THE EXTRACTION AND SATURATION OF SOILS WITH VOLATILE ANTISEPTICS

A THESIS

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL
OF CORNELL UNIVERSITY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

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JOHANNES PETRUS DU BUISSON

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By

J. P. du Buisson

Introduction

That partial sterilization of soils is a factor to be considered in soil fertility has been demonstrated beyond doubt during the last thirty years. Partial sterilization may be effected either by heating the soil or by treating it with a volatile, a non-volatile, or a solid antiseptic. However, heating soil and treating it with volatile antiseptics are the two methods that have especially been studied by investigators up to the present time. The effect of heat on soil was first noticed by early bacteriologists. Since then, this phenomenon has been studied variously and extensively. Many conflicting theories have been offered as a solution for the cause of these beneficial effects. Some have attributed them to a biological, others to a chemical or mechanical, change in the soil itself, and still others to all three factors combined.

The present report is limited to the study of volatile antiseptics only. The object of this investigation was to determine, if possible, whether there is any essential difference in the effect of saturation as compared with extraction of different soil types with volatile antiseptics. With this in view, the effect of both saturation and extraction, on separate samples of the same soil types, was studied, in so far as these substances influenced plant growth, ammonification, nitrification, and the total water-soluble salts in the soils used in the experiment.

A comparison of the effects of saturation and extraction was made for the purpose of testing the theory, advanced by Greig-Smith (17), that the volatile antiseptics dissolve the "agricere" that covers the surfaces of the soil particles and by so doing enables higher plants and also bacteria to obtain more nutriment. Extraction with the antiseptics should remove the "agricere" more completely than mere saturation, and might, therefore, be expected to produce a condition more favorable to both higher plants and bacteria.

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[1] A thesis submitted, to the faculty of the Graduate School of Cornell University, in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

Received for publication November 27, 1916.

I. Historical

1. *Increase of Productivity due to Treatment of Soil with Volatile Antiseptics*

The first record of an antiseptic treatment of soil seems to be that of Oberlin (37). After using carbon bisulfide as an insecticide in some of his vineyards that were attacked by *Phylloxera,* he noted a marked increase in the growth of the vines. Girard (15) found beneficial results from this antiseptic with sugar beet. Pagnoul (38) observed the same phenomenon with buckwheat and with mustard. His observations with mustard are corroborated by Wagner (51). Mach (32) reported greater yields with beets, oats, and potatoes, after the application of 200 gm. of carbon bisulfide to a square meter of soil. Wollny (53) obtained increased results in pot experiments as a result of carbon bisulfide treatment. Koch (23) found increased growth with buckwheat and mustard and beneficial results in vineyards. In 1911 the same author (24) reported the following relative green weights for buckwheat: untreated soil, 100; application of 200 c.c. ether, 153; of 500 c.c., 179. Hiltner and Störmer (20) obtained increased yields for buckwheat on soil treated with carbon bisulfide. Moritz and Scherpe (35) report an increased yield with potatoes and rye with carbon bisulfide. Nobbe and Richter (36), treating soil with ether, chloroform, carbon bisulfide and benzene, report the following relative dry weights: 118, 114, 122, 122, respectively, against 100 for untreated. Egorov (10) noticed higher yields of oats with carbon bisulfide treatment. Darbishire and Russell (9) found an increase in the yield of buckwheat and mustard on soil treated with chloroform, carbon bisulfide, ether and toluene. Likewise there was an increased yield of turnips on soil with formalin as an antiseptic. Russell and Hutchinson (43) obtained greater yields with wheat and rye on toluene-treated soil than on mustard soil. Sherpe (45) reports an increased yield of rye on soil treated with carbon bisulfide. Emmerrich, Leiningen and Loew (11) noticed a beneficial effect with carbon bisulfide on cane seedlings. Stone (48) similarly obtained better growth with lettuce after treating the soil with carbon bisulfide. Gainey (14), while experimenting with toluol, carbon bisulfide and chloroform, found increased yields with oats, wheat, and buckwheat.

It is evident from these results that the ability of partially sterilized soils to yield larger crops is a general one. Furthermore, it holds for all the soils studied and for the various volatile antiseptics examined. According to Russell and Hutchinson (43) this seems to be true for all plants except for those of the leguminous order.

2. *The Effect of Partial Sterilization on the Ammonifying and Nitrifying Power of the Soil*

Here will be considered some of the investigators who noted the effect of volatile antiseptic on the nitrifying and ammonifying power of the soil. The data are very conflicting on this point. Wagner (51) found a decrease in nitrification with carbon bisulfide treatment. Coleman (8) reported an immediate inhibiting effect on nitrate formation on soil treated with carbon bisulfide, but after a time found an increase.

Lipman (27), on the other hand, reports a beneficial effect both for ammonification and nitrification. Störmer (49) and Scherpe (45) both observed an increase in ammonification but a detrimental effect on nitrification. The results of these two investigators are corroborated by the more extensive work done in England, especially by Russell and Hutchinson (43), who found the production of ammonia after partial sterilization at first slow, then rapid, and then more or less constant. Goodey (16), Hutchinson and MacLennan (21), Buddin (5) and others report similar results.

Laidlaw and Price (26) noted that in partially sterilized soil more ammonia was produced but a cessation of the nitrifying process took place. On the other hand, Chaudon de Briailles (7), Pagnoul (38), Koch (24) and Fred (13) all report that partial sterilization enhanced the process of nitrification after a considerable duration of time. Notwithstanding the fact that the reported results are somewhat conflicting, there appears to be a pronounced indication that the volatile antiseptic treatment of the soil inhibits, at least for a time after the treatment, the nitrification process. This inhibition is then followed by a marked stimulation.

3. *The Effect of Volatile Antiseptics upon the Total Water-Soluble Salts in the Soil*

The literature on this subject is very meager. Most of the investigators have studied the availability of plant-food due to the effect of partial sterilization with heat. Koch (23) does not believe that carbon bisulfide directly liberates plant nutrient elements, but states that as carbon bisulfiide stimulates plant growth, it is reasonable to expect that more plant-food is removed from the soil. Darbishire and Russell (9) found that soil treated with carbon bisulfide was able to supply the plants with 75 per cent more phosphoric acid, 40 per cent more potash and 50 per cent more nitrogen than the untreated soil. Using plants as indicators, Russell and Hutchinson (43) showed that more nitrogen, phosphorus and potassium were removed from soil treated with carbon bisulfide than from the untreated soil.

The partial sterilization of the soil by heat has been more extensively studied. Frank (12), Kruger and Schneidewind (25), Lyon and Bizzell (31), Pickering (40), and Stone (48) demonstrated that soluble plant and bacterial nutrients have been increased in partially sterilized soil with such treatment. As partial sterilization with volatile antiseptics is analogous in many respects to sterilization with heat, it would seem that more plant nutrients should become available when the soil is treated than when untreated with such volatile antiseptics.

4. *Methods of Treating the Soil with Volatile Antiseptics and the Effect upon Biological Processes*

Various methods have been employed for treating the soil with volatile antiseptics. The general method under field conditions seems to have been the introduction of the antiseptic by means of holes bored in the soil at regular intervals. Mach (32) added 200 gm. of carbon bisulfide per square meter. Koch (23) applied 60 c.c. of carbon bisulfide and ether respectively, to 20 kg. of soil. Hiltner and Störmer (20) applied 516 gm. of carbon bisulfide to a square meter of soil as follows: three holes were made, each 30 cm. deep, in every square meter of soil; the carbon bisulfide was poured into the holes, which were immediately filled up with soil; the plot of soil was afterward spaded over to insure equal distribution of the antiseptic; the soil was not seeded nor samples taken for biological determination, as the case might be, until all odor from the antiseptic had disappeared. Koch (24) and Fred (13) used similar methods for the different antiseptics, the latter working with pot experiments.

Nobbe and Richter (36) applied to the first set of experiments 62 gm. of ether to each pot of 3600 gm. of soil. To the second set having the same quantity of soil and known as the ether emulsion treatment, 300 c.c. of ether and 300 c.c. of water were added. The soils were then thoroughly mixed with the antiseptic, put into air-tight boxes with a small receptacle containing ether, for a given time, and then exposed to the free atmosphere. In a third test, hydrogen peroxide was used. A 30 per cent solution diluted with 750 c.c. of water was applied to each pot of soil as above stated. The soil was thoroughly mixed and was then considered ready for the growth of plants. The authors also report experiments with ether, carbon bisulfide, chloroform and benzene where the method of treatment was identical as under the second set described above.

Darbishire and Russell (9) added 25 c.c., respectively, of carbon bisulfide, chloroform, toluene, ether and benzene to 1 kg. of soil. The pots with soil were covered and allowed to stand for a period of one week. The soil was then spread open in a thin layer and the antiseptics allowed to evaporate. The evaporation took about 3 days. Russell and Hutchinson (43) employed a similar method but used only 2 c.c. of toluene per kilogram of soil where plants were to be grown. For the determination of the ammonifying and nitrifying power of the soil, 40 gm. of toluene were added to a receptacle holding 800 gm. of soil. A second series was treated similarly, but the toluene allowed to evaporate at the end of 3 days, while in the first series the antiseptic remained in the soil during the whole period of experimentation.

