sulfate which stick to the glass.) Cool, dilute and titrate as above. After such treatment the blank is 0.35 (instead of 0.4 cc.) for steels with under 0.5 per cent C, and 0.5 cc. for 0.60 to 0.70 C, and 0.6 cc. for 0.90 to 1.25 C steels. The blanks are the same with or without the persulfate treatment for steels of over 0.50 per cent carbon.

The ferrous ammonium sulfate solution may be standardized against 0.1 *N* permanganate, the strength of which has been determined with sodium oxalate. The iron value of the permanganate multiplied by 0.917 gives the vanadium value.

By this method the following results were obtained, the chromium in expts. 9, 10, 13 and 14 being added as $K_2Cr_2O_7$ before the solution of the steel.

The following steels were employed:

- A—U. S. Bureau of Standards Sample No. 24, containing 0.15 per cent V, 0.35 per cent C, and a trace of Cr.
 B—U. S. Bureau of Standards Sample No. 30, containing 0.21 per cent V, 0.37 per cent C, and 1.35 per cent Cr.
 C—A steel casting containing 0.215 per cent V, 0.30 per cent C, and no Cr.
 D—A plain steel containing 0.85 per cent C.
 E—A plain steel containing 1.25 per cent C.

TABLE I—VANADIUM DETERMINATIONS BY SIMPLIFIED METHOD

Expt.	Sample	Weight of sample Grams	Persulfate added Grams	Vanadium found Gram
1	A	2	0	0.148
2	A	4	0	0.146
3	B	2	0	0.206
4	B	4	0	0.208
5	C	2	0	0.216
6	C	4	0	0.216
7	C	2	0	0.222
8	D	2	0	0.210
	E	2	0	0.210
9	D	2	0	0.210
	1.3% Cr	2	0	0.200
10	E	2	0	0.200
	1.3% Cr	2	0	0.200
11	C	2	7	0.216
	D	2	7	0.216
12	C	2	7	0.216
	E	2	7	0.216
13	D	2	7	0.216
	1.3% Cr	2	7	0.210
14	E	2	7	0.210
	1.3% Cr	2	7	0.210

From these results it is apparent that in general for such materials, the method is accurate to 0.01 per cent vanadium.

If chromium also is to be determined, it is determined in a separate portion of the sample, using any of the usual volumetric methods.

AMERICAN STEEL FOUNDRIES, CHICAGO

THE EFFECT OF CERTAIN ORGANIC COMPOUNDS ON WHEAT PLANTS IN THE SOIL—PRELIMINARY PAPER

By FRED W. UPSON AND A. R. POWELL

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In recent years our knowledge of the chemical nature of soil organic matter has been greatly extended through the work of a number of investigators, chief among whom are Jodidi and the several workers in soil fertility investigations of the United States Bureau of Soils. A very complete historical account of the work on soil organic matter and of the older views regarding it has been presented by Schreiner and Shorey¹ and by Jodidi.² Through the work of these

investigators and their co-workers, we have come to regard the soil organic matter not as consisting of three or four compounds of rather indefinite properties, but as being made up of a large number of different organic compounds which result from plant and animal residues through the agency of the various chemical processes which are taking place in the soil. From various soils there have been isolated and identified up to the present time, more than half a hundred definite organic compounds. Among the various classes of organic compounds represented are acids, aldehydes, alcohols, amino acids, resins, esters, glycerides, hydrocarbons, sugars, amines and other nitrogenous compounds. The methods by which these compounds have been isolated and identified are somewhat involved and need not be considered here.

The toxic effect on wheat plants of the various organic compounds which have been isolated from various soils has been extensively studied by Schreiner¹ and his co-workers. With two exceptions,² the work

by these investigators on the toxic effect of organic compounds has been determined by growing plants for short periods in distilled water cultures containing the various compounds. The organic compounds studied are either those which have been isolated from the soil or those which may result through the breaking down of plant and animal residues.

Many of the compounds studied have been shown to be more or less toxic to wheat plants in comparatively low concentrations, 10–200 parts per million of solution. Some few have been found beneficial to the growth of wheat plants in water solution. In many cases the addition of fertilizer salts to the culture solution has partially or completely overcome the toxic effects of the organic compounds.

