil (Casoron) was applied at the rates of 10, 15, and 20 pounds to the acre. In each picture, starting from the left, the charcoal treatments were 0, 5, 10, and 20 lb/1000 square feet. The check picture in the lower right is included to give a comparison to the amount of deactivation that took place at the different rates of Casoron.

PLATE III

EXPLANATION OF PLATE IV

Measureable effects are on growth of oats. Such growth reflects herbicide and charcoal at different rate combinations. Terbutol (Azak) was applied at the rates of 12, 18, and 24 pounds to the acre. In each picture, starting from the left, the charcoal treatments were 0, 5, 10, and 20 lb/1000 square feet. The check picture in the lower right is included to give a comparison to the amount of deactivation that took place at the different rates of Azak.

PLATE IV

EXPLANATION OF PLATE V

Measureable effects are on growth of oats. Such growth reflects herbicide and charcoal at different rate combinations. Simazine (Princep) was applied at the rates of 3, 9, and 18 pounds to the acre. In each picture, starting from the left, the charcoal treatments were 0, 5, 10, and 20 lb/1000 square feet. The check picture in the lower right is included to give a comparison to the amount of deactivation that took place at the different rates of simazine.

PLATE V

PLATE VI

EXPLANATION OF PLATE VI

Measureable effects are on growth of oats. Such growth reflects herbicide and charcoal at different rate combinations. Dalapon (Dowpon) was applied at the rates of 3, 6, and 10 pounds to the acre. In each picture, starting from the left, the charcoal treatments were 0, 5, 10, and 20 lb/1000 square feet. Charcoal did not have any noticeable affect on Dowpon.

DISCUSSION OF RESULTS

The results of this experiment revealed that the herbicides used in this study could be deactivated by activated charcoal, with the exception of dalapon. Looking at the herbicides as a whole, it was shown in the experimental results that the higher the rate of charcoal the greater the herbicide deactivation. By examining each herbicide separately more conclusions can be drawn.

Charcoal overcame the effect of DCPA on oats at the rate of 5 lb/1000 square feet. Height and per cent live plants were approximately equal in comparison to the check. There was a difference in the dry weight between the various rates of DCPA and the check, but in many cases not enough to be significant. Root inhibition was nullified at the 5 pound level of charcoal.

Charcoal did not affect the germination and per cent live plants in the bensulide treatments. In comparison to the check, the 35 lb/A rate of bensulide showed a reduction in the dry weight of the oats. Charcoal did not nullify all the effects of bensulide at the 35 lb/A level. The oats had few roots, and pulled out of the soil easily at the 0 rate of charcoal, but root inhibition was nullified at the 5 pound level of charcoal.

A definite pattern was observed in dichlobenil treatments throughout the experiment. The higher the rate of dichlobenil, the more charcoal it took to deactivate it. In comparison to the check, dichlobenil at 10 lb/A was deactivated at the 5 pound charcoal level; dichlobenil 15 lb/A was deactivated at the 10 pound charcoal level; and dichlobenil 20 lb/A was deactivated at the 20 pound charcoal level as determined by per cent germination, plant height, and dry weight.

Terbutol did not show a definite germination pattern or effect on per cent live plants. A trend was established on plant height and dry weight similar to that of dichlobenil in this experiment: the higher the rate of terbutol, the more charcoal was needed to deactivate the herbicide. All rates of terbutol were apparently deactivated at the 20 pound charcoal level. A significant stimulation effect of terbutol on growth of oat plants, in comparison to the check, resulted from herbicide applications. Root inhibition and a reduction of plant growth were nullified at the 5 pound rate of charcoal on the 12 lb/A rate of terbutol; 10 pound rate of charcoal on the 18 lb/A rate of terbutol; and a 20 pound rate of charcoal on the 24 lb/A rate of terbutol.

An observable pattern was not established for simazine until 20 days after planting. At this time the plant populations started to decrease at the lower levels of charcoal depending upon the rate of simazine. At the rate of 3 lb/A of simazine apparent deáctivation occured with application of 10 pounds of charcoal. At the 9 lb/A rate of simazine deactivation occured with the 20 pound level of charcoal in comparison to the check. Partial inactivation of simazine 18 lb/A occured at the 20 pound level of charcoal but herbicide damage was evident in the growing points of the oats.

Throughout this experiment charcoal did not have any noticeable effect on dalapon. There was no indication that dalapon could be deactivated with the use of activated charcoal. Dalapon is primarily a grass killer and is usually applied as a post emergent herbicide, whereas the other herbicides used in this experiment are pre emergent herbicides.