5. *The Relative Effect on Crop Yields of the Different Volatile Antiseptics in the Partial Sterilization of Soils*

Though several investigators have studied different antiseptics, carbon bisulfide has been used to a greater extent than any other. Koch (23) reports that better crop yields were obtained with carbon bisulfide as an antiseptic than with ether under similar conditions. In 1911 the same author (24) pointed out an increase of crop yield with increase of quantities of carbon bisulfide and ether used, but not necessarily proportional to the amount applied. The effectiveness again was in favor of carbon bisulfide.

According to the crop yields reported by Nobbe and Richter (36), the order of effectiveness of the antiseptics used was as follows: carbon bisulfide, benzene, chloroform, and ether. It would seem from the relative weights reported for buckwheat by Darbishire and Russell (9) that carbon bisulfide is better than chloroform and the latter superior to ether as an antiseptic. For mustard the following order was observed by the same authors: chloroform, benzene, carbon bisulfide, and toluene, with an average relative yield of 118 against 100 for the untreated soil. From the meager literature available it is apparent that some antiseptics are more effective than others.

6. *Suggested Theories in Explanation of the Effect of the Partial Sterilization on Soil Fertility*

A number of views have been advanced to explain the cause of the beneficial effect that higher plants and bacterial flora derive from partial sterilization of soils by volatile antiseptics. These will be discussed in the order of their priority.

Koch (23) holds that partial sterilization has a direct stimulating effect upon the higher and lower forms of plant life in the soil. He is not the only investigator to produce data substantiating this veiw. Nobbe and Richter (36), Egorov (10), Fred (13) and others are of the same opinion.

Hiltner and Störmer (20) advanced the so-called indirect selective theory of the antiseptics as related to the growth and activity of bacterial flora. They maintain that the harmful organisms are suppressed, whereas the beneficial bacteria are stimulated by the changes brought about in the soil as a result of such treatment.

In 1909 Russell and Hutchinson (43) announced their protozoa theory. These investigators believe that the protozoa in the soil hold in check the multiplication of the bacteria, especially those of the ammonifying type. They hold that an antiseptic destroys most of the large organisms that prey on the bacteria. The latter, although temporarily suppressed by the antiseptic, are later able to multiply unhindered and so attain numbers greatly in excess of those found in normal soils. The greater number of bacteria is assumed to cause more plant nutrients and nutrient elements to be elaborated and, consequently, larger crop yields are produced. Fred (13), Sherman (47) and others, however, have given data showing that some protozoa are not so detrimental to bacteria as Russell and Hutchinson believe.

Previous to Russell and Hutchinson's work, the existence of protozoa in soil was reported by Celli and Fiocca (6), who isolated 6 species of amœbæ. Other investigators in England who have reported the presence of protozoa in the soil are Goodey (16), Martin (33), and Martin and Lewin (34). In Germany, Hiltner (19), Tsujitani (50), Emmerich, Leiningen and Loew (11), Killer (22) and others have noted the same phenomenon. In the United States the presence of such organisms has been observed by Gainey (14), Lodge and Smith (28), Rahn (41), and Sherman (46, 47). Peck (39) has observed their presence in Hawaii soil. Loew (29, 30) reported their presence in the soil of the Alps, in Japan, the Island of Borkum and in Porto Rico.

Bolley (1, 2, 3) considers the parasitic fungi in the soil as the chief cause, in many cases, of poor vegetative growth. The effect of the partial sterilization is to destroy or check the parasitic fungi and, consequently, allow the plant to grow unhampered.

Greig-Smith (17) has advanced the "agricere" theory. The agricere is considered to be a waxy substance, which covers, as it were, the soil particles. When the soil is treated with antiseptics this agricere is destroyed and conditions are rendered more favorable for the liberation of nutrients for plants and bacteria.

Greig-Smith (17) and Bottomley (4) have proved the presence of bacterio-toxins in soil. Greig-Smith found them to a greater degree in poor than in rich soil. He claims that the toxins check bacterial activity in the soil.

Summary of Literature

1. Treatment of soil with volatile antiseptics has a definite beneficial effect on plants subsequently grown on such soil.

2. The ultimate effect of partial sterilization is an increased production of ammonia and nitrates.

3. Heat sterilization of soil liberates plant nutrients. As the treatment of soil with volatile antiseptics is somewhat similar in effect to heat sterilization, a like phenomenon may probably result.

4. In general, the application of volatile antiseptics to field soil is made in holes bored for that purpose. In greenhouse and laboratory experiments the antiseptic either is allowed to volatilize after treatment or is left in the soil.

5. Some volatile antiseptics seem to be more effective sterilizing agents than others.

6. Different theories as to the beneficial effects of volatile antiseptics may be stated as follows:

a. Koch believes that antiseptics have a direct stimulating effect on plant and bacterial life.

b. Hiltner and Störmer consider the action as a disturbance of the equilibrium of the soil flora.

c. Russell and Hutchinson attribute the beneficial effects of volatile antiseptics to the suppression of the soil protozoa, which are considered to hamper ammonification.

d. Bolley considers the checking of certain harmful parasitic fungi in many cases as the real influence of partial sterilization.

e. Greig-Smith believes that the solution of certain waxy material in the soil by volatile antiseptics affords conditions for a more ready availability of plant nutrients.

II. Conditions and Methods of Experimental Procedure

The experimental data embodied in this report were derived from two sources: greenhouse studies and laboratory investigations.

Both parts of the report were carried out in the Soil Technology Department of Cornell University, beginning with the spring of 1915 and continuing through the summer of 1916.

1. *Pots.*

Four classes of receptacles were used for the vegetative part of the experiment.

(a) Glazed crockery pots of ½-gallon capacity, 4½ inches in diameter and 6 inches deep, holding 2½ kg. of dry soil.

(b) Small ordinary unglazed flower pots of 500-gm. capacity, 5 inches in diameter and 5 inches deep. These were used for the ether-treated soils described under Experiment I.

(c) Unglazed clay flower pots of ½-gallon capacity, 6 inches in diameter and 6¼ inches deep. These pots were used in Experiment XI for the growth of the wheat crop, having been previously dipped into paraffin in order to cut down evaporation and diffusion through the sides.

(d) Glazed crockery pots of 2-gallon capacity, 8 inches in diameter and 6 inches deep, each holding about 5 kg. of soil.

It was noticed that the root systems which developed in the smaller pots were too crowded, and to eliminate this unfavorable condition larger pots were employed, notwithstanding the fact that greater quantities of the volatile solvents were necessary.

2. *Soils.*

Dunkirk clay loam and Volusia silt loam soils were used. Both are typical soils in the vicinity of Cornell University. The Dunkirk clay loam was surface soil obtained from the experimental plots of Caldwell Field. The Volusia silt loam was surface soil from the Stevens farm on Turkey Hill.

Unpublished results of bulk analysis for Dunkirk clay loam soil are as follows:

FROM 9 SAMPLES OF TOMPKINS COUNTY SOIL

	Surface %	Subsoil %
C (organic carbon)	1.670	0.440
CO_2	trace	0.260
K_2O	1.740	2.110
CaO	0.430	0.830
MgO	0.450	0.690
Na_2O	1.090	1.280
N	0.186	0.082
P_2O_5	0.123	0.126

Unpublished results of bulk analysis for Volusia silt loam soil are as follows:

FROM 11 SAMPLES OF TOMPKINS COUNTY SOIL

	Surface %	Subsoil %
C (organic carbon)	1.960	0.650
CO_2	trace	trace
K_2O	1.630	1.970
CaO	0.270	0.240
MgO	0.240	0.250
Na_2O	0.850	0.960
N	0.169	0.086
P_2O_5	0.153	0.127

The soil in a majority of cases was obtained in bulk. After being allowed to dry, it was reworked in order to get rid of lumps and stones, the latter being especially numerous in the Volusia silt loam. The soil was then sieved through a 2-mm. sieve, except that used in Experiment I, which was passed through a 10-mm. sieve.

3. *Treatment of Soils.*

In order that the discussion of the different experiments may be easier to follow, and to avoid repetition, a description will be given of the various solvents employed with an explanation of the different terms used.

The organic solvents utilized in this experimentation were alcohol, benzene, ether, commercial gasoline, and toluene.

It will be seen from the experiments which follow that the alcohol treatment was applied to both types of soil on three different occasions. Ether, gasoline, and toluene, on the other hand, were each applied twice to Dunkirk clay loam soil as a treatment and only once to Volusia silt loam. Benzene was applied only in Experiment I to Dunkirk clay loam.

The treatment in general consisted in extracting and saturating each type of soil with the individual solvents.

(a) Extracted soil.

By extraction it is to be understood that definite quantities of the solvent were applied to definite quantities of soil. The ratio was a variable one. In case of alcohol and ether, for example, the ratio was 3 of solvent to 1 of the soil. With gasoline, benzene, and toluene the ratio was 4 to 1. The previously prepared soil was placed in a receptacle and the proper amount of solvent added. The soil was thoroughly stirred three times a day as long as the extraction lasted, which varied from 1 day for alcohol, to 8 days for gasoline. At the end of the extraction the solvent was siphoned off. The soil thus treated was then spread out on thick paper in a well ventilated dark room until, as far as could be determined by the odor, the solvent had disappeared entirely. The time varied also in this case from 3 days for alcohol to 10 days for gasoline. Moisture determinations were then made and the soil was ready for experimentation.

(b) Saturated soil.

Each soil was saturated with the respective solvents during the same period as in the extraction above described. The soil was then spread out and the solvent allowed to evaporate. The drying continued for the same length of time as for the extracted soil. Moisture determinations were then made and the soil was considered ready for use.