While a knowledge of the effect of these compounds on the growth of wheat seedlings in water solution is of the greatest importance, nevertheless we should

¹ A summary of the effect of various organic compounds on growth is given in *Bull. 87*, Bur. of Soils, U. S. Dept. Agr., p. 70.

² Schreiner and Skinner have studied the effect of coumarin (*Bull. 77*, Bur. Soils, p. 16) and of salicylic aldehyde, U. S. Dept. Agr. (*Bull. 108*, 5, 12), on wheat plants in the soil.

¹ *Bull. 53*, Bur. of Soils, U. S. Dept. Agr., p. 21.

² *Biochem. Bull.* 3, 17.

not assume from results obtained in this manner that these compounds will exhibit the same behavior toward plants growing in the soil. Conditions are much more complex in the soil. Adsorption and other surface effects, aeration, the effect of chemical compounds and the action of microorganisms are all factors which are of little importance in the water culture, but which play a much more prominent rôle in the soil.

Extensive work on the behavior of these organic compounds toward plants in the soil, is necessary before we are able to draw final conclusions in regard to the relation of these substances to soil fertility.

EXPERIMENTAL PART

The present paper deals with the behavior of vanillin, salicylic aldehyde, cumarin, quinone and dihydroxystearic acid toward wheat plants in the soil.

Vanillin is of special interest because it exists in many plants in the form of a glucoside. Vanillin or substances which give rise to it have been reported in oats,¹ asparagus shoots² and other plants. Quite³ recently it has been isolated from ungerminated wheat seeds and from seedlings five days old. It has recently also been isolated from Florida soils.⁴

Vanillin has been shown by Schreiner, Reed and Skinner⁵ to be toxic to wheat seedlings grown in distilled water solution, 500 parts per million being sufficient to cause death in nine days. It was noticeably toxic in much lower concentrations. Schreiner and Skinner⁶ have shown also that vanillin is much less toxic in water solution in the presence of fertilizer salts.

EXPERIMENT 1—The soil used in this experiment came from a meadow which has long been in blue grass. It is a black silt loam of excellent texture and rich in organic matter. Approximately 1800 g. of dry soil were mixed with the required amounts of vanillin, potted and brought to the proper moisture content with distilled water. After standing 24 hours, ten wheatseeds were planted in each pot. Complete germination was secured in each. After the plants were well sprouted each pot was thinned to five plants. The experiment lasted from October 20 to November 28th (39 days). At the end of this time the pots were opened, the soil very carefully removed from the roots and the green and dry weights of the whole plant determined. The results are shown in Table I, A.

TABLE I—RESULTS WITH VANILLIN

No.	TREATMENT	A			B			C		
		Green weight	Dry weight	Relative growth	Green weight	Dry weight	Relative growth	Green weight	Dry weight	Relative growth
1	Soil untreated.....	19.2	2.21	100	48.1	7.58	100	51.0	6.4	100
2	Same + 250 p. p. m. vanillin.....	19.2	2.20	100	51.5	7.43	107	51.8	6.39	101
3	Same + 500 p. p. m. vanillin.....	18.8	2.09	98	47.7	7.20	99	58.2	7.13	114
4	Same + 1000 p. p. m. vanillin.....	18.6	2.16	97	48.4	7.46	101	50.1	6.57	98

The roots were not visibly injured in any way even in the highest concentration of vanillin. A photograph serves to show this more clearly. Plate I shows the plants from Experiment 1: Nos. 1, 2, 3 and 4 show the plants from the untreated soil and from the soil

containing 250, 500 and 1000 parts per million vanillin respectively.

EXPERIMENT 2—This is a duplicate of the first experiment except that the plants grew till December 23rd (64 days). The results are shown under B in Table I.

EXPERIMENT 3—This experiment was carried out in the same manner as Experiments 1 and 2 except that the vanillin was added to the soil in water solution. This experiment ran from October 30th to December 29th (60 days). The results are given under C in Table I.

EXPERIMENT 4—Another experiment was carried out using soil from a field which has been under cultivation for about thirty years. It is a silt loam of excellent texture, but much less fertile than the soil used in the previous experiments. The plants grew from November 30th to February 3rd. Three plants were grown in each pot, the green weights of the tops only being recorded (Table II).

