A. RADERMACHER and Z. KLAS

ON FERVORIZATION OF PLANT NUTRIENT-SUBSTRATA

O utjecaju fervorizacije hranjivih supstrata na razvoj biljaka

I. INTRODUCTION

This publication is the result of the researchwork, which the authors undertook with the collaboration of Prof. V. Vouk during the years 1938/39. Prof. Vouk sterilized soils in order to examine the influence of brown-coal in its supposed ability to stimulate plant growth and observed the well- known stimulating effect on vegetable growth by means of sterilizing soil. Our research aimed to analyse the effect of soil sterilization, not as it had been usual up till now by means of chemical, physical or micro-biological soil analysis, but more in the way of a physiological analysis of the whole appearances, because this side of the problem, as it seemed to us, had been neglected.

Indeed the facts proved, that we were right.

After having made ourselves familiar with the effect of sterilization of the soil on the development of plants, we were convinced, that the act of sterilizing was not the key to the problem. The expression: »sterilization« leads to misunderstanding, because the success of our water-culture experiments, as will be shown in the next pages, was evidently not owing to the annihilation of germs by heating the soil, but in the

The editor's remark. The experimental work presented in this paper has been elaborated in the Botanical Institute of the Natural Sciences Faculty at the University of Zagreb as late as 1938/39. The preliminary report with several significant statements and results has been published 1940. at »Proceedings of the Nederl. Academie van Wetenschapen (Vol. XLIII., No. 8)« under the title »Report on Fervorization on Plant Nutrient Substrata«, while a rich rest experimental material has remained unpublished. The authors, due to certain circumstances, have given up the work in the Botanical Institute (1939), and with the beginning of the World War they were not able to finish the whole presentation of the work. Only when the war was finished, it was possible to begin with the textual working on the experimental material. The final results of this revision are presented in this paper.

Dr. A. Radermacher died on Dezember 4th, XII. 1954.

heating itself. To show this difference in principle, we had to introduce a new word: »F e r v o r i z a t i o n«, which means the treatment of the nutrient-substrata by heat, usually moist heat by means of an autoclave, (fervor, latin = heating by hot steam). Anyway during the process of fervorization the soil will change its chemical, physical and micro-biological qualities, that is to say, its whole state is changed. The soil, as we like to say, is brought into »F e r v o r s t a t e«. To give the reader a good conception of this fervorstate in its total aspect we cannot at the very moment, though old researches. we happened to come across by surveying the literature, have already given valuable informations and have shown us the way for further investigations. But little we know about the fervorstate, so much more we know about the effect of this fervorstate of the soil regarding the plant growth. The latter in its total aspect we have called the »F e r v o r e f f e c t«.

By introducing the three new conceptions: Fervorization, Fervorstate and Fervoreffect we hope to put the problem in a new light, principally by eliminating the old conception »sterilization«, putting the emphasis on the micro-biological factor, which, as we will show later on, has nothing to do with this problem. The physiological analysis demanded at the same time to replace the complex nutrient-substrata, which is soil, by an artificial solution of chemicals (nutrient-solution) as a more exact and better medium for our experiments. Further on we got proof, that the fervoreffect on plant growth had manifested itself much stronger in a so called water-culture than in the hitherto used soil cultures.

In the water-cultures we had only to deal with two basic-components viz. the distilled water and the nutrient salts, so logically we had to examine both basic-components with regard to the fervorization. The first experiment, by which the distilled water alone was fervorized, after which we added the nutrient salts, gave a suprising and quite unexpected result, namely that the fervorized distilled water alone was sufficient to produce the fervoreffect.

The physiological analysis of the fervoreffect by isolation of the single basic-components gave very interesting results, which will be published in this treatise going into particulars of all experiments. But we are convinced of the fact, that by these first experiments we are still far from the truth and are only approaching the subject by showing a new way for further investigations. So, as we will show at the end of this treatise, from the result of these experiments arise many questions, which, at the very moment, we are not in the position to answer.

Before entering into minute description of the various experiments and their results, we will first give a short account of the history from the beginning till this day of the effort of different investigators on the domain of the so called soil sterilization. But here we will little consider the practical side of the problem, which would be to use the soil sterilization for fertilizing purposes, because our real aim was, to give a scientifical contribution to this theory.

Although, as Fletcher (5) comunicated, in the Presidency of Bombay it was usance from times immemorial, to fertilize the seedbeds by heating the ground, soil heating, from a scientific point of view, took place for the first time in 1888. It was Franke (6), who was the first to carry out the experiments in this direction. After Franke there came a time, in which sterilized grounds were pretty lively studied. In the years 1896–1912 a series of publications appeared, which treated this subject from more or less different points of view. After this time however it seemed, as if the scientific interest in this problem had nearly completely vanished. While during the recent years only now and then an author touched on this subject and then only incidentally, on the other hand there even appeared a description of many apparatuses for the application of soil sterilization in the practical horticulture.

Influenced by the views and demands of Schuebler (22) and Justus v. Liebig (14) the investigations, the general soil examinations as well as the examination of the sterilized soils, referred first and principally to the physical and chemical qualities of the ground. Only later on, one got to the insight, that the proper plant growth on previously heated soils had to be studied.

Franke, the first investigator, who treated this problem, established, that heated soils contained larger quantities of soluble nutrient salts than not heated soils. He found, that his heated peaty soil contained more than twice- and his sandy soils, treated in the same way, nearly the double quantity of soluble substances than the same not heated soils. From the results of his analyses he concluded, that the reasons for the increase of the crops from pre-heated soils were chemical changes, which took place by heating the soils.

Franke's results were confirmed by Liebscher (15). He reported, that by steaming the soils the phosphoracid passed over into a difficult soluble condition and further on, that part of the present nitrogen escaped, while an other part had been made easier accessible for the plants. Liebscher conceived the heat sterilization of the soils as a kind of nitrogen fertilization. He thought as the chief result of his examination of the influence of soil heating, to have proved the assimilation of air-nitrogen by oats and mustard. It is interesting, that in consequence of this, not so much the problem of soil heating, but just this Liebscher thesis was the reason for series of publications with sterile soils. This research, though it had quite another purpose, gave all the same an important contribution to the proper question of soil heating Of these labours we mention here the investigations by Pfeiffer and Franke (18). They agreed with Liebscher so far, that soil heating was a process, by which the difficult soluble nitrogen combinations of the soil were disclosed. Pfeiffer and Franke worked with vegetation-vessels and experimented in that way, that they put these vessels into brass steam kettles with a pressure of 1 atm., in which the vessels stayed for 3 hours. After 6 days they repeated this

method. The average of the crop figures of their experimental series was 27.6 : 14,8, that is to say, the experimental plants (mustard) in the pre-heated soils obtained a higher crop of dry weight of 86, 5% than the not heated soils. Also the comparison of the N=contents was in the same line. The analysis of the plants from pre-heated soils in N=contents. were 179,5% higher than from the not heated soils, so that the authors themselves said: »im äusseren Habitus der Pflanzen machte sich dieser Umstand bereits sehr frühzeitig deutlich merkbar« (l. c. p. 145).

In the same year a publication appeared by L. Richter (20). The title of it was: »Über die Veränderungen, welche der Boden durch das Sterilisieren erleidet«. From this we stated, tha L. Richter tried to take hold of the problem on a wider basis. At the research station at Tharand during some years vegetation experiments with oat- and mustard- plants in sterilized soil were made, to study the precision of the effect of the soil organismus. The vegetation vessels were exposed about 6 hours at a stretch for some days at the temperature of the boiling water. »Nun zeigen sich aber in der Regel derartige Verschiedenheiten im Wachstum der Pflanzen in sterilisierter und nicht sterilisierter Erde, dass dieselben nicht wohl durch die Abtötung der Mikroorganismen erklärt werden können, sondern ihren Grund in gewissen Veränderungen haben müssen, welche der Boden selbst durch das Sterilisieren erleidet!« (l. c. p. 269). Among other things he observed a proper change of colour of the young leaves. emerging from the leaf margins, the appearance of irregular brown spots in the sterilized ground, which also encreach on the roots in these parts of the soil and cause partly their death and at last a heterogeneous humidity of the sterilized earth. But »trotz ihrer Krankheitserscheinungen etwickeln sich jedoch die Pflanzen meist üppiger als die der nicht sterilisierten Gefässe und ergeben eine Trockensubstanz mit durchschnittlich höherem Stickstoffgehalt als diese.« (l. c. p. 270). Control experiments with inoculation of the sterilized ground with a watery extract of unsterilized ground showed similar appearances. These Richter could not trace back to the activity of the soil organisms but it was evident: »dass jene Veränderungen eine Folge der durch das Sterilisieren bewirkten Veränderungen des Bodens selbst sein mussten.« (l. c. ibid).

The earth at Tharand, with which they experimented, was a poor gardensoil with an average humus percentage. Richter took average samples of the unsterilized soil, of the above mentioned sterilized soil and equal samples of the sterilized soil, to which water had been added before the sterilization. From these samples he made series of partly chemical and partly physical determinations. First he determined the *moister content*. This was the smallest in sterilized not infiltrated soil. The *volume weight* of the fresh soil samples was a little larger than that of sterilized earth samples. The value of the *porosity*, of the *capacity to absorb water* and *ammonia* was the largest in the sterilized- not before infiltrated soils. It was higher here than in the infiltrated sterilized and in the not sterilized soils. The *absorbtion capacity for ammonia* was the

highest in the not heated soils and a little smaller in the sterilized not previously infiltrated soil, in any case larger than in the heated previously infiltrated soil. Concerning the *whole nitrogen contents*, Richter found, that: »Während der Gesamtstickstoffgehalt unverändert geblieben war ... wurde ein Teil der *Stickstoffsubstanz* durch das Sterilisieren in *leicht lösliche Form* übergeführt«. (l. c. p. 273). Striking was also the effect of the sterilization on the *disclosure of the organic substance*. Richter concluded from his tables, resulting from his experiments, that: »sich die *Gesamtmenge der im kalten Wasser löslichen Stoffe* bei der Sterilisierung fast *verdoppelt*, während der darin enthaltene Anteil an *organischer Substanz* nahezu auf das *Dreifache* gestiegen ist. Die Aufschliessung war besonders weit fortgeschritten in dem Falle, wo der Erde vor dem Sterilisieren Wasser zugesetzt worden war«. (l. c. p. 274). Like Pfeiffer and Franke, Richter as well observed in sterilized pots a *loss of nitrogen*, which after hir measurements was about 200 mg per kg soil. While Pfeiffer and Franke thought, that the loss of nitrogen was caused by the escape of the nitrogen during the sterilization, Richter doubted about this supposition. He was inclined to accept, that the evaporation of the nitrogen was caused by the activity of micro-organisms. He too announced new experiments about this question, but we could not find any relative publication. Richter accentuated the disclosing proces and thought emphatically, that, however, in spite of the established loss of nitrogen: »noch ungefähr 100 mg von der aufgeschlossenen Stickstoffmenge zurückbleiben, welche uns die grössere Ausbeutung an Stickstoff bei von sterilisierten Töpfen stammenden Ernte genügend erklären«. (l. c. p. 273). From the results of his experiments he concluded: »Das allgemein üppigere Wachstum ... der Pflanzen in sterilisierter Erde müssen wir in erster Linie als eine selbstredend indirekte Wirkung der aufgeschlossenen organischen Substanz ansehen ... Was die oben erwähnte, in sterilisierten Töpfen beobachtete Krankheitserscheinung anbetrifft, so ist wahrscheinlich, dass dieselbe durch die zersetzten Humussubstanzen hervorgerufen wird, deren anfänglich zu konzentrierte Lösung die Wurzeln zu schädigen scheint«. (l. c. p. 273/74)

In the general treatment of the question of fertility of the arable land and its determination König with Hasenbäumer and Coppenrath (11) touched also the behaviour of it, when heated. Their efforts, as far as we can judge from the work of König (10), tried to find a Method, which made a current and sure rule of fertilization possible. Therefore one must have above all the possibility, to make sure at any time about the existing quantity and quality of the soil nutrients. So they put the question: »ob durch die Aufhebung des kolloidalen Zustandes mittels Erhitzen des Bodens auf etwa 200° eine Lösung der adsorbtiv gebundenen Nährstoffe in Wasser erzielt werden könne«. (l. c. p 471). In the beginning their results of the abolition of the colloidal condition by heating failed, but later on they reached their aim by steaming the ground and they mentioned: »dass aus der Menge

besonders an Phosphorsäure und Kali in der durch Dämpfen erhaltenen wässerigen Lösung des Bodens geschlossen werden muss, dass wir es hier in der Tat mit adsorbtiv gebundenen Nährstoffen zu tun haben«. (l. c. p. 472). As the next problem the authors saw the establishment: »welcher Dampfdruck notwendig ist, um die grösste Menge an löslichen Mineralstoffen zu erhalten und in welchem Verhältnis dieselben zu den durch die Pflanzen aufgenommenen Bodennährstoffen stehen«. (l. c. ibid.). We did not find however in the literature any relative publication of these authors. We must remark, that these investigators each time used 250 g of different soils in brass boilers, containing 3–4 l water. This they broght during 3 hours at a pressure of 4 atm. into the autoclave.

In the following respective work, which we cite after Merkenschlager (17), because the original was not obtainable, by Dietrich (4), we found the accentuation of the proper appearance, which we must still often mention and discuss, namely the appearance of the double effect of the heat sterilized soils on the particular phases of the development of *Sinapis alba*. Dietrich established, that the soil heating in the beginning of the development of these plants had effect in a negative sense, by retarding the development. This bad development of the plants in the youth Dietrich put on account of a poison, which resulted from the change of the organic matter of the soil by sterilization. The proportion of the damage should depend on the quantity of the poison and the susceptibility of the plant. By adding calciumcarbonat, this influence on the sterilized soils was done away with. The good development of the plants in the later state of growth Dietrich declared, by supposing, that now the disclosed nutrient salts are effective. From Dietrich also came the expression of the »Luxuskonsumption« made by *Sinapis alba* in heat sterilized grounds with soluble nitrogen. (Merkenschlager, p. 5).

The next publication and also the first, which by far was of a plant physiological character, was that by Schulze (23). He reported on certain: »besondere Wachstumsunterschiede, welche sich bei ein und derselben Pflanzenart zeigten, je nachdem sie in sterilisierten oder nichtsterilisierten Boden gleicher Herkunft wuchs«. (l. c. p. 137). These differences showed themselves above all in the retardation in the beginning and in the luxurious growth of the oats in the sterilized soil later on. As there was no essential difference in the weight of the crops in these experiments, Schulze only spoke of a: »zeitliche Verschiebung in der Produktion von Pflanzensubstanz«. But he mentioned already at that time, that he observed in other experiments very considerable increases of the production of the plant substances, owing to the sterilization of the soils. This led him at last, to take up the study of the sterilization effect, the results of which were given in the before mentioned and in the following treated publication. In this Schulze considered also the work of Richter, that of Krüger and Schneidewind (13) analogous to that of Richter, but not available to us and further on the more remote work of Märker (16).

Schulze used for his experiments a field and a meadow soil of Marburg and a gardensoil. As experimental plants he used oats, mustard, peas and buckwheat and a mixture of grasses. Schulze sterilized the humid soil in the autoclave at 125° C for 1 hour, but in some experiments at 100° C during 18 hours. It must be mentioned, that Schulze, as he said himself, was interested especially in the importance of the sterilization for the practical vegetation-experiments. He gave all his cultures a manure, consisting of a mixture of nutrient salts free from nitrogen. Considering also the question, whether in consequence of the sterilization a change of the supplied nutrient salts did not take place, he therefore manured a part of the culture-vessels after the sterilization.

The results of these experiments caused Schulze, to give up his former idea of the more: »zeitliche Verschiebung in der Produktion von Pflanzensubstanz«, but at the same time they showed him the complexity of the problem of the sterilization of the soil. Generally we could say, that Schulze's results established, what was known till now, that is to say, if plants were cultivated in heat sterilized soils, first there will take place a retardation, but afterwards a considerable increase of the development of the plants, which found its expression in an increase of the crop. Like the earlier mentioned authors, Schulze, too, observed the appearance of illness of the plant and its cure by addition of lime, disclosure of the soil nutrient, raised reception of nitrogen, increase of the crop a. s. o.. But the greater and larger application of his experiments, which made possible a comparing treatment with regard to the plants and soils, gave him a thorough insight in the problem, as we see from his summary: »Unsere Versuche haben also ergeben, dass in sterilisiertem Boden wachsende Pflanzen im wesentlichen unter der Einwirkung zweier entgegengesetzt wirkender Faktoren stehen. Je nach der allgemeinen Beschaffenheit des Bodens enstehen beim Sterilisieren mehr oder weniger schädlich wirkende Zersetzungsprodukte, welche die Versuchspflanzen je nach dem Grade ihrer individuellen und ihrer durch die Art bedingten Empfindlichkeit mehr oder weniger stark beeinflussen. Dem entgegen wirkt der das Wachstum der Pflanzen befördende Einfluss der Aufschliessung der Nährstoffe des Bodens, insbesondere seines unlöslichen nicht ohne weiteres zugänglichen Stickstoffvorrates. Je nachdem nun der eine dieser Faktoren in einzelnem Falle überwiegt, kommt eine Erhöhung oder eine Verschiebung der Ernte an Pflanzensubstanz zustande« (l. c. p. 147).

Thought the experiments of Schulze, concerning the effect of particular soil sterilization and the influence of this sterilization upon the salts given as fertilizer, gave no convincing results, yet it is due to Schulze to be the first, who touched on this subject. He was also the first, who recognised and expressed the importance of different soils as well as the kind of plants with in the reach of our problem.

The next investigators were Koch and Lüken (9). They made their experiments with the light sandy soil of Lüneburg. The problem of the soil sterilization, resp. the effect of the soil sterilization established

of Richter as well as by Krüger and Schneidewind, particularly the disclosure of the phosphoric acid. and of the nitrogen-combinations seemed to them very important, especially with regard to the technics of the soil bacteriological vegetation experiments. They sterilized the nitrogen-poor sandy soil of Lüneburg during 2 hours in the autoclave with a pressure of 2 atm. and observed the effect of the soil treated in this way on oats-cultures. Notwithstanding their soils were poorer than the soils, used by Richter, and in it they found only 3% of the N-quantity of Richter's soil, they established however a strong increase of the crop. In general and in detail the authors followed principally, the work of Richter and accepted too his reasons of the explanation for the appearance of the increase of the crop. They confirmed, what Richter had found, the damaged state of the development of the young oats-cultures in the sterilized grounds, but they tried to conclude this from other reasons. In their second series of experiments they did not bring the soils into zinc-vessels but into ordinary pots about which they said the following: »In diesen Blumentöpfen zeigte nun der Hafer, die erwähnten Krankheitserscheinungen nicht und es erschien damit klar bewiesen, dass tatsächlich das Zink der in der erst erwähnten Reihe benutzen Vegetationsgefässe an der Entwickelungshemmung der Jungpflanzen schuld sei« (l. c. p. 166). Further on they mentioned the dark green colour of the leaves of the plants in sterilized soil and proved the influence of the season on the results of the experiments.

After a silence of about 12 years there appeared again a treatise, concerning the effect of the soil sterilization by heat (1912). The author Czermak (3) examined at the same time changes, which the physical qualities of the soil underwent by frost, heat and by adding some salts. He confirmed the established influence of the season on the results of the experiments, stated by Koch and Lueken. Also his observation about appearances of illness noticeable by the change of colour in the youth and by the better development of the plants afterwards in heat sterilized soils, were similar to the observation of the before mentioned authors. It was also the same case, when he established the relatively quick increase of the N-contents as well as the premise: »dass die an sich geschädigte Pflanze eine ganz auffallende Luxuskonsumption an Stickstoff betreibt.« (l. c. p. 103). Czermak treated the soil for his cultures with steam during 2 hours at a pressure of 3 atm. (l. c. p. 109); the ones for the physical-chemical examination were treated twice during 2 hours at a pressure of 1,5–2,5 atm. (l. c. p 91). Czermak tried to explain the results of his experiments by a combined effect of the change of the physical and chemical conditions of the soil. He thought it ordinary: »dass die Wärme eine ausserordentlich kräftige Wirkung auf den Boden wird äussern können, wozu wohl auch eine rein chemisch aufschliessende Tätigkeit hinzutreten mag.« (l. c. p. 93), but he thought,: »dass im allgemeinen werden jedoch diese Verhältnisse so liegen, dass mit einem Erhitzen des Bodens eine kräftige Koagulation verbunden ist, die eine

Verkleinerung der Bodenoberfläche und somit auch der Hygroskopizität zur Folge hat.« (l. c. p. ibid.). The idea, that the mentioned temporary bad condition of the plants, which was noticed in the heat sterilized soils, was caused by the sterilization and in connection with this the annihilation of the micro- organisms, C z e r m a k declined distinctly. But of special interest was his next unmotified remark: »dass es des weitern bekannt ist, dass stark kolloidhaltige Marschböden durch blosses Austrocknen deutliche Erhöhung der Löslichkeit wichtiger Pflanzennährstoffe so der Phosphorsäure und des Kalis aufweisen.« (l. c. p. 102)

In the same year (1912) appeared a treatise, concerning the soil sterilization, by R u s s e l l and P e t h e r b r i d g e (21). The original we had no access to. But this treatise was summarized in a publication in the following year (1913) by the same authors in the »Journal of the board of Agriculture.« To this we refer. This was the reason, that we unfortunately did not know, why the authors gave up the expression: »sterilization«, as it was formerly used in general for heat treatment of the soil and introduced the expression: »Partial sterilization«. We could only see, that »partial sterilization« of the soil could be reached by two methods. The soil was heated by steam or dry heat of 200° F (93° C) or it could be treated by chemical means (antiseptics). The effect of this »partial sterilization«, described by the authors in their first publication, consisted of three kinds:

1. the bacterial activity of the soil is increased and plant food is made more rapidly;

2. disease arganisms and pests are killed or greatly reduced in number, and

3. the changes going on in the soil are somewhat modified, so that certain unusual substances are present which produce special effects on the plants. (l. c. p. 809).

The authors mentioned: »that up to the present time heat has been found to give the better results, because it not only kills the various detrimental and disease organisms, but it also brings about a certain amount of decomposition, thus lightening the subsequent work of the food -making bacteria, while in some instances it improves the physical condition of the soil. Chemical treatment is cheaper and more convenient in practise, but, on the other hand, less effective, even when thoroughly done; it is also difficult to effect thoroughly, since some of the antiseptics cannot readily be distributed uniformly in the soil, even by watering, because they are absorbed by the top layer of soil from their solutions or emulsions.« (l. c. p. 809/10).

The authors thorght in general, that »partial sterilization« should mean a profit for the horticulture.

In the following we report the second publication of the above mentioned authors. We shall restrict ourselves for the moment only, to what they revealed in regard to »partial sterizilation«.

According to Russell and Petherbridge, there was »sufficient evidence of any difference in effectiveness«, if the soil was directly heated or by the action of steam. But on account of preventing overheating and to attain a quicker and a more equal heat the use of the steam heating was more profitable. The authors described also methods and apparatuses, which were used for steam heating. One of them, used in America, was built on the principle of a warming pan.

The earth should not be treated too early in order to prevent infection afterwars, resp. the treated soil should not stay too long in the open air, before it is used. But it is not necessary, to heat the soil immediately before use, as the mould-fungi, which appeared during the course of time in the heated not cultivated soil, did not injure the growth of the plants.

About the behavior of the plants in such a »partial sterilized« soil Russell and Petherbridge observed a retardation of the germination and a handicap of the young growth. All this howewer did not refer to the roots of the young plants, which in the contrary in treated soil were far better and richer developed than the roots in the untreated soil. In that part of the plants, shown above the earth, in the heated soil the deep dark green colour of the leaves was noted and some times also a deeper colour from anthocyan (Tomato). The duration of the retardation of the development depended on the season, the light and the soil, but after the appearance of the second leaves generally a strong growth took place, in which case the plants in the treated soil surpassed those in the not heated soil.

The authors also examined the effect of steam heating in so called ill soils, especially owing to tomato, cucumber and wine-ill soils, and established by »partial sterilization«:

1. it cures the sickness; 2. it kills the disease organisms in the soil; 3. it increases the supply of plant food; and 4. it leads to some changes in the habit of the plants, which, however, may be of very little value to the commercial grower'. (l. c. p. 817). On virginal loams and composts »partial sterilization« had three beneficial effects: 1. It kills any disease organisms or competing forms in the soil; 2. It increases the supply of plant food; 3. It leads to changes in the habits of the plant. (l. c. p. 824).

Besides also here was observed, that the plants in »partial sterilized« grounds by equal treatment resp. manure were darker green and stronger in leaves, had stronger shoots, earlier and larger flowers and more fruits. Their leaves below stayed longer than those of the unsterilized soils. The authors thought the reasons of the stronger growth to be in connection with the greater supply of food and that the difference between the not treated and the »partial sterilized« soils could nearly be compensated by addition of a sufficient and useful fertilizer. Therefore they recommended the treatment of »partial sterilization« in the case of such conditions in horticulture, where in mass-cultures less care and fertilizer could be used. According to this recommendation they

examined chiefly sets of *Chrysanthemum* cultures, continuing their former experiments. The authors mentioned the »extraordinary practical importance«, a circumstance, to which we should connect an especial physiologic signification. It was about the establishment of the fact, that the increased growth did not conduct to a prevailing luxuriant vegetation and retarded flowering and crop. But these experiments with *Chrysanthemum, Tomato* and *Cucumber* were made with only few individuals. From the 8 examined sorts only »*White Queen*« showed a retardation in heated soil. In the beginning of the development whole yellow leaves were produced, which also later on never received their natural colour. The »*Phoebe*« prospered a little better in soils treated with Formaldehyd and Calciumsulphit. »*David Ingamells*« showed their flowers rather late and very well developed in the heated soils.

In the fern-cultures the advantage of the steamed soil was this, that such soil was free of mosses, algae and other formations, which would compete with the development of the fern spores and also a considerable improvement of the growth was effected. Two examined varieties of peas did not show any remarkable difference neither in colour nor in the height of shoots in untreated and in steamed soil. The germination of *Tobacco* was strongly retarded and the young plants in the steamed soil stayed for a long time after those of the not treated soil. At the end of the experiment they reached the normal., but in no way surpassed it. The authors suggested, that after their information in USA and in Transvaal, in spite of their results, in these countries people got considerable advantages, by steaming the soil, also with the *Tobacco*-plants.

All experiments were made in pots and the authors remarked especialy, that they had not any experience of »borders«. They also mentioned the circumstance, that the cultures in the steamed soils demanded less but frequently to be watered, what must be especially noticed, because on account of the wet aspect of these soils in the practise the water-gifts were administrated too small and this led to a sudden drying up. They intended, to set up experiments, to overcome the observed retardation of the germination and the growth of the young plants in the steamed soils, but here they did not succeed.

After all the first and the second publication of Russell and Petherbridge were in close connection with the practise of horticulture. Beside the description of apparatuses a great part of this treatise, which for the time being is of no particular interest to us, contained calculations and practical profits, which could be obtained by steaming the soil. There were also business calculations. But in spite of this, their treatise brought also a number of particular data, which stated either what was known already or contained new observations and therefore should have been treated on a larger basis.

Leaving the chronological way, we will in connection with the work of Russell and Petherbridge mention the publication of Bewley (1). Also this publication is more or less pointing to the practise and much more than those of the other two authors. It principally

deals with technical references and descriptions of the methods of sterilization and apparatuses, touching the horticulture practise or as it was called in the introduction: »This bulletin deals with the practical aspects of sterilising soils both on a large scale in glashouses and in small quantities for market garden work and propagation purposes. (l. c. p. V)« In the question, what was to prefer the heating or the steaming of the soil, B e w l e y thought, that: »both methods are beneficial if properly conducted with due regard to the type of soil the nature of its contaminations«. (l. c. p. 25). He found, that: »backing is more severe upon the organic matter in the soil than is steaming, and it is not surprising, to find, that backed soil differs appreciably from steamed soil in physical condition«. (l. c. p. ibid.), but: »Both methods increase the fertility of the soil, for they convert complex organic and unorganic substances into simpler forms, which are either absorbed directly by plant roots or are quickly changed into full plant foods by certain bacteria, that are resistant to heat and are not destroyed. Further these bacteria find unlimited scope in the sterilized soil, because other organisms, which compete with them in normal soils, but are less resistant to heat, are destroyed during the sterilization. Both methods destroy fungi and bacteria, that infect plant roots and cause disease«. (l. c. p. ibid.).

In connection with his investigations about the effect of brown-coal. on the growth of plants V o u k (24) used also the method of »partial sterilization« of the soil with the purpose, to cut out at least partly the micro-biological factor in his experiments. The experimental plants were *Sinapis alba.* There were set up 4 series of experiments: 1. sterilized soil without brown-coal; 2. sterilized soil with 50/100 brown-coal; 3. not sterilized and without brown-coal; 4. not sterilized with 50/100 brown-coal. The sterilization took place in the autoclave twice each time 1 hour with a pressure of $2^1/_2$ atm. and at 138,5° C. In the course of the experiment at first he noted during about a month a very characteristic retardation of the cultures in sterilized soil without and with addition of brown-coal. Later on, however, this was replaced by an especial rich growth, so that at last the plants in sterilized soils with or without brown-coal not only surpassed by far in every respect those in normal soil but also the plants in not sterilized soil with brown-coal. We must lay stress upon the fact, that in the V o u k's experiments the sterile cultures were always watered with sterilized water. Especially were striking the strong thick shoots, the luxuriant development of the leaves as well as the deep green colour. From the tables of the crops the author resulted: »dass die sterilisierten Kulturen ohne Rücksicht auf die Zugabe von Braunkohle ungefähr denselben Ertrag gegeben haben wie die nichtsterilisierten mit Branukohledüngung und bedeutenderen Mehrertrag als die nichtsterilisierten Kulturen ohne Braunkohlezugabe«. (l. c. p. 32). An further as the brown-coal fertilizer in sterilized cultures had had apparently no part in the acceleration of the growth: »Es genügte die

Wirkung der Sterilisation allein die Pflanzen zu ihrer maximalen Entwicklung zu bringen«. (l. c. p. ibid.). V o u k's conception of the effect of the sterilization was: »eine bis heute vollkommen ungelöste Frage«, and found: »dass alle diesbezüglichen bisher aufgestellten Hypothesen nicht befriedigen können«. (l. c. p. ibid.).

The history of the heat treatment of the soil showed as the history of so many other scientific problems characteristic alternative phases. The time of strong interest and intensive work alternated with a time, in which every interest was nearly completely extinguished, to rouse up brightly again, stirred up by the most different motives. Such a phase of stagnation in the investigation of our problem we have now. It was, as if the scientific world had lost every interest, doubting at last, so far as we could see, about the possibility of a further penetration into this problem. But on the other side the practical horticulture took possession of the »partial sterilization« and already apparatuses were built, which not only made it possible to introduce this method into the horticulture, but also made it profitable especially in England and America. With both we don't agree. On one side premature uses of the results of laboratory experiments, which were not yet analysed as a whole and finished, were the cause of heavy and unnecessary disappointments in the profession, but on the other side we must admit, that the undertaken scientific investigations, if they did also not result in clear and fixed explanations of the effect of the growth of the plants by heat treatment of the soil, however, with their varying arrangements of the experiments, had established many details as a fact and with that had brought many important contributions to the solution of the problem. In general the road for further investigations was not blocked, only the spur and the touching points for further research were lost among the multiple premature hypotheses.

If we surveyed once more the present results of the investigations up till now, we would find as the first in which all investigators agree, the establishment, that the heat treatment of the soils produced changes, which influenced the growth of the plants. Theoretically imagined, these changes could concern all or some qualities of the soil. The most important qualities for the growth of plants were of chemical, physical and micro-biological nature. In consequence the analysis was conducted in these three directions, and we will summarize the most important results of this investigation.

Concerning the chemical qualities, the investigators agreed, that by the heat treatment of the soil certain processes of decomposition took place, by which especially the phosphate-and the nitrogen-compounds were attacked. Though one found the total quantity of nitrogen in heated and in unheated soils to be equal (R i c h t e r), the extraction of the heated soils produced a considerable higher value of nitrogen compound soluble in water and the dry substance of the plants cultivated in heated soils also showed a higher contents of nitrogen. This was

explained by the replacement of the soil-nitrogen from insoluble resp. slowly soluble into reading soluble nitrogen and thus, it was easier and abundantly used by the plants. The process of decomposition also concerned the organic substances and led to the result of the products of decomposition of the humus mould of acid nature (M ä r k e r), the effect of which could be softened resp. abolished by the addition of lime. The quantity of this product of decomposition, which was called »Giftstoff«, depended on the kind of the soil. The most unfavorable were meadow grounds and then the fieldsoil. The most favorable was the garden soil (S c h u l z e).

The effect of the heat treatment on the physical qualities of the soil was not so thoroughly studied. R i c h t e r found displacements due to the porosity (difficult reception of water) of the soil and to the weight of the volumen. Besides the authors accepted as a well known fact, that the heat affected a gel-forming of the soil colloids.

Owing to the changes in the micro-biological conditions of the soil by treatment the expression »partial sterilization« was introduced. With this expression they accentuated, that by such a heat treatment between fixed limits of temperature not all micro-organical life was destroyed and the soil was only partly »sterile«. Also the thesis (of which we do not know the origin) was set up, that heat treatment of the soil destroyed the present disease-bearers. R u s s e l l and P e t h e r b r i d g e concluded from their experiments, that heat treatment could also be considered as a remedy for »ill-soils«. Anyhow we must be aware of the fact, that a direct comparison between the micro-cultures of the heated and not heated soils, which alone could confirm the above mentioned thesis, has never been made, as far as we know.

Referring to the behaviour of plants in heat treated soils all investigators established, when the experiments were continued until full development of the plants, in the beginning, a depression of the growth, which after a certain time was overcome by the plants and turned into a luxuriant development, which surpassed the control cultures in not treated soils. The investigators called our attention especially to the rich development of the leaves and shoots as well as to the deep dark green colour of the plants. With the exception of M e r k e n s c h l a g e r (16) and H i l t n e r (7) all the other mentioned investigators found, that the dry substance of the cultures in heat treated soils gave an increase in comparison with normal cultures, the quantity of which depended upon the kind of the plants, the soil, experimental time a. s. o., but it reached in some cases nearly 100%. If the vegetative growth was, however, luxurious, it hand no bad influence on the flowers and fruits, in the contrary the flowers and the fruits were stronger and more abundant. (R u s s e l l and P e t h e r b r i d g e).

During the first period of the development of the plants in heated soils with the exception of the retardation of the growth, certain symptoms of illness could especialy be noticed on the leaves. It concerned

the appearence first established by Richter and later on by other investigators of the change of colour, dispersing from the margin of the leaves. This and the retardation of the growth were put down to the production of the decomposition of organical nature, which resulted from the heat treatment of the soils.

III. METHOD OF THE EXPERIMENTS

As we see from this historical survey, the details of the methods of the research of the soil, treated by heat, were quite differently dependent on the purpose of the research werk. First of all with respect to the used temperature, which amounted generally to about 100° C as far as the statements go. But also higher temperatures were used even to 700° C (Merkenschlager). The duration of the treatment showed still more differences. The soil was treated 1×2 hours (Koch–Lueken), 2×2 hours (Czermak), 1×3 hours (König, Hasenbäumer and Coppenrath), 5×3 hours (Pfeiffer–Franke) a. s. o. The used pressure varied from 1–4 atm. Concerning the quantities of soil, used in these researches, they amounted in the principal physical-chemical investigations from 250–500 g and even to some kg in case of special plant physiological investigations. They experimented with light and heavy, acid and alcaline soils with all their variations. Sometimes even artificial soils (König) were used and before, resp. after the treatments manure was added. The plant material too varied vastly, but some plants as mustard, oats and Indian corn were often prefered, also peas were often used.

As our investigations of the effect of the heat treatment have relations to the nutrient-substrata to soil cultures as well as to the so caled water-cultures, this required each time a special method adopted to the substrata and of course appropriate to the purpose of the investigation, about which the following report will deal. We must mention, that all our investigations were carried out at the Plantphysiological Institute of the University of Zagreb and most of them in the glasshouse of the laboratory, while some of them were finished in the glasshouses of the Botanical Garden of the Institute.

a) Soil-cultures

We used for our experiments two kinds of soil, that is to say, two soil-mixtures. The first one, which we called, according to the usage of the gardeners, gardenmould (G), consisting of 1½ part of compost, 3 parts of mould and 1½ part of sand. The other mixture, which we called fieldearth (F), consisted of 5 parts of fieldsoil and 1 part of sand. The fieldsoil was taken from the experimental fields of the Botanical Garden. This soil was a heavy, light gray-brown clay. It was first pulverized and then riddled. The sand, used for both the mixtures, was

first thoroughly washed with the water of the water-works of the town of Zagreb and then dried in the open air. Each component, of which the soils consisted, was measured and then brought into the laboratory, where the mixing took place. Each time, when an experiment was set up, the soils were used up, as the experiments were never made with old soils but always with fresh ones, mixed and prepared in the same manner.

With these soil-mixtures a certain number of Mitscherlich's vessels (Mvs), containing about 5 l, were filled. The number of the Mvs was determined before the beginning of an experiment, because they fixed each time the quantity of gardenmould and fieldsoil, and their components, necessary for the experiment. In all experiments the different objects were represented by 3 Mvs or pots, which were also occasionally used.

The filled Mvs were put into an autoclave and exposed during a certain time to a fixed temperature and corresponding pressure. As will be shown next, we generally used the one time and twice one hour fervorization at 137° C and a pressure of 2½ atm. Where the autoclave, which we used, could only take 2 Mvs at the same time and it took about one hour till 137° C and 2½ atm. were reached, which was very uneconomical with regard to time and costs, the extensive experiments would take. We therefore sought already after the first experiment means to solve this problem and succeeded in fervorizing the double quantity of soil in the same time and with the same consumption of heat, making use of 2 particular zinc-vessels. One half of the soil we put into the Mvs the other half into these zinc-vessels. These 2 zinc-vessels were put one upon the other and filled the whole autoclave. These vessels had in their bottoms 2 splits, each 10 cm long and 1 cm wide. The lower vessel had on its upper edge an open ring, which we could take off and into which the upper vessel could be put. This made it possible, that the steam could penetrate from above into the vessel below and from below into the upper vessel. We must mention, that the upper edge of each vessel had 2 handles. With these handles we could take the hot vessels out of the autoclave. The autoclave was connected with the gas-main of the town and was filled with distilled or rain-water.