(c) Untreated soil.

The soils spoken of as untreated in this report are the respective soils, which were worked up in the same manner as the portions taken for the two treatments just described. The soil was spread out for the same period as those described under the treatments above, and after moisture determinations were made were ready for use.

4. *Moisture Control.*

The soil used for the vegetative work in the greenhouse was kept at 30 per cent moisture. The incubated soil was kept at 25 per cent moisture. Both calculations were on the moisture-free basis. The former percentage was considered to be the optimum moisture for plant growth. The 25 per cent moisture was used for all the incubated soils on which tests were run for nitrification, ammonification and total water-soluble salts. This percentage was considered the optimum moisture content for organisms.

5. *Incubation.*

To test the ammonifying and nitrifying power of the soil, incubation tests were run. These were carried out by placing 100 gm. of air-dried soil in 8-ounce bottles plugged with cotton. Incubation temperature was that of the laboratory.

6. *Methods Used for Determining Nitrates, Ammonia and Total Soluble Salts.*

The methods used for determining nitrates and ammonia were those described in Bulletin 31 of the Bureau of Soils of the United States Department of Agriculture.

7. *General Plan of Experimentation.*

That the data may be presented in as clear a form as possible, a general plan will be presented first and discussed in detail afterwards. The vegetative and laboratory parts of the work were divided up into the following separate experiments:

Vegetative Experiments

Experiment I. Oats, spring of 1915 (followed by buckwheat of Experiment IV, summer of 1915).

Experiment II. Wheat, summer of 1915 (followed by oats of Experiment V, 1915-1916).

8. *Diagramatic Plan of Experimentation*[2]

Experiment I Direct effect of volatile antiseptic on *oats.*	*Experiment II* Direct effect of volatile antiseptic on *wheat.*	*Experiment III* Direct effect of volatile antiseptic on *oats.*
Experiment IV Residual effect of volatile antiseptic on *buckwheat* after *oats* (Experiment I).	*Experiment V* Residual effect of volatile antiseptic on *oats* after *wheat* (Experiment II).	*Experiment VI* Effect of water-soluble alcoholic extract from soil treated with volatile antiseptic as in Experiment III upon *oats* in water cultures.
	Experiment VII Direct effect of volatile antiseptic on the chemical condition of the soil treated with volatile antiseptic as in Experiment II.	*Experiment VIII* Direct effect of volatile antiseptic on the chemical condition of the soil treated with volatile antiseptic as in Experiment III.
Experiment IX Residual effect of volatile antiseptic upon the chemical condition of the soil after *oats* (of Experiment I) and *buckwheat* (Experiment IV).	*Experiment X* Residual effect of volatile antiseptic upon the chemical condition of the soil after *wheat* (Experiment II) and *oats* (Experiment V).	*Experiment XI* Physical condition of the soil upon certain chemical factors. Soil of Experiment III studied directly after the *oats.*

Experiment XII

The direct effect of volatile antiseptics upon development of acid in the soil. Soil treated exactly as in Experiments I, II and III.

Experiment III. Oats, spring and summer, 1916. (Soil later studied chemically. See Experiment XI.)

Experiment IV. Buckwheat following oats. (See Experiment I.)

Experiment V. Oats following wheat. (See Experiment II.)

Experiment VI. Water culture experiments.

Laboratory Investigations

Experiment VII. Soil incubated for 3, 6 and 12 weeks. The soil was treated with volatile antiseptics exactly as in Experiment II.

[2] It is to be noted that Experiments I, II and III are comparable, also Experiments IV and V, Experiments VII and VIII, and Experiments IX and X. Experiments VI, XI and XII are each to be considered separately.

Experiment VIII. Soil incubated for 2, 4 and 6 months. The soil received the same treatments with volatile antiseptics as in Experiment III.

Experiment IX. Soil incubated and studied chemically after harvesting the buckwheat of Experiment IV. The buckwheat followed an oats crop (Experiment I).

Experiment X. Soil studied chemically directly from pots after harvesting crop of oats (Experiment V) which followed a crop of wheat (Experiment II).

Experiment XI. Soil studied chemically from pots and simultaneously incubated after harvesting a crop of oats (Experiment III).

Experiment XII. The study of the development of acids in soils immediately after the treatment with alcohol as an antiseptic.

III. Vegetative Experiments

As outlined in the general plan, the experimental part is subdivided into different experiments which will be discussed in their numerical order.

Experiment I

The Effect of Volatile Antiseptics Applied to the Soil upon the Following Oat Crop

Both Volusia silt loam and Dunkirk clay loam soils were extracted and saturated with 90 per cent alcohol in this experiment. Furthermore, benzene, ether, toluene and gasoline, respectively, were applied to Dunkirk clay loam alone. After the soil was treated as already described, 2 kg. of soil were weighed out in duplicate, into the ½-gallon glazed crockery pots. In case of the ether-treated soils, however, only 500 gm. of soil were used in the small flower pots.

The soils stood in the pots for 8 days before seeding. On April 13, 1915, all the pots were seeded with oats, 16 seeds to a pot. When the plants were 2 inches high, all were removed except eight of uniform size. At this time, 300 gm. of clean quartz sand were spread over the surface of the soil in each pot. This was to act as a mulch and decrease the amount of water lost by evaporation.

The seeds in the treated soil in most cases germinated a day, and in the case of gasoline from 2 to 3 days, later than the seeds in the untreated soil. This, however, was not the case with the seeds in the ether-treated soil, the germination period being the same as that of the seeds in the untreated soil.

During the first 4 to 6 weeks of growth, the plants in all the pots with treated soil (ether being an exception again) did not show the same amount of growth as the plants in the untreated soil. The saturated soil maintained a slight advantage over the extracted soil. From this period on, however, there was a marked increase in growth of the plants on the treated soils, as can be seen from the dry weight of the plants (Table I), which were harvested on July 21, 1915, after the crop had passed the blooming stage and was about to ripen.

Conclusions Regarding Experiment I

These results indicate a decided benefit to crop growth in favor of the treated soils. The saturated soils responded better to the treatment than extracted soils. This is shown not only by the average data but also by every individual treatment.

The 90 per cent alcoholic antiseptic seems to have affected the crop growth most beneficially, ether next, then benzene, and finally, toluene. The gasoline antiseptic had a detrimental effect, the extracted treatment even more so than the saturated treatment.

TABLE I

RESULTS OBTAINED WITH OATS GROWN ON SOILS PREVIOUSLY TREATED WITH VOLATILE ANTISEPTICS, EXPRESSED AS AVERAGE DRY WEIGHTS

(Planted April 13, 1915; harvested July 21, 1915)

Soil Type	Volatile Antiseptic	Untreated		Saturated Soil		Extracted Soil	
		gm.	Relative Weights	gm.	Relative Weights	gm.	Relative Weights
VSL[1]	Alcohol	2.50	100	2.75	110	2.50	100
DCL[2]	Alcohol	1.70	100	3.15	185	2.90	170
DCL	Ether[3]	1.05	100	1.65	157	1.25	119
DCL	Gasoline	1.75	100	1.65	94	1.30	74
DCL	Toluene	1.95	100	2.35	121	2.20	113
DCL	Benzene	2.05	100	2.65	129	2.30	112
Grand Average		1.80	100	2.40	133	2.07	115

[1] Volusia silt loam.
[2] Dunkirk clay loam.
[3] With ether treatment only 6 plants were left in each pot to mature.

All of the antiseptics lengthened the period for germination except ether, which treatment produced no variation from the untreated soil.

Experiment II

The Effect of Volatile Antiseptics Applied to the Soil upon the Following Wheat Crop

This experiment was begun in August, 1915. The organic solvents used were alcohol, ether and toluene on both Dunkirk clay loam and Volusia silt loam.

Two-kg. flower pots were used into which were weighed 1800 gm. of alcohol and toluene-treated soil, respectively. In the case of the ether treatments, 1400 gm. of soil were used. On September 2, 1915, these pots were seeded with Galgalos wheat, 20 seeds to a pot. The young plants were later thinned to 10 plants of uniform size.

The first important consideration here was the germinating power of the seeds in these differently treated soils. Invariably, the seeds in the untreated soil germinated 2 or 3 days sooner than on the treated soil and showed for the first 3 weeks a distinctly better growth. This was especially noticed with the alcohol and the toluene treatments. The ether did not show this inhibiting effect. As the growing period progressed, the plants on the treated soils gradually improved, and showed a healthier color and a more vigorous growth at the end of 5 weeks.

On account of a bad attack of mildew, to which wheat is especially subject when grown in the greenhouse during the summer, this crop had to be harvested on October 17, thus growing for only 6 weeks. Although these results are not so reliable and conclusive as from plants grown to maturity, nevertheless the dry weights shown in Table II show a distinct tendency in favor of the treated soil.