TABLE II—RESULTS WITH VANILLIN

TREATMENT	No.	Green weight	Relative growth	No.	Green weight	Relative growth
Soil untreated.....	1	6.5	100	4	6.69	100
Same + 500 p. p. m. vanillin.....	2	6.39	97	5	6.59	99
Same + 1000 p. p. m. vanillin.....	3	5.9	90	6	6.49	97

These experiments show that vanillin is not appreciably toxic to wheat plants when present in the soil even in quantities as high as 1000 parts per million. Vanillin is therefore, to say the least, much less toxic in the soil than in water cultures. Even with the addition of fertilizer salts in the most favorable combinations, solutions containing only 50 parts per million of vanillin gave a relative growth of wheat plants¹ of 88.

Salicylic aldehyde has very recently been found in a soil by Schreiner and Skinner.² These investigators have also determined its effect on corn and wheat in distilled water cultures and also in the soil. They find that in distilled water, growth of wheat is reduced by the presence of 25 parts per million salicylic aldehyde, 69 per cent and that in concentrations of 50, 100 and 200 parts per million this substance produced death.³ Much the same effect was produced on corn grown in nutrient solutions: 10 parts per million of the aldehyde gave a relative growth of 60 after 25 days, whereas 200 parts per million gave a relative growth of only 10.

The effect of salicylic aldehyde on wheat and corn in soil in pots was also determined.⁴ Salicylic aldehyde in 50 parts per million gave a relative growth of wheat of 61, after 22 days and in concentrations of 100 and 200 parts per million caused death: 50 parts per million of the aldehyde reduced the growth of corn in soil 24 per cent and in quartz sand 60 per cent. These experiments were carried out in paraffined wire pots described in Circular 18 of the Bureau of Soils.

EXPERIMENTS WITH SALICYLIC ALDEHYDE

For these experiments the soil selected was the same as the one used in Experiment 4 with vanillin. Pots holding about 1800 g. of soil were employed. The aldehyde was dissolved in water and added to the soil in the proper proportions.

¹ Schreiner and Skinner, *Bur. Soils, U. S. Dept. Agr., Bull. 77*, 21.

² U. S. Dept. Agr., *Bull. 108*, 1 (1914).

³ *Ibid.*, 108, 3; Skinner, *Biochem. Bull. 3*, 390; *J. Am. Soc. Agron.*, 6, 108.

⁴ U. S. Dept. Agr., *Bull. 108*, 5.

¹ de Rawton, *Compt. rend.*, 125, 797.

² von Lippman, *Ber.*, 18, 1335.

³ Sullivan, *This Journal*, 6, 920.

⁴ Shorey, *J. Agr. Res.*, 1, 357.

⁵ *Bur. Soils, U. S. Dept. Agr., Bull. 47*, 31.

⁶ *Ibid.*, *Bull. 77*, 20.

EXPERIMENT 5—This experiment with salicylic aldehyde was carried out in the same manner as the vanillin experiments. Ten wheat seeds were planted in each pot and the plants thinned to five after they were well sprouted. The experiment ran from November 22nd to January 2nd. Section A of Table III shows the weights of the tops only.

TABLE III—RESULTS WITH SALICYLIC ALDEHYDE

No.	Treatment	A			B		
		Green wt. G.	Dry wt. G.	Relative growth	Green wt. G.	Dry wt. G.	Relative growth
1	Soil untreated.....	6.7	.85	100	12.7	2.51	100
2	Same + 10 p. p. m. salicylic aldehyde	6.8	.89	102	12.1	2.29	95
3	Same + 25 p. p. m. salicylic aldehyde	6.2	.77	93	11.8	2.30	93
4	Same + 50 p. p. m. salicylic aldehyde	5.7	.73	85	12.2	2.42	96
5	Same + 100 p. p. m. salicylic aldehyde	6.2	.75	93	12.3	2.47	97

EXPERIMENT 6—This experiment is a duplicate of Experiment 5, except that it ran till January 28th. The results are shown under B in Table III.