The fervorized soil was spread on a garden-table and thoroughly mixed with a handshovel. Lumps, which were found, were crushed by hand. Then the prepared and labelled Mvs were filled with the still hot soil. We must point out, that we did not find any difference between the development of plants in the soils fervorized in Mvs or in the zinc-vessels.

Another difficulty was the heating of the soils to 70° C. The best solution of this question proved to be a water-bath in the open autoclave. Therefore the autoclave was filled to a definite height with distilled water. On a support in the autoclave one of the above described zinc-vessels was put, which by its slits in the bottom allowed the water, to

pass into the vessel. Into this we put 6–7 Vouk's glass-cylinders, filled with the experimental soils. Of course we took care, that the water in the autoclave could not penetrate into these vessels. 2 thermometers were attached in cork-rings. One was brought between the wall of the autoclave and the zinc-vessel and the other into the zinc-vessel. The difference of the temperature between both was such, that after some experience and attention the temperature in the zinc-vessel could easily by regulated. Apart from this, we also put a thermometer into each glass-cylinder, filled with soil. These were put into the soil, which had to be heated, in 3 different layers, one into the middle, one into the upper part and one into the lower part of the cylinder, to get a good picture and control of the heating process. As we did not only want, to reach a definite temperature but also to keep this temperature during the process as much as possible, a constant attention was demanded. The further fervorizations of the soils were of course quite the same. In case, that twice was fervorized, the second treatment took place the following day. The fervorization to 100° C was reached without any difficulty. The autoclave was only shut, but was not made tight. The steam could escape normally by the valve.

Further manipulations took place, when all the Mvs with their contents were cooled down to chamber temperature, Concerning the first water gift of the Mvs, they were put into distilled water and the control vessels filled with not treated soil into zinc-cases, filled with water of the water-works. As the time of soaking the treated soils with water took 24 hours, we gave up this system and watered the soils with a spray nozzle, after having put the seeds into it.

Into each Mv we put first 50 and later on 30 local obtained seeds. We stated, that the normal germination of these seeds amounted to 70–80%. Before they were put into the ground, they were selected on equal size and colour. Then they were thoroughly washed in a 1‰ sublimate solution and cleaned with water. After being dried, we put them in rows in the above indicated quantity into the Mvs. Daily the germination was noted in the most exact way during 8–14 days. After some weeks the young plants were thinned out in such a way, that in each vessel the extreme tall and the extreme small plants were removed, so that we should have later on material, which was as much as possible homogeneous. The further way of the experiments and their working out we shall find in the descriptions of the special experiments.

b) Water-cultures

For the water-cultures we used Vouk's-vessels (Vvs), containing 1750 cc. The normal, that is to say, the not fervorized nutrient solutions were made in the usual way. Into the Vvs, filled with distilled water, we put the weighed out nutrient salts in the prescribed succession, after which the vessels were covered with the accessory Vouk's lid, the opening of which was covered with a watch-glass and the whole vessel

was put into the dark room. As the Vvs were not of Jena-glass but of a heavy pure glass of Bohemia, which was very thick, we could not use them to fervorize at a higher temperature on account of the danger of bursting. Therefore we used for the preparation of the fervorized nutrient-solution 2 l Jena-glasses. They were filled with 1750 cc distilled water and the nutrient-solutions were made, as we have described above. Each glass was supplied each time with a fresh wad, put into the autoclave and brought to the desired temperature. Except these glasses, containing the nutrient solutions, we also put into the autoclave one Jena-glass only filled with distilled water. This was fervorized at the same time. Like the treatment of the soil, the nutrient-solutions too stayed one hour in the autoclave, after having reached the desired temperature. Then the glasses were taken out the autoclave and cooled down in the air to the room temperature. In the case. that we used twice 1 hour fervorization, they underwent the same process 24 hours later.

When fervorized twice at 137° C, there was a loss of water of about 130 cc. Therefore in all Jena-glasses the level of the solution was marked before they were put into the autoclave and after the fervorization, they were filled up again to the original level with the water, which we fervorized at the same time.

After the cooling of the nutrient-solutions they were carefully poured over into the Vvs, including the precipitate. Against forming of algae they were covered with black paper-cuffs, bearing the relative labels.

Except the experiments with nutrient-solutions fervorized in this way, there were also experiments, in which either the nutrient-salts were given into fervorized water or the salts alone were fervorized and later on an appertaining quantity of distilled water was added. All salts used, were from Merck, Darmstadt or Kahlbaum and Schering, Berlin.

The used seeds were partly purchased from the local seed trade and partly they came from the Botanical Garden of the University. The seeds of Zea Mais were seeds of a pure line, isolated by Prof. Dr. A. Tavčar, Zagreb, Maksimir. Here we will not fail, to thank Prof. Dr. A. Tavčar for his kindness and willingness to put these seeds at our disposal.

Similar to the soil cultures also in the water-cultures the seeds were selected on size and colour. Then they were treated with 1‰ sublimate solution and afterwards washed with water. They were put into Petri-vessels on humid filtering paper to germinate. Generally 100 seeds were exposed for each experiment. The germs again were selected and for the experiments equally developed, strong and healthy seedlings were chosen. Into each Vv 3–4 seedlings were planted, according to the kind of plant. The seedlings were carefully broght into the mashes of the tulle. To bring the roots into the solution the mashes of the tulle were slightly enlarged. This tulle covered the lower part of the opening in the lid. Then if it was necessary the seedlings were fastened with some wad. On the upper opening of the lid we put reversed watch-glasses, to prevent the tender plants to dry up. After some days the watch-

glasses were taken away and the seedlings, which at this time had not further developed or showed a retarded growth, were removed, and replaced by seedlings from the Petri-boxes. In the course of the experiment from each culture vessel one plant was taken occasinally for nearer examination.

From each object there were at least 3 culture vessels, the same as with the soil cultures, so that we always had sufficient material for examination at our disposal. Of course in each experiment there were also a definite number of control cultures, that is to say, normal nutrient-solution cultures.

Concerning the finishing of the experiments, we must mention especially the determination of the fresh and dry weight. That we did not determine the fresh weight of the roots, had its practical reasons, because cleaning the roots from the adhering precipitation of the nutrient solution or the adhering soil particles would cause a loss of substance. Therefore only the fresh weight of the shoots was determinated. For the determination of the dry weight, the roots and shoots were separated. Then we cut them into pieces and kept them in open Petri-boxes, till they had become air dry. Then the material was put into the thermostate, heated at 80° C. In this the material staved at least 2 days. Then the weight was determined.

Further details will be shown in the description of the experiments.

IV SOIL-CULTURES

I A. Experiment

10/XII/1938—10/VI/1939.

Obj. *Sinapis alba*

6 Mitscherlich's vessels (Mvs) were filled with gardenmould and 6 Mvs with fieldearth. Thus the experimental series consisted of 12 Mvs. The Mvs filled with gardenmould were labelled: G and those with fieldearth with: F. 3 vessels of the G-series and 3 of the F-series were fervorized twice during 1 hour to 137° C at a pressure of 2½ atm. in the autoclave. These vessels were then marked FG and FF.

On 10.-XII.-1938 into each vessel 50 seeds were sown. The percentage of germination, as we stated before, amounted to 78%.

After the sowing the fervorized vessels were watered with boiled water, the other series with ordinary water from the waterworks. The cultures were treated like this during the whole course of the experiment. Then all vessels were covered with glass.

Table 1.

Germination in per cent. Unfervorized soils = 100%

Datum	FG	FF
12. XII. 1938	—	—
13. XII. 1938	10,34	37,50
14. XII. 1938	53,09	91,70
15. XII. 1938	75,43	98,27
16. XII. 1938	86,20	100,00
17. XII. 1938	87,50	101,68

The germination process showed indifferent soils distinct differences. From the sown seeds in the normal gardenmould (G) far more than half germinated on the third day. Also on the fourth day the germination went on. From this time on to the seventh day of the observation the germination went strongly back. In the fervorized gardenmould (FG) the germination was retarded till the third day. It was only 10,34% of the germination in G. On the fourth day it was the strongest and went back first slowly and then again more quickly. The retardation of the germination and the weaker germinating capacity in FG made, that till the end of the experiment the number of germs in FG stayed behind that in the G-series. The number of the germinated seeds in FG was only 87,5% of that in G.

The germination in the normal fieldearth (F) was nearly the same as in the normal gardenmould. On the third day it was strong, then it declined. From the 5th–7th day the germination went down much more again. In the fervorized fieldearth (FF) we found at first also a retardation of the germination. Certainly it was not so striking as in the fervorized gardenmould. On the third day the germination in FF was 30,5% of that in the normal fieldsoil. The germination in FF was the strongest on the 4th day, then the germination declined, but was still stronger than in F with the result, that at the end of the examination the germination was in FF 101,68% opposite 100% in F. In spite of the retardation of the germination at first in FF at last in this soil were a little more seeds germinated than in the normal fieldearth. Here we must mention, that after the end of this examination again and again new germs appeared in the FF cultures. So here the process of the germination was not yet finished. These stragglers were not counted anymore and to make comparisons possible they were removed regularly.

From the 10th day the examination of the germs took place. For this purpose the seedlings were carefully taken with 2 glass-bars out of the grounds and put into labelled glass vessels filled with water. The earth attached to the roots was removed by a fine jet of water, in order to make minute examination possible.

Table 2.

Average length of the seeds in per cent. Unfervorized soils = 100%.

Datum	Height of shoots		Length of roots		Total length	
	FG	FF	FG	FF	FG	FF
20. XII. 1938	94,74	98,28	129,62	76,92	104,70	90,47
27. XII. 1938	86,76	92,37	105,88	87,50	93,13	90,72
3. I. 1939	97,00	107,01	87,75	72,72	92.24	92,07

The height of the shoots was measured from the cotyledons to the rootneck. The length of the roots was measured from the root-neck to the point of the roots.

G showed longer shoots in all examined cases than those from the fervorized soil. During the two first examinations the FG roots were however longer than the G roots. But on the 23th day the G roots were longer.

In the fieldsoil the picture was much more stationary. The found values for the height of shoots and the length of roots as well as the total length of the seedlings were higher in F than in FF. Only one time, the last day of the examination, the height of shoots in FF was higher (107,01%) than in F (100%).

From 20/XII/38–24/I/1939 the roots were examinated with regard to the lateral roots.

Table 3.

Number of the lateral roots, and the ramification.

Datum	G			FG			F			FF		
	Normal	Many	Rich	Normal	Many	Rich	Normal	Many	Rich	Normal	Many	Rich
24. I. 1939	*20*	5	4	4	*17*	9	*10*	*10*	2	5	6	*19*

This table shows the final result of this examination. We saw distinct differences between the normal soils on one side and the fervorized soils on the other side. The seedlings in G and F showed in most cases by far a normal number of lateral roots. Those in FG and FF showed a great ramified rootsystem with in most cases many roots or like in FF even a rich root system. Later on this picture of the roots confirmed again and again this first impression and it became characteristical for all the cultures in fervorized soils.

At the same time the places of the root-swellings of the lateral roots were examined. There also we found an essential difference between the platns from normal and from fervorized soils. (vide *photo–IInd experiment.).*

Table 4.

Places of the lateral roots on the main root.

Datum	G		FG		F		FF	
	Upper third part	All over	Upper third part	All over	Upper third part	All over	Upper third part	All over
24. I. 1939	5	*15*	*24*	4	5	*18*	*7*	*13*

The places of the root-swellings were to be distinguished best in the normal and fervorized gardenmould. While in G most of the lateral roots were developed all over the whole main-root, in the FG cultures we found them directly beneath the root-neck or close to it. The same we found in the fieldearth, though here the difference was not so clearly to be recognised. Later on (Vth experiment) we shall once more come back to this.

On 27.–XII–1938 the first leaves appeared in G and FG and somewhat later in F and FF. On 10.–I–6939 they were completely developed.

Table 5.

Average length of the plants in per cent. Unfervorized soils =100%.

Datum	Height of shoots		Length of roots		Total length	
	FG	FF	FG	FF	FG	FF
10. I. 1939	69,64	87,23	71,87	84,62	70,45	86,46
17. I. 1939	58,22	100,00	90,13	82,14	68,66	92,19
24. I. 1939	52,77	63,00	73,75	101,85	59,23	72,60

This table shows the result of the further measurement of the young plants. The heights of shoots, the length of roots and the total length in G and F were more than in FG and FF. The longer root average on 24th–I–1939 in FF may be of no value in this case. We must mention here, that the unfavorable length of the plants from fervorized soils was noted, when the plants were 55 days old. Concerning the height of shoots of the normal soils, immediately the strong rankness of these pale plants was notable. While the smaller shoots in the fervorized soils showed a striking dark green colour. The rankness of the growth lasted during the whole time of the experiment and became stronger with the advancing age. In the beginning of the observation 65% of the plants in the G cultures had to be supported, as they grew slack and fell down. In the FG cultures there were 27% of such plants. The difference in the fieldsoil was not so great. In the F cultures 27% and in the FF cultures 23% of the plants had to be supported.

We now had to break of the examination of the length of roots, as it was impossible to separate the whole roots from the earch undamaged.

Table 6.

Number of the leaves for 10 plants in per cent. In unfervorized soils = 100%.

Datum	FG	FF
27. XII. 1938	50,00	53,33
3. I. 1939	91,34	95,23
10. I. 1939	82,50	69,69
17. I. 1939	56,00	57,43
24. I. 1939	68,75	81,53

As we perceived above, the leaves appeared on 27th–XII–1938. The number of the leaves was calculated from 10 plants and only related on full developed leaves. At once it was clear, that the number of the leaves in normal soils was significantly greater than in the fervorized soils. As the above table showen, this difference stayed till the end of the examination.

Notable was now the number of the not yet completely developed leaves. At the first control we found them nearly nowhere and at the second only in the G and F cultures. At the third examination the here mentioned soils had only a small advantage over the fervorized soils. At the last observation this advantage disappeared nearly completely and it showed, tha the development of young leaves in the fervorized soils took place fairly energetically.

As to the leaves we must still remark on the following. The colour in G was pale green. In FG, on the contrary, the colour was dark green. The leaves of the F cultures were light green and those of FF were noticeable deep dark green.

Table 7.

Measurements of the leaves in per cent. In unfervorized soils = 100%.

Datum	FG				FF			
	Breadth	Length	Stalk	Total	Breadth	Length	Stalk	Total
10. I. 1939	70.60	77,19	57,14	69,44	100,00	111,11	69,23	93,54
17. I. 1939	70.90	73,53	64,70	70,21	85,71	88.89	78,57	85,36
24. I. 1939	80,77	76,47	70.59	74,51	79,16	84.38	82,35	83.67

This table confirms truly with figures the impression, we received by observing. The leaves from normal soils were larger, even the cotyledons were larger than the leaves and cotyledons from fervorized soils. With relation to the length and width of the leaves and the length of the stalks in the normal grounds they could not be reached by those of the fervorized soils during the whole time of the observation. The largest difference of size was found between the G and FG cultures.

That under such conditions the dry weights of the G and F cultures were higher than in the FG and FF cultures, was not astonishing.

Table 8.

Dry weight of 10 plants in per cent. In the unfervorized soils = 100%.

Datum	Shoots		Roots		Total	
	FG	FF	FG	FF	FG	FF
20. XII. 1938	81,03	77.55	144,44	15,50	89,55	68,42
27. XII. 1938	85,47	—	122,72	—	91,36	—
3. I. 1939	65,02	—	48,39	—	61,13	—
10. I. 1939	59,18	112,96	89.19	140,00	63,12	115.93
17. I. 1939	44,93	40,71	46,29	151,52	45,10	63,13
24. I. 1939	29,79	67,20	100,00	100,00	45,57	68,58

This table confirms in general the value found up till now. An exception to this is only made by the root dry weight of FF in the third period of examination, as we see from this table.

Our results were therefore contrasting to the results of Pfeiffer and Franke. In their heated soils the plants had an essential higher dry weight than in the unheated soils. But this contradiction was only a semblance. Had not already Dietrich pointed out the fact, that heating the soil influences negatively at first the development of *Sinapis alba* and was this fact not later on confirmed by Schulze? The end of our table shows therefore, that we were in the first period of the development. We thus established, that *Sinapis alba* 45 days aster the sowing was still in the first period of development, as Dietrich had mentioned. In this period the heated soils exercised a disadvantageous influence on the development of the plants.

For the second period, which after Dietrich had an advantageous influence on the experimental plants, we extract from our protocol and our photo material the following:

17.–I–39. The stalk of one of the examined plants of G was thin below, thickening towards the middle part and looking swollen.

At this time the cotyledons of G withered, while in the other experimental rows they were still green.

24.–I–39. The cotyledons of FG withered. Those in both the fieldsoils were still green. The leaves of both the gardenmould showed here and there symptoms of illness.

In the vessel FF2 was a culture of *Lachnea carmurosa* Mart. Quellet, *(Pezizaceae).*

The plants in all the vessels were thinned out. Only 10 plants of equal size stayed for further examination.

February 1939. In the beginning of this month the plants in the vessels of G and F showed a strong yellow turning of the leaves and a strong leaf fall.

About this time in the fervorized vessels on the contrary we noted only a fey leaves, which showed more or less a change of colour of the margins. At the end of the month a change of colour appeared. The foliage of the G and F cultures became darker, whereas the leaves of the FG and FF cultures became lighter (Plate 1 and 2).

11.–III–39. The rows were photographed. In general as those photos distinctly show, there was no difference in the height of shoots between G and FG and F and FF. Concerning the foliage, the plants in the normal fieldsoils were nearly leafless, compared with the plants in the fervorized fieldearth. The leaves of F were smaller than the leaves of FF.

21.–III.–39. All plants showed flower-buds.

17.–IV–39. The rows were photographed again (Plate II 1 and 2). The plants of the FG and FF cultures surpassed in height by far those of the G and F cultures. The foliage in FG and FF was thicker and stronger than that in G and F. The development of the flowers in the fervorized soils was much richer and fuller than that of the plants in the normal soils.

All plants had much to suffer from lice. Therefore we fought the lice. After this the vessels were put into glasshouse of the horticulture of our Botanical Garden. Already after some weeks the lice were noticed againd. It was unfortunately impossible to fight them. It seemed ho wever, that they could not do any harm to these strong plants.

10.–VI–39. The experiment was broken off. From the 10 plants of each Mv only the fruit system was taken away, which had meanhwile matured.

3.–VII–39. These fruitsystems were photographed in the following row:F – FF – G – FG. (Plate III 1). This picture distinctly shows, the rich ramified bunches and the numerous siliquae in the fervorized soils. The bunches of the F and G cultures were on the contrary miserable, a little ramified and had only a single or no siliquae at all. In the last case they even had not surpassed the stadium of flowering.

The crop of the plants gave the following result:

30 plant G produced 4,79 g seeds.
30 „ FG „ 8,41 „ „
The difference in favour of the fervorized gardenmould was 3,62 g.
100 plants G produced 15,9 g seeds
100 „ FG „ 28,0 „ „
or normal = 100% and fervorized = 176%.
30 plants F produced 1,44 g seeds
30 „ FF „ 5,16 „ „
The difference in favour of the fervorized gardenmould was 3,72 g.
100 plants F produced 4,8 g seeds
100 „ FF „ 17,2 „ „
or normal = 100% and fervorized = 358%.

II. Experiment.

31/XII/1938–10/VI/1939.

Obj. Sinapis alba.

The soils were the same as in the first experiment. We began this experiment with the control of the weight of the soil in each wessel. The weights were given in the following table in kg.

Table 9.

The weight of the soils in kg.

29. XII. 1938		
Nr	G	F
1	5,68	6,99
2	5,52	6,67
3	5,68	7,34

In the following table 10 we gave first the weight of G and F before the first fervorization in kg. Then the Mvs with the soils were fervorized. After this they cooled down in the following 24 hours to room temperature. Then the Mvs were again weighed.

Table 10.

The weight of the soils in kg before, between and after the fervorization.

Datum	FG				FF		
	Nr	1	2	3	1	2	3
29. XII. 1938		5,56	5,58	5,79	6,79	6,81	7,13
30. XII. 1938 1 time 1 hour fervorized		5,63	5,61	5,83	6,82	7,27	7,15
31. XII. 1938 Twice fervorized 1 hour		5,63	5,61	5,83	6,85	7,40	7,18

After being fervorized again, they were weighed again the following day under the same conditions.

By fervorizing an increase of the weight took place. The behaviour of the gardenmould changed from that of the fieldearth. After the first heating of the gardenearth there was not noted any increase of the weight, when it was heated for the second time. In the fieldearth we perceived every time, when the soil was fervorized an increase of the weight, but in both the FG and the FF this increase was not considerable.

Only in the second vessel FF the increase was each time greater than in the other wessels. The reason of this fact we cannot explain, perhaps it was the condensation of the steam, but this problem we will not discuss here.

31.–XII–1938. 50 seeds of *Sinapis alba* were put into each Mvs, which were water with boiled or ordinary water of the waterworks. Then all Mvs were covered with glass.

Table 11.

Development of the germination in per cent. In unfervorized soils = 100%.

Datum	FG	FF
3. I. 1939	2,50	3,30
4. I. 1939	30,76	60,56
6. I. 1939	99,06	123,87
7. I. 1939	103,73	127,27
8. I. 1939	105,66	128,48
9. I. 1939	106,42	131,04
10. I. 1939	108,10	132,96

The counting of the germinated seeds began on the 3rd day. Like in the first experiment also here already more than half of the seeds put into the normal gardenmould were germinated. The germination was also strong at the 4th day and then decreased sharply till the 10th day of the observation. The fervorized gardenmould gave the same picture as in the former experiment. Till the 4th day there was a retardation of the germination. In G germinated 104 and in FG only 32 seeds, or in percentage, if we put the germinated seeds in G = 100%, in FG there were only 30,76%. On the 6th day the germination in the FG cultures reached practically the figure of G. In the G cultures were germinated 107 seeds = 100% and in FG 106 seeds =99,06%. In this way the development of the germination in FG surpassed the same in G on the 7th day and finished on the 10th day of the observation with a bigger figure of germs, with 120 germs or 108,10% against G with 111 germs od 100%. We must mention, that on the 8th day one germ of the G culture died, which did not happen in the FG cultures.

In the normal fieldearth the germination was in the beginning very strong. Then it came to a standstill, to increase again a little on the last day. The day before the last day of the observation we found one dead germ.

In the FF cultures the retardive effect of the fervorizing was observed till the 4th day. While in F nearly the half of the seeds germinated 71 seeds = 100%, in FF there were only 43 seeds = 60,56% germinated. After this an energetic acceleration of the germination took place. It amounted to 123,87% of the germinated seeds in the normal fieldsoil. This remained far behind. Indeed, the germination in FF became weaker,

but F could not reach this difference till the 10th day. The examination finished with in F 91 germanited seeds or 100% and in FF 121 germinated seeds or 132,96%.

From our protocol we take the following notes about the germination.

6.–I–39. One germ was dead in G. All glasses were taken away from the G series, because the germs were etiolated and pressed against the glasses.

8.–I–39. From all culture the glasses were taken away. All cultures received boiled or ordinary water.

10.–I–39. In all vessels the plants were thinned out. Only 20 plants in each Mv were left. 3 G and 3 FG plants were taken from the vessels and were photographed (photo 4a and 4b). The difference in the height of shoots between the G and the FG plants could distinctly be recognised. The G plants were long. The cotyledons were larde and pale green. As this photo shows, the first leaves began strongly to develop. The roots were extra-ordinary long and thin. Every-where from the root-neck to the point of the roots along the main root the short lateral roots began to show.

The FG plants in the contrary had smaller cotyledons. The hypocotyl was more solid and stronger. The whole plant was deep dark green. There was hardly any development of leaves. The main root was short. Numerous lateral roots, some of them of a considerable length, were around the root-neck or in the upper third part of the main root. The whole root system of the FG plants was fir and strong contrary to the roots of the G plants, which were delicate and tender.

16.–I–39. Cotyledons large, light green and proper developed leaves were noted in the G cultures.

In FG: Cotyledons smaller, deep dark green. Beginning of the formng of leaves.

F and FF: The size of the cotyledons was not so notable different as in the gardenmould. They were a little larger in F than in FF. The colour of the germs in the normal fieldsoil was lighter green and the development of the leaves was more advanced than in the fervorized fieldsoil.

Table 12.

Average length of the plants in per cent. In unfervorized soils = 100%

Datum	Height of shoots		Lenght of roots		Total length	
	FG	FF	FG	FF	FG	FF
16. I. 1939	91,54	82,35	61,22	55.00	79,16	72,22
23. I. 1939	75,56	89,19	59,45	72,97	68,29	124,32
30. I. 1939	75,23	78,65	62.29	93,33	70.48	82,35
6. II. 1939	60,00	83,84	77,64	75,00	66,12	80,70
13. II. 1939	56,80	66,04	78,84	69,44	64,03	67,09

The seedlings now were nearly 3 weeks old, when we started, measuring them. The number, which we took out of the Mvs for the examination, was each time 6 pieces of each row, that is to say, that we took from each vessel 2 plants. This took place every week from 16.–I–39 till 13.–II–39.

From each row, after hoving been examined, we took 2 specimen for the herbarium.

The measurements confirmed the rankness of the growth of *Sinapis alba* in the normal gardenmould. As we can see from the table 12, we get the same picture as in the first experiment. Neither the height of shoots, nor the lenght of the roots, nor the total length of the plants in the normal garden-and fieldsoil were reached by the same soils, which were fervorized, not to mention, that they surpassed them. Here again the statement by Dietrich, Schulze and other investigators came to expression, that the heating of the soil first produced a retardive development of the growth of the plants.

Table 13.

Number of the lateral roots.

Datum	G			FG			F			FF		
	Normal	Many	Rich	Normal	Many	Rich	Normal	Many	Rich	Normal	Many	Rich
13. II. 1939	18	9	3	11	14	5	20	7	2	3	5	22

This table shows the quantity of the noted lateral roots. In the normal garden-and fieldsoil the proportions were such, that most of the plants showed a normal numbler of the lateral roots. Few plants showed already many roots and only a small part of them had a root system, consisting of numerous lateral roots. The fervorized soils show in this regard quite another picture. Most of the plants of FG had many or even abundant lateral roots. The rest showed a normal number. In FF we saw in the clearest manner the increase of the lateral roots in consequence of the fervorizing of the soil.

Table 14.

Place of the lateral roots on the main root.

Datum	G		FG		F		FF	
	Upper third part	All over	Upper third part	All over	Upper third part	All over	Upper third part	All over
13, II. 1939	8	13	19	5	4	14	23	6

This table represents the place of the root swellings of the lateral roots on the main root, which is clearly demonstrated in this photo. (Plate IV. 1 and 2). While in the G cultures these swellings of the lateral roots were distributed over the whole main root, from the root-neck to the point, all over, most of the lateral roots of the FG cultures were in the surrounding of the root-neck and the upper thirt part of the main root. This we can also, see form this photo. This picture was characteristic of the formation of the roots of *Sinapis alba* in the stadium of the youth in the fervorized soils. Later on certainly these differences disappeared, as we could see in our herbarium. What was admitted for the lateral roots were generally all over the main root contrary to the FF cultures, where nearly all lateral roots were only on the upper part of the main root.

Table 15.

Number of the leaves for 10 plants in per cent In unfervorized soils = 100%.

Datum	FG	FF
23. I. 1939	76,92	72,00
30. I. 1939	68,08	66,67
6. II. 1939	59,70	96,00
13. II. 1939	91,46	63,85

Concerning the number of the fully developed leaves, they were the largest in the G and F cultures, and this fact remained till the end of the examination. In the FG and FF cultures the number of the fully developed leaves was fluctuating. One time e. g. at the first examination we had the impression, as if the number of the leaves in fervorized soils would quickly reach the number of the leaves in the normal soils. In this case the number of the leaves in FG was 76,92% and in FF 72% of those in G and F. Something similar took place during the last examination in the gardenmould and on the day before the last day of the examination in the fieldsoil. But in general the impression was like this that till 13.–II–39 to reach the number of the leaves from the forvorized soils appeared nearly impossible. The impression was wavering, but always in the favour of the normal soils.

Quite different from this were the found figures for the not fully developed leaves, which was especially noteworthy in the gardenearth.

Table 16.

Not fully developed number of leaves for 10 plants in per cent. In unfervorized soils = 100%.

Datum	FG	FF
23. I. 1939	55,56	38,89
30. I. 1939	75,00	93,75
6. II. 1939	130.77	72,22
13. II. 1939	146,67	115,31

At the first examination the number of the not yet developed leaves in the G cultures was 18 and in the FG cultures 10, or expressed in percentage only 55,56% against 100% in the G cultures. The following examination was also still in the favour of the plants in the normal gardensoil. And if we make this = 100%, the figure for the FG cultures comes to 75%. Only from the subsequent examinations we noted, that a progress had taken place. During this counting, we noted in G 15 not developed leaves, which we made out 100% and 22 not developed leaves in the FG cultures, therefore amouting to 146,67% of the normal cultures.

In the fieldsoil the development till 13.–II–39 was not so convincing, but the last examination gives indeed a point for the number of the not developed leaves of the FF plants. If we make F = 100%, the counting of the FF gave 115,31%. The last examination showed, that in the FF cultures too the younger leaves from this date on appeared in a much larger number than in the not fervorized soil.

Table 17.

Dry weight of 10 plants in per cent. In the unfervorized soils = 100%.

Datum	Shoots		Roots		Total	
	FG	FF	FG	FF	FG	FF
16. I. 1939	64,96	100,00	272,00	178,00	96,91	126,00
23. I. 1939	77,33	51,43	83.33	160,00	79,05	64,99
30. I. 1939	32,38	94,53	40,00	120,00	33,16	96.95
6. II. 1939	35,88	69,15	100,00	90,00	37,71	72,97
13. II. 1939	39,51	396,80	45.45	130,43	39,67	355,70

The picture of the experimental plants of the G and FG cultures was the same in the first experiment, if we don't take in consideration the dry weight of the roots in the FG cultures during the first and fourth examination. In both cases we noted, that the dry weight of the roots in the fervorized soil was equal or larger than that of the normal soil.

This came much more to expression in the fervorized fieldsoil. By heating, the shoots were just the same as before retarded in their development, the weight of the roots however increased. Only the fourth day of the examination made an exception to this.

That the affect of the fervorization stood chiefly in relation to the development of the root system, this will be proved distinctly later on by the water-cultures. If we therefore look away from the stronger development of the roots and only consider the distinct development of the shoots, we can also conclude from this experiment, that the heating of the soils was not favourable for the development of the plants. Here we must note, that this unfavourable influence was only limited to the stadium of the youth. The plants were 44–45 days old.

From our protocol we take the following morphological notes.

17.–IV–39. The plants of FG and FF surpassed by far those of G and F with regard to the height, the foliage and the strength. (Plate V 1 and 2). In the two first mentioned rows the flowers were stronger, fuller and finer than in the G and F cultures. Later on a distinct difference was noted with regard to the setting in favour of the FG and FF cultures. The bunches in FG and FF were richly ramified, while this was found in the G and F cultures to be weak or not at all. In the FG and FF more siliquae matured than in the G and F cultures.

10.–VI–39. The experiment was broken off. The crop of the seeds was:

G = 3.00 g FG = 8,94 g

The difference in favour of the fervorized garden earth was 5.94 g.

100 plants G produced 14,28 g seeds.
100 „ FG „ 42,57 „ „

Expressed in percentages, we received the following.

G produced = 100%. FG produced = 298%

The crop of the fieldsoil was the following:

F = 2,33 g FF = 4,67 g

The difference in favour of the fervorized fieldsoil was 2,34 g.

100 plants F produced 11,09 g seeds.
100 „ FF „ 22,23 „ „

Expressed in percentages. we received the following:

F produced = 100%. FF produced = 200%.

The crop of the Ist and IInd experiment.

The seeds of both the experiments were mixed. so that the seeds of the G cultures of the first experimnet were mixed with the seeds of the G culture of the second experiment a. s. o.

Between the seeds of the G and FG cultures there was no difference nor in size nor in colour. The F seeds in the contrary were smaller than

those of the FF cultures. Besides the seeds of the F cultures had an orange-yellow colour, whille those of the FF cultures were more yellowish.

From this above mentioned mixture we made a germination-test. On 26th VIII–39 the sowing took place. 50 seeds wers vere put into each germaniting vessel. For each culture there were two of these vessels. They were put into water to suck it up.

Table 18.

Germination in per cent. In unfervorized soils = 100%.

Datum	FG	FF
28. VIII. 1939	80,00	131,71
29. VIII. 1939	93,75	103,12
30. VIII. 1939	90,00	100,00
31. VIII. 1939	86,36	100,00
1. IX. 1939	86,36	—
2. IX. 1939	90,10	—
3. IX 1939	91,30	—
4. IX. 1939	91,30	—

We here give the course of the germination. Principally we wished to know, if the seeds of the fervorized soils were capable to germ. As the table shows, we succeeded herein.

IIIrd Experiment

12/I/1939–31st/I/1939.

Obj. Sinapis alba

The soils were the same as in the preceding experiments, but now we added something new. Up to now the treatment of the soils was like this. A Mv was filled with one kind of soil, put into the autoclave, was fervorized and after having cooled down, the experimental plants were put into it. In this experiment up to this point the treatment remained the same. We now made the following alteration. Two Mvs were filled with the same soil and were treated like the other Mvs. After the heating, they were taken out of the autoclave and being still hot, emptied on a gardeners table, which was covered with zinc. The contents of these two Mvs were then mixed by hand or by means of a shovel, while the soil was still hot. Then a new Mv was filled with this mixture. The remaining soil was put into flower pots. One mixture was made of gardenmould and the other of the fieldsoil. We wished to examine, if the mixed fervorized soils had the same effect on the growth of the plant as the unmixed soils, used up till now, or with

other words. if it should be necessary each time to fervorize the Mvs with the soil or only the soil alone in any quantity.

Like in the second experiment we first ascertained the weight of the Mvs filled with soil.

Table 19.

The weight of the soils in kg.

Nr	9. I. 1939	
	G	F
1	5,56	7.37
2	5,57	7,90

This table gives the weight of the normal soils in kg.

Table 20.

Increase of the weight of the gardenmould during the fervorization.

	FG				
Datum	9. I. 1939	10. I. 1939	11. I. 1939	11. I 1939	11. I 1939
Nr	Normal	Hot	Cold	Hot	Cold
1	5,63	5,80	5,87	5,77	5,79
2	5,34	5,37	5,35	5,37	5,40
3	5,30	5,49	5,50	5,49	5,50
4	5,48	5,51	5,50	5,51	5,53

In this table we find the increase of the weight. First the weights of the normal soils were fixed. It is understood, that this was done with Mv and all. They were weighed again, for the second time, as soon as they came from the autoclave (hot). After 24 hours they had reached the temperature of the room. Then the Mvs were weighed gain. After the second fervorization they were weighed again in the same manner (hot and cold).

After the first fervorization the G vessels showed an increase of weight, when they were weighted, being still hot. After cooling down a further increase of weight took place in FG1 and FG3, while in FG2 and FG4 a decrease was noted. After the heating on the second day the FG1 and FG3 vessels weighed when hat, showed a decrease and with the FG2 and FG4 vessels an increase of the weight was noted again. After having cooled down all G vessels showed again an increase of the weight. The conclusion was, that the weight of the heated gardenmould was higher in any case then the normal gardenmould.

Table 21.

Increase of the weight of the fieldsoil during the fervorization.

	FF				
Datum	9. I. 39	10. I 39	11. I. 39	11. I. 39	12. I. 39
Nr	Normal	Hot	Cold	Hot	Cold
1	7,52	7,60	7,60	7,64	7,64
2	7,75	7,80	7,78	7,82	7,85
3	7,65	7,72	7,72	7,77	7,83
4	7,77	7,83	7,83	7,88	7,94

Apparently this was more obvious in the fieldsoil. The weight remained constant or was increasing. Only one time FF2 showed a loss of weight from hot to cold. We cannot explain the reason for these fluctuations. Perhaps the condensation of the steam, was the reason, as we mentioned above.

After the fervorization we took from each kind of the soils 100 g to determine the pH. To each 100 g we added 100 g distilled water. This mixture remained for 8 hours in Jenaglasses. Every now and then they were shaken, then they were filtered. The G- and F- filtrate had a gray neuance. The filtrate of FG1 and FG2 was red-brown, but the first was darker coloured. The FF-filtrate was in both cases clear with a light yellowish nuance. The pH-determination took place with the Trenél's acidimeter. This was the result:

pH of G = 7,91 pH of F = 8,22

„ „ FG = 7,90 „ „FF = 7,95

The pH of G was similar to the pH of FG. The pH of F was 0,27 larger than FF.

The experiment was arranged like this:

2 Mvs with normal garden earth, labeled: G1 and G2

2 „ „ heated „ „ , „ FG1 and FG2.

2 „ „ mixed head „ , „ FG3 +

2 Flower pots with mixed heated gardenmould, labeled: FG3+pot 1 and FG3+pot 2.

The same we did with our fieldsoils, using the following marks for normal fieldsoil: F1 and F2; for heated fieldsoil: FF1 and FF2; for heated mixed fieldsoil in Mv: FF3 + ; and in the flower pots: FF3 + pot 1 and FF 3+ pot 2. The vessels containing the mixed heated soils were marked with +.

12.–I–39. Into each Mv we put 50 seeds and into each pot 25 seeds of *Sinapis alba.*

Table 22.

The course of the germination in per cent. In unfervorized soils = 100%.

Datum	FG	FG+	FG+pots	FF	FF+	FF+pots
16. I. 1939	87,67	79,45	87,67	112,70	—	25,54
17. I. 1939	104,11	98,63	93,15	125,39	—	44,44
18. I. 1939	106,85	107,89	102,63	132,81	—	56,25

Unfortunately we forgot to put the seeds into the FF3 + vessel, so to receive a definite answer, we had to set up this xperiment once more: (IVth experiment). In spite of this, the experiment was carried on and worked out as far as possible. The results of the pots appear in the tables as one average figure.