Charcoal had a stimulation effect on the check. This effect was not studied and no conclusions can be drawn. Possibilities for this effect might be absorption of heat by the charcoal, increase in porosity of the soil, or a growth chamber effect.

CONCLUSION

This experiment demonstrated a method of herbicide inactivation in the soil by the use of activated charcoal. Activated charcoal successfully eliminated the harmful effects of DCPA, bensulide, dichlobenil, terbutol and simazine as measured by dry weight, height, and per cent live plants.

Rates of 5 to 20 pounds of activated charcoal per 1000 square feet inactivated the herbicides used with the exception of dalapon. In dichlobenil, tertutol and simazine it was shown that with each increase of herbicide, a corresponding increase of charcoal was needed to deactivate the herbicide effect. Generally speaking, if a herbicide rate is not known the 20 pounds of activated charcoal per 1000 square feet would be the most promising dosage to deactivate the herbicide.

Activated charcoal potentially has great value for protecting sensitive crops from herbicide damage. It can reduce the waiting period of time for normal breakdown of residues. Also, more phytotoxic herbicides for effective weed control can be used on sensitive crops. Activated charcoal can lessen the chance of injury form residues of herbicides remaining in the soil. The effect of charcoal on later weed control is still unknown but work is being done on this. Good weed control is achieved when root dips and band applications are used.

Research on the effects of activated charcoal on herbicides is still in the early stage. Research needs to be done on the release of the herbicide after it is adsorbed; the period of time that adsorption can take place; and the breakdown of the herbicide after adsorption, since the adsorbed herbicide may be unavailable to the organisms causing breakdown.

This experiment needs to be tested in field trials to show how applicable these results are in practice. With the increasing use of herbicides, consideration must be given to methods of deactivation of herbicide residues.

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LITERATURE CITED

1. Ahrens, J. F.
Improving herbicide selectivity in horticultural crops with activated carbon. Northeastern Weed Control Conference. 19:366-367. 1965.

2. ___________.
Detoxification of simazine- and atrazine-treated soil with activated carbon. Northeastern Weed Control Conference. 19:364-365. 1965.

3. Andersen, A. H.
The inactivation of simazine and linuron in soil by charcoal. Weed Research. 8:58-60. 1968.

4. Arle, H. Fred, O. A. Leonard, and V. C. Harris.
Inactivation of 2,4-D on sweet-potato slips with activated carbon. Science. 107:247-248. 1948.

5. Coffey, David L., and G. F. Warren.
Inactivation of herbicides by activated carbon and other adsorbents. Weed Science. 17:16-19. 1969.

6. Jagschitz, John A.
Use of charcoal to deactivate herbicide residues in turfgrass seedbeds. Northeastern Weed Control Conference. 22:401-407. 1968.

7. Leopold, A. C., P. van Schaik and Mary Neal.
Molecular structure and herbicide adsorption. Weeds. 8:48-53. 1960.

8. Linscott, D. L., and R. D. Hagin.
Protecting alfalfa seedlings from a triazine with activated charcoal. Weeds. 15:304-306. 1967.

9. Locascio, S. J.
Effect of activated charcoal on the toxicity of dichlobenil to vegetables. Proc. 20th Ann. Meeting Southern Weed Control Conference. 20:157-163. 1967.

10. Lucas, E. H., and C. L. Hamner.
Inactivation of 2,4-D by adsorption on charcoal. Science. 105:340. 1947.

11. Schubert, Oscar E.
Can activated charcoal protect crops from herbicide injury? Crops and Soils. 19:10-11. 1967.

12. Snedecor, G. W.
Statistical Methods. Iowa State College Press, Ames. 1956.

APPENDIX

Table 9. Analysis of variance for per cent germination of oats 5 days after planting.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Blocks	2	617	308.3	1.08
Herbicide	18	19633	1090.7	3.81**
Charcoal	3	23590	7863.4	27.44**
Herb x Char	54	22444	415.6	1.45**
Error	150	42992	286.6	---
Total	227	109276	---	---

*indicates significance at the .05 level: ** .01 level.

Table 10. Analysis of variance for per cent germination of oats 10 days after planting.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Blocks	2	859	429.5	1.76
Herbicide	18	40932	2274.0	9.32**
Charcoal	3	43489	14496.3	59.38**
Herb x Char	54	45440	814.5	3.45**
Error	150	36616	224.1	---
Total	227	167336	---	---

*indicates significance at the .05 level: ** .01 level.