TABLE II

RESULTS OBTAINED WITH WHEAT GROWN ON SOILS PREVIOUSLY TREATED WITH VOLATILE ANTISEPTICS, EXPRESSED AS AVERAGE GREEN AND DRY WEIGHTS

(Planted September 3, 1915; harvested October 17, 1915)

Soil Type	Volatile Antiseptic	Untreated Soil			Saturated Soil			Extracted Soil		
		Wt. of Green Crop	Weight of Dry Matter		Wt. of Green Crop	Weight of Dry Matter		Wt. of Green Crop	Weight of Dry Matter	
			gm.	Relative Wts.		gm.	Relative Wts.		gm.	Relative Wts.
DCL	Alcohol	3.40	0.80	100	6.15	1.35	169	6.65	1.45	181
VSL	Alcohol	5.70	1.20	100	7.20	1.55	127	5.75	1.35	112
DCL	Ether	4.60	0.95	100	7.55	1.37	144	9.35	1.65	173
VSL	Ether	5.50	1.20	100	7.30	1.32	110	8.65	1.60	133
DCL	Toluene	4.60	0.95	100	5.85	1.25	131	5.35	1.20	126
VSL	Toluene	5.30	1.05	100	7.45	1.40	133	7.75	1.40	133
Grand Average		4.85	1.02	100	6.91	1.37	135.7	7.25	1.44	143

Conclusions Regarding Experiment II

The crop in this experiment also responded with greater yields on the treated soils than on the untreated ones. There is a general tendency in favor of the extracted treatments, although there are marked exceptions there, also. The order of effectiveness of the antiseptics according to the results are alcohol, ether and toluene, respectively. The Dunkirk clay loam in general responded better than Volusia silt loam, except for the ether treatment, where the reverse was true. Alcohol and toluene retarded germination, while ether seemed to have no influence, either stimulating or retarding.

Experiment III

The Effect of Volatile Antiseptics Applied to the Soil upon the Following Oat Crop

In the previous experiment the largest pots used were ½-gallon pots. The object in Experiment III was to study the various treatments on larger quantities of soil. Four kg. of soil were used in 2-gallon pots. The Dunkirk clay loam was stock soil which had been kept for 3 years in the store-room. The Volusia silt loam was the same as previously described.

Both types of soil were extracted with 70 per cent alcohol. The gasoline treatments on both types of soil were in the ratio of 4 parts of gasoline to 1 part of soil. Five and 10 days were allowed, respectively, for the evaporation of the alcohol and gasoline.

The soils, after standing for 6 days in the pots, were seeded to oats on March 9, 1916. Twenty-five seeds were planted to a pot, but only fifteen of the resulting plants were allowed to grow. The same phenomenon was observed as in previous experiments, to wit, that the treatment had a retarding effect for the first few weeks of growth. After this period, the plants on the alcohol-treated soil began to show a more rapid growth, extending until the harvest time, June 1, 1916. The plants were in full bloom at harvesting.

TABLE III

RESULTS OBTAINED WITH OATS GROWN ON SOILS PREVIOUSLY TREATED WITH VOLATILE ANTISEPTICS, EXPRESSED AS AVERAGE GREEN AND DRY WEIGHTS

(Planted March 9, 1916; harvested June 1 and June 30, 1916)

Soil Type	Volatile Antiseptic	Untreated Soil			Saturated Soil			Extracted Soil		
		Wt. of Green Crop	Weight of Dry Matter		Wt. of Green Crop	Weight of Dry Matter		Wt. of Green Crop	Weight of Dry Matter	
			gm.	Relative Wts.		gm.	Relative Wts.		gm.	Relative Wts.
DCL	Alcohol	91.90	16.75	100	107.45	21.20	120	133.35	26.10	155
VSL	Alcohol	61.25	10.50	100	100.40	19.70	187	91.75	17.90	170
DCL	Gasoline	32.50	8.95	100	35.75	8.85	98	31.00	7.05	79
VSL	Gasoline	72.05	22.55	[1]100	66.60	17.60	78	71.15	23.10	102
Grand Average		64.45	14.69	100	77.55	16.84	120.7	81.81	18.79	126.5

[1] It should be remembered that the crops from the alcohol-treated soils were harvested on June 1, 1916, whereas the gasoline-treated soil was not harvested until June 30. This is one factor that accounts for the difference in weight from the untreated soil of the Volusia silt loam. The kernels were riper and thus had very little moisture. The green weights do not show this great difference.

The gasoline treatment, on the other hand, did not show up the differences as early as the alcohol treatment did. After 2 months' growth, the plants on the treated soils still continued poorer than those on the untreated soil. About 10 weeks after seeding, the plants began to increase in growth on the treated soil.

It may be noted that on the Dunkirk clay loam, although all the 15 plants remained alive, only 9 plants grew to full height. It seems that for some reason the gasoline treatment had a retarding effect.

Conclusions Regarding Experiment III

A very marked increase in plant growth in favor of the alcohol treatment was noted in this test. The Volusia silt loam saturated yielded better than the extracted treatment. With the Dunkirk clay loam the extracted treatment gave the highest yield. The gasoline treatment, as in Experiment I, shows no beneficial effect. In most cases it was detrimental.

Summary of Experiments I, II and III

1. The antiseptic treatment of soil in pots has a distinctly beneficial effect on the vegetative growth of succeeding oat and wheat crops. There is a slight advantage in favor of the saturated treatments.

2. Alcohol gave better results on plant growth than ether, benzene, toluene and gasoline, respectively. Gasoline is often harmful in its effects, both on plant growth and on germination. Ether seems to have little or no effect in either direction.

3. A stimulating influence of volatile antiseptics on plant growth occurs for both Dunkirk clay loam and Volusia silt loam, but in different degrees. Volusia silt loam, in general, responds the better.

TABLE IV

RESULTS OBTAINED WITH BUCKWHEAT GROWN ON SOILS PREVIOUSLY TREATED WITH VOLATILE ANTISEPTICS AND CROPPED TO OATS, EXPRESSED AS AVERAGE GREEN AND DRY WEIGHTS

(Planted August 5, 1915; harvested October 2, 1915)

Soil Type	Volatile Antiseptic	Untreated Soil			Saturated Soil			Extracted Soil		
		Wt. of Green Crop	Weight of Dry Matter		Wt. of Green Crop	Weight of Dry Matter		Wt. of Green Crop	Weight of Dry Matter	
			gm.	Relative Wts.		gm.	Relative Wts.		gm.	Relative Wts.
DCL	Alcohol	34.25	7.90	100	35.75	8.10	102	32.60	7.9	100
[1]VSL	Alcohol	24.50	6.30	100	35.00	7.40	117	33.50	6.5	103
DCL	Benzene	34.00	8.20	100	40.50	9.30	101	40.00	9.3	113
DCL	Toluene	34.50	8.40	100	44.00	10.40	123	45.50	10.0	119
DCL	Gasoline	26.00	6.45	100	24.30	6.25	97	23.25	5.3	82
Grand Average		30.65	7.45	100	35.91	8.29	108	34.97	7.8	104

[1] In this experiment on the Volusia silt loam with the alcohol treatment, there was a set ot soil fresh from the field. The following results were obtained: green weight of crop 15.5 gm. and dry weight 3.7 gm.

Experiment IV

The Effect of Volatile Antiseptics upon the Second Crop (Buckwheat) Grown after the Antiseptic Treatment of the Soil— Antiseptic: Alcohol, Benzene, Gasoline and Toluene—Crops: Oats and Buckwheat

The soil from Experiment I was taken from the pots, reworked, and the oat roots, as far as possible, removed. The soil was then replaced in each corresponding pot. On August 5, 1915, all the pots, except ether treatments, which were discarded, were seeded to buckwheat, 15 seeds to a pot. The young plants were thinned to 10, when they were 10 inches high.

Observations were made of the growth of these plants. The seeds all germinated at the same time and the growth continued uniformly until about 5 weeks after seeding, when the plants on some of the treated soils showed a slightly better growth, as can be observed from the dry weights of Table IV. The buckwheat was harvested on October 2, 1915. Most of the seeds were ripe and some even ready to fall.

Conclusions Regarding Experiment IV

A residual effect of the antiseptic treatment of soil on plant growth is brought out distinctly in this experiment. It is not so marked, however, as was the direct influence shown in Experiments I, II and III. The saturated treatment again averages better than the extracted. In every case, except the benzene treatment, the saturated soil gave the higher yields. The gasoline treatment, although better on the saturated soil than on the extracted, gave in both cases lower yields than the untreated. If preference is to be given for the effectiveness in increasing crop yields, toluene seems to be slightly more effective than the other antiseptics. Gasoline is distinctly the least efficient. The Volusia silt loam soil responded to the treatment better than Dunkirk clay loam, as expressed in crop growth.

Experiment V

The Effect of Volatile Antiseptics upon the Second Crop (Oats) Grown After the Antiseptic Treatment of the Soil — Antiseptics: Alcohol, Ether and Toluene—Crops: Wheat and Oats

The soil after the harvesting of the wheat crop of Experiment II was taken out of the flower pots, reworked and transferred to ½-gallon glazed earthenware jars. Three hundred gm. of clean quartz sand were added to serve as a mulch. The moisture content was then kept constant until December 15, 1915, when the pots were seeded with oats. The oats were sterilized (52) with calcium hypochlorite powder, 10 gm. in 140 c.c. of water. Out of 20 seeds planted only 12 plants were left growing.

A notable effect here was that all of the plants on treated and untreated soils made the same progress in growth. This continued to be the case for the first two months of the experiment. After this period, however, the plants in the treated soil showed a distinct improvement over the plants in the untreated soil. Hardly any difference in growth was noticed between the saturated and the extracted soils. By the middle of March, 3 months after seeding, all the plants in the treated soil began to show a very healthy dark blue color, in contrast with those on the untreated pots, which did not have this vigorous appearance.

By the beginning of April there was not only a distinct difference in growth between the different treatments, but a difference was also observed between the different types of soil. The Volusia silt loam invariably showed a better growth than the Dunkirk clay loam. This fact becomes easily apparent by a study of the results in dry weights given in Table V. In order that a fair comparison should be obtained between the different treatments, it was thought best to harvest the oats at this stage, although they had just begun to head.