From the above table we observe the retardation of the germination till the 4th day in all vessels of the heated gardenmould. This retardation lasted in the FG and FG+pots till the 5th day. On the 6th day the fervorized gardenmould surpassed the normal in the number of the germs. In the FG vessels this had already taken place on the 5th day.

Already at first examination the fervorized fieldsoil in the Mv showed a much larger number of germs than in the normal fieldsoil. This difference became daily greater in favour of the FF cultures. The FF+pots in the contrary showed a distinct retardation of the germination.

The main roots of the G cultures were most long and thin. As it happened in the FG cultures the main roots at half length were thick or showed swollen parts. Here and there the roots had no hair and glabrous parts appeared. The cultures in FG+pots showed fine roots, which were broken often or showed other damage, when they were taken out of the soil.

In the F cultures the main roots were small and sometimes showed swellings too. Besides they were very delicate, so that they broke often. Most of the FF main roots were very short. Here and there atrophy was noted. Often they showed big swellings. Some root-points were club-shaped. When they were taken out of the ground some of them were broken. The main roots of the FF+pots were also very delicate and thin. They broke even, when taken out of the ground most carefully.

In the G cultures the root-neck was weakly to strongly swollen. On it we sometimes found roots. Incisions of the root-neck occured. In the FG cultures the root-neck was strongly to tuberiformly swollen. There were no lateral roots. In the FG+pots cultures the root-neck here and there was swollen and in one case showed an incision.

The root-neck of the plants in F was mostly strongly swollen and hairy. When the plants became older incisions were noted. Also in the FF cultures the root-neck were swollen. The hairs looked like fur. In the FF+pots we noticed a light swollen root-neck.

For the examination the roots were separated from the shoots. They were then put on an object-plate. Then water was put to it, in order to spread out the root system. This was done with two needles under a monocular-stereoscopic microscope of Reichert, Vienna, Austria.

Table 23.

Number of the lateral roots in per cent. In the unfervorized soils = 100%

Datum	FG	FG+pots	FF	FF+pots
31. I. 1939	69	104	131	87

Daily from 16th I till 31st I-39 the lateral roots were counted. The table above gives the total of the lateral roots in per cent of the last day of examination. The percentage of the lateral roots in FG was 69 expressed in the number of the lateral roots in the G cultures = 100%, as it is, considerable less. In the FG+pots this figure was a little higher than in normal cultures, viz 104%.

In the fieldsoils the proportions were reversed. In FF there were considerable more lateral roots, namely 131%, compared with the F cultures = 100%. The FF+pot cultures had leass lateral roots (87%) than the F cultures. This was not astonishing, considering the slow development of the germs.

From our protocol we noted about the lateral roots:

G: The lateral roots appeared after 5 days. They were long to very long and very delicate. Some were in pairs. Above the root-neck we observed also lateral roots.

FG: The lateral roots appeared likewise after 5 days. They stood in bushes and in pairs. Sometimes the lateral roots were longer than the main root. Once or twice the lateral roots stood above the root-neck.

FG+pots: The lateral roots appeared on the 6th day. Sometimes they stood in pairs. One time they were abnormally short, but sometimes they were longer than the main root.

F: Lateral roots were already present on the 4th day. Sometimes they were longer than the main root. Above the root-neck there were also lateral roots. Notable was the strong ramification.

FF: On the 5th day lateral roots were noted. All were about as long as the main root and in one case even longer. They appeared in bushes or in pairs. They had knots, which were densely haired. The ramification was like in the F cultures.

FF+pots: The lateral roots appeared on the 5th day. They were in pairs and sometimes longer than the main root. Abnormal swellings were observed. The ramification was like in the F cultures.

Concerning the places of the root-swellings of the lateral roots, this experiment confirmed, what we noted already in the former experiments.

With regard to the lateral roots of the 2nd order of these seedlings we could only note their disposition.

Table 24.

Number of the swellings of the lateral roots in per cent. In unfervorized soils = 100%.

Datum	FG	FG+pots	FF	FF+pots
31. I. 1939	149	232	83	47

This table gives the dispositions of the lateral roots in per cent. Those in G and F were 100%. Then the dispositions in FG was 149% and in the FG+pots even 232%. This examination took place from 16th I til 31st I–1939 daily and amounted to many hundreds of examinations. This counts for all the other tables.

In the fieldsoil, probably in connection with the slow growth, FF had only 89% and FF+pots even only 47% of the dispositions compared with those of the normal soil.

Remarks: G: The dispositions appeared after 10 days and in FG too. FG+pots: While in the before mentioned cultures the dispositions of the lateral roots appeared everywhere uniformely, here this occurred only on some places. Only from the 13th day the dispositions appeared regularly.

F: The dispositions were observed after 14 days. FF: The dispositions were noted after 9 days. FF+pots: Here we saw the dispositions of the lateral roots of the second order on the 6th day, but this was unregular and besides there were only few dispositions.

Table 25.

The hairs of the roots.

	Nihil	Thin	Normal	Thick	Like furs
G	6	77	16	1	—
FG	22	23	21	34	—
FG+pots	28	18	18	27	9
F	32	10	25	30	3
FF	25	—	1	22	52
FF+pots	13	—	—	50	37

The hairs were devided into 5 groups, based on a comparison. These hair groups were: no hair, thin, normal, thick and fur like. Table 25 gives the distribution of the hairs in per cent.

In the G cultures the hair was chiefly thinly to normally developed. It was displaced to the normal and thick in the FG cultures. In the FG+ pots the hairs of all groups appeared with a tendency to thick hair.

In the F series all kind of groups appeared. Most of the plants in FF however showed thick hair or fur like. In the FF+pots the hair was even thicker. Most of it was like fur.

About the hairs we noted the following:

G: The hairs were long and delicate.

FG: long hairs.

FG+pots: The hairs were dilecate. Glabrous and dense places of the hair alternated.

F: Thick hairs.

FF: The main root had glabrous places and was alternatively haired with thin and thick haired places.

FF+pots: Delicate and fine hairs.

Developments of the leaves.

G: The development of the leaves began after a fortnight.

FG: The development began after 15 days. The leaves were small to normal.

FG+pots: After 16 days the development of the leaves began.

F: The leaves developed after 15 days.

FF: Like in the F cultures.

FF+pots: The leaves appeared after 17 days.

The experiment only lasted for 19 days and had had an orientating character, concerning the mixture of the grounds.

IVth Experiment.

21/I–13/VI/1939.

Obj. *Sinapis alba.*

The series were fervorized on January 19th and 20th. The arrangement of the experiment was as follows. From the normal gardenmould G there were one Mv and two pots marked with: G and G1 pot and G2 pot. From the fervorized gardenmould there was one Mv, marked: FG. Of the fervorized mixed gardenmould we had one Mv, marked: FG+Mitsch and two pots, marked: FG+pot 1 and FG+pot 2. During the operations the results of the pots were resp. added and appear in the tables as one average figure. The same we did with the fieldsoil.

As usual the Mvs received 50 seeds and the pots 25 each. Then they were put into the water of the waterworks resp. into boiled water. The soaking with water took in the + series about 24 hours. The normal gardenmould and the normal fieldsoil could be drenched quickest.

Table 26.

The course of the germination in per cent. In the unfervorized soils = 100%.

Datum	FG	FG+		FF	FF+	
	Mitsch.	Mitsch.	pot	Mitsch.	Mitsch.	pot
25. I. 1939	40,00	88,00	36,67	107,14	21,43	100,00
26. I. 1939	92,31	138,45	75,00	187,50	181,25	100,00
27. I. 1939	116,67	136,67	114,70	165,21	186,95	235,71
28. I. 1939	123,33	146,67	120,58	168,00	176,00	243,75
29. I. 1939	126,16	153,33	126,47	172,00	180,00	150,00
30. I. 1939	121,87	143,75	125,71	173,07	173,07	200,00
31. I. 1939	125,00	146,87	125,71	173,07	173,07	200,00
1. II. 1939	125,00	150,00	125,71	166,67	166,67	200,00
5. II. 1939	125,00	150,00	140,62	174,07	170,37	220,00

During the germination the Mvs were compared with each other and also the pots with each other resp. with the earth. First we considered the development of the germination in the Mvs. The first counting, as table 26 shows, took place on the 4th day after the sowing. The germination in both the heated soils was smaller than in the normal soils. In the FG cultures the retardation went on till the next day, contrary to the FG+Mitsch, were the germination on this day strongly improved and surpassed the germination in the G cultures. This increase of the germination took place in the FG cultures on the 6th day. From this day on the germination in FG and FG+ was stronger than in the G cultures. Also the FG+poots showed at first in comparison to the G pots a retardation of the germination, which lasted till the 6th day. Then a sudden change took place with the result, that the germination in the normal gardenmould of the pots was surpassed by the heated soil-cultures.

In the fieldsoil we observed in the Mv still the 4th day a retardation only in the FF+ culture. On the following day a strong development of the germination took place in the heated soils, which after some days slackened. On the other hand the germination in the normal fieldsoil went slowly on. As the table shows, the success did not hold on at last. The germination in the heated fieldearth was essentially larger then in the normal soil. The retardation of the germination lasted in the FF+ pots till the 6th day. On the following day a strong increase took place and the result of the germination in the pots was at last the same as in the Mvs.

From our protocol we noted the following:

11.–III–39. The plants were 49 days old. *(Plate VI).* Between the G and FG pots was a distinct difference to the disadvantage of the normal gardensoil. The plants of the G pots were considerably smaller than those in the FG+pots. Here the plants were also stronger. The foliage was much richer. The leaves were much larger and their colour deep dark green compared with the plants of the normal gardenmould.

Generally the growth in the fieldsoil was slower, as the photo distinctly shows. The plants of the FF+pots were smaller than those of the normal fieldsoil. These plants made a more etiolated impression. In the FF+pots a more intensive development of hairs began and the green of the leaves was much darker than that of the plants in the normal fieldsoil.

17.–VI–39. On this day the plants were 86 days old. The Mvs were photographed. (Plate VII 1 and 2.) One picture represents the normal, heated and mixed heated gardenmould. FG and FG+ were longer than G. Further the plants, which were cultivated in the heated soils, were stronger than those in the normal cultures. The leaves of the plants in the fervorized gardensoil were deep dark green, those of the G cultures light green. Besides we noted already a leaf fall in the G cultures, which was not the case in the fervorized soils. The other picture shows normal and fervorized fieldsoil. In this we observe at once the leaf fall in the normal cultures, while the average larger plants of the fervorized fieldsoil were still in full possession of their much richer leaves. Besides the FF and FF+ plants were also stronger than those of the norlal fieldsoil.

After having been photographed, the plants were brought into the glasshouse of the Institute Garden. Here all plants had much to suffer from lice. On 13th VI–1939 the harvest took place. Also here the crop of the seeds of the fervorized soils was a multiple of the crop from the normal soils.

Vth Experiment.

13/II–18/III/1939.

Obj. *Sinapis alba.*

This was the 3rd experiment, in which we used Mvs and flower pots. Also this experiment showed like the two preceding experiments, that tha plants in the Mvs, which were filled with the soil and then heated, had exactly the same behaviour as the plants in the Mvs, which had been filled later on with the heated mixed soils.

On 11th and 12th II 1939 the soils were fervorized in the earlier described larde zinc-vessels. From now on in all experiments the soils were fervorized in these vessels.

The series of the experiment V were set up as follows:

1	Mv	with	normal	gardenmould, marked:	G Mitsch.
1	,,	,,	fervor.	,, ,,	FG ,,
1	,,	,,	mix. ferv.	,, ,,	FG+,,
9	pots	,,	normal	,, ,,	G pot.
9	,,	,,	mix. ferv.	,, ,,	FG+,,

The FG+ Mitsch and the FG+pots were filled with the same gardenmould. The results of the 9 pots were added and appear in the tables as one average figure.

The same was the case with the fieldsoil:

1	Mv	with	normal	fieldsoil, marked:	F Mitsch.
1	,,	,,	fervor.	,, ,,	FF ,,
1	,,	,,	mix. ferv.	,, ,,	FF+,,
9	pots	,,	normal	,, ,,	F pot
9	,,	,,	mix. ferv.	,, ,,	FF+,,

The FF+Mitsch and the FF+pots were filled with the same fieldearth. Here too the results of the 9 pots were averaged in one figure. In this experiment the results of the Mvs were compared with each other and the results of the pots also. The experiment consisted of 42 vessels.

On 13th II 1939 they were planted. The Mvs received 50 seeds and the pots 25 seeds each.

Table 27.

The course of the germination in per cent. In the unfervorized soils = 100%

Datum	FG	FG+		FF	FF+	
	Mitsch.	Mitsch.	Pot	Mitsch.	Mitsch.	Pot
16. II. 1939	—	34,61	55,08	—	100,00	21,43
17. II. 1939	—	48,38	111,29	—	121,73	54,55
18. II. 1939	27,27	72,72	—	48,27	134,48	—
19. II. 1939	58,33	86,11	111,76	96,78	132,25	92,57
23. II. 1939	113,51	100,00	107,38	105,88	132,35	98,82
24. II. 1939	113,15	105,26	105,56	111,76	132,35	97,71
25. II. 1939	115,38	102,56	105,46	117,64	132,35	97,23
26. II. 1939	117,94	110,25	107,10	117,64	135,29	99,44
27. II. 1939	117,94	110,25	107,07	123,53	135,39	98,92

As the table shows in the FG Mitsch and the FG+Mitsch there was till the 6th day a distinct retardation of the germination. The germination

of the normal gardenmould was surpassed on the 10th day by the FG Mitsch and on this day the germination in the FG+Mitsch reached the pace of the normal culture. From this time on the germination proceeded always in favour of the heated soils, whether they were mixed or not. The retardation in the pots, filled with mixed heated gardenmould, did not last so long. It lasted only 3 days. On the 4th day the FG+pots surpassed the germination in the G pots. This did not change during the whole time of examination.

In the fieldsoil the retardation of the germination lasted in the FF Mitsch till the 6th day contrary to the F Mitsch. Then the FF Mitsch surpassed the F Mitsch till the end of the examination. In the FF+Mitsch cultures the germination on the 4th was already equal to the germination in the normal fieldearth. On the following day an acceleration of the germination took place, which was so strong, that the germination in the normal fieldsoil stayed far behind. Concerning the germination in the FF+pots, the retardation of the germination lasted during the whole time of the examination. Only about the end the FF+pots reached nearly the germination in the F pots.

Here we must add, as we remarked befors, that in the heated soils afterwards every now and then new germs were noted again. The straggllers in this experiment were also every time removed. In the normal cultures there were no retarded germs at all. Therefore the following was shown. The seeds in the normal soil germinated much better in the beginning, but later on they were surpassed by the fervorized soils.

From 28th II–7th III 1939 the germs were daily examined. The examination took place as in the former experiments.

Table 28.

Average length of the germs in the gardenmould in per cent. In the unfervorized gardenmould = 100%.

Datum	FG Mitsch.		FG+Mitsch.		FG+pot.	
	Root	Hypocotyl	Root	Hypocotyl	Root	Hypocotyl
28. II. 1939	123,43	72,20	110,31	127,78	168,00	107,54
1. III. 1939	58.14	100,00	97,67	89,23	134,61	93,44
2. III. 1939	59,18	112,50	61,22	101,78	82,97	76,78
3. III. 1939	110,25	66,00	74,35	104,00	79,59	85,45
4. III. 1939	82,92	68,85	87,80	81,46	116,67	94.00
5. III. 1939	55,84	91,30	57,14	106,52	72,09	97,67
6. III. 1939	54,41	69,09	52,94	90,91	75,00	69,23
7. III. 1939	108,61	63,04	97,82	102,17	97,87	97,70

Regarding the average legth of the roots, the reproach could be made, that obtained results here are not exact, because series of plants were taken away on account of broken roots, which we stated each time in our protocols, as to this we must declare, that in all series of the experiment these damages to the roots were observed.

The figures of the root length in the FG Mitsch was fluctuating. But the table shows, that most of the values of the root length were smaller than those in the normal gardenmould. If we do not take in consideration the first value of FG+Mitsch, the preceding results was unequivocally confirmed. Here we refer once more to the photo of the seedlings of the experiment II, being very characteristical for the development of the seedlings in the normal and heated gardenmould.

We found the same proportions in the pots as in the Mvs.

The hypocotyl is in G Mitsch higher than in FG Mitsch. The values for the FG+Mitsch were fluctuating. In the pots, filled with normal gardenmould, the hypocotyl was mostly smaller than in the Mv. With one exception the hypocotyl in the FG+pots was smaller than in the G pots.

Table 29.

Average length of the germs in the fieldsoil in per cent. In the unfervorized fieldsoil = 100%.

Datum	FF Mitsch.		FF+Mitsch.		FF+pot	
	Root	Hypocotyl	Root	Hypocotyl	Root	Hypocotyl
28. II. 1939	85,71	96,36	80,00	118,18	106,89	103,63
1. III. 1939	106,06	92,42	127,27	112,12	70,91	94,91
2. III. 1939	76,47	100,00	111,76	150,00	91,66	95,65
3. III. 1939	109,67	77,19	122,58	92,98	146,15	104,08
4. III. 1939	69,04	117,39	76,18	126,00	161,53	86,36
5. III. 1939	100,00	122,50	92,68	145,00	139,28	92,30
6. III. 1939	77,78	83,01	150,00	92,45	140,00	124,73
7. III. 1939	90,56	100,00	69,81	114,63	110,34	116.21

The average length of the roots of the seedlings was in most cases largest in the normal fieldearth. In the mixed fervorized fieldsoil, in FF+Mitsch, the roots were sometimes longer and in an other examination shorter than in the normal fieldsoil. The length of the roots in the FF+ pots was nearly always longer than in the F pots. We must note, that the difference was sometimes considerable.

The hypocotyl in the normal fieldsoil of the Mv was in most of the cases longer than in the heated soil, or mostly smaller than in the mixed heated fieldsoil of the Mv. In the pots the proportion of the length of the hypocotyl between normal and mixed heated fieldsoil was fluctuating. Sometimes the hypocotyl was longer in the normal soil, other times again shorter, compared with the hypocotyl of the mixed heated fielsoil.

Table 30.

Qualities of the main roots in per cent.

	Normal	Crooked	Swelled
G Mitsch.	100	—	—
FG ,,	76	6	18
FG+ ,,	47	—	53
G pot	100	—	—
FG+ ,,	65	26	9
F Mitsch.	100	—	—
FF ,,	80	15	5
FF+ ,,	84	11	5
F pot	100	—	—
FF+ ,,	60	28	12

This table shows, that besides the length, also other qualities of the roots were always noted. In the normal gardenmould the roots showed, as we expected, no change at all, and they behaved as we described in former experiments. In the heated gardenmould most of the main roots were indeed normal. In examining them, we noted still 18% swellings and here and there the main roots were crooked. In the mixed heated gardenmould only 47% of the main roots were normal against 53%, which also showed swellings. In this soil no crooked main roots were found. In the pots with normah gardenmould, as we could suppose, 100% of the main roots were normal. The FG+pots shoved 65% normal, 26% crooked and 9% swollen main roots.

In the normal fieldsoil all roots were normal. The heating of the nutrient-substrata had as result. that there were only 80% normal main roots, 15% were crooked and the rest=5% showed swellings. In the FF+Mitsch culture the behaviour of the main roots was nearly the same as in the FF Mitsch. In the F pots all plants had normal roots. In the FF+pots, in the contrary, there were only 60% normal main roots, 28% were crooked and 12% showed swellings.

Table 31.

Qualities of the root – neck in per cent.

	Normal	Incision	Swelled	Like fur
G Mitsch.	88	—	12	—
FG „	77	—	23	—
FG+ „	49	11	11	29
G pot	85	—	15	—
FG+ „	29	14	24	33
F Mitsch.	53	—	20	27
FF „	31	16	11	42
FF+ „	25	—	20	55
F pot	53	—	26	21
FF+ „	4	4	32	60

The fervorized soils also influenced the root-necks. They were in most of the cases (88%) normal in the unheated gardenmould. 12% of the plants had a swollen root-neck. In the FG Mitsch 77% were normal and 23% were swollen. In the mixed heated gardenmould the influence of the soil was still more distinct. Only 49% were normal. The rest showed incisions (11%) or were swollen (11%). But it was especially noteworthy, that 29% was haired like fur. In the G pots the root-necks were practically quite normal. (85%). In the FG+pots only 29% was normal, 14% showed an incision and 24% were swollen. One third part of the plants (33%) had a root-neck with a dense fur. In the normal fieldsoil only half of the plants had normal root-necks, 20% were swollen and 27% were covered with fur. In the FF Mitsch we found 31% and in the FF+Mitsch culture even 25% of the plants, which had a normal root-neck. Incisions were found in FF Mitsch (16%), 11% were swollen and 42% had a root-neck covered with a thick fur. In the FF+Mitsch culture 20% were swollen and 55%, this is more than the half of the root-neck, were covered with fur. Generally the results of the F pots were nearly equal to those of the F Mitsch culture. The plants in the FF+pots on the other hand had only few normal root-necks (4%). The incions amounted to 4% only. 32% of the *Sinapis alba* had swollen root-necks and 60% were covered with fur. We must note, that the incisions were found only on older seedlings.

Table 32.

The hairy roots in per cent.

	Nil	Weak	Normal	Strong	Hers fur
G Mitsch.	—	36	64	—	—
FG „	—	—	40	60	—
FG+ „	—	5	35	55	5
G pot	—	38	54	8	—
FG+ „	4	16	12	64	4
F Mitsch.	—	4	27	65	4
FF „	—	5	5	9	81
FF+ „	—	—	—	14	86
F pot	—	—	52	40	8
FF+ „	—	—	12	16	72

Like in the former experiments also here the kind of the hairs of the of the roots were divided into 5 groups. With the exception of the FG+ pots all roots were haired. The glabrous roots (4%) we may perhaps regard as an exception. The hairs of the roots were strongly influenced by the fervorization, as the table shows, which gives the total of hair in percentage of there particular series. The hair was sometimes thin in the unheated cultures and mostly normal, indifferent if they came from the Mvs or the pots. By fervorizing, in the garden- and fieldsoils in Mvs and in pots a shifting took place from normally to thickly haired and »fur like« ones as the table distinctly shows.

From 28th II–7th III–39 we daily noted the lateral roots and we give here the average of the found values with their percentage.

Table 33.

Length of the lateral roots >< 5 mm in per cent. In unfervorized gardenmould = 100%.

Datum	FG Mitsch		FG+Mitsch.		FG+pot	
	< 5 mm	> 5 mm	< 5 mm	> 5 mm	< 5 mm	> 5 mm
7. III. 1939	29,73	93,67	47,74	74,86	102,77	84,89

The result of the normal gardenmould we make 100%. Except this, we had divided the roots into two classes, one, in which the lateral roots were smaller than 5 mm and the other, in which the lateral roots were longer than 5 mm. Generally the proportions were like this, that the biggest number of long lateral roots were noted in the normal gardenmould. In the FG+pots the number of the lateral roots smaller than 5 mm was a little higher than in the G pots.

Table 34.

Lenght of the lateral roots >< 5 mm in per cent. In unfervorized fieldsoil = 100%.

Datum	FF Mitsch.		FF+Mitsch.		FF+pot	
	< 5 mm	> 5 mm	< 5 mm	> 5 mm	< 5 mm	> 5 mm
7. III. 1939	62,85	101.28	91.43	120,51	125,00	112,50

This table is the result of the same reflections as the former but now in relation to the fieldsoil. Fieldsoils behaved themselves somehow different to gardenmould. In the fervorized fieldsoil the number of the lateral roots, larger than 5 mm, was always higher than that in the normal soil. On the other hand the number of the lateral roots, smaller than 5 mm, in the normal fieldsoil surpassed the number of the lateral roots in the heated fieldsoil with the exception of the FF+pots.

Table 35.

Place of the lateral roots on the main root in the gardenmould in percentages.

Datum	G Mitsch		FG Mitsch		FG+Mitsch		G pot		FG+pot	
	Upper third part	All over	Upper third part	All over	Upper third part	All over	Upper third part	All over	Upper third part	All over
7. III. 1939	—	100	90	10	90	10	—	100	90	10

This table shows the summary of the daily observations of the dispositions of the root swellings of the lateral roots from 28 th II–7th III 1939 in per cent. The number of these dispositions in the normal soil we made 100%. They were found all over the main root. In the fervorized gardenmould they could be found in most cases, as we mentioned before, either directly below the root-neck or in the upper third part of the main root.

Table 36.

Place of the lateral roots on the main root in the fieldsoil in percentages.

Datum	F Mitsch		FF Mitsch		FF+Mitsch		F pot		FF+pot	
	Upper third part	All over	Upper third part	All over	Upper third part	All over	Upper third part	All over	Upper third part	All over
7. III. 1939	50	50	79	21	85	15	25	75	100	—

This is the same table as before, but now in relation to the fieldsoil. The table shows, that the difference in regard to dispositions of the root swellings between normal, heated and mixed heated soils was not so evident. But we could see, that in normal soils the lateral roots were all over the main root and in the treated soils in the upper part. This was expressed distinctly in the mixed heated fieldsoils.

Table 37.

Swellings of the lateral roots of the second order in per cent.

Datum	*Gardenmould*				
	G Mitsch	FG Mitsch	FG-Mitsch.	G pot	FG+pot
7. III. 1939	100	72,22	72,22	100	50
	Fieldsoils				
	F Mitsch.	FF Mitsch.	FF–Mitsch.	F pot	FF–pot
	100	41,76	35,29	100	120

The dispositions of the lateral roots, shown in this table, are expressed in per cent. We noted them first on 3rd III–1939, which was about 20 days after the sowing. Most of the dispositions we found in the normal soil. Only in the FF+pots were more of such places than in the F pots. On the other hand the number of these places of the lateral roots in the FG+pots was only half of that in the G pots.

Table 38.

Not full developed leaves of 10 plants in per cent. In unfervorized soils = 100%.

Datum	FG Mitsch.	FG + Mitsch.	FG + pot.	FF Mitsch.	FF + Mitsch.	FF + pot.
28. II. 1939	—	100,00	50,00	100,00	100,00	100,00
1. III. 1939	100,00	65,00	38,46	50,00	100,00	100,00
2. III. 1939	80,00	60,00	86,67	150,00	300,00	86,95
3. III. 1939	100,00	80,00	72,22	33,33	83,33	76,67
4. III. 1939	173,08	126,89	86,67	76,67	76,67	76,67
5. III. 1939	192,30	100,00	76,67	130,43	156,52	100,00
6. III. 1939	150,00	100,00	86,95	150,00	150,00	130,00
7. III. 1939	130,00	100,00	88,46	130,43	69,56	88,46

This table shows in the usual way the number in per cent of the developed leaves, related to normal = 100%. First we must note, that the development of the leaves in the FG Mitsch was the latest, about a

fortnight after the sowing. The number of the not fully developed leaves stayed in the FG Mitsch and in the FG+ Mitsch about three weeks behind the number of the G Mitsch. Then we can see an increase and in FG Mitsch this development was so strong, that it could not be surpassed by the normal gardenmould. From this moment the development in the G Mitsch was equal to that of the FG+Mitsch. During the time of observation the FG+pots could not reach the development of the G pots.

The delay in the development of the leaves in the fervorized fieldsoil lasted a little longer than in the normal fieldsoil. At last the development of the leaves in the FF Mitsch surpassed that in the F Mitsch and this culture could not reach the FF Mitsch. The results of the mixed heated soils were fluctuating. But generally there were more young leaves than in the not heated soil. In the pots the results between the normal and heated soils showed nearly the same fluctuations.

Table 39.

Number of the leaves of 10 plants in per cent. Unfervorized soils = 100%.

Datum	FG Mitsch.	FG+ Mitsch.	FG+pot.	FF Mitsch.	FF+ Mitsch.	FF+pot.
5. III. 1939	—	23,07	46,15	—	—	—
6. III. 1939	153,84	23,07	125,00	—	15,00	30,00
7. III. 1939	100,00	100,00	65,00	46,15	123,07	100,00

This table shows, that there was a distinct retardation in the number of the fully developed leaves in FG Mitsch and FG+Mitsch. On 6th III–1939 an acceleration was noted. The following day the same took place in the FG+pots was fluctuating.

In the fervorized fieldsoil and also in the normal fieldsoil of the pots a visible retardation in the number of the fully developed leaves was shown. In the FF Mitsch this retardation was 46,15%, which lasted still at the end of the examination, while the FF+Mitsch with 123,07% had surpassed the number of the fully developed leaves of the unheated soil. The FF+pots reached the F pots on the last day of the examination.

Table 40.

Measurement of the leaves of the gardenmould in per cent. In unfervorized soil = 100%.

Datum	FG Mitsch.			FG+Mitsch.			FG+pot.		
	Breadth	Length	Stalk	Breadth	Length	Stalk	Breadth	Length	Stalk
11. III. 1939	68,18	75,00	64,70	45,45	50,00	41,17	39,47	92,95	100,00

Daily we measured the length and the width of the fully developed leaves at their largest place and also the length of the stalks from 5th III–11th 1939. From the found values we calculated the average and expressed this in the usual way in per cent. These results are shown in table 40. What we noticed about the foliage by sight, was confirmed by the measurements. The normal gardenearth in the Mv had, compared with the FG Mitsch and the FG+Mitsch, the largest leaves, compared with the FG+pots, was still greater. In the normal gardenmould the stalks in the G pots and in the FG+pots was the same.

Table 41.

Measurement of the leaves of the fieldsoil in per cent. In unfervorized soil = 100%.

Datum	FF Mitsch.			FF+Mitsch.			FF+pot.		
	Breadth	Length	Stalk	Breadth	Length	Stalk	Breadth	Length	Stalk
11. III. 1939	48,85	42,85	50,00	71,42	61,90	58,33	84,61	75,00	80,00

This table shows the results of the leave-measurements in fieldsoil cultures, just like the latter regarding gardenmould. Also in the fieldsoil the general observation confirmed, that plants in the Mv or in pots showed larger leaves and longer stalks in the normal soil than in the fervorized fieldsoil.

Table 42.

Dry weight of shoots in per cent. In unfervorized soils = 100%.

Datum	FG Mitsch.	FG+ Mitsch.	FG+pot.	FF Mitsch.	FF+ Mitsch.	FF+pot.
28. II. 1939	44,44	37,03	171,20	132,14	71,42	109,58
1. III. 1939	80,00	80,00	85,00	152,00	108,00	136,67
2. III. 1939	88,99	123,80	141,51	108,10	108,10	112,78
3. III. 1939	81,08	108,10	69,87	100,00	125,00	75,18
4. III. 1939	75,18	56,39	90,70	100,00	100,00	106,02
5. III. 1939	54,74	91,77	75.94	69,95	92,70	104,21
6. III. 1939	66,67	53,33	85,83	46,24	47,36	76,50
7. III. 1939	79.87	84,98	53,33	96,11	103,33	98,19
8. III. 1939	48,00	63,20	81,50	74,33	105.33	94,93
9. III. 1939	97,89	92,63	90,45	35,09	47,17	106,73
10. III. 1939	66,67	65,20	63,20	63,20	53,20	100,00

This table shows the day weight, which was ascertained from the examinated plants form 28th II–10th III–1939. It gives the average weight of the shoots in per cent of the normal soil = 100%. From this table we calculated the averages in mg as well as in per cent and give this in the following table.

Table 43.

Average of table 42. in per cent and mg. G = 100% = 278 mg; G pot = 100% = 241 mg.; F = 100% = 257 mg; F pot = 100% = 179 mg.

Datum		FG Mitsch.	FG+ Mitsch.	FG+pot.	FF Mitsch.	FF+ Mitsch.	FF+pot.
10. III. 1939	%	68,34	72,30	80,08	71,95	73,54	99,44
	mg	190	201	193	184	189	178

The weight of the shoots of the unheated gardenmould and fieldsoil was the largest. This confirms the results of the former experiments and also the results from older literature, according to which the development of *Sinapis alba* showed a retardation in the youth stadium. If indeed Hiltner a. o. drew from this the conclusion, that *Sinapis alba* in heated soils generally did not develop, here we must beg to differ. If it gave the impression as far as the shoots were concerned, as if the heating of the soils did injury to their development, this was impossible to accept for the roots, of which we give the dry weight in the following table. Merkenschlager in his monography about *Sinapis alba* also hardly considered the roots. He only observed the influence of the heated soils on the shoots. But in our research the roots and shoots we considered just as important. And if the heated soils had a retarding influence on the development of the shoots, we will here once more emphatically mention, that this fact was long ago recognized by the older investigators, and this never allowed the conclusion, that heated soils had an injurious influence, as previous investigators recognized, that after the period of retardation an increase took place, which fact was confirmed by our experiments. Russell and Petherbridge were the only ones, as we know from literature, who referred to the stronger development of the roots in heated soils. This fact will later on show itself very distinctly in the water-cultures, as after all the influence of the heat shows itself more in the development of the rots than in the development of the shoots.

Table 44

Dry weight of the roots in per cent. In unfervorized soils = 100%.

Datum	FG Mitsch.	FG+ Mitsch.	FG+pot.	FF Mitsch.	FF+ Mitsch.	FF+pot.
28. II. 1939	100,00	85,71	113,04	160,00	100,00	225,00
1. III. 1939	50,00	250,00	16,67	180,00	200,00	100,00
2. III. 1939	112,50	237,50	113,04	83,33	150,00	157,50
3. III. 1939	200,00	360,00	100,00	62,50	125,00	88,46
4. III. 1939	93,47	78,26	133,33	111,11	91,66	166,67
5. III. 1939	166,67	155,56	232,50	100,00	150,00	151,51
6. III. 1939	100,00	100,00	162,50	88,46	100,00	123,07
7. III. 1939	86,67	43,33	81,25	100,00	123,07	100,00
8. III. 1939	365,00	330.00	100,00	140,00	82,50	125,75
9. III. 1939	53,33	23,07	100,00	66,00	26,00	100,00
10. III. 1939	—	—	60.61	113.79	113.79	95,45

As we already mentioned, the ascertainment of the dry weight of the shoots was not sufficient, to study the influence of the heated soils. Therefore this table gives the dry weight of the roots. Also here we calculated the average of the above mentioned table and noted it in per cent and mg, as the following table shows.

Table 45.

Average of the table 44. in per cent and mg. G = 100% = 31 mg; G pot = 100% = 33 mg; F = 100% = 38 mg; F pot = 100% = 31 mg.

Datum		FG Mitsch.	FG+ Mitsch.	FG+pot.	FF Mitsch.	FF+ Mitsch.	FF+pot.
10. III. 1939	%	132,26	161,29	106,06	107,89	118,42	122,58
	mg	41	50	35	41	45	38

Unequivocally this table shows, that in spite of the youth stadium of the plants the dry weight of roots in the fervorized soils was larger even sometimes considerable larger than in the normal garden-and fieldsoil.

Table 46.

Height of shoots in per cent. In unfervorized soils = 100%.

Datum	FG Mitsch.	FG— Mitsch.	FG—pot.	FF Mitsch.	FF+ Mitsch.	FF—pot.
18. III. 1939	61,53	49,57	114,28	53,01	62,65	97,73

From this table we learn, needles to say, that in the youth stadium the development of the shoots was generally the strongest in the unheated soils. An exception to this were the FF+pots. The plants, of which the dry weight of the shoots was determinated, were 33 days old, when the experiment was finished.

We must note, that on 17th II–1939 we had to leave the glasshouse on account of lice.

Vth Experiment.

1/IV–5/VII/1939.

Obj. *Sinapis alba*

From the results of the up to now obtained figures follows, that at first a retardation of the shoots of *Sinapis alba* took place.

The further investigations of the photo-material and the crops of the seeds represent the second phase of the research, which shows first an acceleration and later an increase of the growth of our experimental plants in heated soils. In this and the following experiments we intended to find an optimal time and temperature for the growth of Sinapis alba in the given soils. The hitherto obtained observations are the results of a comparison between unheated soils and soils heated to 2×137° C. This we want to alter.

For this purpose we started the following experiment with gardenmould:

3 Mvs with normal gardenmould		marked:	G1,	G2,	G3.
3 „ „ heated „	1× 70° C	„	G1 1× 70,	G2 1× 70,	G3 1× 70.
3 „ „ „ „	2× 70° C	„	G1 2× 70,	G2 2× 70,	G3 2× 70.
3 „ „ „ „	1×100° C	„	G1 1×100,	G2 1×100,	G3 1×100.
3 „ „ „ „	2×100° C	„	G1 2×100,	G2 2×100,	G1 2×100.
3 „ „ „ „	1×137° C	„	G1 1×137,	G2 1×137,	G3 1×137.
3 „ „ „ „	2×137° C	„	G1 2×137,	G2 2×137,	G3 2×137.

The fieldsoil was treated in the same way. Three vessels of all series were set up, and they were labelled in the following way.

Normal marked: F1, F2, F3.

Heated	1× 70° C	marked:	F1 1× 70,	F2 1× 70,	F3 1× 70.
„	2× 70° C	„	F1 2× 70,	F2 2× 70,	F3 2× 70.
„	1×100° C	„	F1 1×100,	F2 1×100,	F3 1×100.
„	2×100° C	„	F1 2×100,	F2 2×100,	F3 2×100.
„	1×137° C	„	F1 1×137,	F2 1×137,	F3 1×137.
„	2×137° C	„	F1 2×137,	F2 2×137,	F3 2×137.

On 30th and 31st III–1939 were fervorized. On 1st IV the determination of the pH took place.

Table 47.

pH of G-normal = 7,80	pH of F-normal = 8,42
„ „ G 1 70 = 7,92	„ „ F 1 70 = 7,98
„ „ G 2 70 = 7,92	„ „ F 2 70 = 8,05
„ „ G 1 100 = 7,95	„ „ F 1 100 = 8,30
„ „ G 2 100 = 8,20	„ „ F 2 100 = 8,16
„ „ G 1 137 = 8,14	„ „ F 1 137 = 8,15
„ „ G 2 137 = 8,08	„ „ F 2 137 = 8,42

H_2O = pH 6,80

In the gardenmould the pH was fluctuating between 7.80 (normal garden mould) and 8,20 (G 2 × 100). So by fervorizing normal garden-soil it became more alkaline. Studying the table we first found a strong rising from G normal to G2 × 100. Then the pH decreased to G2 × 137.