Table 11. Analysis of variance for per cent germination of oats 15 days after planting.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Blocks	2	290	145.0	1.34
Herbicide	18	51981	2887.8	26.63**
Charcoal	3	26145	8715.0	80.37**
Herb x Char	54	48620	900.4	8.30**
Error	150	16265	108.4	---
Total	227	143310	---	---

*indicates significance at the .05 level: ** .01 level.

Table 12. Analysis of variance for per cent live plants 20 days after planting.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Blocks	2	1197	598.5	5.02**
Herbicide	18	76665	4259.2	35.76**
Charcoal	3	55623	18541.0	155.67**
Herb x Char	54	74450	1378.7	11.58**
Error	150	17866	119.1	---
Total	227	225801	---	---

* indicates significance at the .05 level: ** .01 level.

Table 13. Analysis of variance for per cent live plants 30 days after planting and at cutting date.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Blocks	2	789	394.5	4.32*
Herbicide	18	98997	5499.8	60.25**
Charcoal	3	62229	20743.2	227.26**
Herb x Char	54	94256	1745.5	19.12**
Error	150	13691	91.3	---
Total	227	269962	---	---

* indicates significance at the .05 level: ** .01 level.

Table 14. Analysis of variance for height in centimeters at cutting date.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Blocks	2	43	21.53	7.65**
Herbicide	18	7739	429.92	152.69**
Charcoal	3	3731	1243.52	441.65**
Herb x Char	54	3913	72.46	25.74**
Error	150	442	2.82	---
Total	227	15868	---	---

* indicates significance at the .05 level: ** .01 level.

Table 15. Analysis of variance for gram dry weight at cutting date.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F Value
Blocks	2	0.7068	0.3534	4.0314*
Herbicide	18	64.7058	3.5948	41.0084**
Charcoal	3	54.4187	18.1396	206.9325**
Herb x Char	54	39.9583	0.7400	8.4414**
Error	150	13.1489	0.0877	---
Total	227	172.9385	---	

* indicates significance at the .05 level: ** .01 level.

SOME EFFECTS OF ACTIVATED CHARCOAL ON SELECTED HERBICIDES

by

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B. S., Kansas State University, 1968

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In the last ten years, there has been an increased interest in the deactivation of herbicides with activated charcoal. With the increasing use of herbicides that are highly persistent and biologically active, it has become necessary to find methods of deactivating these residues. The objectives of this study were to determine if activated charcoal would deactivate a selection of herbicides; and to determine the amount of activated charcoal necessary to deactivate these herbicides at different rates.

This experiment was conducted in the fall of 1968 in a growth chamber. A randomized block design was used with three observations per cell. Three rates each of DCPA, bensulide, dichlobenil, terbutol, simazine, and dalapon were used. Charcoal was applied at 0, 5, 10, and 20 pounds per 1000 square feet to pots receiving herbicide at the three rates. Missouri Oats 0-205 was used as the indicator plant in this study. At five day intervals a count of per cent live plants was taken for each container. At the end of the 30 day period the plants were cut at ground level and randomly measured to determine height. The plants were then oven dried and dry weight was taken for each individual plot.

The results of this experiment revealed that the herbicides used in this study, with the exception of dalapon, could be deactivated by applying activated charcoal. Examining the herbicides as a whole, it was shown that the higher the rate of charcoal the more deactivation occured.

A definite pattern was observed with dichlobenil, simazine, and terbutol; the higher the rate of herbicide, the higher the rate of charcoal needed to deactivate the herbicide. In comparison to the check, dichlobenil at 10 lb/A was deactivated at the 5 pound level of charcoal; dichlobenil

15 lb/A was deactivated at the 10 pound level of charcoal; and dichlobenil 20 lb/A was deactivated at the 20 pound level of charcoal. Simazine indicated a similar trend, but with simazine applied at 18 lb/A there was herbicide damage with the 20 pound charcoal rate. A higher rate of charcoal is needed to achieve normal plant height and dry weight at higher rates of terbutol; the percent live plants on terbutol plots was not affected.

Generally speaking, charcoal overcame the effect of DCPA and bensulide applied at 5 pounds per 1000 square feet. With the 5 pound rate of charcoal, root inhibition was nullified. Throughout this experiment charcoal did not have any noticeable effect on dalapon. There was no indication that dalapon could be deactivated with the use of activated charcoal. Charcoal had a stimulation effect on the checks but no conclusions could be drawn.