EXPERIMENT 7—The same method was used as in the preceding experiments, except that higher concentrations of the aldehyde were used and the experiment ran from January 15th to March 6th. A of Table IV gives the results.

TABLE IV—RESULTS WITH SALICYLIC ALDEHYDE

No.	Treatment	A			B		
		Green wt. G.	Dry wt. G.	Relative growth	Green wt. G.	Dry wt. G.	Relative growth
1	Soil untreated.....	8.5	1.6	100	4.5	.33	100
2	Same + 100 p. p. m. salicylic aldehyde	7.8	1.55	92	3.8	.25	84
3	Same + 200 p. p. m. salicylic aldehyde	8.4	1.73	99	3.3	.20	73
4	Same + 500 p. p. m. salicylic aldehyde	8.0	1.59	94	4.4	.34	98

EXPERIMENT 8—The effect of salicylic aldehyde on corn was also determined. The experiment ran from February 3rd to March 6th. Two plants were grown in each pot and the method was the same as the one used in the wheat experiments. The results are given under B in Table IV.

Our experiments indicate that salicylic aldehyde is much less toxic to wheat and corn plants in the soil than in water cultures. The toxic effect on wheat, even in a concentration of 500 parts per million, is practically negligible. This does not agree with the results of Schreiner and Skinner.¹ In order to determine whether this difference was due to the method or to the soil we repeated the experiment, using the paraffine wire pots according to the method of Schreiner and Skinner.¹

EXPERIMENT 9—Wheat was grown for twenty-two days in paraffined pots. At the end of this time the tops only of the six plants from the check pot weighed 0.98 g. while those from the pot treated with 100 parts per million of the aldehyde weighed 1.09 g. The soil which we used was a silt loam of loose texture and fairly high in organic matter, while the one used by Schreiner and Skinner is described as "a heavy clay loam."

Our experiments show that the effect of salicylic aldehyde on the growth of wheat and corn is different for different soils. We are of the opinion that aeration and absorption are important factors in overcoming the effect of the aldehyde. It is probable that the explanation of our results is to be found in the fact that the soil used was of a looser texture and more absorptive than the one described by Schreiner and Skinner.

Preliminary experiments on the behavior of coumarin, quinone and dihydroxystearic acid toward wheat

plants in the soil indicate that the effect is entirely different from the effect of these substances in water solutions. Quinone in concentrations below 500 parts per million in soil is beneficial to the growth of wheat. The other two substances are somewhat more toxic in the soil than is vanillin. A complete series of experiments with these compounds is in progress. Experiments are also in progress to determine the fate of these compounds and also of vanillin and salicylic aldehyde, in the soil.

CONCLUSIONS

The behavior of vanillin and of salicylic aldehyde toward wheat plants in the soil is shown to be quite different from the behavior of these substances in water cultures.

The behavior of salicylic aldehyde is shown to be different in different soils.

The necessity for more extended experiments of the nature of those here reported, has been demonstrated.

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THE ENGINEERING PROPERTIES OF SOILS

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The engineering properties of soils are of interest to all peoples living under civilized conditions, and engineering questions concerning the soil are of importance next to that of productiveness. The construction and maintenance of drainage, irrigation or commercial canals, the proper foundations for architectural structures, the construction and operation with safety of mines and quarries, and the protection afforded by levees and embankments are all dependent directly in most cases and indirectly always on these engineering properties. Attention has not been given to the subject in proportion to its importance. Lately, however, engineers and engineering societies have evidenced a growing interest in the subject, as it is realized that while the engineering features of the superstructures have been worked out with much care and detail, the properties of the soil on which the foundation rests are very little understood.

The statement has been made that nothing is known of these properties. This, however, is rather misleading; the facts are that the properties that the engineer has to deal with are mainly the physical properties of the soil and these have been studied systematically for some years, mainly from the agricultural standpoint. So it is well to see in what way the two studies are related so that needless work may be avoided.

Approaching the problem from the engineering standpoint, the properties of the soil on which the engineer wishes information are the rigidity of the soil, its cohesiveness, its penetrability, and its porosity. These are the properties that determine the weight which the soil will support under structural conditions, the height to which a retaining wall of soil will stand without additional support, the resistance

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¹ Loc. cit.