Also in the fieldsoil the pH was fluctuating, but in an other manner. When normal fieldsoil was heated to 1 × 70 under normal pressure the pH decreased from pH 8,42 to 7,98, then it rose 8,30 in F 1 × 100. It went down again to 8,15 in F 1 × 137 to rise again in F 2 × 137 to the pH of F normal.

On 1st IV–1939 into each MV 30 seeds were put.

Table 48.

The course of the germination in the gardenmould in per cent. In unfervorized gardenmould = 100%.

Datum	G 1×70	G 2×70	G 1×100	G 2×100	G 1×137	G 2×137
4. IV. 1939	118,30	85,00	105,00	108,33	86,67	11,67
5. IV. 1939	114,06	106,25	103,12	104,68	106,25	90,62
6. IV. 1939	110,44	108.94	101,49	102.98	102,98	108,94
7. IV. 1939	111,76	104,40	107,35	102.94	104,40	111,76
8. IV. 1939	107,04	102,81	105,63	98,59	101,41	111,26
9. IV. 1939	107,04	102,81	108,45	101,41	111,26	115,49
11. IV. 1939	106.94	102,77	108,33	106,94	111,11	118,05

In the gardenmould was a retardation of the germination till the 4th day after the sowing in G 2 × 70, G 1 × 137 and G 2 × 137. In G 2 × 137 the retardation lasted till the 6th day, while in the first two series the retardation disappeared the following day. At the end of the time of the examination in G normal the fewest seeds were germinated. The more the soils were fervorized the more seeds were germinated. This increase of the germination was obvious, when we compared the normal soil with all once fervorized soils and again with all twice heated soils.

Table 49.

The course of the germination in the fieldsoil in per cent. In unfervorized fieldsoil = 100%.

Datum	F 1×70	F 2×70	F 1×100	F 2×100	F 1×137	F 2×137
4. IV. 1939	352,94	158,82	370,51	417,64	358,82	47,06
5. IV. 1939	215.15	169,69	206,06	227,27	209,09	175,75
6. IV. 1939	217.14	194,28	202.85	225,71	197,14	188,57
7. IV. 1939	190,24	173,17	180,49	195,12	168,29	168,29
8. IV. 1939	179,54	165,91	168,18	186,36	161,36	163,64
9. IV. 1939	172,34	157,44	159,57	176,59	157,44	155,32
11. IV. 1939	168,75	160.41	158.33	175,00	156,25	156.25

This table shows the progress of the germination in the fieldsoils. A retardation of the germination lasted till the 4th day in F 2 × 137. This changed into an acceleration of the germination on the following day. In all cultures the germination on the 4th day surpassed the germination in the normal fieldsoil mostly multiple At last the germination was like this, that in the fervorized soils a much larger quantity was germinated than in the normal fieldsoil.

Table 50

Average length of the germs in the gardenmould in per cent. In unfervorized gardenmould = 100%.

Datum	G 1×70	G 2×70	G 1×100	G 2×100	G 1×137	G 2×137
7. IV. 1939	100,00	67,56	113,89	89,18	54,05	38,39
18. IV. 1939	87,80	82,92	106,09	92.68	63,41	54.87

Average length of the germs in the fieldsoil in per cent. In unfervorized fieldsoil = 100%.

Datum	F 1×70	F 2×70	F 1×100	F 2×100	F 1×137	F 2×137
7. IV. 1939	137,50	118,75	231,25	225,00	143,75	93,75
18. IV. 1939	79.03	91,93	132,25	108,06	85,48	74,19

The average length of the germs shows the usual picture. The germs in the normal gardenearth, if we don't take in consideration those in G 1 × 100, were the longest. The germs in G 2 × 100 reached nearly the length of those in the normal cultures.

In the fieldsoil the proportions at the first examination were totally different. Only F 2 × 137 was like in the former experiments shorter. The germs of all the other cultures on the contrary were longer, some, even considerably longer than those in the normal fieldsoil. We shortly refer to F 1 × 100 with 231,25% and F 2 ×100 with 225,00%. During the second examination on 18th IV–1939 F 1 × 100 with 132,25% and F 2 ×100 with 108,06% kept their larger length in comparison with normal. All other cultures showed average smaller germs than F normal.

With regard to the germs we noted:

4.–IV–39. The cotyledons in G 1 × 100 were chlorotic.

5.–IV–39. The under-side of the cotyledons in G normal was noticeable on account of a strong forming of anthocyan. This was the same in: G 1 × 70, G 1 × 100, G 2 × 100 and G 1 × 137.

In the fieldsoil we found this in: F 1 × 70, F 2 × 70, F 1 × 137 and in F 2 × 137.

Chlorotical germs were found in the gardenmould in: G 1 × 137 and in the fieldsoil in F 1 × 137 and F 2 × 137

6.–IV–39. Anthocyan in G 1 × 70 had nearly disappeared. On the upper-side of the cotyledons in the gardenmould we noted anthocyan in G 1 × 137 and G 2 × 137; in the fieldsoil in F 1 × 137 and F 2 × 137.

Compared with G normal the cotyledons of G 1 × 137 and G 2 × 137 were noticeable small.

The germs of G normal and G 2 × 70 were etiolated.

In F 1 × 100 and F 2 × 100 the first formation of the leaves began.

7.–IV.–39. The development of the leaves began also in the gardenmould in G 1 × 100 and G 2 × 100. This development went on in the fieldsoils F 1 × 70, F 2 × 70 and F 1 × 137.

9.–IV–39. Everywhere the development of the leaves began.

Distinctly we could distinguish the light and dark green germs. The parting of these colours lay between 2 × 70 and 1 × 100. The more the soils were fervorized the darker the green was.

12.–IV–39. In all series of the gardenmould the anthocyan had disappeared. Only in G 2 × 137 there was anthocyan on the veins of the cotyledons. In the fieldsoil on the contrary everywhere spurs of anthocyan could be observed.

Table 51.

Average length of the plants in the gardenmould in per cent. In unfervorized gardenmould = 100%.

Datum	G 1×70	G 2×70	G 1×100	G 2×100	G 1×137	G 2×137
1. V. 1939	106,97	112,21	136,04	127,90	96,51	84,30

Average length of the plants in the gardenmould in per cent. In unfervorized gardenmould = 100%.

Datum	F 1×70	F 2×70	F 1×100	F 2×100	F 1×137	F 2×137
1. V. 1939	60,78	73,85	82,35	71,89	67,32	56,21

On 1st V 1939 all vessels were thinned out, leaving 7 plants. The length of the whole harvested materiel was averaged and calculated for 10 plants. The results of this shows the above table. In the gardenmould the growth was already stronger, when once heated to 70° C (106,97%) than in the normal cultures (100%). Then the length increased regularly to G 1 × 100 (136,04%). G 2 × 100 with 127,90% was also still considerable longer than G normal. Then the percentage fell in G 1 × 137 beneath 100% and in G 2 × 137 the development was still less (84,30%).

In the fieldsoil the average length of the shoots was calculated in the same way as that of the gardenmould. F normal had unequivocal the highest shoots and F 2 × 137 the smallest shoots. Here the height with 56,21% was only a little more than half of the height in the normal cultures. We noted, that on 9th–V–1939 the culture G 2 × 70 died in consequence of the lice-fighting. (Plate VIII 1).

On 31st–V–1939 the shoots of all the G 1 vessels were harvested and examined. They were then two months old. On 10th–VI–1939 the Mvs G 2 and G 3 were all broken off. They were two months and 10 days old. Each time we determinated the height of shoots, the fresh weight and the dry weight. Besides we examined the qualities of the bunches. The result of this we will find in the following tables

Table 52.

Average length of shoots in the gardenmould in per cent. In unfervorized gardenmould = 100%.

Datum	Row	1×70	2×70	1×100	2×100	1×137	2×137
31. V. 1939	G1	103,56	100,89	121,54	136,25	123,33	92,42
10. VI. 1939	G2	135,38	115,02	145,00	151.91	149,31	139,75
10. VI. 1939	G3	85,85	—	96,89	124,86	115,11	121,11

The table shows the average height of the shoots at the different days of the examination. At the age of 60 days all heated soils had surpassed the normal gardenmould with respect to the height. In G1 2 × 100 the shoots were even (with 136,25%) considerable longer than in the normal soil. G1 2 × 137 made an exception. The height of the shoots in this Mv amounted to 92,42% compared with G1 normal = 100%. But this fact shows, that G1 2 × 137 slowly but decidely reached the height of the plants in the normal gardenmould, and even surpassed it, when the time of observation was long enough. This was proved by the following examination. Here the plants were 70 days old. On this day, 10th-VI-1939 all the shoots in the series G2 and G3 were generally considerable longer than those in the normal soil. Here the only exception was made by G3 1 × 70 and G3 1 × 100. Here distincly the second phase, of which Dietrich, Koch and Lüken a. o. older investigators had spoken, could be noticed. That is, why an acceleration of the growth had taken place. Of this fact Hiltner a o. did not report.

Table 53.

The fresh weight of the shoots of 10 plants in the gardenmould in per cent. In unfervorized gardenmould = 100%.

Datum	Row	1×70	2×70	1×100	2×100	1×137	2×137
31. V. 1939	G1	121,29	113,22	135,09	153,26	144,40	92,74
10. VI. 1939	G2	111,09	123,50	115,88	93,58	73,20	98,50
10. VI. 1939	G3	84,73	—	70,69	104,34	64,00	91,36

The fresh weight was calculated for 10 plants. It was, as the table shows, at the first examination in the fervorized soils higher than in the normal. G1 2 × 137 made an exception. It was only 92,74% of G1 normal = 100%. At the following examinations in the G2 series only the fresh weights of G2 1 × 70, G2 2 × 70 and G2 1 × 100 were higher and in all other cultures smaller than the normal cultures. In the G3 series G normal had the largest fresh weight. Only G3 2 × 100 with 104,34% was higher than G3 normal. Generally the 70 days old shoots had a smaller fresh weight than the shoots of the normal gardenmould.

Table 54.

The dry weigth of the shoots of 10 plants in the gardenmould in per cent. In unfervorized gardenmould = 100%.

Datum	Row	1×70	2×70	1×100	2×100	1×137	2×137
31. V. 1939	G1	110,40	93.60	112,80	162,40	123,20	76,00
10. VI. 1939	G2	130,79	75.27	122,79	149,94	154,91	128,91
10. VI. 1939	G3	66,44	—	77,51	120.75	115.38	126,29

This table shows the dry weight of shoots calculated for 10 plants. After the determination of the weight the shoots were exposed in a thermostate for 2–3 days to a temperature of about 80° C. 60 days old G1 2 × 70 with 93,60% and G1 2 × 137 with only 76,00% had a smaller shoot dry weight than G1 normal = 100%. The dry weight of the shoots in the other fervorized cultures were all larger. The highest weight reached the G1 2 × 100 with 162,40%. At the second examination on 10th IV–1939 the shoot dry weight of G2 2 × 70 with 75,25% stayed behind G2 normal. All other plants of the fervorized soils in the G2 series showed a higher weight than G2 normal. In the G3 series the weaker and the shorter the soils were fervorized, the more the cultures stayed behind the G3 normal cultures. The limit lay between G3 1 × 100 and G3 2 × 100. The dry weight of G3 2 × 100 to G3 2 × 137 was larger than G normal.

Concerning the flowering in the gardenmould on 31st V–1939 we noted most of the buds in G1 1 × 70 and G1 1 × 137. The aestivations in G1 2 × 137 were nearly as strong. In G1 normal and G1 1 × 100 the amount of bunches, forming buds, was the same. The experimental results of the series G2 and G3 were totalised. We found the weakest formation of buds in G 2 × 70 and G 2 × 100. In G normal and G 1 × 70 the formation of buds was nearly equal and also the strongest, whereas on 10th VI–1939, when this development of the buds was noted, most of the buds in the heated soils were already developed to full flowering.

On 31st V–1939 in G1 2 × 100 a rather rich flowering was noted. In the other soils about this time the flowers began to develop. Only in G1 1 × 70 we could not discover flowers. The results of the series G2 and G3 were added again. On 10th VI–1939 G normal had by far the smallest number of flowers. The more the soils were fervorized, the more its influence on *Sinapis alba* could be noted. The highest value was reached in the G 2 × 100 series a. s. o. including the 2 × 137 series.

At the first examination on 31st V–1939 no fruits could be noted and no settings could be seen either. The results of the examination on 10th VI–1939 of the series G2 and G3 were totalised The settings or the developed siliquae in G normal were small and mostly miserably developed. They looked a little better in G 1 × 70. The two following fervorized soils showed more and better developed siliquae. In G 2 × 100 to G 2 × 137 the bunches were strongly developed, bearing striking big quantities of siliquae filled with many seeds.

We now come to the fieldsoils. On 31st V–1939 the first series were harvested.

Table 55.

Average length of shoots in the fieldsoil in per cent. In unfervorized fieldsoil = 100%.

Datum	Row	1×70	2×70	1×100	2×100	1×137	2×137
31. V. 1939	F1	78,72	75,31	84,73	65,76	64,44	54,03
5. VI. 1939	F2	103,18	91,39	101,70	99,36	94,68	87,88
5. VI. 1939	F3	89,49	82,20	109,98	98,23	93,95	93,44

This table shows the results of the average height of the shoots expressed in per cent of the normal fieldsoil = 100%. These plants at the time were two months old. At this age we noted, that the plants in the normal soil were the highest and in F1 2 × 137 with 54,03% the smallest. On 5th VII–1939 the other series were harvested. Generally this picture was about the same at the age of 95 days. The difference between normal and heated soils were now indeed considerably smaller. Even in some cases F2 1 × 70 (103,18%), F2 1 × 100 (101,70%) and F3 1 × 100 (109,98%) the fervorized soils surpassed the normal fieldsoil. But this difference was only small.

Table 56.

The fresh weight of shoots in the fieldsoil in per ceit. In unfervorized fieldsoil = 100%.

Datum	Row	1×70	2×70	1×100	2×100	1×137	2×137
31. V. 1939	F1	135,82	148,58	161,82	118,37	147,75	115,75
5. VII. 1939	F2	135,84	127,02	156,83	168,37	169,05	181,62
5. VII. 1939	F3	114,82	102,78	138,81	149,88	127,81	196,24

This table shows the fresh weight of the shoots in per cent. Here something was shown, which we had already distinctly noted, during the time of observation. In spite of the highest shoots in the normal fieldsoil the fresh weight from this soils was considerably smaller than that in the fervorized soils. All notes gave mostly a significant higher value of the fresh weight. The influence of the fervorization came to expression not so much in the height of the shoots as in the stronger vegetative growth. The development of the leaves was much stronger. They were much larger. That is why in all examinated cases the fresh weight was higher.

Table 57.

The dry weight of shoots in the fieldsoil in per cent. In unfervorized fieldsoil = 100%.

Datum	Row	1×70	2×70	1×100	2×100	1×137	2×137
31. V. 1939	F1	97,61	105,97	109,56	80,27	104,58	105.58
5. VII. 1939	F2	78,39	55,12	62,18	61,03	98,29	82,24
5. VII. 1939	F3	110,50	97,03	130,87	148,56	111,13	187,07

This table shows the results of the dry weight of the shoots. On 31st V–1939 the dry weight of the plants from the heated soils was nearly equal to that of the normal fieldsoil, in F1 1 × 70 (97,61%) and in F1 2 × 100 it was with 80,27% smaller than the dry weight of the normal soil. All other dry weights from fervorized soils were higher than normal. The same we noted in the F3 series, which were harvested on 5th VII-1939. The difference was, that the dry weights from all the fervorized soils, with the exception of F3 2×70, were now harvested the same day, behaved themselves in a quite different manner and with the following reason. These series stood during the whole time of the experiment between the series F1 and F3. During this time these two series formed a thick bush of foliage causing a disadvandtageous influence especially with regard to the light. Though the work-room in the glass-house of the laboratory was rather spacious, it was impossible, to make a different arrangement of this experiment. Therefore the middle series show distinctly, that they had not been, in the position to assimilate to the same extend as the series on the outside. This is the reason, why we give here a photo (Plate VIII 2), showing a total view of the arrangement of the experiments in their different stadia. To have a better view, one of the middle series was taken out of the experiment.

On 31th V–1939 the plants, showing buds, were noted. In F1 1×100 we found the highest figure of buds and nearly the same quantity in F1 2×70 and F1 2×100. The least formation of buds was noted in F1 normal. It had not yet a third of the buds of F1 1×100. In general the development of the plants in the different types of soil of the fieldearth was far behind the development of the plants in the gardenmould. At the first examination only few inflorenscences were noted. They were found on the main shoots of the F1 normal culture. At the second examination F3 1×70 and F3 2×137 showed the richest flowering. We must note, that in the heated soils all fruit-systems were better and more beautifully developed than those of the normal cultures. (Plate III 2).

VIIIth Experiment

20/VI–4/VII/1939.

Obj. *Sinapis alba.*

In this experiment we consider the course of the germination in the fieldsoil under the influence of different components of time and temperature.

Table 58.

The course of the germination in the fieldsoil in per cent. In unfervorized fieldsoil = 100%.

Datum	1×70	2×70	1×100	2×100	1×137	2×137	3×137	4×137	8×137
23. VI. 1939	55,93	32,20	54,23	98,30	111,86	32,20	54,23	42,37	88,13
24. VI. 1939	78,87	80,28	84,50	105,63	100,00	84,50	59,15	53,52	101,40
25. VI. 1939	81,08	112,16	85,13	104,05	100,00	109,45	74,32	55,40	100,00
26. VI. 1939	91,89	118,92	94,59	106,75	113,51	116,21	86,48	68,92	104,05
27. VI. 1939	93,67	112,65	91,14	107,59	106,32	111,39	82,27	72,15	101,26
28. VI. 1939	101,26	115,19	94,93	108,86	111,39	110,12	86,07	77,21	105,06
4. VII. 1939	111,69	120,78	111,69	112,98	110,39	112,98	109,09	92,20	118,18

Here the germination in the normal and the fervorized fieldsoil was compared. Besides we heated the fieldsoil, as the table shows, in our attempt to find the optimum of the fervoreffect in the autoclave to 137° C during 8 houres.

On 20th VI–1939 we put 100 seeds into each earthen-ware germination box, with differently heated soils.

Like we knew already, in all heated soils we had to deal with a retardation of the germination, except in 1×137. The same happened in the former experiments. The retardation was strongest in 4×137. Here we saw a tendency of the germs of these series, to approach the number of germs in the normal fieldsoils. But 4×137 never reached the number of the germs in the normal cultures not even at the end of the observation. Only 92,20% germinated and in the normal culture 100%. The retardation of the germination was also expressed in the 3×137 and in the 1×100 cultures. This retardation lasted till the 8th day after the sowing. But after a fortnight the germs of the above mentioned soils had surpassed the normal soil by resp. 109,09 and 111,69%. In 1×70 the retardation lasted till the 7th day. In the other cultures it was shorter. Then an increase of the germination took place in the fervorized soils with which the germination in the normal fieldsoil could not keep up. On the last day of the examination the germination was strongest in 2×70 with 120,78% and in 8×137 with 118,18%.

From our protocol we note:

Generally the need of water from normal to 2×100 was larger than from 1×137 to 8×137.

23.–VI–39. We noted in the 2×137 cultures the before mentioned fungus *Lachnea*.

24.–VI–39. Notably similar were the germs in the 2×100, 1×137 and 8×137 cultures. On the bottom of 3×137 we found *Lachnea* too.

26.–VI–39. A change of colour was noted. Normal was light green. The more the fieldsoil was fervorized, the darker the green colour was. 2×100 was already blue-green. This colour kept constant up to 8×137.

27.–VI–39. The germs in 3×137 were unequal, expressed in the different lenght of the germs.

3.–VII–39. On this day we noted, that the change of colour was not so regular as before, like the following table shows.

Table 59.

Normal = light green	1 × 70 = a little darker than normal
2 × 70 = darker than normal	1 × 100 = darker than normal
2 × 100 = „ „ „	1 × 137 = „ „ „
2 × 137 = darkest	3 × 137 = light green
4 × 137 = darker than normal	8 × 137 = „ „

4.–VII–39. The harvest took place, after which we noted the folloving:

Normal: 2 germs were dead. The germs were slack and fell over. The main root was long and showed only few lateral roots.

1×70: The roots were normal. The germs stood firmer in the soil.

2×70: The same as in 1×70.

1×100: There was no difference between this and the two preceding series.

2×100: The lateral roots were planted mostly beneath the root-neck.

1×137: 3 germs were dead. The lateral roots were on the main root just below the root-neck.

2×137: Notable was the dark green colour of the germs. Below the root-neck there were many lateral roots.

3×137: The germination was irregular. At this time many seeds started to germinate. The germs were rank, light green and different in length. The lateral roots same as in the former series.

4×137: Many seeds now began to germinate. The growth was rank and the germs were different in length. The colour was dark green. The lateral roots were all over the main root.

8×137: The growth was rank. The colour was between normal and 3×137. Few lateral roots and hardly any in the neighbouhood of the root-neck.

VIIIth Experiment

20/VI–13/X/1939.

Obj. *Sinapis alba.*

Already Richter, perceived, that plants mostly developed more luxuriantly in heated soils than in normal soils, though they showed signs of illness in their youth. Dietrich analized this process of the development so far, that he stated in the youth a retardation in the heated soils in the developement of *Sinapis alba.* Further he observed an increase in the sebsequent growth of the *Sinapis alba* plants in the heated soils, whereby these plants surpassed those in the normal soils. (Plate IX 1). These results were confirmed by many other previous investigators and we also came to the same conclusion. The retardation of the development in the youth stadium has been proved distinctly with figures in our experiments. The subsequent strong growth of *Sinapis alba* in the heated soils was so striking and convincing, that up till now we contented ourselves with the notes of our protocols and the photos. This experiment should prove the fervoreffect with figures. We must note, that we began this experiment rather hate in the year. Nevertheles we were absolutely sure of ourselves, having the experience from former experiments, that the crop from heated soils would be much larger than the crop from normal soils.

Already König, Hasenbäumer and Coppenrath had been searching for an optimum of the steam pressure, to make the largest quantity of mineral nutrients soluble. We also tried this earlier, by altering the components of time and temperature to some extent, but did not succeed. Therefore we altered the time-component at 137° C still more. We fervorized to 8×137° C, whith means, that during 8 days the soil was each day fervorized during 1 hour to 137° C at a pressure of 2½ atm. Conform to this 4×137 was treated a. s. o. The effect showed itself during the course of this experiment.

For this experiment we only used fieldsoil. Each series consisted of 3 Mvs, into which 30 seeds were put on 20th VI–1939.

Table 60.

The course of the germination in the fieldsoil in per cent. In unfervorized fieldsoil = 100%.

Datum	1×70	2×70	1×100	2×100	1×137	2×137	3×137	4×137	8×137
23. VI. 1939	80,35	64,28	75,00	87,50	39,28	8,93	10,71	10,71	12,50
24. VI. 1939	90,32	96,77	95,16	93,55	83,87	61,29	72,58	62,90	48,39
25. VI. 1939	93,65	100,00	100,00	100,00	104,76	76,19	87,30	80,95	69,84
26. VI. 1939	92,30	110,76	107,69	103,07	107,69	89,23	92,30	86,15	80,00
27. VI. 1939	92,64	105,88	105,88	100,00	104,40	89,70	98,52	85,29	85,29
28. VI. 1939	92,64	105,88	107,35	101,47	107,35	91,17	101,47	89,70	91,17
3. VII. 1939	104,28	110,00	114,28	98,57	108,57	97,14	102,96	90,00	94,28

This table shows the usual picture. In all heated soils we stated a retardation of the germination. This was so strong in 2×137, 4×137 and 8×137, that it could not reach the normal germination on the last day of the observation. In the 2×100 cultures the number of the germs fluctuated round the normal. In the other heated soils the acceleration of the germination began sometimes earlier, sometimes later with the result at last, that the amount of the germs in the fervorized soils surpassed that in the normal cultures. We must note, that the stragglers only appeared in the heated soils and that we removed them, without counting them.

From our protocol we note:

25.–VI–39. In the first Mv of 2×137 and in all the vessels of 3×137 and 4×137 *Lachnea* was noted.

27.–VI–39. The first leaves appeared.

28.–VI–39. The first Mv of 2×137 had no more *Lachnea*. The same was the case in the third vessel of 3×137 and in the first Mv of 4×137. Now the fungus appeared in the second Mv and the third Mv of 2×137. The plants from the normal soil to 1×100 had a larger need of water than those of the other soils.

10.–VII–39. All plants smaller than 2 cm were removed.

Table 61.

Average height of shoots in per cent. In unfervorized fieldsoil = 100%.

Datum	1×70	2×70	1×100	2×100	1×137	2×137	3×137	4×137	8×137
10. VII. 1939	85,71	85,71	100,00	128,53	100,00	85,71	85,71	71,42	85,71
20. VII. 1939	93,75	87,50	87,50	118,75	106,25	81,25	87,50	68,75	68,75
31. VII. 1939	103,84	100,00	100,00	123,07	130,76	103,84	100,00	98,30	100,00
11. VIII. 1939	112,82	130,77	120,51	151,28	130,77	105,13	100,00	97,49	130,77
22. VIII. 1939	116,67	116,67	122,92	150,00	133,33	102,08	110,41	122,92	118,75
11. IX. 1939	83,54	84,81	96,20	106,33	107,59	79,74	92,40	89,27	110,12
2. X. 1939	125,75	118,18	124,24	122,73	122,73	121,21	146,97	151,51	157,57
13. X. 1939	110,29	110,29	132,35	120,58	136,76	126,47	135,29	136,76	144,12

This table shows the growth with regard to the height. Generally a retardation of the growth took place in the fervorized soils. The results of 1×100 we must perhaps regard as a happening by chance, as at the next examination on 20th VII–1939 the height was considerable smaller than in the normal culture. Only 2×100 and 1×137 were larger or the same as normal at the first examination. We found the strongest retardation of the growth in the 4×137 culture. This lasted 52 days. At the age of 63 days, however, in the fervorized soils all plants were grown to such an extend, that it was impossible for the plants in the normal soil, to keep pace with the others. At the end of

the experiment the plants were 113 days old. They showed the following: Already by increasing the temperature to 70° C the fervoreffect could be noticed, as shown by experiment VI (Plate IX 2). At 70° C, – we chose this temperature, because we met similar temperatures below 100° C also in the open air, – the fervoreffect was indeed small, but it was there. The higher we made the temperature, the more the fervoreffect was showing. This concerned all series of the experiment for the once as well as the twice fervorized cultures. Concerning the duration of the fervorization, the table about the height of shoots shows, that the fervoreffect, when heated tvice, was the same or smaller than by heating once to the same temperature. The same could be said about the height of shoots with regard to the heating during 3 and 4 hours. Only by heating during 8 hours the shoots were higher. Therefore the greatest fervoreffect could be obtained by the longest fervorization.

From our protocol we note:

10.–VII–39. Normal. The weeds were removed. Here and there the leaves showed white spots.

1× 70: Some leaves showed white spots.

2× 70: Occasional appearance of white spots on the leaves.

1×100: All Mvs showed buds. Besides white spots were noted on the leaves.

2×100: The plants were growing rankly. The leaves showed white spots.

1×137: Numerous formation of buds

2×137: Some leaves had white spots. Bud-formation was smaller.

3×137: The formation of the buds was normal.

4×137: The leaves had white spots. The germination in the first Mv was little.

8×137: Here and there the young leaves were chlorotic.

At the end we must once refer to the above mentioned table. We must establish, that the abnormal high plants in the normal soil on 11th IX–1939 did not make it easy to compare their growth with the same in the fervorized soils.

Already Pfeiffer and Franke had drawn our attention to the habitus of the plants in the heated soils. This habitus was also known to us from our own experiments. The leaves were larger and stronger and the foliage of the plants in the fervorized soils was more luxurious than in the normal soil. (Plate X 1).

Table 62.

Fresh weight of shoots in per cent. In unfervorized soil = 100%.

	1×70	2×70	1×100	2×100	1×137	2×137	3×137	4×137	8×137
31. VII. 1939	127,33	104,47	102,43	173,84	193,42	121,92	123,42	116,18	136,00
11. VIII. 1939	126,63	133,80	101,40	128,16	192,62	156,80	157,27	117,13	186,38
22. VIII. 1939	148,03	74,32	136,24	180,68	165,11	126,53	124,57	123,86	131,02
11. IX. 1939	142,37	106,33	97,59	93,75	148.35	157,70	192,62	129,67	147,18
2. X. 1939	111,74	161,62	139,51	156,42	130,86	323,34	321,78	401,14	277,26
13. X. 1939	155,98	130,72	214,86	139,62	220,07	352,15	368,98	483,12	364,00

This table shows us the result of the fresh weight. Immediately after the harvest this was determinated. It was plain, that the fresh weight only in one case, – the observation on 11th IX 1939 fell out, – during the whole time of the examination was smaller in the fervorized soils than in the normal soil. But otherwise we must establish, that the fresh weight was always considerable higher than in the normal cultures. Though in the beginning the height of shoots was smaller, as the table of the height of shoots shows, the fresh weight of the plants in the heated soils was always higher than that of the plants in the normal cultures. The fervor-effect therefore came to expression not so much in the height of these shoots as in the growth of all parts of the plants. The older the plants, the more this was expressed. From the last examination row of the table we saw, that the optimum of fervorization lay between 3 and 4 times fervorizing. The (Plate X. 2) photo confirms this too. But we must admit, that this optimum is of cours only valid for *Sinapis alba* in the used loamy, clayvey and heavy fieldsoil. The optimum of other plants in other soils can only be determined by similar experiments. Concerning the optimum, we have to add the following. We suggested the possibility, that the optimum might be at 100° C or a lower temperature, if the soil should have been fervorized longer. Informations about this could only be given by new experiments.

Table 63.

Dry weight of shoots in per cent. In unfervorized soil = 100%.

Datum	1×70	2×70	1×100	2×100	1×137	2×137	3×137	4×137	8×137
31. VII. 1939	117,60	101,60	107,20	157,60	176,00	134,40	135,20	111,20	124,00
11. VIII. 1939	156,52	150,87	110,00	168,26	283,91	147,82	160,87	106,52	186,95
22. VIII. 1939	160,46	92,09	154,08	222,79	165,81	146.51	141,86	124,65	130,23
11. X. 1939	130,30	100,26	89,78	98,24	136,23	119,82	134,74	102,63	116,93
2. X. 1939	114,58	169,27	132,40	125,79	103,41	259,34	293,07	302,64	230,35
13. X. 1939	172,18	194,26	250,22	171,63	241,61	345,47	362,03	417,99	337,52

After having dried the plants for some days in the open air, they were put for 2–3 days into a thermostate, which was kept on a constant temperature of 80° C. The table shows the dry weight of the plants in per cent. What we said about the fresh weight, could also be said about the fresh weight, could also be said about the dry weight. The figures confirmed our observations in the former experiments. Further we must conclude, that the fervoreffect of the dry weight also depended upon the components time and temperature and upon the age of the examined plants. Therefore we have to consider two components of time.

The determination of the dry weight confirmed the results of the fresh weight, where the optimum was concerned, which lay also between 2 and 3 times fervorizing during 1 hour to 137° C. The found values were $3^1/_2$–$4^1/_2$ times larger than those of the normal fieldsoil.

Up till now we had limited ourselves, to determine the fervoreffect on the shoots, so we also tried to examine the fervoreffect on the roots, which we supposed to be much larger. But the cleaning of the roots of this voluminous material, which was examined, by removing the adherent soil, was impossible. After having rinsed the roots for many days in vain, we were at last forced, to give it up. At the same time we were experimenting with water-cultures and these showed a special fervoreffect upon the development of the roots, conform our former experience.

Examining the development of the bunches, we noted the following:

31.–VII–39. On the chief-axis from normal to 2×100 buds were found. From 1×137 to 3×137 the buds had developed into flowers. In the 1×137 cultures well developed siliquae were noted.

22–VIII–39. All cultures now showed developed flowers. In the normal fieldsoil were numerous buds. During later observations we noted new buds in the heated soils. Noticeable was the general much richer ramification of the flowering in the fervorized soils. At last we found here more numerous and stronger siliquae. We beheld generally the same picture as in the former experiments.

IXth Experiment.

18/X–18/I/1939.

Obj. *Sinapis alba.*

We must remark, that this experiment was started in an unfavorable season. This last experiment should give us a view upon the development of *Sinapis alba* under the influence of the fervorized distilled water. We filled 6 Mvs with the usual fieldsoil. The first series received water from the waterworks of the town and were labelled: W1, W2, W3. The other series were watered with fervorized distilled water and the Mvs were marked: FW1, FW2, FW3. The water, used in the FW series, was fervorized twice, each time 1 hour at 137° C under a pressure of $2^1/_2$ atm. On 18th X–1939 50 seeds were put into each Mv.

Table 64.

The course of the germination in the fieldsoil watered with fervorized water in per cent. Watered with unfervorized water = 100%.

Datum	FW
22. X. 1939	67,69
23. X. 1939	76,31
25. X. 1939	79,48
26. X. 1939	81,25
27. X. 1939	83,75
28. X. 1939	86,25
30. X. 1939	86.42

The results of each group of 3 Mvs were totalised. This table shows the results of the germination First we must note, that generally in both series the germination stayed far behind the normal germination. We put this on account of the influence of the season, as also K o c h and L u e k e n and later C z e r m a k had observed. From the table we see, that the germination in the W vessels began at once and strongly, while the FW vessels showed the well known retardation of the germination. which we have noticed in the fervorized soils. On the 5th day after the sowing half of the seeds in the W vessels had germinated. This figure was never reached by the Mvs treated with fervorized water. The retardation-phase was very distinct as the percentages show.

26.–X–39. In W1 and W2 the first flowers appeared and also in FW1 and FW3.

30.–X–39. There was no difference in the height of shoots between the W an FW cultures.

31.–X–39. In all vessels there was weed, which we removed. No difference in the amount of the germinated plants could be noted.

4.XI–39. In the W cultures the first 2 leaves were fully developed exactly as in the former fieldsoil experiments. The plants in the FW cultures did not show any fully developed leaves. This retardation of the development of the plants is now a well known fact from former experiments in the fervorized soils.

15.–X–39. In the W cultures a soil fungus appeared, which disappeared on 20th XI–1939. This appearance of the fungus was not noted in the FW cultures.

28.–XI–39. All the plants in the FW cultures were slightly chlorotic. The leaves were here larger than in the W cultures. These plants stayed behind in the general growth, but the difference was only small between the W and the FW plants.

6.–XII–39. At this day the plants were about 7 weeks old. We then thinned out the plants. Only 10 plants of about equal size and strength were left. The W plants were slack. They fell down and had to be

supported, exactly like in the former experiments in the normal fieldsoil. The FW plants in the contrary kept upright, in which manner they showed the same qualities as the plants in the fervorized soils

15.–XII–39. A change of colour took place. The plants of the FW cultures showed a deeper dark green than those of the W cultures. This difference, however, was slight and did not last.

6.–XII–39. The cotyledons began to wither. They withered quickly. After some days they fell down in both the cultures.

23.–XII–39. Here and there the first leaves began to fall. We must note, that we gathered the fallen leaves from the resp. culture vessels.

6.–I–40. In all cultures we made notes about the leaf-fall. We noted, that in the FW cultures the leaf-fall was stronger than in the W cultures, which is an opposite behaviour to that in former experiments. There, in the normal fieldsoil, the fall of the leaves was larger than in the fervorized soils, as we can distinctly see from the photos But here we did not know, if this fall was caused by the season or the fervorized water. The experiment took place in the middle of the very strong winter 1939/1940. Then we determinated the average height of the shoots from 10 plants.

Table 65.

Height of shoots.

Datum	W	FW
18. I. 1940	100,00	108,57

The table shows the results of the measurements of the height of shoots. In the age of 3 months the plants in the FW cultures were a little longer than those in the W cultures. This was analogical to the results of our former experiments. So the fervoreffect was noticeable, but only weak.

Table 66.

Fresh weight of shoots.

Datum	W	FW
18. I. 1940	100,00	93,80

This table shows the fresh weight expressed in per cent. The fresh weight of the plants was contrary to our former results smaller in the FW cultures than in the W cultures. But the difference was small.

Table 67.

Dry weight of shoots.

Datum	W	FW
18. I. 1940	100,00	112,84

This table shows the dry weight in per cent for 10 plants. Here the fervoreffect was distinct like in former experiments. The dry weight of the FW cultures with 112,84% was far above the dry weight of the plants in the normal fieldsoil, watered with ordinary water.

This experiment therefore shows, that probably fervorized distilled water produces fervoreffect. Here we must note, that also in the water-cultures the produce of *Sinapis alba* in fervorized water with additional salts was not high. To investigate the influence of the fervorized distilled water in the fieldsoil on *Sinapis alba* further experiments were made necessary.

Summary of the soil-cultures.

The fervorization of the gardenmould and the fieldsoil, used in our experiments with Sinapis alba as experimental plant, gave the following result:

1. The fervoreffect on the germination consists in 2 phases. First a distinct retardation of the germination. This lasted a few days. In the secondphase, after about 7–8 days, a spontaneous growth began. The germination was then increased to such an extend, that it not only reached, but even surpassed the germination in the normal cultures.

2. The fervoreffect was shown in a retardation of the development of the hypocotyl and in an increase of clorophyll and anthocyan.

3. The fervoreffect came to expression in a characteristical habitus of the roots. The ramification of the roots increased and a stronger development of the root hairs took place. In the youth stadium the lateral roots were in the fervorized soils either just below the root-neck or in the upper third part of the main root.

4. The fervoreffect on the root-neck was noticeable by thickly planted hair like fur and in an older stadium by incisions of the root-neck.

5. The fervoreffect with regard to the growth of the shoots consisted in 2 phases. (First time component). The first phase was expressed by a retardation of the growth. This lasted till after the 40th day of the

experiment. Probably so many negative results of the experiments in literature (e. g. Merkenschlager) are due to this fact. In the second phase an increase of the growth took place. This even could appear 70 days after the sowing.