TABLE V

RESULTS OBTAINED WITH OATS GROWN ON SOILS PREVIOUSLY TREATED WITH VOLATILE ANTISEPTICS AND CROPPED TO WHEAT, EXPRESSED IN AVERAGE GREEN AND DRY WEIGHTS

(Planted December 15, 1915; harvested April 17, 1916)

Soil Type	Volatile Antiseptic	Untreated Soil			Saturated Soil			Extracted Soil		
		Wt. of Green Crop	Weight of Dry Matter		Wt. of Green Crop	Weight of Dry Matter		Wt. of Green Crop	Weight of Dry Matter	
			gm.	Relative Wts.		gm.	Relative Wts.		gm.	Relative Wts.
DCL	Alcohol	8.90	2.35	100	29.05	6.45	274	30.65	6.15	261
VSL	Alcohol	35.60	6.80	100	44.90	9.15	135	40.95	8.60	126
DCL	Ether	8.85	2.05	100	23.20	4.85	236	23.65	4.45	217
VSL	Ether	26.50	5.40	100	30.10	5.70	105	27.95	5.60	104
DCL	Toluene	8.95	2.15	100	20.50	4.40	204	24.45	4.90	227
VSL	Toluene	23.70	5.00	100	48.65	9.50	190	39.35	7.90	158
Grand Average		18.75	3.79	100	32.73	6.67	190.6	31.16	6.26	182

Conclusions Regarding Experiment V

The residual effects from the antiseptic treatments on crop growth are brought out more markedly in this experiment than in the previous one. The saturated treatment again gave higher results than the extracted, except on the Dunkirk clay loam treated with toluene. The alcohol shows the highest benefit as measured in crop growth, with toluene next and ether last. There is only one exception to this order. The relative crop weights indicate a better response for the Dunkirk clay loam soil.

Summary of Experiments IV and V

1. A residual effect of the antiseptic treatment of soil upon the second crop is distinctly brought out in these experiments. The advantage is generally in favor of the saturated treatment.

2. The relative influence of the different antiseptics as measured by yields indicates that alcohol is most effective, and gasoline, the least.

3. The Volusia silt loam in general excels Dunkirk clay loam in its response to volatile antiseptics, as measured by the yield of the second crop after the antiseptic treatment.

Experiment VI

The Effect of the Alcoholic Extract of Soils upon Oats Grown in Water Cultures

The object in this experiment was to study the effect on plant growth of the residue of the alcoholic extract obtained in Experiment III. For this purpose the alcoholic residue obtained from recovering the alcohol extract of both Dunkirk clay loam and Volusia silt loam was evaporated to dryness on water bath. It was then taken up three consecutive times with 70 per cent alcohol, digested and filtered each time. Finally the residue was taken up with distilled water previously treated with carbon black.

The water-soluble portion of this alcoholic soluble material was then determined. From the Dunkirk clay loam soil 0.5 gm. was derived, and from the Volusia silt loam soil 1.1 gm., the alcoholic-soluble residue being, respectively 2 and 3.1 gm. This water-soluble residue was used in growing oats in the following way. Half of this water filtrate of both types of soil was added in the proportions of 5, 50 and 100 parts per million, respectively, to a full nutrient solution of the following composition:

COMPOSITION OF NUTRIENTS

$Ca(NO_3)_2$	2.70 gm.
$MgSO_4$	0.60 gm.
KCl	0.75 gm.
KH_2PO_4	1.50 gm.
$FeSO_4$	0.05 gm.
Distilled H_2O	10.00 liters

Full nutrient solutions served as checks to the above. The other half of the extract was added in the same proportions as above to carbon-black-treated distilled water. Distilled water solutions served as checks in this case. Oat seedlings were grown in these solutions for one month, all of the solutions being replaced once during this period. Four plants as uniform as it was possible to obtain were grown in each 8-ounce bottle.

Conclusions Regarding Experiment VI

From the data it seems that a soluble substance has been removed from the soil, which in water culture, is detrimental to plant growth. Its injurious effect in all cases with one exception was brought out more in the presence of nutrients than with distilled water alone. The toxic effect was not apparent in the soil itself as has already been shown in previous experiments; if it were, its influence would have been noticed in the comparison of the saturated and extracted treatments of Experiments I, II and III. As this was not the case, the results seem to substantiate the work of other investigators in their conclusion that a substance, toxic when in water culture, may not be toxic in the soil itself.

TABLE VI

RESULTS OBTAINED WITH OATS GROWN IN WATER CULTURE AND TREATED WITH WATER-SOLUBLE ALCOHOLIC EXTRACT FROM SOIL, EXPRESSED AS GREEN AND DRY WEIGHTS

(Plants grown for one month

Soil Type	Treatment	Check			5 p. p. m. of Extract			50 p. p. m. of Extract			100 p. p. m. of Extract		
		Weight Green Crop	Weight of Dry Matter		Weight Green Crop	Weight of Dry Matter		Weight Green Crop	Weight of Dry Matter		Weight Green Crop	Weight of Dry Matter	
			gm.	Rel. Wts.		gm.	Rel. Wts.		gm.	Rel. Wts.		gm.	Rel. Wts.
VSL	Distilled H_2O	1.3925	0.1837	100	1.3923	0.1750	95	1.3949	0.1656	90	1.2689	0.1648	88
VSL	Full Nutrient	5.7888	0.7005	100	3.3616	0.4154	59	3.4100	0.4499	64	3.4962	0.4840	69
DCL	Distilled H_2O	1.4340	0.1917	100	......	......	..	0.9601	0.1107	57	1.3250	0.1680	87
DCL	Full Nutrient	4.8863	0.7788	100	3.3167	0.4773	61	2.7311	0.4705	60	1.7294	0.3813	48
Grand Aver.		3.3754	0.4637	100	2.3569	0.3559	71.6	2.1240	0.2992	67.7	1.9549	0.2995	73

IV. Laboratory Investigations

Experiment VII

The Effect of Alcohol and Toluene Treatments on Ammonification and Nitrification in the Soil and upon the Total Soluble Salts after Incubation for Periods of 3, 6 and 12 Weeks

The effect of the alcohol and toluene treatments on the ammonifying and nitrifying power of the soil and upon the total water-soluble salts after periods of 3, 6 and 12 weeks, was first taken up. For this a portion of the alcohol and toluene-treated soils described under Experiment II was utilized directly after the treatment with the volatile antiseptics. Nitrates and total soluble salts were determined from duplicate samples of each treatment. Ammonia was determined from other duplicate samples.

TABLE VII

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM WITHOUT TREATMENT AND SUBSEQUENT TO TREATMENT WITH ALCOHOL, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
After 3 weeks	8.25	100	Nil	Nil	Nil	Nil
After 6 weeks	25.60	310	Nil	Nil	Nil	Nil
After 12 weeks	61.00	739	2.3	28	1.65	20
AMMONIACAL NITROGEN[1]						
After 3 weeks	11.05	100	24.1	218	22.90	207
After 6 weeks	70.00	633	109.3	965	193.10	1748
After 12 weeks	16.80	152	65.4	588	94.50	855
TOTAL WATER-SOLUBLE SALTS						
After 3 weeks	64	100	75	117	73	114
After 6 weeks	62	97	72	113	70	109
After 12 weeks	78	122	83	130	77	120

[1] By ammoniacal nitrogen is meant ammonia expressed as nitrogen.

Conclusions Regarding Experiment VII

The antiseptic treatment exerts a definite effect on the nitrifying and ammonifying processes of the soil. The nitrifying power was practically inhibited by the alcohol and toluene treatments during the first 6 weeks, but at the end of 12 weeks small amounts were found. During the same period, there was a gradual increase of ammonia reaching its maximum at the end of 6 weeks followed by some depression.

The difference between the saturated and extracted treatments varied, but not to a marked extent. The Dunkirk clay loam soil responded more

TABLE VIII

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM, WITHOUT TREATMENT AND SUBSEQUENT TO TREATMENT WITH ALCOHOL, EXPRESSED IN PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
After 3 weeks	4.0	100	Nil	Nil	Nil	Nil
After 6 weeks	9.6	240	Nil	Nil	Nil	Nil
After 12 weeks	44.5	1112	1.85	46	2.2	55
AMMONIACAL NITROGEN						
After 3 weeks	22.4	100	27.3	122	21.5	96
After 6 weeks	96.2	429	109.3	487	172.5	769
After 12 weeks	24.7	110	39.6	177	44.9	200
TOTAL WATER-SOLUBLE SALTS						
After 3 weeks	121	100	128	106	99	82
After 6 weeks	125	103	130	107	116	96
After 12 weeks	130	107	85	70	76	63

TABLE IX

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM WITHOUT TREATMENT AND SUBSEQUENT TO TREATMENT WITH TOLUENE, EXPRESSED AS PARTS PER MILLION OF DRY SOIL

Time	Untreated		Toluene Saturated		Toluene Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
After 3 weeks	8.30	100	Nil	Nil	Nil	Nil
After 6 weeks	38.75	467	Trace	Trace	Nil	Nil
After 12 weeks	59.05	711	70.25	845	3.20	39
AMMONIACAL NITROGEN						
After 3 weeks	18.90	100	25.30	134	34.90	185
After 6 weeks	68.60	363	132.05	698	132.10	698
After 12 weeks	5.50	28	12.35	64	33.15	175
TOTAL WATER-SOLUBLE SALTS						
After 3 weeks	53	100	52	98	51	96
After 6 weeks	62	117	65	123	57	107
After 12 weeks	80	151	83	156	57	107

to the treatment than Volusia silt loam. The toluene antiseptic seems not quite as effective as the alcohol. The general results compare closely.

