THE INFLUENCE OF CARBON DIOXIDE AND OTHER CHEMICALS
ON VEGETATIVE AND REPRODUCTIVE ACTIVITY OF PLANTS.

by

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THE INFLUENCE OF CARBON DIOXIDE AND OTHER CHEMICALS ON VEGETATIVE AND REPRODUCTIVE ACTIVITY OF PLANTS.

Introduction.

The so-called rest period of plants is merely a period in the life history of the plants when vegetative activity becomes inactive. Annual plants reproduce by seeds. The old sporophyte before its death produces the young sporophyte, the seed. Seeds are said to pass through a definite rest period. Perennial plants, of which both root and stem produce vegetative growth until late autumn, remain more or less active during the winter; also those perennials used in the lawn or garden, many of which have lost their power of producing seeds, cease to grow on the occurrence of cold weather. This cessation of growth suggests a rest period, notwithstanding the fact that plants may retain their foliage and exhibit no change in external appearance.

It is generally accepted at the present time that the action of ether upon plants in the early stages

of rest, or the resting period, is the nature of an arrest, or complete cessation of growth, and that as a result of this intensified suspension of all activity on the part of the plant, the usual or normal resting period is greatly abridged and the plant is at once thrown into growth when subjected to suitable conditions of temperature, moisture and light. Since deciduous woody plants are more or less influenced by anesthetics, and probably all plants can be multiplied by cuttings, it was believed that these might also respond to the same chemicals used in breaking or influencing the rest period.

Due to a lack of material and conditions making it impossible to complete some of these investigations, many of the plans outlined could not be prosecuted to a favorable conclusion. Just so far as possible the writer has followed the original plans relative to the influence of carbon dioxide and other chemicals on vegetative and reproductive activity of plants.

Experiments and conclusions embodied in this thesis give the results of these investigations in detail in so far as time and facilities would permit conducting the investigation. When specimens became pathological, investigation was discontinued, since further work would give unreliable results.

HISTORICAL DISCUSSION OF EFFECTS OF CHEMICALS ON VEGETATIVE AND REPRODUCTIVE ACTIVITY.

The influence of such chemicals as carbon dioxide, ether and chloroform, applied either as vapors or gases, inducing growth to begin in dormant plants or to act as a stimulant in plants in a growing condition, is not well understood. According to Drude (41), Leclerc, more than fifty years ago, made the initial investigations relative to the effect of ether on plants. Since then, and especially during the last twenty or twenty-five years, many investigators have tested the effects of ether, as well as other vapors and gases, on plants in connection with the experimental study of respiration and transpiration, (but it is only recently - the last ten or twelve years - that anesthetics have been used for forcing dormant plants into growth).

The nature of anesthetics on plants has, for some time, been a subject of much study, not only because of scientific interest but the practical value which might result from a knowledge of these facts.

As early as 1873 and 1874, Heckel (58a) studied the behavior of *Berberis* stamens while they were under the influence of chloroform. Again, in 1874 he used

chloroform, chlorohydrate and nitrous oxide on the stamens of both *Berberis* and *Ruta*. Also during the same year both anesthetics and narcotics were applied on many species of plants to determine sensitiveness and movement. In 1879 Giglioli (53) used ether, etc., in both gaseous and liquid form on dry and wet seeds to test the effects on their germinating powers, and found that all seeds do not possess the same powers of resistance to such treatments, since the soaked killed much more easily than the dry ones. Ten years later Townsend (132) determined the effects of ether on the germination of seeds and spores. He found that slight ether fumes caused the seeds of Zea Mays, Avena sativa, Phaseolus vulgaris and Cucurbita pepo, and the spores of Mucor and Penicillium, to germinate quicker.

In 1905 Latham (81) discovered that ether and chloroform hastens the development of spores of Sterigmato-cystis nigra and Penicillium glaucum. In 1879 Arloing (8) induced a *Mimosa* plant to absorb ether and chloroform mixed with water through a tube. The resulting "intoxication" lasted nearly two hours, during which time all sensitiveness was lost. Sensitiveness returned with the passing of the effect of the drugs. Macchiati (90) used the same drugs for the same purpose in 1880 and gave it as his opinion that the vaporization of the chemicals causing a lowering of the temperature about the plant influenced it to such an extent as to prevent movement, yet this was

disproven by Cugini the following year. In 1882 Detmer (39) used chloroform in studying respiration in young pea plants. The treated plants made no advance in growth or development, finally dying, the explanation offered being that chloroform fully inhibited the growth of the cells, yet respiration continued vigorously.