6. The fervoreffect was expressed not so much in the development of the shoots as in the stronger vegetative growth of all parts of the plant above the ground. This came to expression in the fresh weight as well as in the dry weight. The increase of the crops amounted here to 4–4½ times the figure of the normal soils.

7. The fervoreffect came to expression in the dark green colour of the foliage.

8. The fervoreffect was distinctly expressed in the development of the flowers and seeds. In the fervorized soils the development of the bunches was much more luxurious, the flowers more numerous, their colour stronger and the siliquae longer and fuller developed than in the normal soils. The fervoreffect on the seeds resulted in 2–3½ times larger crops.

9. The fervoreffect was especially expressed in the dry weight of the roots.

10. The fervoreffect depended on the duration of the fervorization. (Second time component). This was shown more by the increase of the vegetative growth of the plants, expressed in the fresh and dry weight, than by the increase of length (height) of the shoots. The greatest effect in the height of shoots had 8×137° C.

11. The optimum fervoreffect on the fresh and dry weight lay between 3 and 4 times fervorizing. The difference between 1 and 2 times fervorization was striking. Anyhow we never reached the optimum in our experiments by fervorizing twice to 137° C, which was the ordinary procedure.

12. The fervorefect depend on the temperature (Temperature component). We perceived this even at a relative low temperature (70° C), be it in a smaller degree. The higher the temperature, the stronger the fervoreffect was. In our experiments it reached its maximum at 137° C.

13. Fervorized distilled water alone was sufficient, to produce the fervoreffect on Sinapis alba in our fieldsoil.

14. By fervorizing the weight of the soils increased. The soaking of the water in fervorized soils was essentially slower than in normal soils.

15. There more the soils were fervorized the smaller the need of water of the plants was during and short after the germination.

As we have explained, we were directly interested in the problem of the fervoreffect on plant growth by heating resp. steaming nutrient-substrata.

The soil in all its complexities represents the natural but not the only possible nutrient- substrata for landplants especially not these days, where already successful experiments have led to introducing the so called »water-cultures« into the horticulture.

Therefore we must not wonder, that, long before our soil culture experiments were finished, several considerations induced us, to make use of the classical water- culture methods, in solving the problems of fervorization. Some of the more important reflections have been given already in the introduction. To begin with the idea of the exclusion of the micro-biological as well as of the physical facts, was impossible to exclude, from the soil-cultures. *These components,* as the historical survey of the investigation after the reason and the effect of the soil heat treatment have shown, *were again and again put on the foreground, in order to explain the soil heating.*

On February 22nd 1939 an orientating experiment was set up, with one normal and one twice during 1 hour, at 137° C heated, at a pressure of $2^1/_2$ atm. von der Crone nutrient-solution (2). This experiment was finished on April 19th and showed in its course as well as in its results of the obtained crop, *that the effect of the heat treatment of the nutrient-substrata did not only exercise an influence on soils but also on nutrient-solutions.* The establishment of this fact was for our further investigation of a decisive signification and was the primary reason, to make series of water-cultures, which will be described in details in the following experiments.

Ist Experiment.

21/IV–17/VII/1939.

Obj. *Zea Mais.*

The results of the first orientating water-culture experiment showed us the necessity of a profound investigation into this matter. The questions, which arose first, were the following:

1) To which extent was the fervorization influenced by the duration of the treatment of the nutrient-solutions?

2) Did it make any difference to the fervoreffect, if the nutrient-solutions were treated under other temperature- and pressure-conditions?

3) How did the of the nutrient-solutions influence other plants?

The first two questions arose in connection to our soil cultures, in which we also tried, to separate the time- and temperature-components in the treatment of the nutrient-substrata. The third question we wished

to handle by series of experiments, nearly simultaneously arranged with different kinds of plants. Among other things it seemed desirable to us, to arrange an experiment with pure line seeds As we have already told in the chapter: »methods of the experiments«, such seeds of *Zea Mais* were most kindly put at our disposal by Prof. Dr. A. Tavčar. With these seeds, treated as usually and laid out for germination, we made the experiment, which we will discuss here.

Owing to the above mentioned questions and conform to the resp. soil experiments we arranged 3 parallel series with the von der Crone nutrient-solution, which were treated in the following way.

1) Not fervorized.
2) Fervorized once during one hour at 70° C = 1 × 70
3) „ twice „ „ „ „ 70° C = 2 × 70
4) „ once „ „ „ „ 100° C = 1 × 100
5) „ twice „ „ „ „ 100° C = 2 × 100
6) „ once „ „ „ „ 137° C with 2½ atm. = 1 × 137
7) „ twice „ „ „ „ 137° C with 2½ atm. = 2 × 137.

The planting of the germs in the Vouk's-vessels (Vvs) took place in the formerly mentioned way. It must be noted, that here as well as in all the following experiments the nutrient salts were separately weighed out for each Vouk's vessel in an Erlenmayer-receiver, filled with distilled water. In this way the possible source of errors, the eventual unequal distribution of the insoluble salts, was avoided. After the treatment each Erlenmayer, containing nutrient-solution- was carefully poured over in the resp. Vvs. Into each Vv we put on 23th IV 1939 three equally developed germs. We will now describe the course of the experiment and its results, according to the notes from our experimental records.

When the experiment had lasted for 8 days, distinct differences were shown in the development of the roots of the particular cultures. All the cultures in the fervorized nutrient-solutions had a root system with longer roots than those in the not treated solutions. The longest roots we found in the 1 × 70 cultures, then followed with diminishing lenght resp. the cultures 2 × 70, 2 × 137, 1 × 137 and at a greater distance the 2 × 100 and 1 × 100 cultures. During the following days this difference in length gradually disappeared and we observed a beginning differenciation in the thickness of the root system On 13th V–1939 we noted, that the obviously best developed roots were in the 1 × 137 cultures, but the weakest development was always to be found in the normal cultures. Indeed, they reached the same length as the 2 × 137 cultures, but they were by far not so thick. The root system of 2 × 100 showed a brownish colour. Concerning the development of the shoots, on 9th V–1939 we found the longest stalks in the 2 × 70 cultures, but on 13th V–1939 they were surpassed by the 1 × 100 and 2 × 100 cultures. The 2 × 100 cultures distinguished themselves about this time by its deep green colour. Appearance of chlorosis was already noted on 4th V–1939 in the 2 × 70 and the 2 × 137 cultures. But on the 6th the chlorosis was already disappearing in the 2 × 70 cultures, in the 2 × 137

cultures, however, it stayed and it was on 16th V–1939 even more severe in the younger leaves than in the old leaves. On 6th V–1939 we also noted chlorosis in the normal cultures and on 16th V–1939 on the newely formed leaves of these cultures appeared yellowish spots.

As we also tried to know something about the forming of the substance in the particular phases of the experiment, on 19th V–1939 one plant of each culture was taken away and examined. The results of the normal cultures were as well as in all the following experiments appreciated at 100%.

Table 68.

The fresh, dry and total dry-weight of the plants in per cent. The values for the unfervorized v. d. Crone's nutrient solution = 100%, calculated for 10 plants.

	1×70	2×70	1×100	2×100	1×137	2×137
Fresh weight of shoots	132,81	133,93	130,43	129,86	*133,93*	124,17
Dry weight of shoots	139,11	*152,93*	146,94	147,72	146,54	117,34
Dry weight of roots	168,72	196,29	208,65	*233,33*	196,29	160,91
Total dry weight	145,25	*163,37*	161,78	162,38	158,41	126,04

As this table shows, in all the fervorized solutions the fresh and dry weight of the stalks and the dry weight of the roots was higher than in the normal v. d. Crone nutrient-solutions. Especially the high dry weight of the roots was noticeable.

On 20th V–1939 in all cultures the tulle was taken away. The plants were fixed in the opening of the lid by means of well fitting perforated corks. All cultures were filled up with the appertaining treated and untreated distilled water.

In the further course of the experiment on 19th V–1939 we noted, that the points of the leaves from the 1 × 70 and 2 × 100 cultures became yellow and on 24th V–1939 the colour became still more yellow and the plants withered. This took place in all the cultures. It might be possible, that this happened in connection with the tobacco fumigation of the glasshouse on 22nd V–1939. We must mention, that on 24th V–1939 a distinct decrease of the chlorosis in the young leaves of the 2 × 137 cultures was observed. On 2nd VI–1939 the length of the stalks was measured. The highest value of the stalk length we found in the normal cultures and in less degree in the 1 × 137, 2 × 137, 1 × 100, 2 × 100, 2 × 70 and 1 × 70 cultures. On 10th VI–1939 whitish stripes on the leaves of the normal cultures were perceived. In the 1 × 137 and 2 × 100 cultures we noticed spots of anthocyan on the veins of the leaves and on the young leaves. On 15th VI–1939 the plants were taken away, to be examined. We must mention, that we split the stalks, in order to examine the condition of the not yet developed inflorescences. This the following table shows.

Table 69

Inflorescence.

	Norm.	1×70	2×70	1×100	2×100	1×137	2×137
Length of the ears	5 cm	2½ cm	7½ cm	7 cm	16 cm	10½ cm	10 cm
Lateral panicles	—	—	+	—	+	++	+
Withered	—	—	point	+	point	—	points

About the other conditions of the cultures we noted:

Rootsystem. Generally this was well developed in all the cultures and in the upper part better than in the lower. The roots in the 2 × 70 and the 2 × 100 showed a yellowish to gray-yellow colour. Besides, they were here and in the 1 × 137 cultures apparently thicker than in the other cultures. The 1 × 100 cultures distinguished themselves by a thick and evenly developed root system. In the 2 × 137 cultures there were fewer lateral roots than in the 1 × 137, but they looked stronger.

Stalk system. In all cultures were noted local appearances of chlorosis. Partly the leaves and especially their margins were rippled. Sometimes the points of the leaves were dry. The normal cultures suffered most, with exception of the points of the leaves, which were not dry. In the 1 × 70, 2 × 70, 1 × 100, 2 × 100 and 1 × 137 cultures the appearance of chlorosis and of rumples was less, but here we noted the dry points of the leaves. This was the weakest in the 1 × 137 cultures. In the 2 × 137 cultures no stripe-chlorosis at all was noted and only few rumples. Here neither the points of the leaves were dry, only the young leaves showed to some degree a yellowish colour. Otherwise anthocyan was noted, the strongest in the 2 × 100 cultures.

The other results are summarized in the following table.

Table 70

The length, fresh, dry and total dry weight of the plants in per cent. In unfervorized nutrient solution = 100%.

	1×70	2×70	1×100	2×100	1×137	2×137
Height of shoots	95,71	114,29	100.00	102,86	*102,86*	77,14
Length of roots	*115,38*	107,69	97,43	93,59	91,02	61,54
Fresh weight of shoots	62,63	77,35	68,83	79,03	83,16	68,90
Dry weight of shoots	76,09	84,78	86,09	102,39	*116,52*	101,52
Dry weight of roots	84,77	105,96	94,70	130,46	*170,19*	139,07
Total dry weight	78,23	90.02	88,21	109,33	*129,79*	110,80

If we compare these results with those of 19th V–1939, it is noticeable, that at this time, about a month later, only in the root dry weight of the 1 × 137 cultures a considerable increase could be noted. Accor-

ding to the above results, the normal v. d. Crone cultures had in spite of the chlorotical and morbid symptoms not only reached the other cultures in the fervorized nutrient-solutions especially the 1 × 70, 1 × 100, and 2 × 70 cultures, but also surpassed them.

As we feared, that the nutrient-solutions would be nearly exhausted, on 21st VI–1939 the cultures were transplanted into fresh prepared nutrient-solutions. In the further course of this experiment we were principally interested in the process of the appearance and the development of the inflorescences. But then again, as we will notice in the following, chlorosis and other signs of illness in some cultures appeared. We must remark, that on 4th VI–1939 all vessels were filled up again with the appertaining water.

Stalk system. Already on 24th VI–1939 we observed again an appearance of chlorosis in both rows of the 2 × 137 cultures. On 29th VI–1939 this was already strongly visible, while in the third row the chlorosis at the end of the experiment got a little bit better. This chlorosis led in the second row at last to partial dying of the leaves, which began already on 8th VI–1939 under appearances of curling up and withering. On 11th VII–1939 heavy damage was observed in both the normal cultures as well as in the 2 × 70 cultures and in a somewhat less degree in the 1 × 70 cultures. At the same time the 1 × 137 cultures showed in both rows deep dark green leaves with a silky brightness. Thus they stayed till the end of the experiment. The 1 × 100 and 2 × 100 cultures did not behave the same in the two rows. While in the second row the 1 × 100 cultures at that time nearly showed no damage at all, in the third row chlorosis was distinctly observed. In the 2 × 100 cultures it was reverse. The leaves in the third row were of a beautiful dark green, while in the second one they showed numerous yellow spots.

Inflorescence. The coming out of the inflorescences and their development in the single cultures of both experimental rows were too irregular, to permit any conclusion. Therefore we only mentioned the observed situation on 11th VII-1939. In the normal cultures no inflorescences could be observed. In the 1 × 70 cultures there were small, dried out, hardly developed ears and in the second row we found a spadix of 22 cm long. The 2 × 70 cultures showed in the 3rd row two female spadices, each 16 cm long, but in the second row the not yet grown out ears were drying up. Similar proportions, concerning the two experimental rows, we found in the 2 × 70 and the 1 × 100 cultures. In the 2 × 100 cultures in the contrary in both the rows the ears were nicely developed and in the second row a female spadix began to come out. But totally different were the two rows of the 1 × 137 cultures. While the culture of the second row showed richly ramified well developed and great ears, the flowering was stunted in the third row. Lastly the 2 × 137 cultures had in the second row chlorotic and partly dried up ears of an average size.

On 15th VII–1939 the plants of the second on 17th VII–1939 the third row were taken out. Generally the conditions of the cultures were not much changed, though already on 11th VII–1939 existing differences were more accentuated. We must mention the following. In the normal v. d. Crone cultures in both the rows neither the male nor the female inflorescences were developed. In the second row the youngest 3 leaves were stuck together and rotting leaf points were here also noted. At the stalk of the culture in the second row a strong formation of anthocyan as well as many hairs on the leaf sheaths were noticed. In the second row of the 1 × 70 culture the fragility of the upper part of the stalk contrary to the massive built of the plant in the third row was striking. This showed a dark green colour of the leaves and of the stalk, besides a formation of anthocyan on the leaf sheaths, but no ear. The plant of the second row showed a badly developed ear and besides a female spadix, which was 25 cm long. The colour of the leaves was here also dark green, but the upper leaves showed damages. The 2 × 70 culture of the third row had no ear, but 2 spadices, 17 and 12 cm long. Stalk and leaves were dark green without anthocyan and with hair on the leaf sheats of the young leaves, but also gum-formation in the knots. The 2 × 70 culture of the second row had also dark green leaves, but at the upper leaves here and there damages appeared. The leaf sheaths contained anthocyan. The ear was extremely weakly developed. There was no female spadix at all. In the culture 1 × 100 there were in the second row dark green, but damaged leaves, besides many dried leaves as well as an empty chlorotic ear. The third row had dark green, not damaged leaves, leaf sheaths with hair, weakly to normally develloped ears and a flowering spadix, 30 cm long. But inside the stalk there were symptoms of illness. The leaves of the 2 × 100 culture (2nd row) were spotted yellow or showed weak chlorotic stripes (3rd row). In spite of this both the parallel cultures had the best developed inflorescences. Except the present ears there was also a female spadix, 16 cm long. Like on 11th VI–1939 the greatest differences we found in the parallel rows of the 1 × 137 cultures. The culture in the third row produced dark green, rumpled leaves and black brown coloured knots and internodes. The ears were missing. In the second row on the contrary we observed a rich flowering and well developed ears, besides a spadix of 11 cm. The leaves were of a normal dark green, showing hardly any damage. This culture was also striking by its extraordinary rich formation of the lateral roots. Definite differences were also perceived in the 2 × 137 cultures. In the second row we noticed a feeble plant, the leaves of which with exception of the 3 youngest leaves were dead or partly decayed. The ear was chlorotic and badly developed. The female spadix was 15 cm long and was spotted brown. In the third row we observed between the leaf veins only a light chlorosis, which had not infected the upper leaves at all. On the margins of the leaf sheaths there was hair. Formations of anthocyan on the lower side of the leaves could be noticed. There was a badly developed ear, which had not yet come out.

In the parallel rows there were strong individual differences, which made us decide, not to discuss the course of the development of these plants at all, but only to give the results of the measurements in figures for each experimental row.

Table 71

The results of the crop of row II in per cent. In unfervorized nutrient – solution = 100%.

	1×70	2×70	1×100	2×100	1×137	2×137
Max. length of leaves	84,85	84,85	80,30	93,94	78,79	57,57
Max. breadth of leaves	100,00	100,00	100,00	100,00	125,00	125,00
Height of shoots	103,61	102,04	80,61	122,45	89,79	101,02
Length of roots	133,33	124,44	128,89	131,11	133,33	153,33
Fresh weigth of shoots	89,04	100,05	65,52	98,37	82,29	73,91
Dry weight of shoots	86,42	101,06	76,63	101,76	93,03	92,94
Dry weight of roots	60,97	102,58	65,81	98,37	71,29	81,93
Total dry weight	80,95	101,38	74,31	101,12	88,12	90,58

The same results of row III.

	1×70	2×70	1×100	2×100	1×137	2×137
Max. length of leaves	128,20	133,33	130,77	141,02	146,15	133,33
Max. breadth of leaves	100,00	100,00	100,00	100,00	100,00	125,00
Height of shoots	71,43	72,53	109,89	72,53	79,12	106,59
Length of roots	86,96	132,61	121,74	123,91	117,39	152,17
Fresh weigth of shoots	94,99	96,51	81,82	64,29	65,95	103,99
Dry weight of shoots	85,77	72,54	67,58	66,93	79,17	104,38
Dry weight of roots	107,57	117,17	100,50	80,81	120,71	182,83
Total dry weight	88,48	78,10	71,68	68,66	76,46	114,16

IInd Experiment.

28/IV–27/VI/1939.

Obj. *Vicia Faba.*

The seeds, bought at the local seeds trade Teply, in Zagreb, were selected according to size, shape and colour. Then they were desinfected with a 1‰ sublimate-solution, rinsed and put on humide filtering paper in Petriboxes to germ. On 28th IV–1939 from these germs were selected two equivalent germs and planted in the usual way into the Vvs, filled with the resp. fervorized and normal v. d. Crone nutrient-solutions. The

experiment consisted like the *Zea Mais* experiment of 3 parallel rows of nutrient-solution, which had been treated in the following way.

Normal – 1×70 – 2×70 – 1×100 – 2×100 – 1×137 – and 2×137.

Regarding the course of the experiment, we extract from the experimental protocol the following. In the development of the roots as well as the shoots, which began on 7th V–1939 strong individual differences could be observed from the beginning. Not only that the picture of the cultures in the 3 parallel rows differed more or less, but there was also a considerable difference in the development of the two experimental plants of the same vessel. It was striking, that the roots of the 1 × 137 cultures in all the 3 rows showed already on 5th V–1939 a brownish change of colour, which increased in the course of time. On 13th V–1939 such a change of colour was also noted in the 2 × 100 cultures. Except this, we observed at the same time in the 1 × 70 and 1 × 100 cultures a strong and in the 2 × 137 cultures a weaker tendency of the main roots to grow upward. White and straight main roots were only noticed in the 2 × 70 and normal cultures (Plate XI 1). On 16th V–1939 we observed, that the 1 × 100 cultures had brownish roots too. The brown colour of the roots lasted till 20th V–1939. Then all these brown roots showed long and white lateral roots. The mentioned irregularity of the experimental plants caused us, to reduce all cultures to one plant in one culture vessel. This took place on 25th V–1939. On 1st VI–1939 the length of all shoots and roots was determinated. We calculated the results in percentage, based on the normal culture, which we appreciated at 100%.

Table 72

The height of shoots and the length of roots in per cent.

	Norm.	1×70	2×70	1×100	2×100	1×137	2×137
Height of shoots	100,00	97,67	84,83	81,00	124,33	174,33	175,67
Length of roots	100,00	114,69	97,18	92,09	100,00	171,19	211,86

At this time we noted in the 2 × 137 and in the 1 × 137 cultures a strong increase of the length of the roots and the shoots, compared with the normal cultures. With regard to the length of the shoots this became more comprehensible, if we put in the foreground, that as we noted on 2nd VI–1939, the strongest development of the lateral sprouts began in the normal cultures, which in the 2 × 137 cultures till now had not taken place and which in the 1 × 137 cultures was only very weak, as the following table shows.

Table 73

Total figures of the lateral shoots.

Normal	1×70	2×70	1×100	2×100	1×137	2×137
11	9	7	8	3	1	—

Certainly in the other cultures especially in the 2 × 100 cultures the length of the shoots and the number of the lateral sprouts was not as above in a reversed proportion. We also noted, that the formation of the sprouts till now started at the base of the main shoots. (Plate XI 2).

In the further course certain symptoms of illness were observed in the normal and in the 1 × 70 cultures as well as on 8th VI–1939 also in the 2 × 70 cultures (brown black change of colour of the young leaves and the points of the leaves), but on the other hand the development of the flower buds on 11th VI–1939 in the 2 × 137 and the 1 × 137 cultures were observed as well. On 13th VI–1939 the vessels were filled with the resp. treated water. On 14th VI–1939 the third row was broken up. The examination of the plants gave the following results.

Shoot system. The normal culture showed short stagnated sprouts at the base of the main sprout, the top parts of which as well as those of the side sprouts were dead. Except these, one of the highest full grown leaves was also dead and two following leaves showed on the lamina yellow spots. In the 1 × 70 culture we found, that the top part of the main shoot as well as two developed leaves were dead, but from the lateral sprouts, developed at the lower part of the main shoot, only the lowest was stunted. The 2 × 70 culture showed a beginning of lateral sprouts. The death of the top part of the main shoot as well as the beginning of the withering and the further on turning yellow of the upper leaves were noted. In the 1 × 100 culture dried top parts of the main shoots and yellow spots on the 2 top leaves were observed. One of the lateral sprouts was here nearly as long as the main shoot. The 2 × 100 culture showed a strong main shoot with well developed leaves and elements of flowers. This could not go on, because the inflorescence axis was dried out. The youngest of the lateral sprouts was beginning to turn brown. Only the lowest leaf was dead. In the 1 × 137 culture there was no formation of a lateral sprout, but the main shoot was strongly developed and had already flowers, but the flower axes was partly dead. The leaves were like in the 2 × 100 culture, only the lowest were dead. The 2 × 137 culture at last had a strongly developed main shoot and a rich flowering. The leaves were very well developed. There were 2 lateral sprouts, one larger and one smaller.

Root system. In the normal culture the main root had suddenly stopped growing, but was well developed in the other cultures. In the 1 × 100 culture the main root showed already a thickening of the root

point, which was strongest in the 2 × 137 culture. This was, however, not observed in the 1 × 137 culture. In the 2 × 100 culture we also noted the tendency of winding of the thickened point of the main root. Concerning the lateral roots, they were all pretty richly developed in all cultures, but showed in the main roots of the 1 × 100, 2 × 100 and 2 × 137 cultures similar thickened points, which were also bent in the 2 × 100 culture.

The results of the measurements and the determination are given by the following table

Table 74

Results of the measurements of the plants in per cent. The unfervorized nutrient solution = 100%.

	1×70	2×70	1×100	2×100	1×137	2×137
Height of shoots	110,00	103,30	76,70	150,00	*296,70*	246,70
Length of roots	166,00	125,00	100,00	110,00	185,00	*220,00*
Fresh weight of shoots	90,76	80,29	92,91	122,18	122,55	*186,09*
Dry weight of shoots	83,39	77,86	79,05	98,02	99,61	*162,45*
Dry weight of roots	84,74	71,18	89,74	138,97	103,38	*167,79*
Total dry weight	83,65	76,60	80,12	105,76	100,32	163,46

As we saw, the values of the length of the shoots and the roots in the normal cultures, except those in the 1 × 100 cultures, were surpassed by all the other cultures, the values of the shoot dry weight only by the 2 × 137 cultures. The important increase of the total dry weight of the 2 × 100 and 1 × 137 cultures must be put on account of the increase of the dry weight of the roots.

As we noted on 24th VI–1939, that in the normal cultures the leaves went on turning yellow, the experiment, that is to say, the remaining rows, one and two, were broken up on 27th VI–1939. The experimental plants were examined, described and prepared for the determination of the fresh and dry weight.

Shoot system. The withering on 14th VI–1939 was noted first in the normal cultures, and was also observed in the leaves of the lateral shoots of the first and second order. The green colour was only noted in the surrounding of the leaf weins. In the 1 × 70 cultures the lateral roots began to wither and to die. The uper leaves withered too and showed yellow spots. The second row of the 2 × 70 cultures showed the same picture as the 1 × 70 cultures, but in the first row the lateral shoots were still green. In the 1 × 100 cultures we noted in the second row a kind of with's brush (Hexenbesen) and mostly dried rests of lateral shoots, otherwise there were in the 2 experimental rows green leaves with the beginning of yellow spots. In both the 2 × 100 cultures the long green lateral shoots were still alive and in the second row a dried element of an inflorescence. The top parts of the main shoot were here as in all up till now described cultures withered. In the 1 × 137

culture first row and the 2 × 137 both rows they were still living and fresh. The culture 1 × 137, first row, was far better conserved than the parallel second row. While here withered elements of the flowers and yellowish leaves were met, in the first row the lateral shoots were flowering as well and the leaf fall was only noted at the main shoot. Otherwise they were healthy and green. Both the 2 × 137 cultures showed a strong habitus with green leaves and numerous flowers. Those of the second row had fallen off.

Root system. Generally the lateral roots of the normal cultures in the experimental first row were better developed than in the second row, but here the main root in the lower part decayed, which we also observed in the first row of the 1 × 70 culture. Otherwise the roots in the 1 × 70 cultures were thinner but longer than in the normal cultures. Decay of the roots as well as yellowish to brown change of colour we found in the 2 × 70 cultures, in which at the same time long lateral roots, coming out of the upper part of the main root, were noted. In the 1 × 100 cultures the main and lateral roots were healthy though a little brownish in the upper part. Except long lateral roots on the upper part of the main root numerous shorter, but white lateral roots were found at the lower part. Similar conditions we noted in the 2 × 100 cultures, but the main root was here thickened in the lower part. In the root system of the 1 × 137 cultures and the 2 × 137 cultures we did not observe any particularity. They were generally well developed.

The following table contains the summarized results of the measurements of the two experimental rows.

Table 75

Results of the measurements of the plants in per cent. The unfervorized nutrient solution = 100%.

	1×70	2×70	1×100	2×100	1×137	2×137
Height of shoots	96,49	78,94	83,15	143,85	249,00	*422,80*
Length of roots	114,65	82,02	114,65	132,58	175,28	*238,20*
Fresh weight of shoots	109,62	72,19	102,34	201,74	194,39	*290,37*
Dry weight of shoots	97,18	68,54	83,09	138,02	158,68	*214,55*
Dry weight of roots	122,22	63,88	150,00	*225,00*	172,22	*225,00*
Total dry weight	100,80	67,87	94,37	150,60	160,69	*216,06*

The 2×70 cultures therefore showed in every respect to belong to the most stagnated cultures, while the 2×137 cultures surpassed the normal cultures by far. But this time also the 1×137 as well as the 2×100 cultures reached values of the total dry weight which surpassed considerably the total dry weight of the normal cultures, which in this case were not only derived from the increase of the root dry weight. Of special interest should be the striking correlation between the height of the shoots and that of the total dry weight.

IIIrd Experiment.

29/IV–12/VI/1939.

Obj. *Sinapis alba.*

This second *Sinapis alba* experiment was arranged in connection with the *Zea Mays* and *Vicia Faba* experiments. Our purpose was, except controlling the behaviour of cultures in treated nutrient-solutions at different temperature and times, with a varying duration and the repeating of the first *Sinapis alba* experiment, also to secure a possible answer about the treatment of other nutrient-solutions.

For this task we made the following arrangements.

As substrata we chose the v. d. Crone's nutrient-solution and the Bruch's nutrient-solution. Here we have the chemical compound of the two nutrient-solutions.

	H_2O	KNO_3	$KHPO_4$	$Ca_3(PO_4)_2$	$CaSO_4 + 2\,H_2O$	$MgSO_4 + 7\,H_2O$	$Fe_3(PO_4)_2$	NaCl	$FCl_6 + 6\,H_2O$ 5% L
Bruch	1000 cc	0,5 g	0,25 g	—	0,25 g	0,25 g	—	0,005 g	one drop
v. d. Crone . .	1000 cc	1,0 g	—	0,25 g	0,50 g	0,50 g	0,25 g	—	—

These two nutrient-solutions were a bit different in chemical composition as well as in the degree of the concentration. Besides, this in essential, the quantity of unsoluble salts in Bruch's solution was considerable smaller than that of the v. d. Crone. Concerning the relations of temperature and time, they were the same as in th soil experiments. The experimental series consisted of:

Bruch Normal – 1×70 – 2×70 – 1×100 – 2×100 – 1×137 – 2×137
v. d. Crone „ „ „ „ „ „ „ ,

three Vvs from each, which made 42 culture vessels.

After the treatment of the nutrient-solutions, distinct differences in colour, as a result of the fervorization, were observed. While the Bruch's nutrient-solution changed from normal-colourles to a colour of blue gray tinge in the 2×137 solutions, the v. d. Crone nutrient-solutions with a normal steel blue colour changed generally into a yellow colour. We could observe in the 1×70 and 2×70 cultures an opalescence, in the 1×100 cultures a weak gray-green, in the 2×100 tray-green with a yellowish hue, this was stronger in the 1×137 and was predominating in the 2×137 solutions. The v. d. Crone solutions 2×137 changed in a yellow weak green tinged colour.

Before we used these solutions, we first determinated the pH concentration of the different nutrient-solutions as well as from the used distilled water.

Table 76

The determination of the pH in the different substrata.

Substrate	norm.	1×70	2×70	1×100	2×100	1×137	2×137
Distilled water	5,85	6,45	6.55	7,35	6,25	6,40	7,00
v. d. Crone nutr. sol.	6,48	6,80	6,80	6,20	5,90	5,08	5,62
Bruch's nutr. sol.	7,92	7,88	7,66	7,85	7,48	7,75	6,38

The successive results were too divergent, to permit any conclusions. Generally we may say, that the Bruch's solutions showed itselves to be the more constant under this treatment, while in this respect we found the greatest varietes in the distilled water.

Meanwhile on 24th IV–1939 the seeds of *Sinapis alba* were put into Petriboxes to germinate and from the selected equal germs 3 were put into each Vv on 29th IV–1939.

Before we discuss the course of this experiment, we must establish, that in the series of Bruch in the normal as well as in the heated solutions the seedlings did not thrive and withered just like the cultures in the solution of Knop, which we had tried out in the orientating experiment. After this experience the solutions of Bruch were not used any more and the forthcoming descriptions of the experiment in our protocol are related only to v. d. Crone solutions.

On 5th V–1939 we noted, that the development of the root system did not show only a difference between the rows but also *in* the rows, even in some vessels we noted variations in this respect. Excepting the 1×137 culture, which in rows nr 1 an nr 2 were characterized by very short brownish main roots and few lateral roots (in row nr 3 the main root was a little longer and had more lateral roots) and the 2×137 cultures with generally long main roots and very long lateral roots, we can say, summarizing, that there were long as well as short main roots which were covered with many or few lateral roots. If the lateral roots were short, then there were many of them, if they were longer, then they were smaller in number. In the normal cultures as well as in the 1×70 cultures the lateral roots were generally attached to the upper part of the main root. Like the development of the roots in the 1×137 cultures, the development of the leaves was here also weaker. From 7th till 13th V–1939 different shifting values in the length of the roots were observed. On 7th V–1939 the 2×70 cultures showed the best and

longest root system with well developed root hairs. In the 1×70 and 2×137 cultures we perceived a better root system than in the normal cultures. On 9th V–1939 the 1×100 cultures came in this respect near the 2×70 cultures and on this followed with diminishing values the 1×70, normal, 2×137 and the 2×100 cultures. The roots of the 1×137 cultures seemed to be crumpled and were brown. On 13th V-1939 the 1×70 cultures had the longest root system, followed by the 2×70 cultures, similarly developed were the 1×100, 2×137 and the normal cultures. In the 2×100 cultures the root system was short, but contrary to the 1×137 cultures, healthy. Concerning the height of the shoots, we observed on 13th V–1939, that it was increasing from the normal cultures to the 2×70 cultures, then decreasing to the 1×137 cultures, to increase again in the 2×137 cultures.

On 18th V–1939 there were buds in all the rows of the 1×70 and 2×70 cultures and on the 19th V–1939 they were noted in all the 2×137 cultures as well as in one normal culture. On 24th V–1939 the length of the roots was again compared. In the 1×137 cultures we found the smallest and in the 2×137 cultures the longest roots. The 2×100 cultures had a shorter root system than the 1×100 cultures. With respect to the height of the shoots we got the impression, that it increased from the normal cultures to the 1×137 cultures and decreased a little in the 2×137 cultures. On 25th V–1939 all culture vessels were filled up again with the appropriate water. On 2nd VI–1939 all shoots were measured and the occurrence of buds and flowers were noted.

Before we give the results of these determinations, we must communicate, that one row, the third one, was not placed on one of the middle tables of the laboratory-glasshouse, but on a bracket of the glasshouse near the window, owing to lack of space. As this different position had obviously infuenced the results of the experiment to a certain degree, especially with regard to the figures of the shoot system, we only totalized the results of the 1st and 2nd row and mentioned separately those, concerning the 3rd row. But we must note, that also within one and the same culture sometimes strong individual differences among the plants could be noticed.

Table 77

Average height of shoots in per cent. In the unfervorized solution = 100%.

	1×70	2×70	1×100	2×100	1×137	2×137
Row I and II	169,87	190,38	203,21	235,25	227,57	135,89
Row III.	125,91	134,09	152,27	159,09	222,73	215,00

With regard to the state of flowering, all the rows of the normal cultures were mostly in bud as well as the 1×100, 2×100, 1×137 and the 2×137 of the 1st experimental row, the 2×-37 culture of the 2nd row and the 1×70 culture of the third row. In all the other cultures there were either exclusively, as in the 2×70, 1×100, 1×137 and 2×137 cultures of the 3rd row and the 1×137 culture of the 2nd row, or predominant flowers.

On 12th VI–1939 the experiment was broken up, in order to make a general description of the state of development of the plants, after which the plants were prepared for the determination of the fresh weight of the shoots and the dry substance. About the development of the shoots we noted the following.

The leaves of the normal cultures were in all rows dark green, but the margins were already getting yellow and the lower-sides of the leaves showed red connected colorations. The leaf veins were noticeable thick and white, the leaves in the upper part were stagnated, the buds did not come out, they were miserable and stagnated. In the 1×70 cultures the leaves were of normal size, but had a yellow green colour. In the 3rd row the highest leaves were of a deep dark green, in the 2nd row they looked about the same as in the normal cultures, only less green. Withered buds were found. In the 2×70 cultures the leaves were smaller than those in the 1×70 culturs and showed, especially those at the lower parts of the shoots, yellow margins, coming out from the points of the leaves. Here and there fruit swellings, most of them withered, and many buds. The 1×100 cultures were the same in all the 3 rows and showed leaves of normal size of a dark green colour. The top of the shoots stopped growing, but there were many swellings for future lateral shoots. The inflorescences appeared partly developed, partly withered. The 2×100 cultures had normal and in the upper part dark green leaves. The lateral shoots and inflorescences were not quite normally developed but better than those of the 1×100 cultures. We also noted fruit-swellings. The 1×137 cultures had sappy green leaves, normal lateral shoots and inflorescences with rich fruit swellings. Very much alike these cultures were the 2×137 cultures in the 3rd row. In the 2nd and 1st row on the contrary we noted in the upper part of the 2×137 cultures yellow green leaves and slightly stagnated flower-axes with normaly developed flowers. (Plate XII 2).

For the above mentioned reason we do not want to give the averages of all the 3 experimental rows, so we only give the results of each row separately.

Table 78

The results of the measurements of the experimental row I, II and III in per cent. In unfervorized nutrient solution = 100%.

Experimental row I	1×70	2×70	1×100	2×100	1×137	2×137
Height of shoots	115,42	141,67	145,83	188,75	265,42	211,25
Fresh weight of shoots	109,18	119,39	111,57	108,84	143,20	156,12
Dry weight of shoots	124,28	131,83	123,79	101,76	116,24	134,56
Dry weight of roots	200,00	140,00	134,00	94,00	166,00	214,00
Total dry weight	129,91	132,44	124,55	101,19	119,94	140,48
Experiment row II						
Height of shoots	142,27	144,09	183,18	225,91	245,45	121,36
Fresh weight of shoots	124,53	135,63	133,72	131,95	146,37	78,55
Dry weight of shoots	132,19	132,66	146,66	142,61	125,51	72,63
Dry weight of roots	242,42	251,51	342,42	272,72	251,51	181,82
Total dry weight	137,57	138,46	156,21	148,96	131,66	77,96
Experimental row III						
Height of shoots	121,87	128,40	155,64	147,86	246,30	281,32
Fresh weight of shoots	122,03	154,24	145,74	101,13	101,69	158,14
Dry weight of shoots	118,76	126,61	141,85	103,16	97,65	154,40
Dry weight of roots	187,50	125,00	187,50	150,00	96,25	250,00
Total dry weight	124,65	126,47	145,77	107,18	97,54	162,59

IVth Experiment.

30/IV–28/VI/1939.

Obj. *Solanum lycopersicum.*

These seeds were bought at the local seed trade Teply, Zagreb. They were selected according to size, desinfected with a 1‰ sublimate solution and put on filtering paper in Petriboxes for germination. On 30th IV–1939 the neccessary number of possible equal germs were selected and planted in the usual way in the Vvs, containing the nutrient-solutions. The arrangement of the *Solanum lycopersicum* experiment was the same as in the experiment with *Zea Mays* and *Vicia Faba* and consisted therefore of 3 parallel rows of the v. d. Crone nutrient solution, treated as in the other experiments.