That these data corroborate the results of Russell and Hutchinson (43) and most other investigators can be seen from the literature, viz: that nitrification is inhibited, and ammonification gradually increased for a certain time. The latter then gradually decreases or remains constant, while the former is later stimulated.

TABLE X

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM WITHOUT TREATMENT AND SUBSEQUENT TO TREATMENT WITH TOLUENE, EXPRESSED IN PARTS PER MILLION

Time	Untreated		Toluene Saturated		Toluene Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
After 3 weeks	4.1	100	Nil	Nil	Nil	Nil
After 6 weeks	17.2	420	Trace	Trace	Trace	Trace
After 12 weeks	48.6	1180	2.6	63	1.9	46
AMMONIACAL NITROGEN						
After 3 weeks	20.6	100	25.3	124	26.2	127
After 6 weeks	101.1	49	122.6	610	130.6	660
After 12 weeks	19.4	94	39.7	193	33.7	164
TOTAL WATER-SOLUBLE SALTS						
After 3 weeks	121	100	145	120	133	110
After 6 weeks	124	103	137	114	127	105
After 12 weeks	129	107	135	111	121	100

There is a general tendency for the total water-soluble salts to increase correspondingly to the duration of incubation. The general influence of the treatments with volatile antiseptics seems to be slightly to increase water-soluble salts. No definite difference can be noted between different soils or between the two methods of applying the antiseptic. The data regarding water-soluble salts are variable.

Experiment VIII

The Direct Effect of Alcoholic and Gasoline Treatments on Ammonification and Nitrification in the Soil and upon Total Soluble Salts Incubation for Periods of 2, 4 and 6 Months

For this investigation, definite quantities were taken of the same soil as that used in Experiment III. The incubation periods were 2, 4 and 6 months, respectively.

The incubation temperature during this time varied from 18° to 26° C. The experiments with the alcohol treatment was begun on January 26, 1916, whereas with the gasoline-treated soils incubation was started on February 22.

TABLE XI

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM WITHOUT TREATMENT AND SUBSEQUENT TO TREATMENT WITH ALCOHOL, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
After 2 months	6.70	100	Nil	Nil	Nil	Nil
After 4 months	50.50	753	Nil	Nil	Nil	Nil
After 6 months	59.40	886	29.20	435	46.3	691
AMMONIACAL NITROGEN						
After 2 months	5.75	100	23.00	400	19.3	335
After 4 months	6.45	112	13.40	233	8.0	139
After 6 months	Trace	Trace	1.25	21.7	Trace	Trace
TOTAL WATER-SOLUBLE SALTS						
After 2 months	104	100	106	102	122	117
After 4 months	132	127	112	108	113	108
After 6 months	146	140	157	151	115	110

TABLE XII

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM WITHOUT TREATMENT AND SUBSEQUENT TO TREATMENT WITH ALCOHOL, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
After 2 months	19.2	100	Nil	Nil	Nil	Nil
After 4 months	24.8	129	Nil	Nil	Nil	Nil
After 6 months	60.6	314	4.8	25	Trace	Trace
AMMONIACAL NITROGEN						
After 2 months	5.9	100	23.8	403	23.8	403
After 4 months	Trace	Trace	11.4	193	12.3	209
After 6 months	Trace	Trace	7.6	129	11.0	186
TOTAL WATER-SOLUBLE SALTS						
After 2 months	170	100	78	46	72	43
After 4 months	168	99	72	43	79	46
After 6 months	194	114	88	52	79	46

TABLE XIII

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM WITHOUT TREATMENT AND SUBSEQUENT TO TREATMENT WITH ALCOHOL, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Gasoline Saturated		Gasoline Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
After 2 months	7.50	100	Trace	Trace	Trace	Trace
After 4 months	21.40	285	8.9	119	7.7	103
After 6 months	24.80	331	20.5	273	19.2	256
AMMONIACAL NITROGEN						
After 2 months	7.47	100	15.2	203	15.2	203
After 4 months	Trace	Trace	Trace	Trace	Trace	Trace
After 6 months	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
After 2 months	167	100	121	72	123	74
After 4 months	136	81	137	82	123	74
After 6 months	120	72	116	69	103	62

TABLE XIV

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM WITHOUT TREATMENT AND SUBSEQUENT TO TREATMENT WITH GASOLINE, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Gasoline Saturated		Gasoline Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
After 2 months	16.8	100	Trace	Trace	Trace	Trace
After 4 months	51.1	304	11.3	67	18.2	108
After 6 months	15.5	92	198.0	118	196.0	118
AMMONIACAL NITROGEN						
After 2 months	9.2	100	14.3	155	12.8	139
After 4 months	Trace	Trace	11.4	124	Trace	Trace
After 6 months	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
After 2 months	180	100	170	94	166	92
After 4 months	168	93	161	89	177	98
After 6 months	176	97	166	92	170	94

Conclusions Regarding Experiment VIII

The general results shown by this test verify those of Experiment VII. It should be remembered that this experiment ran for a period twice as long as the previous one and that certain differences may be attributed to that fact.

Nitrification was inhibited for a certain time for the alcohol and gasoline treatments. This influence endured longer for the former than for the latter. The ammonifying process must have previously reached its maximum point according to the findings of Experiment VII, and was gradually decreasing.

As in Experiment VII, there is a general tendency for the soluble matter to increase with duration of incubation. No very definite conclusions can be drawn as to the effects from the different antiseptics or to differences between the two soils.

Experiment IX

The Effect of Volatile Antiseptics upon Nitrification and Ammonification in the Soil and upon the Total Water-Soluble Salts, the Soil Having been Cropped to Oats (Experiment I) and to Buckwheat (Experiment IV) Subsequent to the Antiseptic Treatment

After harvesting the crop of Experiment IV the soil was taken from the pots, reworked and maintained in a loose structural condition during incubation. Tests were made at the beginning and after 14 days for nitrates, ammonia and total soluble salts with the results given in Tables XV to XIX.

TABLE XV

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATE AND AS AMMONIA IN DUNKIRK CLAY LOAM PREVIOUSLY TREATED WITH ALCOHOL AND CROPPED TO OATS, AND THEN TO BUCKWHEAT, JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
At beginning	4.50	100	14.2	316	3.9	87
After 14 days	17.30	384	17.1	380	20.9	464
AMMONIACAL NITROGEN						
At beginning	17.95	100	4.8	27	4.2	23
After 14 days	9.80	55	4.1	23	4.3	24
TOTAL WATER-SOLUBLE SALTS						
At beginning	132	100	133	101	119	90
After 14 days	112	85	100	76	134	102

TABLE XVI

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM PREVIOUSLY TREATED WITH ALCOHOL AND CROPPED TO OATS AND THEN TO BUCKWHEAT JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
At beginning	3.9	100	7.2	185	9.4	241
After 14 days	7.5	192	18.7	480	22.2	570
AMMONIACAL NITROGEN						
At beginning	4.3	100	5.7	132	12.9	300
After 14 days	10.3	240	8.7	202	7.3	170
TOTAL WATER-SOLUBLE SALTS						
At beginning	52	100	68	131	70	135
After 14 days	64	123	102	196	94	181

TABLE XVII

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM PREVIOUSLY TREATED WITH TOLUENE AND CROPPED TO OATS AND THEN TO BUCKWHEAT JUST PRIOR TO TESTS, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Toluene Saturated		Toluene Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
At beginning	7.0	100	15.7	224	16.80	240
After 14 days	10.8	154	14.9	213	16.20	231
AMMONIACAL NITROGEN						
At beginning	5.3	100	5.5	104	4.15	77
After 14 days	3.7	70	4.0	75	2.80	53
TOTAL WATER-SOLUBLE SALTS						
At beginning	141	100	227	161	193	137
After 14 days	137	97	231	164	210	149

TABLE XVIII

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM PREVIOUSLY TREATED WITH BENZENE AND CROPPED TO OATS AND THEN TO BUCKWHEAT JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

NITRIC NITROGEN

Time	Untreated		Benzene Saturated		Benzene Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
At beginning	5.9	100	6.0	102	6.20	105
After 14 days	8.6	146	14.0	237	10.05	169
AMMONIACAL NITROGEN						
At beginning	6.5	100	5.1	78	3.10	48
After 14 days	Trace	Trace	8.4	129	11.70	180
TOTAL WATER-SOLUBLE SALTS						
At beginning	130	100	144	122	136	115
After 14 days	134	113	129	109	151	128

TABLE XIX

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM PREVIOUSLY TREATED WITH GASOLINE AND CROPPED TO OATS AND THEN TO BUCKWHEAT JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

NITRIC NITROGEN

Time	Untreated		Gasoline Saturated		Gasoline Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
At beginning	17.80	100	12.80	72	12.80	72
After 14 days	17.80	100	23.50	132	24.80	139
AMMONIACAL NITROGEN						
At beginning	3.95	100	4.20	106	4.15	105
After 14 days	9.20	233	3.15	80	4.10	104
TOTAL WATER-SOLUBLE SALTS						
At beginning	148	100	317	214	301	204
After 14 days	177	119	242	163	224	151

Conclusions Regarding Experiment IX

The data of this experiment indicate that the residual effect of the antiseptics is very low, a condition which should be expected after so long a period. Between the saturated and extracted treatments no marked difference is found, either as to nitrification or ammonification. There was a general tendency for a decrease in ammonification the longer the incubation was carried on.