Normal – 1×70 – 2×70 – 1×100 – 2×100 – 1×137 – 2×137.

The experimental rows nr 1 and nr 2 had in each vessel 3 plants in opposition to row nr 3 with only 2 plants.

In the course of the experiment we perceived with regard to the development of the cultures the following. Already on 5th V–1939 we observed in all vessels the development of lateral roots. On 6th V–1939

in all cultures the first leaves were unfolded. On 7th V–1939 in the normal cultures the short and numerous lateral roots were striking, whereas the 2×137 cultures distinguished themselves by very long main roots and very few lateral roots. About the height of the seedlings on 16th V–1939 we noted a considerable retardation in the 1×137 cultures, while the 2×70, 1×100 and 2×100 cultures were the longest; the normal, 1×70 and 2×137 cultures were slightly shorter, but equally developed. The normal and 2×100 cultures guttated very strongly, as we noted on 23rd V–1939, the 2×137 normally and the 1×137 only weakly. By comparing the development of the shoots and roots, we concluded on 24th V–1939, that the best developed shoots and roots were in the 2×70 cultures. Generally the height of the shoots went up from normal to the 2×70 cultures and went down a bit to the 1×137 cultures, to rise again steeply to the 2×137 cultures. The measuring of the shoots on 2nd VI–1939 gave the following results.

Table 79

Height of shoots in per cent. In unfervorized solution = 100%

Exp. Rows I, II and III	1×70	2×70	1×100	2×100	1×137	2×137
Average height of shoots	102,94	98,24	94,71	108,23	97,65	*142,35*

As we saw with regard to the height of the shoots, a change resp. a displacement of their values from 24 V – 2nd VI–1939 had taken place and the normal cultures surpassed in this relation the 2×70 cultures, but stayed, however, far behind the 2×137 cultures. (Plate XIII 1). As the cultures were now intensively growing, on the 8th VI–1939 we added fervorized and distilled water. An examination of the cultures on 10th VI–1939 resulted in a better and richer developed root system in the 2×100, 1×137 and 2×137 cultures, compared with the normal, 1×70, 2×70 and 1×100 cultures. (Plate XIII 2) On 12th VI-1939 we observed that the points of the main shoots were drying up in all the 2×70 cultures. This drying up was accompanied by the forming of many lateral shoots. Also the 1×70 cultures showed withered points, but the forming of the lateral shoots was much less. The control cultures, viz the normal cultures, were equal to the 1×70 cultures. On 14th VI–1939 experimental row nr 2 was broken up, the cultures were examined and prepared for the determination of the fresh and dry weight. As a result of the examination of the cultures normal, 1×70, 2×70 and 1×100, the points of the main shoots were withering, which in the 2×100 cultures only just began and in the 1×137 and 2×137 cultures on the other hand were not withering at all. In close relation to this was perhaps the forming of the lateral shoots, which in the normal cultures, 1×70, 2×70, 1×100 and 2×100 were more or less developed and which in the 1×137 and

2×137 cultures were absent. Concerning the leaves, their development and colours, we must mention here, that the leaves of the 1×137 and 2×137 cultures were distinguished by their size and deep green colour. The leaves of the normal cultures showed yellow spots, which were also noticed in the 1×70 cultures, though in a lesser degree. The colour of the 2×70, 1×100 and 2×100 cultures was, compared with the 1×137 and 2×137 cultures, yellowish. But the 1×137 and 2×137 cultures showed at the places of the insertions of the leaves knotty swellings and the 2×137 cultures were showing besides warts on the epidermis at the lower part of the shoots. All cultures had a richly developed root system, but the richest and thickest root system was exhibited by the 2×137 cultures. The result of the measurements is shown in the following table.

Table 80

Results of the average measurements of the height of shoots and the length of roots in per cent. In unfervorized solution = 100%.

Experimental Row II.	1×70	2×70	1×100	2×100	1×137	2×137
Height of shoots	105,26	100,00	91,52	63,26	173,68	*205,26*
Length of roots	96,55	98,82	95,55	*117,24*	98,27	96,55
Fresh weight of shoots	99,72	89,66	82,74	73,06	124,42	*175,62*
Dry weight of shoots	99,02	83,51	76,48	69,26	86,34	*149,26*
Dry weight of roots	105,08	80,87	73,68	93,33	77,19	*201,05*
Total dry weight	103,81	84,65	75,87	74,96	84,35	*160,53*

The rows nr 1 and nr 2 were further observed. On 20th VI–1939 in the 2×137 cultures appeared buds, which developed normally. On 21st VI–1939 all vessels were filled up again with the appropriate water and on the 28th VI–1939 the whole experiment was broken up. The plants were taken away, to be examined. Apart from this we must mention, that in the 1×70 cultures between the plants and the wadding strong *Lachnea* cultures were developing. The comparison of the cultures had the following result.

Shoot system. In the normal, 1×70 and 2×70 cultures the main shoots were dead. In the 1×100 and 2×100 cultures the process of dieing off was restricted to the points of the mains shoots, but this did not take place in the 1×137 and 2×137 cultures. While in these two cultures no lateral shoots were formed, all the other cultures showed more or less perfect lateral shoots, the number and the height of which were rather variable. (Plate XIV 1) Remarkable was the hair of the plants, which in the 1×137 and 2×137 cultures was strongest, in the 1×100 and 2×100 cultures well developed, whereas the other cultures especially the 1×70 cultures were only thinly haired resp. showed almost bare shoots. Warts appeared on the epidermis of the 1×137 and 2×137

cultures. The formation of leaves was in all cultures normal, excepted in the 1×70 cultures, where besides normal leaf formation also leafless shoots were noted and only differences with regard to the colour of the leaves were observed. While the 1×137 and 2×137 cultures showed striking sappy, deep green leaves, in the normal and 1×70 cultures a yellowish green was predominating, same as in the leaves of the main shoots of the 2×70, 1×100 and 2×100 cultures. The leaves of the lateral shoots on the contrary were here perceptible greener. Except the 1×137 and 2×137 cultures we observed at the margins of the leaves in all the other cultures, the strongest in the 1×70 cultures colorations of anthocyan. Bud-swellings were only noted in the 1×137 cultures and in a more developed state in the 2×137 cultures. In the last cultures except the buds we also perceived a fully developed flower. (Plate XIV 2)

Root system. This was in all the cultures generally well developed. The results of the measurements is given in the following table. We must mention, that in this table the results of the two rows were averaged.

Table 81

Average results of the height of shoots and the length of roots and the fresh, dry and total dry weight of the plants in per cent. In unfervorized solution = 100%.

Exp. Row I and III.	1×70	2×70	1×100	2×100	1×137	2×137
Height of shoots	109,09	104,54	103,40	129,20	256, 81	*342,04*
Length of roots	104,84	133,87	106,45	*119,35*	108,06	101,61
Fresh weight of shoots	91,64	90,61	94,85	137,33	*196,21*	188,34
Dry weight of shoots	98,48	103,78	95,45	144,69	*205,30*	200,00
Dry weight of roots	109,68	96,77	116,13	138,71	232,26	*306,45*
Total dry weight	106,13	102,45	99,38	143,19	210,49	220,24

When we compare the table of the results of the 2nd row with this table, we find, that the largest yield of dry substance in both cases was obtained in the 2×137 cultures. There were two striking facts, that after a fortnight's continuation of the experiment the 2×137 cultures went on increasing and that in this period the 1×137 cultures especially with regard to the total dry weight instead of a decrease of the yield now gave an average increase, almost reaching the 2×137 cultures. Similar to the 1×137 cultures, if not the same, the 2×100 cultures behaved, which at this time also recovered and at last surpassed the yield of dry substance of the normal culture. Also in this fortnight a further development of the 2×70 and 1×100 cultures took place, showing better results. They nearly reached the dry weight of the normal cultures. The proportion of the 1×70 cultures to the normal stayed about the same as a fortnight ago.

Returning once more to the 2×137 cultures, we must point out, that on 14th VI–1939 as well as on 28th VI–1939 the most diverging values in the height of the shoots and in the dry weight of the roots we found between these cultures and the normal cultures. With reference to the first examination, the change in proportions between the normal and the 2×137 cultures may be of interest, therefore we give here once more the data. On 16th V–1939 after the experiment had lasted a fortnight the proportions of the height of the shoots between normal and the 2×137 cultures were 1 : 1. On 2nd VI–1939 the measurements resulted in the proportion 1 : 1,4, on 14th VI–1939 it was already 1 : 2 and on 28th VI–1939, which was after one month, we found the proportions to be 1 : 3,4. With the 1×137 cultures it was the same case, with this difference, that these cultures began to vary later. On 2nd VI–1939 the 1×137 cultures with reference to the height of the shoots stood a little behind the normal cultures. On 14th VI–1939 the proportion was 1 : 1,7 and at the end of the experiment 1 : 2,5. Certainly the drying up of the main shoots, observed on 12th VI–1939, hampered the normal cultures to grow further and as a compensation the formation of the lateral shoots started, but it was important, that these also showed no intensive growth. Though we are far from considering the special strong growth of the 2×137, cultures as a benefit, we must establish this fact, because similar proportions were also noted in the experiments with other plants. With regard to the root dry weight we found in this happening partly an explanation for the increase of the yield of plant substance.

Vth Experiment.

14/V–4/VII/1939.

Obj. *Sinapis alba.*

The results of the last discussed water-culture experiments showed accordingly, that the effect of our treatment of the v. d. Crone solution was the strongest, by heating twice, during 1 hour to 137° C. This effect should be once more examined with *Sinapis alba* in the solutions, treated 1×137 and 2×137. For several reasons we resolved, to examine at the same time, how experimental plants would behave in 2×137 heated distilled water with an addition afterwards of nutrient salts. Also we wished to know, if, in case such a solution would be once more exposed to 2×137° C, this would make any difference to the cultures in comparison with plants in nutrient solutions, treated in the usual way.

The experiment consisted of 3 parallel rows and was arranged as follows:

v. d. Crone normal – v. d. Crone 1×137 – v. d. Crone 2×137

2×137 H_2O+ v. d. Crone salts – (2×137 H_2O+ v. d. Crone salts) 2×137.

In the usual manner 3 germs of *Sinapis alba* were put into the VVs, filled with the above mentioned solutions.

In the course of the experiment we observed the following.

On 19th V–1939 we found in the cultures Crone normal and the 2 × 137 H_2O + Cr. s roots and shoots nearly equally developed. Especially the main roots of these cultures were proportionally long and ramified at the top. Then followed the (2×137 H20+Cr s) 2×137 cultures and at last the v. d. Crone 2×137 with a main root nearly ramified all over and short lateral roots. In the v. d. Crone 1×137 the roots were short, but showed many swellings of the lateral roots and a tendency to turn yellow. Apart from this, we noticed in these cultures small and dark green cotyledons. Otherwise in all series and rows the unfolding of the leaves took place.

The examination of the cultures on 1st VI–1939 showed with relation to the shoot system a further development of the leaves in all the rows. But in the v. d. Crone 1×137 we only noted two pairs of leaves, while in the other cultures the 3rd pair was already rather developed. In regard to the height of the shoots and the size of the leaves the v. d. Crone 1×137 cultures were backward, but they were attracting attention, though less than before by their dark green colour. The cultures 2×137 H_2O+ Cr s and the cultures (2×137 H_2O+ Cr s) 2×137 were about equal. Both the series were well developed. There was hardly any difference betwen the v. d. Crone-normal and Crone 2×137. With relation to the root system the measurements gave the following results.

Table 82

Average length of roots in per cent. In unfervorized solution = 100%.

	1×137	2×137	2×137 H_2O+Cr. S	(2×137 H_2O+Cr. S) 2×173
Length of roots	19,66	81,36	182,03	155,93

As we saw, the v. d. Crone 1×137 was the most backward with relation to the root system.

Buds, which we noted here and there on 2nd VI–1939, were found in all cultures on 10th VI–1939. The 2×137 H_2O+ Cr s and the (2×137 H_2O+ Cr s) 2×137 were also noticeable by their luxurious root and shoot sytem. (Plate XV 1). The 1st row was broken up, to work out the results.

Table 83

Results of the measurements of row I in per cent. In unfervorized solution = 100 %.

	1×137	2×137	2×137 H_2O+Cr. S	(2×137 H_2O+Cr. S) 2×173
Aver. height of shoots	65,81	139,89	133,16	113,99
Fresh weight of shoots	33,65	102,65	125,46	113,99
Dry weight of shoots	27,93	93,09	100,00	110,21
Dry weight of roots	3,00	5,11	14,11	12,01
Total dry weight	15,46	49.09	57.57	61,11

Though the cultures in the fervorized nutrient solutions according to their habitus looked considerably better than the normal cultures. the measurements had as result, that with relation to the root dry weight and the total dry weight these cultures kept behind the normal cultures, even when they, with relation to the fresh and dry weight of the shoots, reached or surpassed the normal cultures. The results of the v. d. Crone 1×137 showed, that these cultures were in no respect equal to normal cultures, because all the figures were below those of the normal cultures.

On 16th VI–1939 inflorescences were noted in the 2nd row of the 2×137 H_2O+Cr. s. (Plate XV 2). On 21st VI–1939 all vessels were filled up with the appropriate water. On 4th VII–1939 the 2nd and the 3rd row were broken up, in order to work out the results.

From the morphological examination in the normal cultures we noted strong hairy shoots, many shoots of about 15 cm, but also many dried up undeveloped flowers. (Plate XVI 1) The v. d. Crone 1×137 cultures showed well developed shoots with inflorescences, which had partly formed siliquae. At the base of the shoots we noted spots of anthocyan. The v. d. Crone 2×137 showed a normal colour of the leaves, well developed shoots and a rich disposition of flowers and sigiquae. The shoots of the 2×137 H_2O+ Cr s cultures were thin and had formations of anthocyan at the bases. Flowers and fruits were normally developed and the leaf colour showed a darker nuance than those of the v. d. Crone 2×137 cultures. In the (2×137 H_2O+Cr s) 2×137 cultures were thick shoots with large leaves. The flowers and fruits were very well developed. Especially in the 3rd row the abundant forming of fruit was striking. (Plate XVI 2)

Before we give the results, we want first to say something in general, that both the experimental rows showed, with regard to the yield, considerable, at least essential differences. These differences may be partly traced back to the fact, that the 2nd row was in the shade of row nr 1 and nr 3, but otherwise, that in the beginning in the normal cultures one plant was taken away on account of damage, so that the two plants, which stayed, had of course much more nutrient-solution to their dis-

posal than the normal cultures of the row nr 3, which consisted of 3 plants like all other series of these two experimental rows. Therefore perhaps the results of the crop in the normal cultures were too high. As all values were calculated in % of the normal cultures, this flattered figure depreciated the values of the yield of the other series. That is why we prefer, to put down the values of the yield of the two rows separately and refrain from giving a survey of the rows nr 2 and nr 3 combined.

Table 84

Results of the measurements of the rows II and III in per cent. In unfervorized solution = 100%.

Experimental Row II.	1×137	2×137	2×137 H_2O+Cr. S	(2×137 H_2O+Cr. S) 2×137
Aver. height of shoots	190,71	211,82	183,97	194,10
Fresh weight of shoots	91,45	105,48	75,34	104,38
Dry weight of shoots	89,79	116,49	84,89	108,83
Dry weight of roots	82,00	73, 33	82,00	93,33
Total dry weight	88.94	111,78	84,58	107,13
Experimental Row III.				
Aver. height of shoots	383,87	423,14	387,41	430,26
Fresh weight of shoots	119,95	172,55	118,14	201,12
Dry weight of shoots	128,04	186,38	149,59	321,39
Dry weight of roots	113,69	132,93	109,59	250,68
Total dry weight	126,52	180,72	145,30	213,91

VIth experiment.

24/V–17/VII/1939.

Obj. *Fagopyrum esculentum.*

Referring to the already treated water-culture experiments, we carried on with our further researches in two directions. First we wished to examine the effect of the treatment of the v. d. Crone solution on several plants, but in the second place a further investigation of the important question, viz, if, the distilled water would be fervorized alone adding the v. d. Crone nutrient salts afterwards, this would already produce a change in the development of the plants in comparison with the normal v. d. Crone nutrient solution.

On account of lack of space and as we were rather convinced, that the 2×137 treatment was the most favorable, we limited our scheme of research.

As usual 3 germinated *Fagopyrum esculentum* plants (seed farm Bot. Garden, Zagreb) were put into the Vvs, filled with the nutrient-solutions. The experiment consisted of 3 parallel rows, treated as follows:

v. d. Crone normal – v. d. Crone 2×137 – 2×137 H_2O+ Cr salts.

The last substrata was prepared as follows. Distilled water was usually fervorized twice, each time for 1 hour in the autoclave at 137° C under a pressure of 2½ atm. Then it cooled down to the temperature of the room. After this the appropriate quantity of the v. d. Crone nutrient salts were added. The solution was prepared for each culture vessel separately, to avoid errors, like an unequal distribution of the difficult soluble salts.

In the course of the experiment we stated the following.

Table 85

Average height of shoots in per cent.

Experimental Row I, II and III.	Normal	2×137	2×137 H_2O+Cr. S
Height of shoots	100,00	94,65	96,26

On 1st VI–1939 all cultures showed leaf buds. With regard to the height of the shoots important differences were not noticed. (Plate XVII 1)

As we wished to be informed as exactly as possible about the values of the single cultures in their early phases of development, the experimental row nr 1 was broken up on 15th VI–1939, having lasted only for 3 weeks. The plants were analized, giving the following results.

Table 86

Results of the measurements of row I in per cent.

Experimental Row I.	Normal	2×137	2×137 H_2O+Cr. S
Aver. height of shoots	100,00	101,15	92,31
Aver. length of roots	100,00	76,09	104,35
Fresh weight of shoots	100,00	82,71	80,15
Dry weight of shoots	100,00	76,63	82,93
Dry weight of roots	100,00	85,71	77,14
Total dry weight	100,00	77.92	82,08

As we can see, at this time the 2×137 and the 2×137 H_2O+ Cr s cultures had generally not surpassed the normal cultures. Only with regard to the height of the shoots we found a little higher figure in the 2×137 cultures. The same took place with regard to the length of the

roots in the 2×137 H_2O + Cr s cultures. But if we take into consideration, that on 1st VI–1939 the 2×137 cultures were with regard to the height of the shoots below normal, we may conclude, that in 10 days the plants recovered remarkably.

Table 87

Height of shoots in per cent.

Experimental Row II and III.	Normal	2×137	2×137 H_2O+Cr. S
Height of shoots	100,00	119,42	118,45

In connection with this, we have here also given the values of the height of the shoots of the other 2 rows, which were likewise determinated on 15th VI–1939. As we can see, also these experimental rows gave higher values for the height of the shoots in the 2×137 cultures than those in the normal cultures, and different from the results of the row nr 1 the 2×137 H_2O+ Cr s showed also higher values than the normal cultures with regard to the height of shoots.

On 21st VI–1939 all cultures were filled up with the appropriate water. On 30th VI–1939 the withering of the points of the shoots and the rolling up of the leaves began in the normal cultures. This resulted in the 2×137 H_2O+ Cr s cultures, with the exception of one plant, which cultures we noticed a great consumption of liquid, making it necessary on 4th VII–1939, to fill up again the vessels with the resp. treated water. On 14th VII–1939 in the normal cultures we noted a gradual dying of the plants, starting from the top. The 2×137 on the contrary showed richly flowering and fructiferous plants. The same took place in the 2×137 H_2O+Cr. s cultures, with the exception of one plant, which was withering. (Plate XVII 2) On 17th VII–1939 the experiment was broken up. The plants were carefully examined, described and prepared for further determinations. The results of the two rows were totalized, because except the one mentioned plant in the 3rd row of the 2×137 H_2O+Cr. s cultures both rows were almost the same.

Shoot system. Concerning the shoot system, we noted in the normal cultures, that the withering and dying, which began already on 30th VI–1939 and the symptoms of illness at the top part of the main shoot of the experimental plants were still in progress. We also observed the beginning of the development of lateral shoots. In spite of this fact most of the leaves were rolling up and withered. Most of the flowers were dried up too and of the scanty fruits only few were normally developed, the others were dried up. The 2×137 cultures on the contrary showed strong plants with well developed and sappy green leaves, numerous flowers and rich fruits. The formation of the lateral shoots

was by far more developed than in the normal cultures and healthy and well developed lateral shoots were noted, which were 23 and 37 cm long. Also the 2×137 H_2O+Cr. s cultures consisted, with the exception of one withering plant, generally in well developed plants, the foliage of which was quantitative and qualitative similar to the 2×137 cultures. The forming of lateral shoots had also taken place here, but the reached length was only 17 cm. It was remarkable, that the flowers in the contrary to the 2×137 cultures were nearly all to be found at the top of the plants and that the fruits had not yet reached the mature stadium.

Root system. Concerning the root system, we noted, that its length was rather variable, but it seemed to us, that the root system of the normal cultures was the weakest developed.

Table 88

Results of the measurements of the experimental rows II and III in per cent.

Experimental Rows II and III.	Normal	2×137	2×137 H_2O+Cr. S
Aver. height of shoots	100,00	*217,11*	179,21
Aver. length of roots	100,00	*121,84*	77,01
Fresh weight of shoots	100,00	*156,20*	138,02
Dry weight of shoots	100,00	*160,64*	150,69
Dry weight of roots	100,00	*347,22*	336,11
Total dry weight	100,00	*170,39*	160,38

Here we give the results of the measurements. With regard to the working out of the experimental rows nr 2 and nr 3 and the comparison of their results, with the results of the former measurements and with the results of the experimental row nr 1, which was broken up about a month earlier, we will mention the following. Limiting ourselves first to the values of the shoot system on 15th VI–1939 and on 17th VI–1939 we note, that the highest value was this time shown by the 2×137 cultures, but that the value of the 2×137 H_2O+Cr s also surpassed those of the normal cultures. Indeed, this follows consequently from the results of the measurements on 15th VI–1939 and shoows at the same time, that the difference of these cultures with the normal cultures in this period of a month had considerably increased. The proportions of the cutures were on 15th VI–1939 1 : 1, 2 : 1,2 and later on 17th VII–1939 1 : 2, 1 : 1,7.

Though in the 2×137 H_2O+Cr s cultures a much more intensive growth of the height of the shoots took place, compared with the normal cultures, they were considerably surpassed by the 2×137 cultures. As the length of the roots was, as we mentioned, rather variable, we do not take then any more in consideration and turn to the far more important results of the production of the plant substance and compared

with the resp. figures on 15th VI and 17th VII–1939. The results with relation to the shoot fresh weight of the 1st experimental row on 15 VI–1939 show, that the normal cultures were here the most successful. But the results on 17th VII–1939 of the 2nd and 3rd row were quite similar and the normal cultures showed the smallest values. Also the total dry weight of the shoots and roots of the normal cultures in the 2 nd and 3rd row were not the highest any more, but showed on the contrary the smallest values. The highest value we found in the 2×137 cultures, and the 2×137 H_2O+Cr s stayed only 10% behind the 2×137 cultures. The proportions of these cultures were on

15th V –1939=1 : 0, 8 : 0,7
17th VII–1939=1 : 3, 4 : 3,3!

Concerning the typical behavior of the 2×137 H20+Cr s, we must first refer to the in this experiment stated weaker growth and as it seems the later maturity, compared with the 2×137 cultures. We will return to the fact, that as the *Fagopyrum* experiment shows the appertaining time 1 hour) heated distilled water with the addition of the appertaining quantity of nutrient salts made a substrata, by the help of which it was posible, to increase the yield. Anyhow we must be aware of the special signification of this fact.

VIIth Experiment.

23/VI–6/X/1939.

Obj. *Tagetes erecta.*

In connection with the *Fagopyrum esculentum* experiment an analogical experiment with *Tagetes erecta* was arranged. The seeds (seed from Bot. Garden, Zagreb) were treated as usual and 3 seeds were put into each Vv. The experiment consisted of nutrient-solutions, treated as follows:
v. d. Crone normal – v. d. Crone 2×137 – 2×137 H_2O+v. d. Crones salts.

In the course of this experiment we noted.

On 7th VII–1939 the height of the shoots and the length of the roots were measured. We noted the following values.

Table 89

Results of the measurements of the height of shoots and the length of roots in per cent.

	Normal	2×137	2×137 H_2O+Cr. S
Aver. height of shoots	100,00	91,25	77,50
Aver length of roots	100,00	88,88	96,29

Very remarkable was the difference in colour of the single experimental rows. While the colour of shoots and leaves of the normal cultures was on the average green, the colour of the 2×137 cultures was lighter. The 2×137 H_2O+Cr s on the contrary were of an intensive dark green. (Plate XVIII 1). On 20th VII–1939 we repeated the measurements, which gave the following figures.

Table 90

Results of the measurements of the height of shoots and the length of roots in per cent.

	Normal	2×137	2×137 H_2O+Cr. S
Aver. height of shoots	100,00	126,31	93,16
Aver length of roots	100,00	194,74	147,46

As we saw, the growth of the plants during these 13 days increased considerably in the treated nutrient-solutions. While the 2×137 cultures surpassed the normal cultures with regard to the height of the shoots (26%) and with regard to the length of the roots (94%), the 2×137 H_2O+Cr s cultures only stayed behind with regard to the height of the shoots (7%), but the length of the roots was (47%) higher than in the normal cultures.

On 21st VII–1939 2×137 fervorized water was given to all the cultures and by error also to the normal cultures. Remarkable was the behaviour of the cotyledons. They distinctly started withering in all the cultures except in the 2×137 cultures, where they were still relatively fresh. From one plant in the normal cultures the lower leaves were turning yellow, resp. withered. On 24th VII–1939 again water was given, but now the normal cultures received only the prescribed distilled water. In the further course of the experiment all young beaves of the 2×137 and the 2×137 H_2O%Cr s cultures took to a deep green colour, but we must note, that the leaves of these cultures were partly rolled up resp. rumpled. The shoots of the normal cultures looked stagnated. On 1st VIII–1939 we added again water to the cultures. After the passing stagnation of the normal cultures we observed on 3rd VIII–1939 a striking increase of the growth. As the need of water went up constantly, perhaps as a result of the high temperature of the air, we had to add water again on 11th VIII–1939. On 19th VIII–1939 new measurements of the shoots and roots were taken, the results of which will be found in the following table.

Table 91

Results of the measurements of the height of shoots and the length of roots in per cent.

	Normal	2×137	2×137 H_2O+Cr. S
Aver. height of shoots	100,00	195,28	152,19
Aver length of roots	100,00	97,72	72,72

As we saw, a further shifting of the figures for the height of shoots and the length of roots took place. Concerning the height of the shoots, the normal cultures were the least, but with regard to the length of the roots the most advanced of the cultures. (Plate XVIII 2). With regard to the error made on 2ist VIII–1939 (addition of fervorized water) a certain reservation is neccessary in judging the values of the normal cultures.

On 25th VIII–1939 also in the other experimental rows the lower leaves began to wither. On 5th IX–1939 all cultures received water again. The intensity of growth in the normal cultures became remarkably smaller. On 19th IX–1939 the 2×137 and the normal cultures showed flower buds, which were, however, considerable better developed in the 2×137 cultures. On 24th IX–1939 we noted, that most of the leaves in the normal cultures showed strong colorations of anthocyan. On 1st X–1939 these leaves showed signs of dying off. At the same time the flower buds became visible in the 2×137 H_2O+ Cr s. On 6th X–1939 the experiment was broken up, to prepare for the measurements. The morphological examination showed the following differences i the habitus of the plants. In the normal cultures the main shoots were at 2 places stagnated and showed beneath these places remarkable swelings. The plants had lateral shoots, btu in the top of the shoots the scanty buds were stagnated. The shoots showed a beginning of warts and with relation to the foliage the lowest and the youngest leaves were withered and the other leaves contained much anthocyan. The 2×137 cultures showed a strong development of warts, a fully and strongly developed foliage of a fresh green colour. They were flowering and had numerous buds also on the lateral shoots. These platns were not only striking by their splendid development but developed than the plants in the normal cultures and had buds everyalso on account of their production of a strong odour. The 2×137 H_2O+Cr s cultures were represented by plants, which were not so strong as those in the 2×137 cultures, but all the same they were better where. The shoots were slightly suffering from warts. The colour of the leaves was light green.

Table 92

Results of the measurements in per cent.

	Normal	2×137	2×137 H_2O+Cr. S
Height of shoots	100,00	*231,75*	205,00
Length of roots	100,00	*111,76*	86,27
Fresh weight of shoots	100,00	*128,45*	122,66
Dry weight of shoots	100,00	129,12	*131,23*
Dry weight of roots	100,00	146,03	*150,16*
Total dry weight	100,00	131,39	*133,31*

These were the results of the measurements. In the 2×137 H_2O+Cr s cultures of *Tagetes erecta* we obtained a still better result than in the same with *Fagopyrum esculentum*, which is to say, that with the exception of the growth, these cultures surpassed with relation to the total dry weight and the dry weight of the shoots and the roots separately not only the normal cultures, but were even equivalent to the 2×137 cultures. As we did not dispose of a sufficient number of cultures to persue during the course of the experiment the variations in the production of the plant substance, we only manifested the change in the proportions of the height of the shoots.

	Normal	2×137	2×137 H_2O+Cr. s
On 7th VII–1939 we noted the proportion	1	: 0,9	: 0,7
„ 20th VII–1939 „ „ „ „	1	: 1,2	: 0,9
„ 19th VIII–1939 „ „ „ „	1	: 1,9	: 1,5
„ 6th X–1939 „ „ „ „	1	: 2,3	: 2,0

The conclusion, that the intensity of the growth in the normal cultures during the experiment decreased in opposition to the gradual increase of the growth in the 2×137 and 2×137 H_2O+Cr. s cultures, became already evident from the *Fagopyrum esculentum* and the *Tagetes erecta* experiments, but it should be affirmed again by an other experiment.

VIIIth Experiment.

25/VIII–6/XI/1939.

Obj. *Tagetes erecta.*

On account of the mentioned error in the former experiment (adding fervorized water to the normal cultures) a rehearsel of the *Tagetes* experiment was desiderable. A new experiment was arranged on 25th VIII–1939. But the same considerations, which had led us to arrange the *Fagopyrum* experiment, to examine one of the nutrient-solutions, consisting of fervorized water with the addition of the v. d. Crone nutrient salts (2×137 H_2O+Cr s) led us consequently to the intended variation of this experiment, which we will describe here. The following nutrient substrata were prepared.

1. v. d. Crone normal. (To the measured quantity of distilled water we added one after the other the prescribed nutrient salts. *Normal.*

2. v. d. Crone twice, during 1 hour fervorized at 137° C under a pressure of 2 1/2 atm. *2×137.*

3. The nutrient salts in the Schott's glasses were fervorized twice for 1 hour at 137° C under a pressure of 2 1/2 atm. After this we added the usual quantity of the usual distilled water. *2×137 Cr s+H_2O.*

4. The nutrient salts in the Schott's glasses were fervorized for 1 hour at 137° C under a pressure of 2 1/2 atm. Then we added the distilled water, which was also fervorized twice for 1 hour at 137° C under a pressure of 2 1/2 atm. *2×137 Cr s+2×137 H_2O.*

5. The usual quantity of water fervorized twice for 1 hour at 137° C under a pressure 2 1/2 atm. To this we added one after the other the weighed out salts of the v. d. Crone solution. 2×137 H_2O+Cr. s.

6. To the nutrient salts of v. d. Crone, weighed out as usual, one ofter the other we added the distilled water. *Cr s+H_2O.*

7. First the nutrient salts of v. d. Crone were weighed out one after the other as prescribed, and afterwards the twice for 1 hour at 137° C under a pressure of 2 1/2 atm. fervorized water, was put to it.

Cr s+2×137 H_2O.

We observed the following: The crust of fervorized salts, 2×137 Cr s at the bottom of the Schot's glasses stayed practically unaltered, when shaken with the prescribed quantity of distilled water, whereas in case we used fervorized water, 2×137 H_2O, instead, the fervorized salts desintegrated immediately. Fervorizing the Crone salts for the first time. condensed water got into one of the Schott's glasses of the 3rd experimental row and covered the whole bottom of the glass.

From the prepared nutrient solutions 3 parallel rows were arranged. Into the VVs of the row nr 1 and nr 2, 3 germs and into the row nr 3, 4 germs were put. This took place on 25th VIII–1939.

Already on 30th VIII–1939 we could observe in all the cultures the appearing of the first leaves, as well the forming of lateral roots. On 4th IX–1939 we noted the beginning of the second pair of leaves. On 5th IX–1939 a weak chlorosis was observed in some leaves of the 2×137 Cr s+H_2O cultures. On 10th IX–1939 it had nearly disappeared. On 15th IX–1939 in all the 3 rows of the 2×137 Cr s+2×137 H_2O cultures damage of the leaves was observed. Comparing the plants on 20th IX–1939 with each other showed, that the shoots of the normal 2×137 and the 2×137 Cr s+H_2O cultures were green, those of the 2×137 Cr s+2×137 H_2O and the 2×137 H_2O+ Cr s cultures became reddish up to the cotyledons, while in the Cr s H_2O cultures as well as in the Cr s+2×137H_2O cultures the 2nd internode was turning red. On 1st X–1939 in all cultures, excepted the 2×137 Cr s+H_2O cultures and the 2×137 Cr s+2137 H_2O cultures, we noted the forming of anthocyan on the shots. On 10th X–1939 the points of the leaves were

also becoming a little red, in the first and second row of the Cr s+H_2O cultures. The 3rd vessel of the series 2×137 Cr s+H_2O showed brown leaf points. In this vessel we used the solution of the Schott's glass, into which the condensed water entered during the first fervorization. One plant of the 2×137 Cr s+2×137 H_2O culture showed a weak chlorosis at the top of the shoot. All cultures received additional water, and the 3 row was reduced to 3 plants in each vessel. The height of the shoots and the length of the roots were measured.

Table 93

Height of shoots and length of roots in per cent. In unfervorized solution = 100%.

	2×137	(Cr. S) 2×137 + H_2O	(Cr. S) 2×137 +(H_2O) 2×137	(H_2O) 2×137 +Cr. S	Cr. S. + H_2O	Cr. S. (H_2O) 2×137
Height of shoots	*166,66*	131,37	127,45	150,98	95,42	138,56
Length of roots	109,00	106,66	109,00	117.66	87.66	*123,33*

As this table shows, all cultures in nutrient-solutions, which had been exposed to whole or partial fervorization (H_2O or Cr. s) showed with relation to the height of shoots higher values than the not fervorized nutrient-solutions. Also, though in less degree, this was the case with relation to the length of the roots. (Plate XIX-1).

On 11th X–1939 the withering of the cotyledons was observed and of one plant in the normal culture we noted the withering of the lower leaves as well. Comparing the root system of the cultures on 16th X–1939 we noticed certain differences. The normal cultures showed in the upper part no lateral roots. Also the Cr s+H_2O cultures, which generaly showed a badly developed root system with brown root points as well as the 2×137 Cr s+2×137 H_2O had in the upper part of the main roots hardly any lateral roots. The 2×137 H_2O+Cr s cultures showed in this part only few lateral roots. On the other hand in the 2×137, 2×137 Cr s+H_2O and Cr s+2×137 H_2O cultures they were at this spot well developed. On 20th X–1939 all cultures received water. Except the normal and the Cr s+H_2O cultures, all the plants in the vessels showed buds. An examination of the plants on 25th X–1939 showed, that in the normal cultures the points of the main roots were brown black and swollen to about 2 cm., while the shoot system showed hard leaves and stagnated shoot tops. In the Cr s+H_2O cultures we met equal condition. The main root was brown and thick, the lateral roots were thickened at their points the shoot tops stagnated and the leaves hard, while in all the other cultures the leaves were soft and weak. Other cultures showed a brown coloured root system, except the 2×137 and the 2×137 Cr s+2×137 H_2O cultures. The 2×137 H_2O+Cr s cultures had beaufully developed

roots, but they showed brown points. Also in the Cr s+2×137 H_2O the points of the main roots were brown. In the 2×137 Cr s+H_2O cultures new roots were formed but some of them were brown and thick. In the 2×137 cultures we noticed again the appearance of warts on the base of the shoots. (Plate XIX-2). On 28th X–1939 all cultures received water. On 6th XI–1939 the whole experiment was broken up. Two specimen of the normal, 2×137 and 2×137 H_2O+Cr s were pressed for the herbarium. The rest of the plants we prepared for further examinations.

The morphological determination gave the following result.

Shoot system. Concerning the shoot system, we found, that the 2×137, 2×137 Cr s+H_2O and the Cr s+2×137 H_2O cultures showed strongly developed plants with flowers and buds. (Plate XX). The plants of the 2×137 H_2O+Cr s cultures had also flower buds, but the long stretched internodes reminded us of etiolated plants. The shoots of the 2×137 Cr s 2×137 H_2O plants had numerous buds, but they were often more delicate than strong. In the normal and the Cr s+H_2O cultures the stagnated main shoot and the relativelz short lateral shoots were remarkable. Besides, here were no buds, which we had found in all the other cultures.

Root system. As to the root system we must mention in the first place the plants of the 2×137 Cr s+2×137 H_2O cultures, but we also observed a strongly and richly ramified root system in the 2×137, 2×137 H_2O+Cr s as well as in the Cr s+2×137 H_2O cultures. In the last mentioned cultures the roots were indeed brown, but without any disease symptoms. The normal and the Cr s+H_2O cultures had brown (especially in the older parts), but generally badly developed roots.

The following table gives the results of the measurements.

Table 94

Result of the measurement in per cent. In unfervorized nutrient-solution = 100%.

Experimental Row I.	2×137	(Cr. S) 2×137 +H_2O	(Cr. S) 2×137 +(H_2O) 2×137	(H_2O) 2×137 +Cr. S.	Cr. S. +H_2O	Cr. S. (H_2O) 2×137
Height of shoots	*310,00*	301,78	247,00	246,47	91,17	205,88
Length of roots	161,11	155,55	138,89	94,44	94,44	*175,00*
Fresh weight of shoots	*232,28*	203,46	138,80	229,02	77,82	179,18
Dry weight of shoots	208,17	190,61	132,56	*220,73*	79,26	157,63
Dry weight of roots	405,00	521,66	471,66	383,33	108,33	*550,00*
Total dry weight	221,59	210,91	155,68	231,82	81,25	184,43
Experimental Row II.						
Height of shoots	267,76	161,20	154,64	*309,83*	98,34	271,58
Length of roots	135,13	118,92	129,73	129,73	59,45	*140,54*
Fresh weight of shoots	187,92	112,44	116,39	*260,54*	110,62	257,05
Dry weight of shoots	191,23	*350,62*	118,52	237,41	120,99	102,47
Dry weight of roots	241,38	*728,44*	275,86	291,38	38,79	118,10
Total dry weight	198,70	*397,95*	138,22	244,06	110,79	104,42
Experimental Row III.						
Height of shoots	*315,33*	111,33	258,00	249,33	103,33	284,66
Length of roots	114,29	80,00	94,29	*142,86*	100,00	*142,86*
Fresh weight of shoots	*276,39*	112,43	171,40	233,01	102,53	246,58
Dry weight of shoots	*236,98*	98,88	163,49	206,35	107,94	223,33
Dry weight of roots	*926,00*	260,00	566,00	620,00	140,00	759,00
Total dry weight	*287,65*	113,68	193,53	236,76	110,29	262,35

If, as a result of this table, within a single experimental row of the 3 rows we found many variations, but we found also in all the cultures of the following nutrient-substrata –

1. fervorized v. d. Crone nutrient-solution,

2. distilled fervorized water with addition of the v. d. Crone nutrient salts,

3. fervorized nutrient salts with addition of distilled water,and

4. fervorized v. d. Crone nutrient salts with addition of distilled fervorized water, – an increase of all the values in the v. d. Crone solutions cultures in opposition to the normal cultures.

Summary of the water-cultures.

1. By fervorizing the v. d. Crone nutrient-solution to 137° C in an autoclave at a pressure of 2 1/2 atm., we obtained a distinct fervoreffect with Vicia Faba, Sinapis alba, Solanum lycopersicum, Fagopyrum esculentum and Tagetes erecta.

2. The fervoreffect in soil cultures and in v. d. Crone nutrient-solutions proved to be the same.

3. The time of fervorization and the height of the temperature proved to be important. The strongest fervoreffect was reached at a temperature of 137° C by heating twice for 1 hour, under a pressure of 2 1/2 atm.

4. To produce the fervoreffect, the fervorization of the water alone, to which the v. d. Crone salts were added afterwards, was already sufficient.

GENERAL SUMMARY

We are now at the end of our treatise. From the results of our experiments many questions have arisen, impossible to answer for the time being. In the following some of them we will only just touch. In any case Radermacher and Klas (19) believe, that a new line of investigations has been established. As a matter of fact there exists already an extensive literature on the benefit of heating of soils– the so- called soil sterilization– and the results of those investigations have already been put into practise. We state, however, that the cause of the amelioration of the soil was not clear hitherto. It has been shown by our experiment with nutrient-solutions, that this amelioration is not merely the result of sterilization, but also of general changes in the state of the nutrient subtratum, caused by heating. To bring this effect to the fore we proposed the term »fervorization«.

Heat sterilization is neither equivalent to chemical sterilization nor to sterilization by freezing. The results of the micro-biological cultures in moist soil sterilized by heat must be judged with caution, for they include not only the normal growth of the cultures but also the growth influenced by fervorization. Therefore it seems important to compare cultures on substrata, sterilized by chemicals, by freezing and by heat.

We are quite alive to the fact that the investigations which we have described must be supplemented in many ways. Nutrient substrata and salts will have to be examined on their behaviour in connection with a far greater variety of plants.

Abowe all it will be neccessary to throw more light upon the changes caused by the fervorization of water. We consider the investigation of this problem a task for chemists and physicists, *whereas for* physiologists *it is of interest to examine whether fervorized water exercises influence on other phenomena of life.*

Finally, it should be remembered that fervorization possibly takes place under natural circumstances. The great fertility of the otherwise poor soil in the tropics may be partly due to the fervorization of the soil caused by the radiation of rays by the sun. There may be similar conditions in other climates.

O UTJECAJU FERVORIZACIJE HRANJIVIH SUPSTRATA NA RAZVOJ BILJAKA

U povijesti studija problema zagrijevanja tala ima, kao i u povijesti mnogih drugih naučnih problema, karakterističnih faza. Doba najživljeg interesa i najintenzivnije obrade izmjenjuje se s doba, kada se čini, da je interes za taj problem gotovo potpuno nestao, da iza nekog vremena, pobuđen najraznoličnijim motivima, ponovo oživi. U takvoj fazi stagnacije istraživanja i istraživalačkog interesa za taj problem, zatekli smo se i mi. Činilo se, kao da je naučni svijet, barem koliko smo mi to mogli pratiti, sumnjajući u mogućnost uspješnog daljeg prodiranja u problem zagrijevanja tala, napustio i svaki interes za nj. No u isto vrijeme trgovačko je vrtlarstvo prisvojilo metodu parcijalne sterilizacije tala i već je u Engleskoj i Americi izgrađivana aparatura, koja bi uvođenje ove metodu u vrtlarsku praksu ne samo omogućila, nego učinila i rentabilnom. Mislimo, da ni jedno ni drugo nije dovoljno opravdano. S jedne strane je već mnoga preuranjena primjena još nedovoljno ili samo jednostrano analiziranih i utvrđenih rezultata laboratorijskih pokusa dovela u praksi do teških i suvišnih razočaranja, a s druge strane, valja istaći, da su izvršena naučna istraživanja, iako nisu dala definitivno i jednoznačno objašnjenje djelovanja zagrijevanja tala na biljno rastenje, ipak utvrdila mnoge pojedinačne činjenice i time dala vrijedne priloge za rješenje problema. Put za dalja istraživanja nije bio zatvoren, samo mu se u mnoštvu suvišne rano postavljenih hipoteza izgubio trag, a time i uporište za dalje analize.

Ako pregledamo rezultate dosadašnjih istraživanja, onda ćemo prije svega naići na konstataciju, u kojoj se svi istraživači slažu, naime da obrađivanje tala zagrijevanjem izaziva u njima promjene, koje utječu na rast biljaka. Teoretski promatrano, te promjene mogle bi se odnositi ili na sva, ili samo na neka svojstva tala. Za biljno rastenje najvažnija su kemijska, fizikalna i mikrobiološka svojstva tala. Na ta svojstva usmjerena analiza dala je ove rezultate:

1. K e m i j s k a s v o j s t v a. Istraživači se slažu u tome, da obradom tala zagrijevanjem u njima dolazi do nekih procesa rastvaranja (Aufschliessung), naročito fosfornih i dušičnih spojeva. Kako je utvrđeno, da je sveukupna množina dušika u zagrijevanjem obrađenoj i neobrađenoj zemlji jednaka (Richter), a u ekstraktima tala obrađenih zagrijevanjem konstatirana je znatno viša vrijednost u vodi topljivih dušikovih spojeva, a i u suhoj supstanciji biljaka, kultiviranih u zagri-

jevanjem obrađenim tlima, veća sadržina dušika, to je postavljeno tumačenje, da zagrijevanjem tala dolazi do prevođenja dušika tla iz netopljivog, odnosno teško topljivog oblika u lako topljivi i zbog toga biljkama pristupačniji oblik. Taj proces zahvaća i organsku supstanciju i vodi do nastajanja kiselih produkata rastvaranja humusa (Märcker), kojih se djelovanje može ublažiti, odnosno isključiti dodavanjem kalcija. Množina nastajanja ovih produkata rastvaranja, koje se u literaturi označuje kao »otrovne tvari«, zavisi od vrste tala: najnepovoljnije je livadno tlo, zatim oranično tlo, a najpovoljnije je vrtno tlo (Schulze).

2. Fizikalna svojstva, odnosno njihove promjene, nisu u tolikoj mjeri istraživana. Richter je našao promjene s obzirom na poroznost (otežano primanje vode) i promjene volumne težine. Inače se kao poznata činjenica pretpostavlja, da zagrijevanje koloide tla prevodi u gel-stanja (Czermak).

3. Mikrobiološka svojstva. Upravo s obzirom na ova svojstva tla uveden je pojam i termin »parcijalna sterilizacija«. Time se hoće naglasiti, da obrađivanje tala zagrijevanjem u nekim temperaturnim granicama ne dovodi do uništenja svakog mikroorganizmičkog života u njima, pa da se takvo tlo može samo djelomično smatrati kao sterilno. Postavljena je i teza, da obrađivanje tala zagrijevanjem uništava u njima eventualne uzročnike raznih oboljenja biljaka. U tome smislu, a na osnovu izvršenih pokusa, Russell i Petherbridge smatraju, da je obrađivanje tala zagrijevanjem upravo lijek za »bolesna« tla.

Što se konačno tiče samih biljaka u zagrijevanjem obrađenim tlima, to su svi istraživači – ukoliko su njihovi pokusi obuhvatili sve razvojne stadije biljaka – utvrdili, da najprije dolazi do depresije biljnog rastenja, iza koje nakon nekog vremena nastaje razvoj, koji je mnogo bujniji od razvoja kontrolnih biljaka u neobrađenim tlima. Istraživači ističu naročito bogati razvoj listova i izboja stabljika, kao i naročito intenzivno tamno zelenilo kultura u zagrijevanjem obrađenim tlima. Osim Merkenschlagera i Hiltnera, svi su ostali autori utvrdili, da se u suhoj tvari ovih kultura polučuje višak prema normalnim kulturama; taj višak zavisi od vrste biljaka i tala, od godišnjeg doba, u kome se pokus postavlja i t. d., a katkada iznosi i blizu 100%. Uz taj bujni vegetativni razvoj dolazi i do snažne i bogate floracije i fruktifikacije (Russell i Petherbridge).

Primjećeno je, da u prvoj razvojnoj fazi biljaka, kultiviranih u zagrijevanjem obrađenim tlima, dolazi uz spomenutu depresiju rastenja do nekih pojava bolesti, koje se očituju naročito na listovima u obliku karakterističnih mrlja, koje se od ruba lamine šire ka njenim ostalim dijelovima. Tu pojavu, analogno kao pojavu prvobitne depresije rastenja, nastojali su protumačiti djelovanjem nekih produkata rastvaranja, koji nastaju kod obrađivanja tala zagrijevanjem, a kojih bi koncentracija bila previsoka za mlade biljke.

Na te, u kratkim crtama izložene rezultate dotadašnjih istraživanja nadovezali smo naša istraživanja, koja smo izvršili god. 1938./39., a u vezi s pokusima prof. dr. V. Vouka, koji je pri svojim istraživanjima o utjecaju mrkog ugljena na rastenje biljaka sterilizirao tla i zapazio poznati stimulativni efekt sterilizacije tala. Naša su istraživanja bila usmjerena na analizu tog efekta, i to ne na dosada uobičajenu kemijsku, fizikalnu i mikrobiološku analizu steriliziranog tla, nego na fiziološku analizu čitave pojave, jer nam se na osnovu literature činilo. da je baš ta strana problema bila razmjerno zanemarena.

Pošto smo se upoznali s pojavom efekta sterilizacije tala- kako se on očituje u razvoju biljaka, stekli smo uvjerenje, da je u ovom slučaju primjenjivanje izraza »sterilizacija« ne samo neprikladno, nego da može dovesti i do nesporazuma, jer se efekt, kao što su to pokazale naročito naše kulture u vodi, nema svesti na djelovanje uništenja mikroorganizama u tlu zbog zagrijevanja, nego upravo na samo zagrijevanje tla. Zbog toga smo uveli pojam »fervorizacija«. Obrađivanje hranjivih supstrata zagrijevanjem, i to vlažnim zagrijevanjem (u autoklavu), nazivamo ovdje ne »sterilizacija«, nego »fervorizacija« (fervor, lat. = vrućom parom zagrijati). Fervorizacijom hranjivo tlo nesumnjivo mijenja svoja kemijska i fizikalna, a i mikrobiološka svojstva, t. j. mijenja se njegovo opće stanje. Tlo je, kako kažemo, u fervornom stanju. U čemu se ovo fervorno stanje u pojedinostima sastoji, to zasada – iako su ranija istraživanja dala vrijedne rezultate i uporišta za dalja produbljivanja – još ne znamo. Bolje nam je poznato djelovanje kojim to fervor-stanje tla djeluje na razvoj biljaka. To djelovanje u njegovoj cjelokupnosti nazivamo »fervor-efektom«.

Uvođenjem novih pojmova: fervorizacija, fervor-stanje, fervor-efekt – mislimo, da smo u čitav problem unijeli novo svijetlo, jer je njima isključena jedna komponenta starog pojma sterilizacije tla, naime oslobađanje hranjivih supstrata od klica mikroorganizama.

Fiziološka analiza, koju smo smatrali kao potrebnu, iziskivala je isključenje kompleksnih hranjivih supstrata, kao što je samo tlo, i uvođenje umjetnih, u kemijskom smislu poznatih hranjivih supstrata, t. j. provođenje pokusa primjenom metode kultura u hranjivim otopinama poznatog sastava. Analiza nam je potvrdila ispravnost i opravdanost ovako provedenih istraživanja: kod pokusnih biljaka kultiviranih u hranjivoj otopini fervor-efekt je bio još izrazitiji nego kod kultura u tlima.

Kod kultura u hranjivoj otopini dvije su osnovne komponente, na koje smo morali obratiti pažnju: voda i hranjive soli. Bilo je logično, da smo najprije ove obje komponente istražili s obzirom na fervorizaciju. Pokusi, u kojima smo fervorizirali samo destilovanu vodu, a hranjive soli dodali naknadno u fervoriziranu vodu, dali su neočekivan rezultat, da naime sama fervorizacija vode može da kod biljaka dovede do fervorefekta.

Fiziološka analiza fervor-efekta izoliranjem pojedinih osnovnih komponenata dala je, kako nam se čini, zanimljive rezultate, koje sada sa opisom svih pokusa (u engleskom tekstu) predajemo naučnoj javnosti

u punoj svijesti, da smo ovim pokusima još daleko od rješenja problema, i da smo njima zapravo samo otvorili novi put za dalje analize.

Kako su naša istraživanja o djelovanju zagrijevanja hranjivih supstrata biljaka obuhvaćala kako kulture u tlima, tako i kulture hranjivim otopinama, to su ona, naravno, iziskivala supstratima, a i cilju istraživanja primjerenu, specifičnu metodiku. Prije nego što je u općim crtama prikažemo, napominjemo, da su sva naša istraživanja izvršena u fiziološkom laboratoriju Botaničkog zavoda Sveučilišta u Zagrebu, i to većina u laboratorijskom stakleniku, a neka u jednom odjeljenju staklenika Botaničkog vrta.

a) Kulture u tlima

Za naše smo pokuse upotrebljavali dvije vrste tala, odnosno smjesa zemlje. Prva smjesa, koju u daljem tekstu označujemo kraticom G, sastojala se iz 1½ dijela komposta, 3 dijela listovke i 1½ dijela pijeska. To je uglavnom t. zv. vrtna zemlja. Druga smjesa, koju označujemo kraticom F – poljska zemlja – sastojala se iz 5 dijelova poljske zemlje i 1 dijela pijeska. Poljsku smo zemlju uzimali sa pokusnih polja Botaničkog vrta. To je prilično teška svijetlosivo-smeđa glina (Tonkleie). Nju smo najprije usitnili, a zatim prosijavali. Pijesak, koji smo dodavali objema smjesama zemlje, prethodno smo sa zagrebačkom vodovodnom vodom temeljito isprali, a ispran na zraku osušili. Svaku smo komponentu tala odmjerili napose i tek smo ih u laboratoriju u spomenutim omjerima smiješali. Pokusi su svaki put postavljeni sa svježim, na isti način priređenim i pomiješanim supstratnim materijalom.

Naprijed navedenim smjesama zemlje napunili smo odgovarajući, unaprijed određeni broj Mitscherlichovih pokusnih posuda. Svaka je varijacija u svakom pokusu bila zastupana sa najmanje 3 Mitscherlichove posude, odnosno 3 glinena lonca, koje smo prigodice također upotrebili. Zemljanim smjesama napunjene posude smještene su u autoklav i tu su određeno vrijeme izvrgavane djelovanju određene temperature i pritiska. Najčešće smo primjenjivali jednokratnu i dvokratnu fervorizaciju kod 137° C kroz 2½ atm. Kako smo u naš maleni autoklav mogli u isto vrijeme smjestiti samo 2 Mitscherlichove posude, a kako je usto trebalo gotovo 1 sat, dok se u autoklavu temperatura digla na 137° C i tlak na 2½ atm., to smo pokušali da, s obzirom na potrebne opsežne pokusne serije, smanjimo vrijeme i troškove fervorizacije, pa smo konstruirali posebne cinčane posude, koje su nam omogućile, da uz jednak utrošak topline i vremena fervoriziramo dvostruku količinu zemlje. Napominjemo, da smo se u posebno postavljenoj pokusnoj seriji osvjedočili o tome, da je za ishod pokusa irelevantno, da li se zemljana smjesa fervorizira napose u Mitscherlichovim posudama ili u našim cinčanim posudama.

Poteškoće zagrijevanja zemljanih smjesa na 70° C u autoklavu riješili smo primjenom metode vodene kupelji u otvorenom autoklavu. Radi toga smo autoklav do određene visine napunili destiliranom vodom. Na stalak u autoklavu postavili smo jednu od naših cinčanih posuda sa prorezom. U tu smo posudu postavili 6–7 Voukovih staklenih posuda za kulture u vodi, koje smo napunili određenom smjesom zemlje. Naravno da smo se pobrinuli za to, da voda autoklava nije mogla doći u te posude. Dva termometra učvrstili smo u plutene prstene: jedan od njih pokazivao nam je temperaturu vode između stijene autoklava i cinčane posude, a drugi temperaturu vode u samoj cinčanoj posudi. Osim toga metnuli smo po jedan termometar u svaku zemljanom smjesom napunjenu Voukovu posudu, i to u različne dubine, što nam je omogućavalo točnu kontrolu procesa zagrijevanja, a i njegovo reguliranje prema našim intencijama. Naravno, da je za to bila potrebna naročita pažnja, jer se nije radilo samo o tome, da se postigne određena temperatura, nego i o tome, da se ta temperatura održi 1 sat u približnoj konstanti.

Fervoriziranje kod 100° C izvršavali smo bez poteškoća u zatvorenom autoklavu s otvorenim ventilom.

Ukoliko nam je bila potrebna dvokratna fervorizacija, to smo drugu fervorizaciju izvršili idućeg dana.

Dalje manipulacije sa zemljanim smjesama obavljene su tek onda, kad su se posude i njihov sadržaj ohladile do sobne temperature. Tada smo fervoriziranu zemlju istresli iz posuda, u kojima smo ju fervorizirali, na vrtlarski stol, ručnom lopaticom dobro je promiješali, a zatim napunili u priređene i signirane Mitscherlichove posude.

Što se tiče prvog natapanja posuda za kulture vodom, to smo u prvo vrijeme kontrolne posude, t. j. one sa nefervoriziranom zemljom, stavljali – da bi upile vodu – u bazen s vodovodnom vodom, a ostale u bazen s destiliranom vodom. Kako je međutim brzina upijanja vode u fervoriziranim tlima trajala 24 sata dulje, to smo od tog postupka odustali i kasnije sve posude, pošto smo posadili sjemenke, obilno natopili ručnom štrcaljkom.

U svaku smo posudu posijali (u pravilnim razmacima) najprije 50, a u kasnijim pokusima 30 sjemenaka gorušice *(Sinapis alba)*. Prethodnim pokusom utvrđena klijavost tih sjemenaka bila je 78%. Nastojali smo, da za pokuse odaberemo kako po boji, tako i po veličini što jednoličnije, zdrave sjemenke. Temeljito smo ih oprali u 1‰ otopini sublimata, ispralj u vodi, i kada su bile suhe, zasijali. Proklijavanje, odnosno nicanje, kontrolirali smo dnevnim pregledima i brojanjima kroz 8–14 dana. Iza par tjedana prorijeđivali smo mlade biljke, uklanjajući iz svake posude kako ekstremno velike, tako i ekstremno malene primjerke, nastojeći da nam ostane u svakoj posudi isti, određeni broj što jednoličnijih pokusnih biljaka.

Što se tiče daljeg vršenja i razrade pojedinih pokusa, upućujemo na iscrpni engleski tekst.

b) Kulture u hranjivim otopinama

Ove smo pokuse izvršili sa hranjivom otopinom po propisu v. d. Crone, a u Voukovim staklenkama zapremine 1750 cc. Normalne, t. j. nefervorizirane hranjive otopine priređene su na uobičajeni način: u destilovanom vodom napunjene posude dodavali smo propisanim redom odmjerene količine hranjivih soli. Iza toga smo na te posude stavili Voukove poklopce, čiji smo otvor zatvorili satnim stakalcem, i smjestili smo ih u tamnu komoru.

Kako Voukove staklenke nisu izrađene od jenskog stakla, nego od čistog, ali debelo lijevanog češkog stakla, to ih nismo mogli upotrebiti za fervoriziranje kod viših temperatura. Radi toga smo upotrebljavali jenske dvolitrene boce. Njih smo napunili sa po 1750 cc destilovane vode i na opisan način priredili hranjivu otopinu. Svaku smo bocu začepili novim čepom od pamuka, smjestili ih u autoklav i izvrgli fervorizaciji. Uz fervoriziranje hranjivih otopina fervorizirali smo uvijek i jednu veću jensku bocu destilovane vode. Iza fervoriziranja izvađene su boce iz autoklava i ohlađene na zraku do sobne temperature.

Kod dvokratnog fervoriziranja kod 137° C nastao je u bocama gubitak tekućine od ±130 cc na litru. Radi toga smo kod svih boca, prije nego što smo ih smjestili u autoklav, označili razinu tekućine, pa smo gubitak tekućine iza fervorizacije nadoknadili u isto vrijeme fervoriziranom destilovanom vodom.

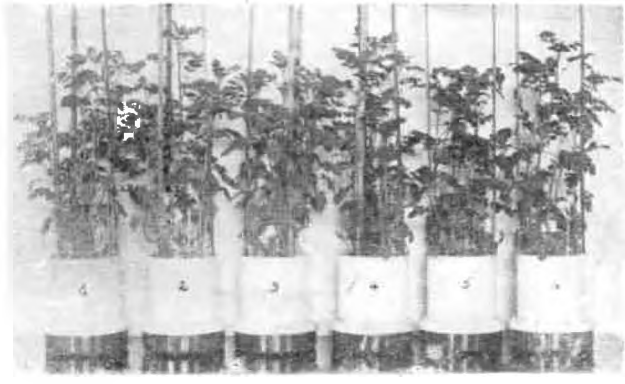
Pošto su se hranjive otopine ohladile, oprezno su sa svim talogom presute u Voukove staklenke. Radi zaštite od eventualnog naseljavanja algi obavili smo staklenke crnim papirnatim ovojima.

Osim pokusa sa na ovaj način fervoriziranim hranjivim otopinama, izvršili smo i pokuse, za koje smo dodavali hranjive soli u čistu fervoriziranu destilovanu vodu.

Za priređivanje v. d. Crone hranjive otopine upotrebljavali smo kemikalije tvrtke Merck, Darmstadt ili tvrtke Kahlbaum i Schering, Berlin.

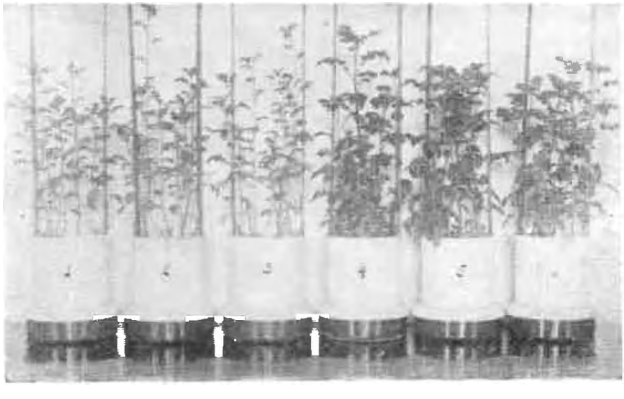
Dok smo se za pokuse u tlima ograničili na gorušicu *(Sinapis alba)*, kao pokusnu biljku, dotle smo u kulturama u v. d. Croneovoj otopini osim gorušice istraživali još kukuruz *(Zea Mais)*, bob *(Vicia faba)*, rajčicu *(Solanum lycopersicum)*, heljdu *(Fagopyrum esculentum)* i *Tagetes erecta*. Sjemenje smo nabavljali dijelom u trgovinama sjemenjem, dijelom u vrtlariji Sveučilišnog Botaničkog vrta. Za pokuse sa kukuruzom odstupio nam je sveuč. prof. dr. A. Tavčar određenu količinu svog uzgojenog materijala čiste linije, pa mu i ovdje na usluzi zahvaljujemo.

Postupak sa sjemenjem, njegovo odabiranje i dezinfekcija, odgovarali su postupku sa sjemenjem za kulture u tlu. Priređene sjemenke isklijavale su u Petrijevim posudama, na vlažnoj bugačici. Obično smo za svaki pokus priredili po 100 komada sjemenaka, a odabirali smo za pokuse po mogućnosti jednako razvijene i zdrave biljčice. Kao kod kultura u tlima, tako je i ovdje, kod kultura u hranjivoj otopini, svaka pokusna



1. *Sinapis alba.*

Normal gardenmould G_1, G_2, G_3. Fervorized gardenmould FG_4, FG_5 FG_6

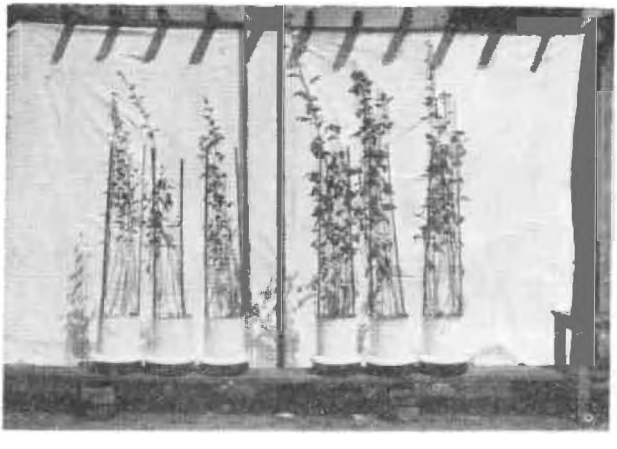


2. *Sinapis alba.*

Normal fieldsoil F_1, F_2, F_3 Fervorized fieldsoil FF_4, FF_5, FF_6.

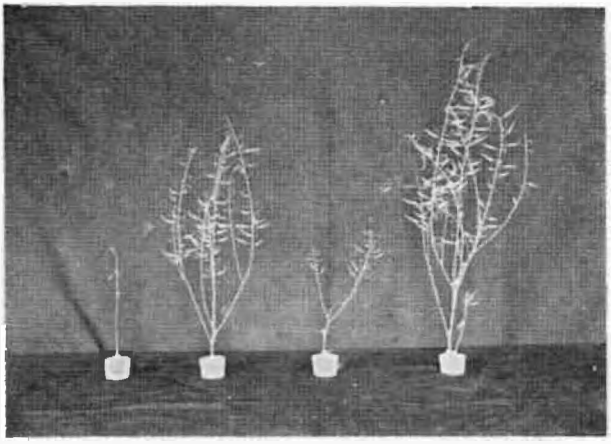
G_1 G_2 G_3 FG_1 FG_2 FG_3

1. *Sinapis alba.*
Normal gardenmould G_1, G_2, G_3. Fervorized gardenmould FG_1, FG_2, FG_3



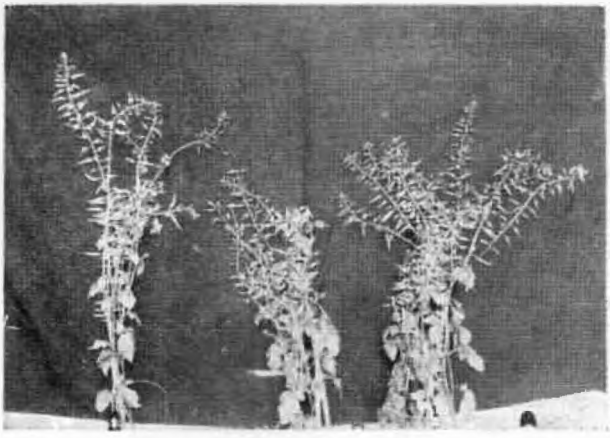
F_1 F_2 F_3 FF_1 FF_2 FF_3

2. *Sinapis alba.*
Normal fieldsoil F_1, F_2, F_3. Fervorized fieldsoil FF_1, FF_2, FF_3.

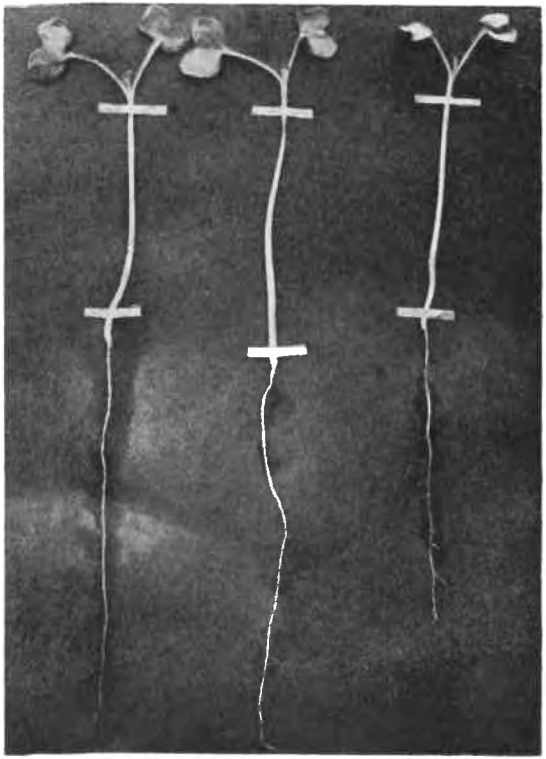


F FF G FG

1. Fruit-system of *Sinapis alba*. Normal fieldsoil-fervorized fieldsoil. Normal gardenmould-fervorized gardenmould.

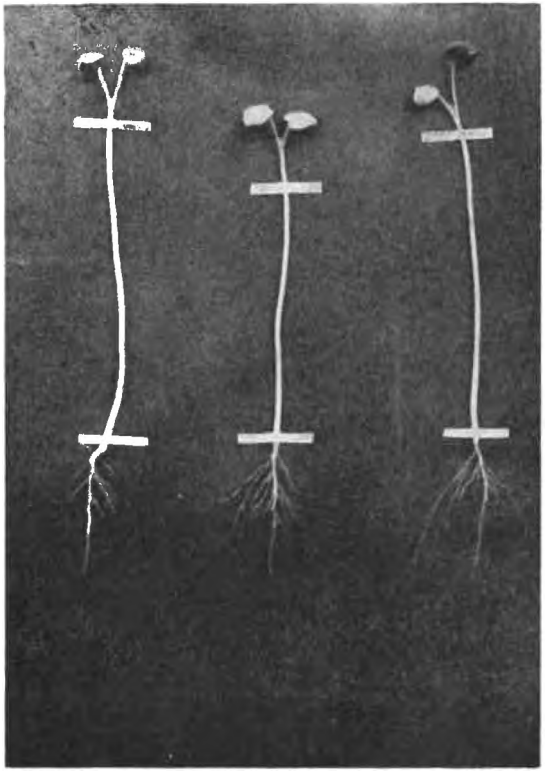


2. Fruit-system of *Sinapis alba*. 2×100–normal–2×137.



G

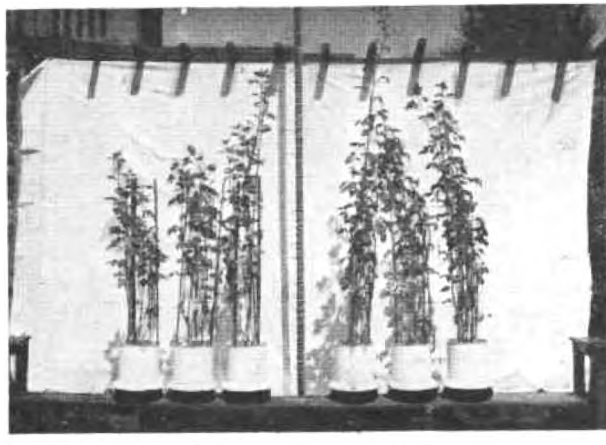
1. *Sinapis alba.*
Germs in normal gardenmould.



FG

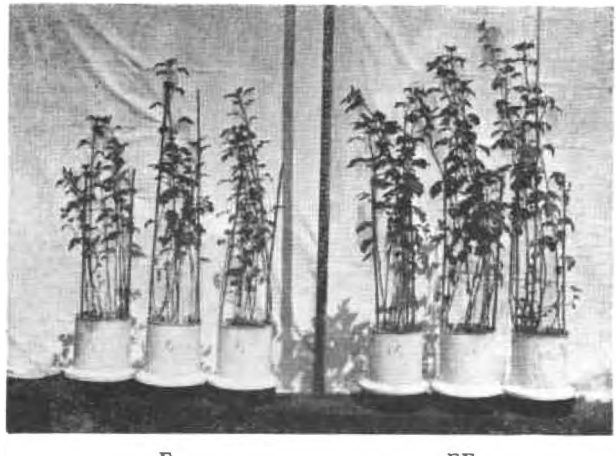
2. *Sinapis alba.*
Germs in fervorized gardenmould.

PLATE IV.



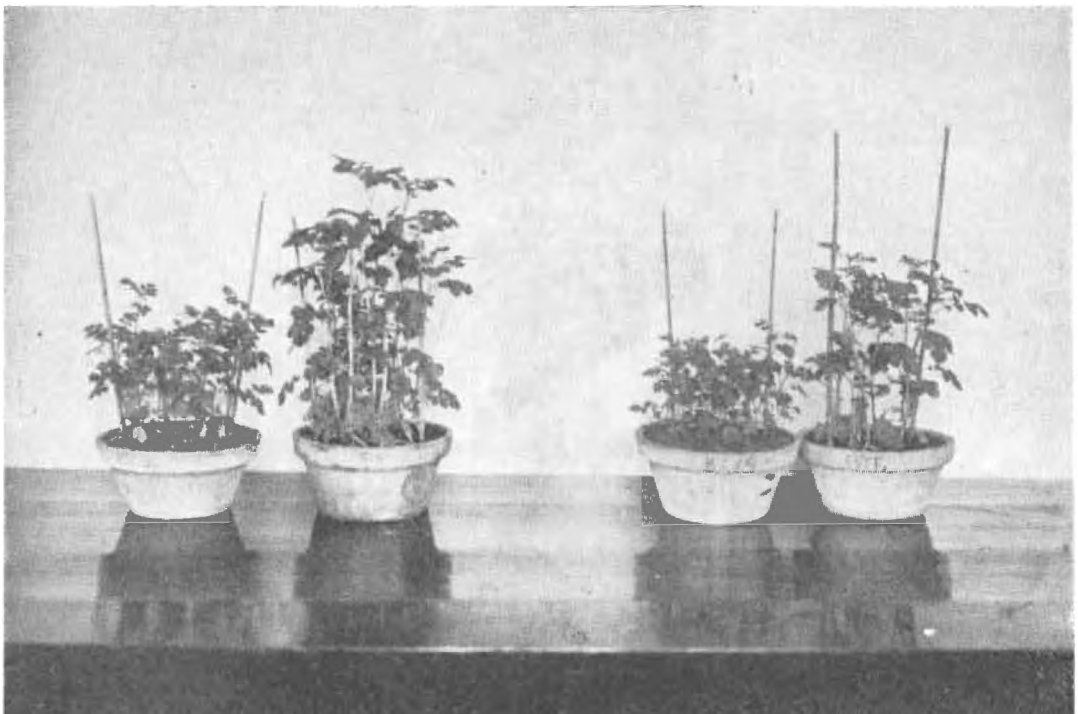
G FG

1. *Sinapis alba.*
Normal gardenmould G_1, G_2, G_3 Fervorized gardenmould FG_1, FG_2, FG_3.



F FF

2. *Sinapis alba.*
Normal fieldsoil F_1, F_2, F_3. Fervorized fieldsoil FF_1, FF_2, FF_3



G FG FF F

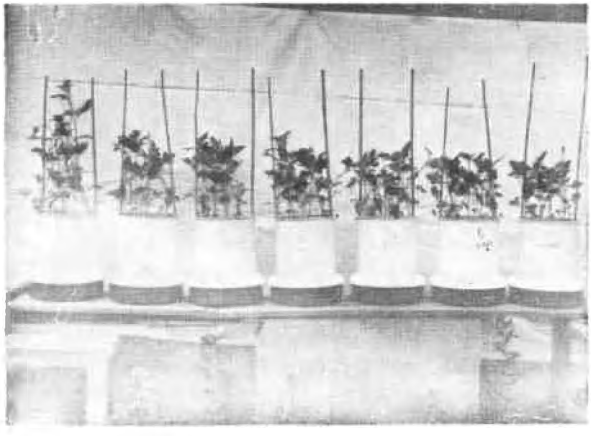
Sinapis alba. Normal–+fervorized gardenmould; +fervorized fieldsoil–normal fieldsoil.

G FG FG+

1. *Sinapis alba.*
Normal gardenmould–fervorized gardenmould–+fervorized gardenmould.