The marked difference previously observed between the two types of soil from the direct treatment already discussed were lacking. The total soluble salts either remained constant or showed a tendency to increase with incubation.

Experiment X

The Effect of Volatile Antiseptics upon Nitrification and Ammonification in the Soil and upon the Total Water-Soluble Salts, the Soil Having been Cropped to Wheat (Experiment II) and to Oats (Experiment V) Subsequent to the Antiseptic Treatment

In Experiment V it has been stated that one pot of each soil was kept for chemical study after harvesting the oats which followed the wheat of Experiment II. This study was carried out by keeping these pots in the laboratory and making determinations for nitrates, ammonia and total soluble salts at the beginning, after 20 days and finally, at the end of 60 days. Samples were taken from these pots with a cork borer of 2 cm. diameter. The holes thus made were filled up with clean sand and the moisture content kept constantly at 25 per cent.

TABLE XX

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM PREVIOUSLY TREATED WITH ALCOHOL AND CROPPED TO WHEAT AND THEN TO OATS JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 20 days	Nil	Nil	Nil	Nil	Nil	Nil
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
AMMONIACAL NITROGEN						
At beginning	3.5	100	5.3	151	5.2	149
After 20 days	3.8	108	5.3	151	5.3	151
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	42	100	45	107	51	122
After 20 days	38	91	39	93	46	109
After 60 days	47	112	45	107	46	109

TABLE XXI

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM PREVIOUSLY TREATED WITH ALCOHOL AND CROPPED TO WHEAT AND THEN TO OATS JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 20 days	Nil	Nil	Nil	Nil	Nil	Nil
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
AMMONIACAL NITROGEN						
At beginning	5.2	100	5.4	104	5.5	106
After 20 days	5.3	102	5.2	100	5.3	102
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	41	100	42	102	42	102
After 20 days	44	107	44	107	37	90
After 60 days	39	95	56	137	60	146

TABLE XXII

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM PREVIOUSLY TREATED WITH ETHER AND CROPPED TO WHEAT AND THEN TO OATS JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Ether Saturated		Ether Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 20 days	Nil	Nil	Nil	Nil	Nil	Nil
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
AMMONIACAL NITROGEN						
At beginning	3.8	100	2.5	66	2.6	68
After 20 days	5.2	137	5.3	139	5.4	142
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	33	100	37	112	39	118
After 20 days	37	112	46	139	47	142
After 60 days	51	154	65	197	45	136

TABLE XXIII

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM PREVIOUSLY TREATED WITH ETHER AND CROPPED TO WHEAT AND THEN TO OATS JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

NITRIC NITROGEN

Time	Untreated		Ether Saturated		Ether Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 20 days	Nil	Nil	Nil	Nil	Nil	Nil
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
AMMONIACAL NITROGEN						
At beginning	5.42	100	2.63	48	2.57	47
After 20 days	5.56	103	5.46	101	2.93	54
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	47	100	45	96	46	98
After 20 days	47	100	41	87	43	91
After 60 days	39	83	72	153	60	128

TABLE XXIV

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM PREVIOUSLY TREATED WITH TOLUENE AND CROPPED TO WHEAT AND THEN TO OATS JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

NITRIC NITROGEN

Time	Untreated		Toluene Saturated		Toluene Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 20 days	Nil	Nil	Nil	Nil	Nil	Nil
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
AMMONIACAL NITROGEN						
At beginning	3.54	100	5.1	144	5.1	144
After 20 days	2.41	68	5.2	147	5.2	147
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	45	100	51	113	42	93
After 20 days	47	104	47	104	41	91
After 60 days	47	104	51	113	54	120

Following the determinations tabulated above, the soils were taken from the pots, reworked and maintained in loose structural condition during the incubation tests. After 20 days determinations were made for nitrates, ammonia and total water-soluble salts. The results therefrom are not reported in tabular form. No nitrates were found in any of the different treatments, nor was any ammonia found with toluene treatment in either type of soil. In case of the alcohol and ether treatments traces of ammonia were found. The total soluble salts hardly varied from the determinations reported at the end of 60 days on the soil as it stood in the pots.

TABLE XXV

TOTAL WATER-SOLUBLE SALTS AND WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM PREVIOUSLY TREATED WITH TOLUENE AND CROPPED TO WHEAT AND THEN TO OATS JUST PRIOR TO THE TESTS, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Toluene Saturated		Toluene Extracted	
	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts	Actual Amounts	Relative Amounts
NITRIC NITROGEN						
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 20 days	Nil	Nil	Nil	Nil	Nil	Nil
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
AMMONIACAL NITROGEN						
At beginning	2.5	100	3.2	128	3.5	140
After 20 days	1.9	76	2.5	100	2.5	100
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	48	100	50	104	41	85
After 20 days	48	100	51	106	41	85
After 60 days	50	104	53	110	46	96

Conclusions Regarding Experiment X

As in Experiment IX, the chemical results indicate little difference between the residual saturated or extracted treatments with volatile antiseptics. The results from the treatments by the two methods are very similar to those obtained with the untreated soil. This holds true for both nitrification and ammonification. The period of incubation did not alter either the nitrifying or the ammonifying results. In Tables XXII and XXIII there is a slight tendency during the first two weeks towards an increase in ammonification with ether as the antiseptic. This was inhibited, however, at the end of 60 days. The total water-soluble salts did not materially change during the process of incubation. No residual effect, of the volatile antiseptics, developed in either soil type.

Experiment XI

Effect of the Physical Condition of Soil Cropped to Oats (in Experiment III), Subsequent to a Treatment with Volatile Antiseptics, upon Total Soluble Salts and upon Water-Soluble Nitrogen Occurring as Nitrates and Ammonia

In order to determine what effect the physical condition of the soil would have upon the nitrifying and ammonifying power of the soil, the following test was carried out. Of the duplicate treatments of each type of soil after harvesting the crop of Experiment III, one pot was maintained undisturbed and determinations made at the beginning, after 21 days and after 35 days, for gasoline-treated soils, and after 21 and 60 days for alcohol-treated soils. The duplicate pot of soil in each case was reworked and maintained in good tilth for the same period of time as above, and is designated in the tables as incubated soil.

TABLE XXVI

EFFECT OF PHYSICAL CONDITION OF SOIL ON TOTAL WATER-SOLUBLE SALTS AND UPON WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM CROPPED TO OATS (EXPERIMENT III) AND SUBSEQUENT TO A TREATMENT WITH ALCOHOL, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts in Pots	Actual Amounts in Soil Incubated	Actual Amounts in Pots	Actual Amounts in Soil Incubated	Actual Amounts in Pots	Actual Amounts in Soil Incubated
NITRIC NITROGEN						
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 21 days	0.99	2.4	Trace	0.54	Trace	0.64
After 60 days	14.20	36.7	2.1	4.60	3.7	5.40
AMMONIACAL NITROGEN						
At beginning	5.1	Nil	5.1	Nil	5.2	Nil
After 21 days	Nil	Nil	Nil	Nil	Nil	Nil
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	85	85	84	86	84	85
After 21 days	146	144	112	112	84	84
After 60 days	120	123	56	55	48	46

Conclusions Regarding Experiment XI

These data indicate that the effect of the antiseptics has been inhibitive. At the beginning of incubation, regardless of differences of soil or in treatment, there was no difference to be seen in the nitrifying or ammonifying processes of the soil. The nitrates and ammonia may have been entirely used up by the plants. Even between the two types of soil there was no marked difference to be noticed. The Volusia silt loam shows a higher yield of nitrates for gasoline treatment. The main point

TABLE XXVII

EFFECT OF PHYSICAL CONDITION OF SOIL ON TOTAL WATER-SOLUBLE SALTS AND UPON WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM CROPPED TO OATS (EXPERIMENT III) AND SUBSEQUENT TO A TREATMENT WITH ALCOHOL, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Alcohol Saturated		Alcohol Extracted	
	Actual Amounts in Pots	Actual Amounts in Soil Incubated	Actual Amounts in Pots	Actual Amounts in Soil Incubated	Actual Amounts in Pots	Actual Amounts in Soil Incubated
NITRIC NITROGEN						
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 21 days	6.6	7.5	Trace	1.1	Trace	1.6
After 60 days	13.3	13.2	1.5	3.0	2.8	3.7
AMMONIACAL NITROGEN						
At beginning	5.1	5.1	5.1	5.1	5.0	5.0
After 21 days	Nil	Nil	Nil	Nil	Nil	Nil
After 60 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	44	45	62	68	46	48
After 21 days	85	85	80	84	86	85
After 60 days	52	54	57	59	50	52

TABLE XXVIII

EFFECT OF PHYSICAL CONDITION OF SOIL ON TOTAL WATER-SOLUBLE SALTS AND UPON WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN DUNKIRK CLAY LOAM CROPPED TO OATS (EXPERIMENT III) AND SUBSEQUENT TO A TREATMENT WITH GASOLINE, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Gasoline Saturated		Gasoline Extracted	
	Actual Amounts in Pots	Actual Amounts in Soil Incubated	Actual Amounts in Pots	Actual Amounts in Soil Incubated	Actual Amounts in Pots	Actual Amounts in Soil Incubated
NITRIC NITROGEN						
At beginning	Trace	Trace	Nil	Nil	Nil	Nil
After 21 days	Trace	3.5	Trace	3.5	Trace	3.6
After 35 days	2.4	8.0	2.6	7.6	3.0	8.5
AMMONIACAL NITROGEN						
At beginning	Nil	Nil	Nil	Nil	Nil	Nil
After 21 days	Nil	Nil	Nil	Nil	Nil	Nil
After 35 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	82	82	88	88	92	94
After 21 days	80	84	74	77	73	82
After 35 days	82	88	76	102	74	99

to be brought out in this experiment is that the physical condition of the soil can be largely eliminated as a factor influencing the nitrifying and ammonifying processes of the soil for the conditions under which these experiments were carried out. The Volusia silt loam treated with gasoline shows greater increase in the nitrifying power of the soil than the corresponding alcohol series.