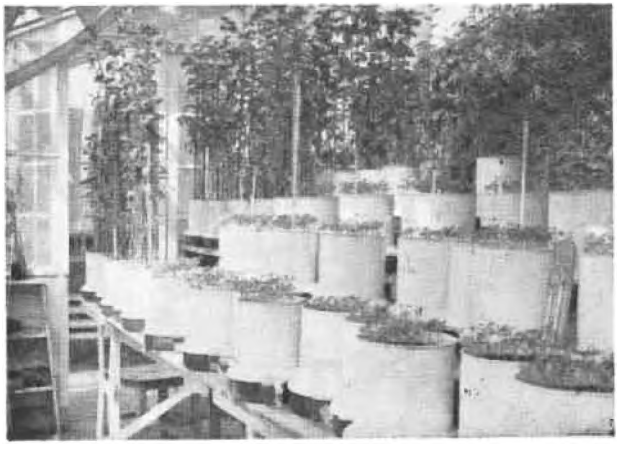
F FF FF+

2. *Sinapis alba.*
Normal fieldsoil–fervorized fieldsoil–+fervorized fieldsoil



F norm. 1×70 2×137

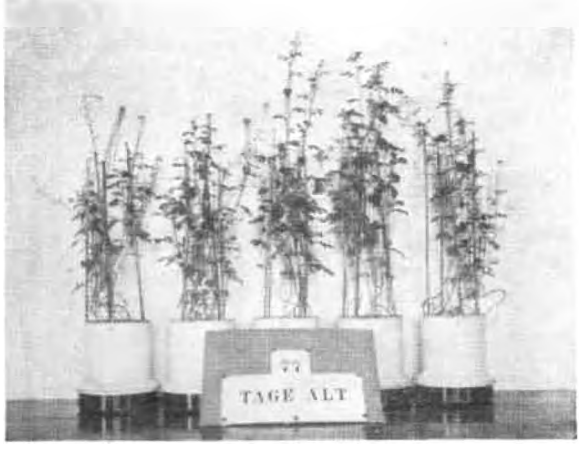
1. *Sinapis alba.*
row II. Normal–1×70–2×70–1×100–2×100–1×137
–2×137



2. Total view of the experiments I, II and VI.

2×70 2×100 Normal 2×137 4×137

1. *Sinapis alba.*
The fervorized soil surpassed the normal soil.



Normal 1×70 2×70 1×100 2×100

2. *Sinapis alba.*
The fervoreffect at 70° C and 100° C

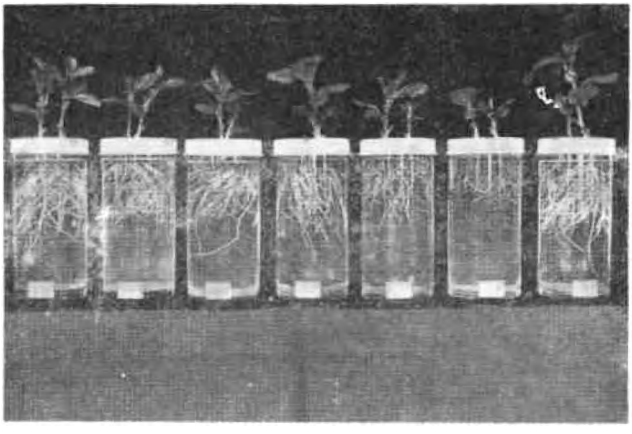
Norm. 1×137 2×137 3×137 4×137 8×137

1. The habitus of *Sinapis alba* in normal–1×137–2×137–3×137–4×137– and 8×137.

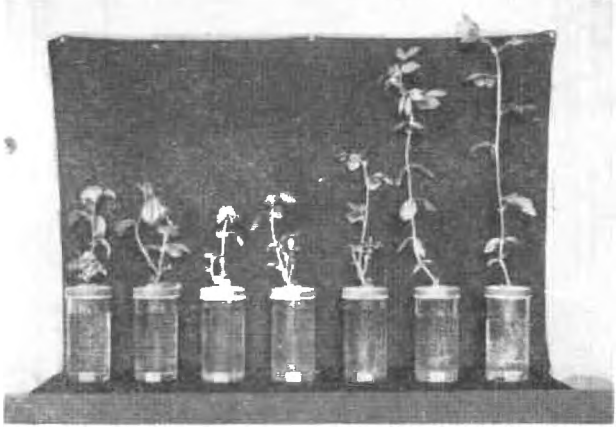
Norm. Total View 8×137

2. Total view. Normal–1×70–2×70–1×100–2×100–1×137–2×137–3×137–4×137–8×137.

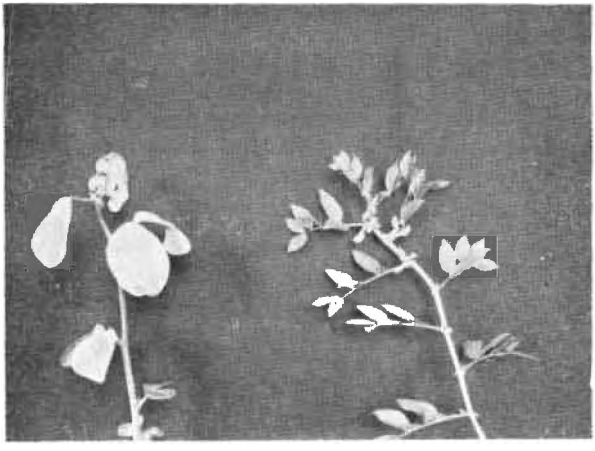
The optimum of the fervorization lay about 3 and 4 times fervorizing.



1. *Vicia faba.*
Normal–1×70–2×70–1×100–2×100–1×137–2×137

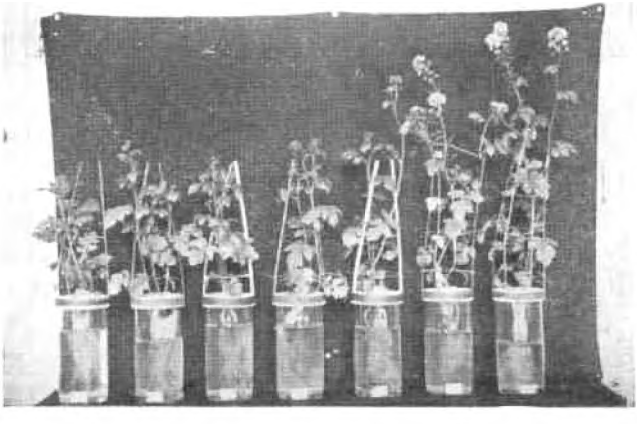


2. *Vicia faba.*
First row. Normal–1×70–2×70–1×100–2×100–1×137–2×137.



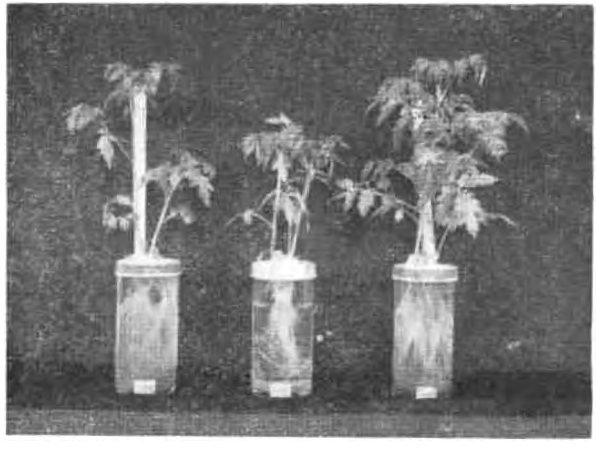
1. *Vicia faba*
Top–parts: normal–2×137.

Norm. 2×137

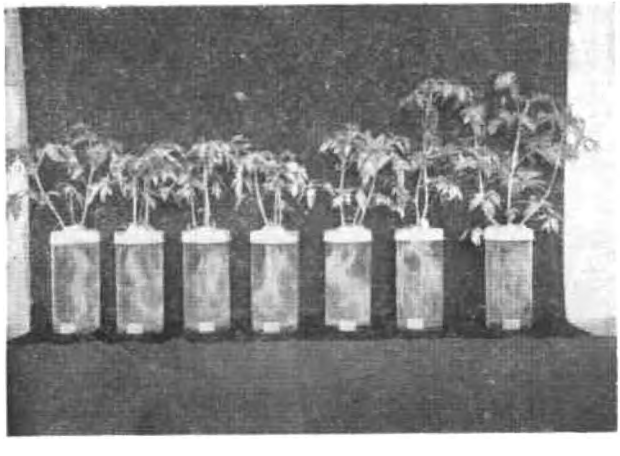


7 5 6 4 3 2 1

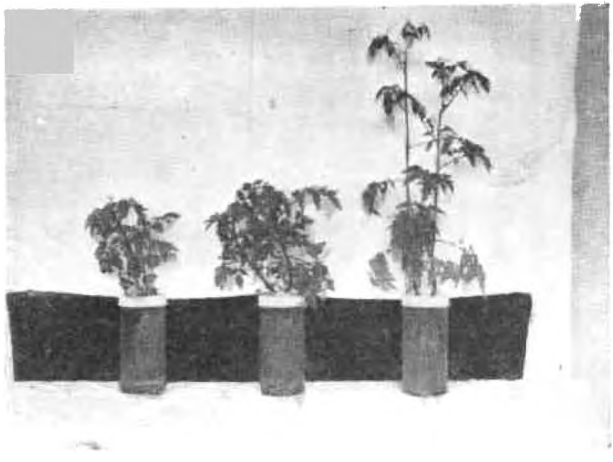
2. *Sinapis alba.*
Third row. Normal–1×70–2×70–1×100–2×100
–1×137–2×137.



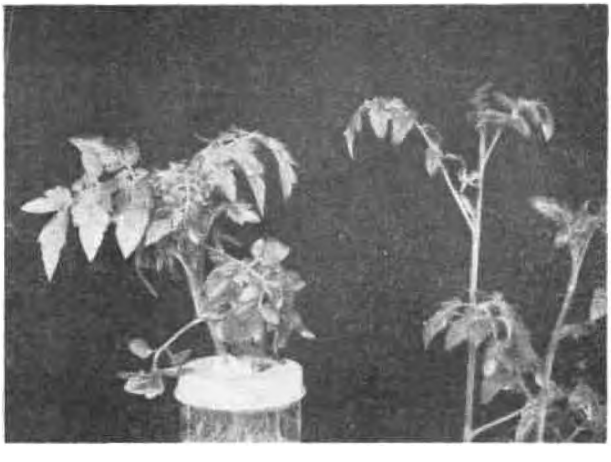
1. *Solanum lycopersicum.*
1×137–normal–2×137.



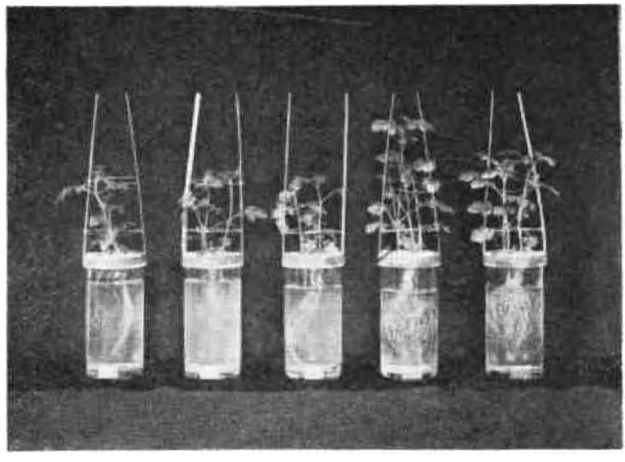
2. *Solanum lycopersicum.*
Normal–1×70–2×70–1×100–2×100–1×137–2×137.



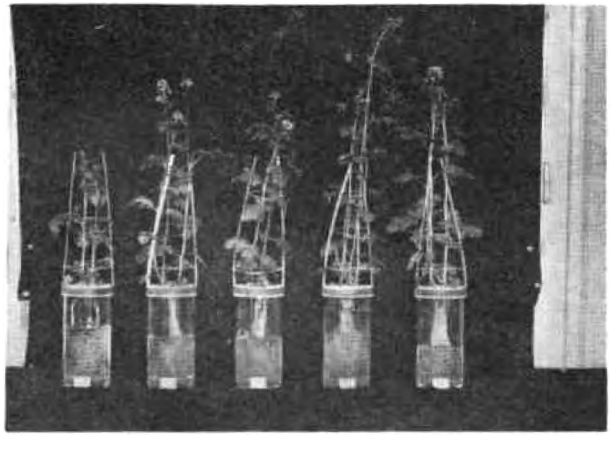
1. *Solanum lycopersicum*
Normal–2×100–2×137.



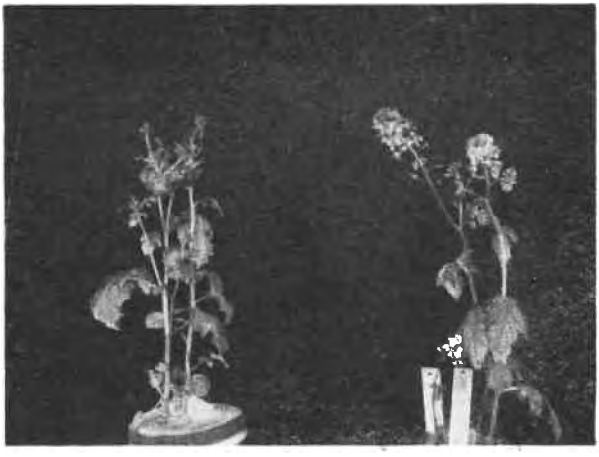
2. *Solanum lycopersicum.*
Top-parts: normal–2×137.



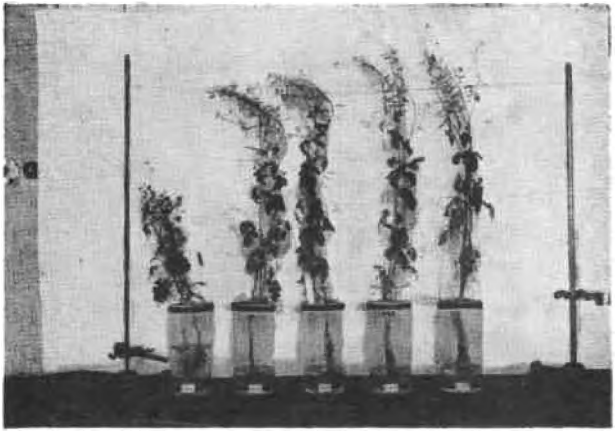
1. *Sinapis alba.*
Normal–1×137–2×137–2×137 H_2O+Cr. s.–
(2×137 H_2O+Cr. s.) 2×137.



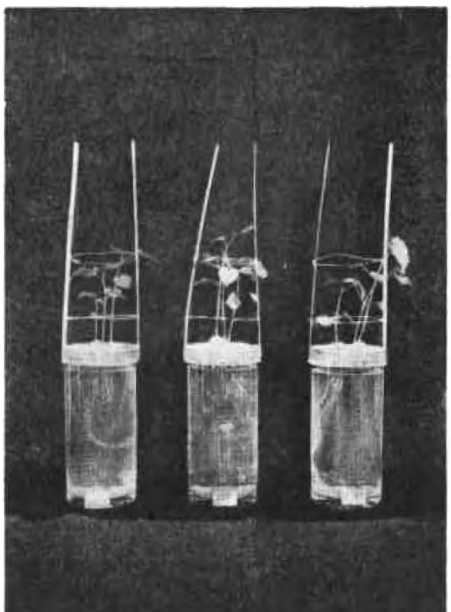
2. *Sinapis alba.*
Normal–1×137–2×137–2×137 H_2O+Cr. s.–
(2×137 H_2O+Cr. s.) 2×137.



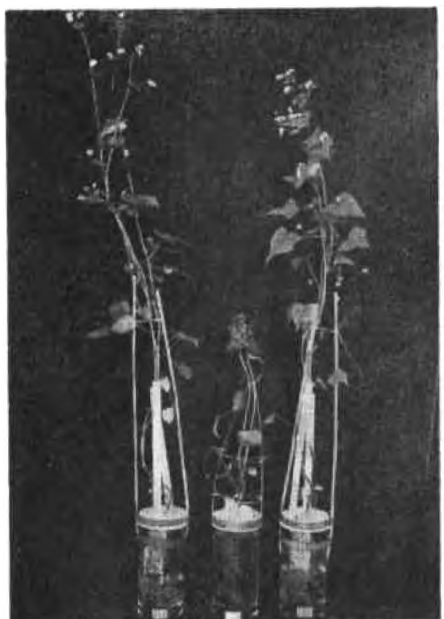
1. *Sinapis alba.*
Inflorescences: normal–2×137.



2. *Sinapis alba.*
Normal–1×137–2×137–2×137 H_2O+Cr. s.–
(2×137 H_2O+Cr. s.) 2×137.

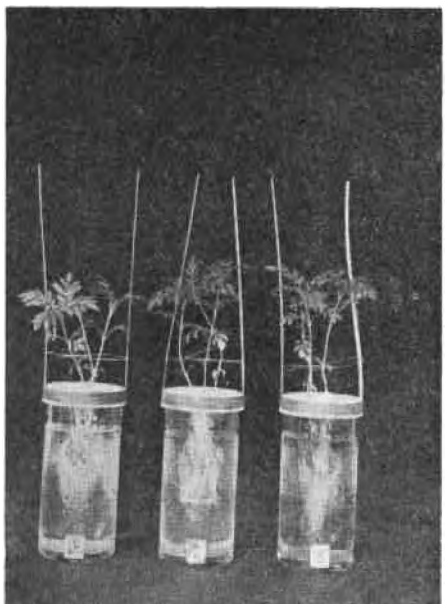


1. *Fagopyrum esculentum.*
Normal–2×137–2×137 H_2O+Cr. s.

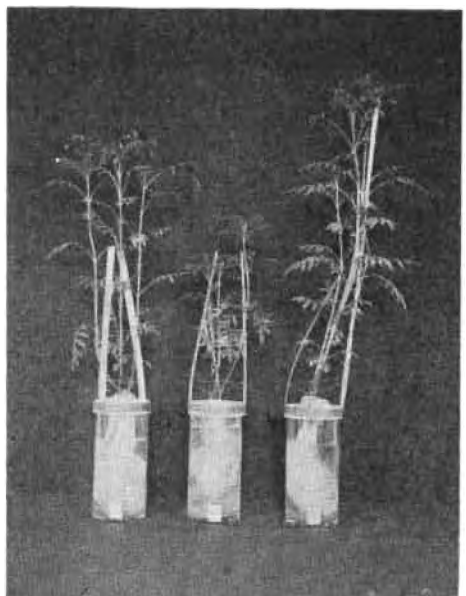


2. *Fagopyrum esculentum.*
2×137–normal–2×137 H_2O+Cr. s.

PLATE XVII.

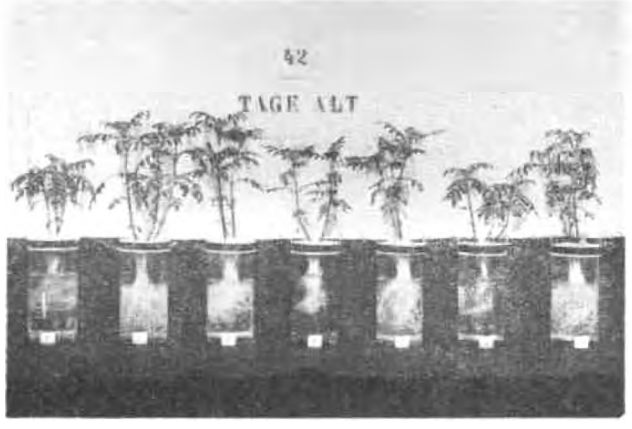


1. *Tagetes erecta*
2×137 H_2O+ Cr. s.–normal–2×137.

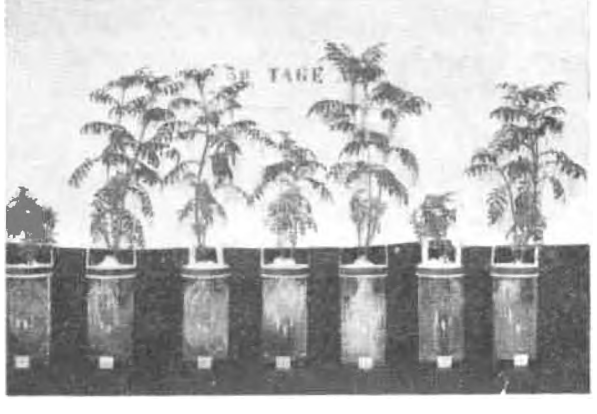


2. *Tagetes erecta.*
2×137 H_2O+ Cr. s.–normal–2×137.

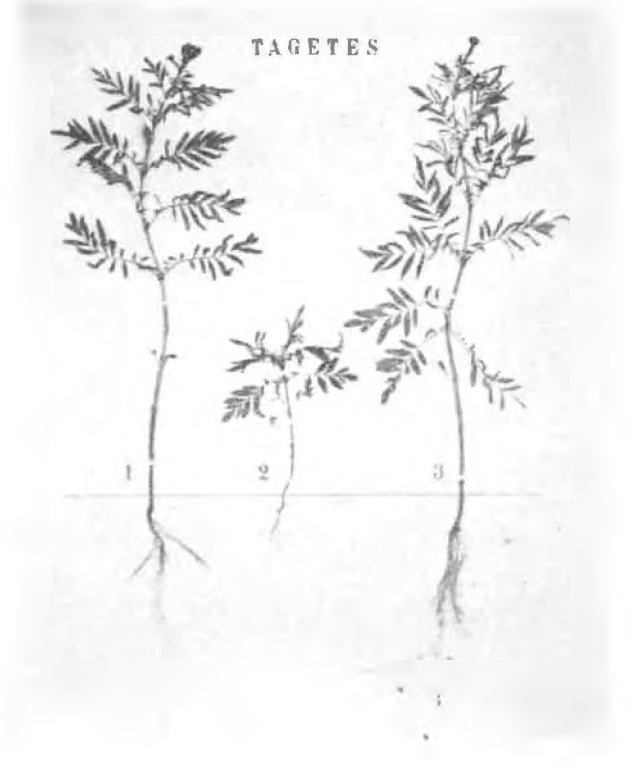
PLATE XVIII.



1. *Tagetes erecta.*
Normal–2×137–2×137 Cr. s.+H_2O–2×137 Cr. s. +2×137 H_2O–2×137 H_2O+Cr. s.–Cr. s.+H_2O-Cr. s.+2×137 H_2O; 42 days old.



2. *Tagetes erecta.*
The same row as 1, now 59 days old.



Tagetes erecta.

Three typical plants from our herbarium:
2×137 H_2O + Cr. s.-normal-2×137

varijanta bila zastupana sa najmanje tri posude, a razumljivo je, da je i svaka pokusna serija sadržavala određen broj kontrolnih kultura, t. j. kultura u normalnoj v. d. Croneovoj hranjivoj otopini.

Što se tiče razrade pokusa, naročito određenja svježe i suhe supstancije, napominjemo, da smo kao i kod kultura u tlima, iz praktičnih razloga, a naročito zbog toga, što ispiranjem korijenja od taložina hranjive otopine, odnosno čestica zemlje, uvijek dolazi do nekih gubitaka, određivali samo svježu supstanciju izboja stabljika. Za određenje suhe supstancije odvojili smo korijenje od stabljika, oboje usitnili i u otvorenim Petrijevim posudama najprije osušili na zraku. Iza toga sušili smo materijal u sušioniku pri 80° C, najmanje dva dana, a tek onda izvršili smo vaganja.

O ostalim pojedinostima metodike i razrade pokusa iscrpno se izvješćuje u engleskom tekstu.

REZULTATI POKUSA

Istražujući fiziološko djelovanje fervorizacije na razvoj gorušice *(Sinapis alba)* u nizu smo pokusa utvrdili:

I. Kulture u tlima

1. Kod proklijavanja, odnosno nicanja sjemenaka očituje se fervor-efekt u dvije faze. U prvoj fazi, koja traje par dana, dolazi do jasno izražene retardacije (usporenja) proklijavanja. Nakon toga, iza otprilike 7 do 8 dana, nastupa faza stimulacije. Proklijavanje sjemenaka se u toj fazi toliko ubrzava, da procenat isklijalih sjemenaka u fervoriziranim tlima ne samo doskora dostiže, nego konačno i prestiže procenat isklijalih sjemenaka u normalnim, nefervoriziranim, tlima.

2. S obzirom na hipokotil, fervor-efekt se očituje retardacijom njegova razvoja i povećanom produkcijom klorofila i antocijana.

3. Fervor-efekt očituje se nadalje u karakterističnom habitusu korijenja. U fervoriziranim tlima dolazi do jačeg razgranjenja korijenja, kao i jačeg razvoja korijenovih dlačica. U mladim stadijima pobočno se korijenje kod biljaka u fervoriziranim tlima razvija ili direktno ispod korijenova vrata ili u gornjoj trećini glavnog korijena.

4. Kod kultura u fervoriziranim tlima u mladim je stadijima korijenov vrat gusto poput krzna obrastao dlačicama, a u starijim stadijima dolazi do utegnuća korijenova vrata.

5. U rastenju stabljike u duljinu očituje se fervor-efekt također u dvije faze. U prvoj fazi, koja traje do iza 40. pokusnog dana, ovo je rastenje kod kultura u fervoriziranim tlima usporeno. U drugoj fazi, koja katkada nastaje tek iza 70. pokusnog dana, dolazi do jasno izraženog ubrzanja ovog rastenja.

6. Fervor-efekt se općenito očituje u jakom vegetativnom rastenju svih nadzemnih dijelova pokusnih biljaka. Ta se činjenica odražava kako u težini svježe, tako i u težini suhe tvari. U našim smo pokusima kod kultura u fervoriziranim tlima postigli težine, koje 4 do $4^1/_2$ puta premašuju težine, postignute u normalnim, nefervoriziranim tlima.

7. Fervor-efekt pokazao se vrlo jasno i u razvoju cvjetova, te plodova i sjemenaka. Kod kultura u fervoriziranim tlima razvoj je inflorescencija mnogo bogatiji, cvjetovi su brojniji, a i boja im je intenzivnija. Komuške su dulje i punije nego kod kultura u normalnim, nefervoriziranim tlima. Produkcija sjemenaka je kod kultura u fervoriziranim tlima bila 2–$3^1/_2$ puta veća od produkcije sjemenaka kod kultura u normalnim tlima.

9. Fervor-efekt očituje se naročito u težini suhe tvari korijenja, koja je kod kultura u fervoriziranim tlima znatno viša nego kod kultura u normalnim tlima.

10. Fervor-efekt zavisi od trajanja zagrijavanja, odnosno fervorizacije tla. Ta se zavisnost očituje kako u prirastu biljne mase, u težini svježe i suhe tvari, tako i u longitudinalnom rastenju izboja. Najjače djelovanje na duljinu izboja postignuto je kod osmokratne fervorizacije (8 × po 1 sat, pri 137° C i $2^1/_2$ atm.).

11. Optimalni fervor-efekt s obzirom na težinu svježe i suhe tvari leži približno između trokratne i četverokratne fervorizacije.

12. Fervor-efekt zavisi i od visine temperature. On se očituje doduše već i kod relativno niske temperature (70° C), ali u mnogo manjoj mjeri nego kod viših temperatura. Što je – naravno u granicama, u kojima smo mi to mogli istraživati – temperatura viša, to je i fervor-efekt snažniji. U našim pokusima bio je on najjače izražen kod fervorizacije pri 137° C.

13. Dodavanje fervorizirane destilovane vode poljskom tlu na našem je pokusnom objektu – *Sinapis alba* – dovelo do pojave fervor-efekta.

14. Fervoriziranjem postaju tla teža. Upijanje vode u fervoriziranim tlima zbiva se daleko polaganije nego u odgovarajućim normalnim, nefervoriziranim tlima.

15. Što su tla više fervorizirana, to je u stadiju proklijavanja i kratko iza njega manja potreba vode.

II. Kulture u hranjivoj otopini

1 Fervoriziranjem v. d. Croneove hranjive otopine kod 137° C i $2^1/_2$ atm. u autoklavu, polučen je izraziti fervor-efekt kod kultura *Fagopyrum esculentum, Sinapis alba, Solanum lycopersicum, Tagetes erecta* i *Vicia faba.*

2. Fervor-efekt je kod kultura u fervoriziranoj hranjivoj otopini identičan sa fervor-efektom, polučenim kod kultura u fervoriziranim tlima.

3. Trajanje fervorizacije hranjive otopine i visina primijenjene temperature utječu na fervor-efekt. U našim smo pokusima postigli najizrazitiji fervor-efekt kod jednosatne fervorizacije hranjive otopine kod temperature 137° C i tlaka od 2½ atm.

4. Za polučenje fervor-efekta dovoljna je fervorizacija destilovane vode i naknadni dodatak hranjivih soli, koje sačinjavaju v. d. Croneovu hranjivu otopinu.

ZAGLAVAK

Kao što je naprijed rečeno, mi ne smatramo, da smo našim istraživanjima riješili problem djelovanja zagrijevanja na hranjive supstrate biljaka. Naprotiv. Rezultati naših pokusa izazvali su mnoga nova pitanja, koja će se morati pokušati riješiti serijama novih istraživanja. Ipak mislimo, da smo našim pokusima sa hranjivom otopinom dovoljno jasno pokazali, da se poboljšanje hranjivih supstrata zagrijevanjem ne može svesti jedino i samo na »sterilizaciju«, nego naprotiv, da je sterilizacija samo jedna od promjena, koju zagrijevanje u hranjivim supstratima uzrokuje. Da bismo naglasili kompleksnost tih promjena i cjelokupni efekt zagrijevanja hranjivih supstrata, uveli smo pojam »fervorizacija«.

Što se tiče same sterilizacije, mislimo. da sterilizacija postignuta zagrijevanjem supstrata nije ekvivalentna ni kemijskoj sterilizaciji, a ni sterilizaciji pri niskim temperaturama. Smatramo, da se rezultati mikrobioloških kultura u vlažnim tlima, »steriliziranim« zagrijevanjem, moraju prosuđivati s nekom rezervom, baš zbog mnogostranosti promjena, koje zagrijevanje u supstratima izaziva. Čini nam se, da bi radi toga bila važna uspoređenja mikrobioloških kultura u supstratima steriliziranim kemijski, smrzavanjem i zagrijevanjem.

Naša istraživanja treba da budu nadopunjena u više smjerova, kako s obzirom na same supstrate i hranjive soli, tako i s obzirom na različite biljke. Ali u prvom redu bit će potrebno razjasniti promjene, koje fervorizacija izaziva u samoj vodi. Dok je to problem, koji treba da riješe kemičari i fizičari, zadatak je fiziologa da istraže utjecaj fervorizirane vode na druge životne pojave i procese.

Konačno treba i imati na umu, da nije isključeno, da do fervorizacije dolazi i u prirodi. Velika plodnost siromašnih tala u tropima mogla bi djelomično biti uvjetovana fervoriziranjem tala, nastalom radijacijom toplih sunčanih zraka. U drugim klimatskim područjima možda postoje slični uvjeti.

TUMAČ SLIKA

Tabla I.

1. *Sinapis alba.* Kulture u normalnom vrtnom tlu G_1, G_2, G_3. Kulture u fervoriziranom vrtnom tlu FG_4, FG_5, FG_6.
2. Kulture u normalnom poljskom tlu F_1, F_2, F_3. Kulture u fervoriziranom poljskom tlu FF_4, FF_5, FF_6.

Tabla II.

1. *Sinapis alba.* Kulture u normalnom vrtnom tlu G_1, G_2, G_3. Kulture u fervoriziranom vrtnom tlu FG_1, FG_2, FG_3.
2. *Sinapis alba.* Kulture u normalnom poljskom tlu F_1, F_2, F_3. Kulture u fervoriziranom poljskom tlu FF_1, FF_2, FF_3.

Tabla III.

1. Plodovi gorušice: normalno poljsko tlo – fervorizirano poljsko tlo; normalno vrtno tlo – fervorizirano vrtno tlo.
2. Plodovi gorušice: 2×100 – norm. 2×137.

Tabla IV.

1. Klice gorušice iz normalnog vrtnog tla.
2. Klice gorušice iz fervoriziranog vrtnog tla.

Tabla V.

1. *Sinapis alba.* Kulture u normalnom vrtnom tlu G_1, G_2, G_3; u fervoriziranom vrtnom tlu FG_1, FG_2, FG_3.
2. Kulture u normalnom poljskom tlu F_1, F_2, F_3; u fervoriziranom poljskom tlu FF_1, FF_2, FF_3.

Tabla VI.

Sinapis alba. Kulture u glinenim loncima: normalno – + fervorizirano vrtno tlo; + fervorizirano poljsko tlo – normalno poljsko tlo.

Tabla VII.

1. *Sinapis alba.* Normalno vrtno tlo – fervorizirano vrtno tlo – + fervorizirano vrtno tlo.
2. 2 *Sinapis alba.* Normalno poljsko tlo – fervorizirano poljsko tlo – fervorizirano poljsko tlo.

Tabla VIII.

1. *Sinapis alba.* serija 2: normalno tlo –1×70–2×70–1100–2×100–1×137–2×137.
2. Cjelokupni pogled na pokuse I, II i VI.

Tabla IX.

1. *Sinapis alba.* Kulture u fervoriziranim tlima prestižu kulturu u normalnom tlu.
2. *Sinapis alba.* Fervor-efekt kultura u 70 i 100° C fervoriziranom tlu.

Tabla X.

1. Habitus kultura *Sinapis alba* u normalnom – 1×137–2×137–3×137–4×137 i 8×137 fervoriziranom tlu.
2. Cjelokupni pogled na pokusne serije: normalno tlo – 1×70–2×70–1×100–2×100 –1×137–2×137–3×137–4×137–8×137 Optimum fervorizacije leži između trokratne i četverokratne fervorizacije.

Tabla XI.

1. *Vicia faba.* Kulture u hranjivoj otopini: normalnoj – 1×70–2×70–1×100–2×100 –2×100–1×137–2×137.
2. *Vicia faba,* serija 1.: normalna – 1×70–2×70–1×100–2×100–1×137–2×137 otopina.

Tabla XII.

1. *Vicia faba.* Vršni dijelovi biljaka iz normalne i 2×137 otopine.
2. *Sinapis alba,* serija 3: Kulture u normalnoj – 1×70–2×70–1×100–2×100–1×137 –2×137. otopini.

Tabla XIII.

1. *Solanum lycopersicum.* Kulture u 1×137 – normalnoj – 2×137 otopini.
2. *Solanum lycopersicum.* Kulture u normalnoj – 1×70–2×70–1×100–2×100–1×137 –2×137 otopini.

Tabla XIV.

1. *Solanum lycopersicum.* Kulture u normalnoj – 2×100–2×137 otopini.
2. *Solanum lycopersicum.* Vršni dijelovi biljaka iz normalne i 2×137 otopine.

Tabla XV.

1. *Sinapis alba.* Kulture u normalnoj – 1×137–2×137–2×137 H_2O+Cr. s. – (2× 137H_2O+Cr. s.) 2×137 otopini.
2. *Sinapis alba.* Kulture u normalnoj – 1×137–2×137–2×137 H_2O+Cr. s. – (2× 137+C. s.) 2×137 otopini.

Tabla XVI.

1. *Sinapis alba.* Cvatovi kultura u normalnoj i 2×137 otopini.
2. *Sinapis alba.* Kulture u normalnoj – 1×137–2×137–2×137 H_2O+Cr. s. – (2× 137+Cr. s.) 2×137 otopini pri završetku pokusa.

Tabla XVII.

1. *Fagopyrum esculentum.* Kulture u normalnoj – 2×137§2×137 H_2O+Cr. s.
2. *Fagopyrum esculentum.* Kulture u 2×137 – normalnoj – 2×137 H_2O+Cr. s. otopini pri završetku pokusa.

Tabla XVIII.

1. *Tagetes erecta.* Kulture u 2×137 H_2O+Cr. s. – normalnoj – 2×137 otopini.
2. *Tagetes erecta.* Kulture u 2×137 H_2O+Cr. s. – normalnoj – 2×137 otopini u kasnijoj fazi pokusa.

Tabla XIX.

1. *Tagetes erecta.* Kultture u normalnoj – 2×137–2×137 Cr. s.+H_2O–2×137 Cr. s. 2×137 H_2O (2×137 H_2O+Cr. s. – Cr. s.+H_2O – Cr. s.+2×137 H_2O otopini. 42 dana stare.
2. *Tagetes erecta.* Isti pokusni niz kao u 1. kulture 59 dana stare.

Tabla XX.

Tri tipične biljke *(Tagetes erecta)* iz našeg herbara, kultivirane u 2×137 H_2O +Cr. s. – normalnoj § 2×137 otopini.

LITERATURA – LITERATURE

1. *Bewley*, Practical Soil Sterilisation with special references to Glasshouse Crops. London (1937).
2. *Benecke*, Zeitschrift für Botanik Bd. 1 p. 235. Jena.
3. *Czermak*, Landwirt. Versuchs-Stationen. *76*. 75 (1912).
4. *Dietrich*. v. Merkenschläger
5. *Fletcher*, Nature, 83, 156.
6. *Franke*. v. Kopeloff, Lint u. Coleman.
7. *Hiltner*, Fortschritte d. Landwirtschaft. *1*. 11. 329 (1926).
8. *Honcamp*. Handbuch der Pflanzenernährung (1931).
9. *Koch* u. *Lücken*, Jour. f. Landwirtschaft. *55*. 161 (1907).
10. *König*. Landwirt. Versuchs Stat.. *64*. 371 (1905).
11. *König, Hasenbäumer* u. *Coppenrath*, Landwirt. Versuchs Stat. *63*. 471 (1906).
12. *Kopeloff, Lint* u. *Coleman*. Centralbl. f. Bakt. Paras. u. Infektkr. II. Abt.. 46. 29.
13. *Krüger* u. *Schneidewind*, v. Koch u. Lücken.
14. *Liebig*. v. König.
15. *Liebscher*. v. Kopeloff, Lint u. Coleman.

15a *Liebscher*. 1893, v. Pfeiffer u. Franke.

16. *Märcker*, v. Schulze.
17. *Merkenschläger*. Sinapis alba, München (1925).
18. *Pfeiffer* u. *Franke*. Landwirt. Versuchs. Stat. *46*. 117 (1896).
19. *Radermacher, Klas. Vouk*. Proceedings of the Nederl. Akad. v. Wettenschapen. XLIII. 8 (1940).
20. *Richter*. Landwirt. Versuchs-Stat. *47*. 269 (1896).
21. *Russel* a. *Petherbridge*. Journ. of the Board of Agriculture. *19* 10. 809 (1012).
22. *Schübler*. v. König.
23. *Schulze*, Landwirt. Versuchs-Stat. *65* 137 (1907).
24. *Vouk*. Kohle u. Pflanzenwachstum, Akad. d. Wiss. Denkschriften. Wien. 1931.