TABLE XXIX

EFFECT OF PHYSICAL CONDITION OF SOIL ON TOTAL WATER-SOLUBLE SALTS AND UPON WATER-SOLUBLE NITROGEN OCCURRING AS NITRATES AND AS AMMONIA IN VOLUSIA SILT LOAM CROPPED TO OATS (EXPERIMENT III) AND SUBSEQUENT TO A TREATMENT WITH GASOLINE, EXPRESSED AS PARTS PER MILLION

Time	Untreated		Gasoline Saturated		Gasoline Extracted	
	Actual Amounts in Pots	Actual Amounts in Soil Incubated	Actual Amounts in Pots	Actual Amounts in Soil Incubated	Actual Amounts in Pots	Actual Amounts in Soil Incubated
NITRIC NITROGEN						
At beginning	2.4	2.4	2.8	2.8	Nil	Nil
After 21 days	3.7	19.0	11.3	18.5	12.0	19.3
After 35 days	7.9	22.7	25.3	36.2	30.0	39.5
AMMONIACAL NITROGEN						
At beginning	6.3	6.2	8.2	8.2	6.5	6.6
After 21 days	Nil	Nil	Nil	Nil	Nil	Nil
After 35 days	Nil	Nil	Nil	Nil	Nil	Nil
TOTAL WATER-SOLUBLE SALTS						
At beginning	35	35	50	50	40	39
After 21 days	50	52	52	80	72	100
After 35 days	65	85	89	102	55	106

Experiment XII

Development of Acid in Soil Due to the Action of Alcohol

The idea was suggested that volatile antiseptics applied to the soil might be oxidized with the formation of an acid. If an acid were formed, it might not only have a depressing effect on the soil organisms but might liberate certain mineral elements in the soil. The effects of volatile antiseptics upon crop growth and bacterial action might thus at least partially be accounted for. In order to test this out, the following experiment was performed.

About 250 gm. of both Dunkirk clay loam and Volusia silt loam were used, separate samples being placed in 2-inch glass cylinders. The various samples were then saturated over night with distilled water, potassium nitrate and 70 per cent alcohol, respectively. The next morning, more water was added to the soils saturated with distilled water and potassium nitrate until about 150 c.c. of solution had percolated through. The alcohol-saturated soil was treated similarly but with the concentration of alcohol previously used. After the initial percolations were obtained, the soils were spread out for 3 days and allowed to dry. They were then percolated again as already described. This second percolate obtained from the soils is designated in the table of data as "after aeration."

Fifty-c.c. quantities of the various percolates were diluted to 200 c.c. with CO_2-free water and titrated against N/10 NaOH. The results reported in Table XXX are the average of duplicate determinations.

TABLE XXX

ACTUAL AND RELATIVE AMOUNTS OF ACID DEVELOPED IN SOIL DUE TO TREATMENT OF ALCOHOL

Type Soil	Percolate	Water		Potassium Nitrate		Alcohol	
		Actual Amts. c.c.	Rel. Amts.	Actual Amts. c.c.	Rel. Amts.	Actual Amts. c.c.	Rel. Amts.
DCL	Initial percolation	0.15	100	0.65	430	0.60	400
DCL	After aeration	0.20	100	0.70	350	0.70	350
VSL	Initial percolation	0.20	100	5.50	2750	0.70	350
VSL	After aeration	0.25	100	0.65	260	0.75	300

Conclusions Regarding Experiment XII

In the case of Dunkirk clay loam, a soil neutral or very slightly acid, the relative amounts of acid as developed by KNO_3 and alcohol in the first percolation are about the same. With the Volusia silt loam, however, a soil intensely acid, the KNO_3 in the case of the initial percolate generates an acidity several times that of distilled water. The alcohol, on the other hand, exhibits about the same results as when percolated through the Dunkirk clay loam. It seems evident that the acidity developed by the alcohol is about at its maximum in both cases.

The second percolate of the soils shows an acidity for the alcohol in both cases lower than in the initial trial. If the antiseptic forms an acid to any degree, the drying action should be expected to augment the acid condition.

From the fact, therefore, (a) that the alcohol reacted about the same for both soils, (b) that the second percolate showed an actual lowering acidity in spite of the aeration of the soil, and (c) that the aeration of the alcohol-treated soils was so low as probably to be within experimental error, it seems impossible to conceive that the development of acids by the action of the antiseptic could be an important factor in influencing plant and bacterial action, especially in the magnitude already described in the preceding experiments.

V. Summary

1. The application of volatile antiseptics to the soils used in this investigation gave beneficial results on the crops subsequently grown thereon.

2. A beneficial, residual effect is observed for the second crop after the application of the volatile antiseptics. This, however, was in all cases less marked than with the first cropping. Both types of soils responded to treatment, but somewhat differently.

3. The volatile antiseptics experimented with had a definite effect upon the ammonification and nitrification of the soil, enhancing the former and inhibiting the latter. There is a tendency for the volatile antiseptics to increase the water-soluble salts of the soil.

4. The effect of the antiseptics upon the ammonifying and nitrifying processes of the soils after two crops were grown seems to disappear.

5. No marked differences were observed as to plant growth and biological activity between the saturation and extraction methods of applying the volatile antiseptics to the soil.

6. In these experiments the physical condition of the soil as indicated by its ammonification and nitrification does not seem to be the cause of the influences noted upon plant growth and bacterial action.

7. By the extraction of soil with alcohol, a substance was removed which was toxic in water cultures but not at all toxic when in the soil itself.

8. The development of acids in the soil as a result of some action or change of the alcohol was found to be too slight to account for the marked effects of volatile antiseptics upon plant growth and bacterial action.

Final Conclusions

The beneficial influences obtained by treating the soil with volatile antiseptics can not be ascribed to a change in physical condition, to a suppression of some toxic material, or to a development of acids from the action of the antiseptics. The method of applying the antiseptics seems to have no marked influence upon the results obtained.

The closely coordinated stimulation of plant and bacterial activity due to the treatment of the soil with volatile antiseptics points strongly towards a biological interpretation, with due regard for the chemical considerations, of the effects therefrom.

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PLATE I

The effect of alcohol and gasoline treatments of Dunkirk clay loam on the growth of oats at the blooming stage.
(For data see Table III.)


DCL
Untreated
DCL
Alcohol Saturated
DCL
Alcohol Extracted

Fig. 1


DCL
DCL
DCL

Fig. 2

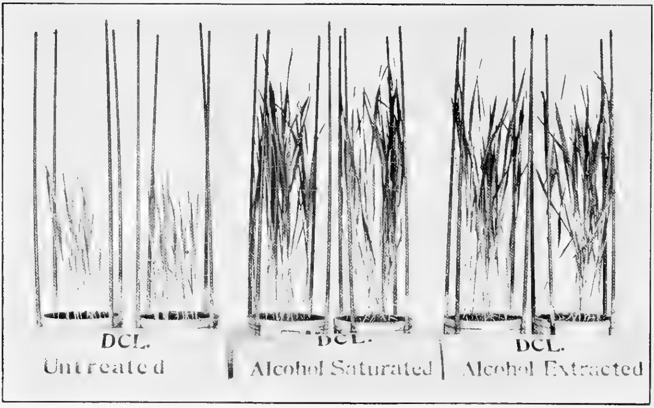
DCL.
Untreated
DCL.
Alcohol Saturated
DCL.
Alcohol Extracted

Fig. 1

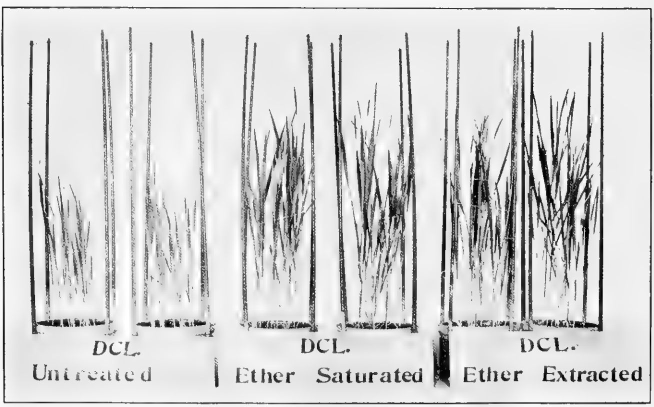
DCL.
Untreated
DCL.
Ether Saturated
DCL.
Ether Extracted

Fig. 2

PLATE II

The effect of alcohol and ether treatments of Dunkirk clay loam soil on the growth of oats just before heading.
(For data see Table V.)