Tassi (126) in 1884 dipped freshly cut flowers of *Crocus* and *Oxalis* in solutions of anesthetics and narcotics and noted the results on the opening and closing of the floral parts.

Lauren (82) in 1891 investigated the effects of ether vapor on very young seedlings. Transpiration, as effected by anesthetics, was studied in 1892 by Schneider (117), and in 1896 by Dixon (40); also in 1898 Sandsten (116) experimented with a number of gases and vapors in regard to their influence on plant growth. He found that ether dissolved in water accelerated the germination of seeds, and that the fumes of ammonia, chloroform and ether, caused an increased growth in twigs and young plants.

Although it has been known since 1878, that the effect of anesthetics on the protoplasm of plants was similar to that upon animals, in so far as it rendered both insensible to external excitation, it was not known until some years later that under certain conditions its after effect upon plants was in the nature of a powerful stimulus to

growth. For the discovery of this reactionary influence of anesthetics upon plants, we are indebted to Dr. W. Johannsen, of the Royal Danish Society of Copenhagen, whose experimental studies upon the anesthetic influence of ether and chloroform upon plants, with relation to acceleration of growth, were first begun in 1890. He believed that the influence of ether upon the plants does not act directly upon growth but rather upon factors which prevent growth. The ether he regards as a disturbance upon the physiological mechanism of the plant. He explains that small amounts of ether favor vegetative activity and large amounts such as are used to break the rest period, weaken the factors which prevent growth, thus indirectly favoring vegetation.

G. Lochot (89) says: "The action of ether depends upon whether the plants have reached or entered a stage of winter repose or not. In the first case etherization will merely advance the flowering period a few days while the blossom will be of equal luxuriance. In the latter case the period of blossoming is hastened several days and the florescent parts made much more perfect. Etherization is most effective early in the season - after January no benefits are derived."

T. Jannock (70) states: "Lilacs etherized August 24 to September 18, when the plants were in full bloom and foliage, gave blossoms that were finer and last-

ed longer than those from retarded plants."

O. Drude (42) states: "Use of ether is artificial production of spring. Growth is hastened about a month sooner by the use of ether than it would normally be by heat alone."

J. E. Howitt (66) induced lilacs to bloom six days earlier than those not etherized. Plants etherized 48 hours instead of 25, bloomed eight days earlier, and when etherized 72 hours, ten days earlier than unetherized plants. By etherization he caused Astilbe japonica to bloom a month to five weeks ahead of a clump not etherized.

Howitt (66) says: "Generally speaking, action of ether varied greatly depending upon whether plants were rested or not. With rested plants, etherization hastens blooming period only a few days, while in non-rested plants it reduces the forcing period by half and gives better blooms. Etherization is not equally effective on all plants. Early blooming shrubs, such as Deutzias, Prunus triloba and Spiraea prunifolia are not benefitted at all by etherization during months of October and November, and are in fact slightly injured by etherization. Lilac blooms were finer and lasted longer than those from retarded plants."

W. Stuart (122) states: "Etherization arrests growth and removes the moisture from the plant tissues in such a manner that it results in a more or less decided

growth acceleration."

M. Butel (26) states: "Strawberries subjected to ether not only flowered and fruited earlier, but also bore a larger yield of fruit than others. Plants etherized for early fruit production give as satisfactory results as plants which are etherized for the production of early flowers."

A. Maumene (94) reports that lilacs, snowballs and Azalea mollis subjected to ether fumes started into growth earlier and came into bloom sooner than those which had not been etherized. He also calls attention, however, to the desirability of considering climate, temperature and season in etherizing plants.

P. Becquerel (15) in 1905 exposed seeds of lupine, peas, alfalfa and clover to ether in a closed receptacle for a period of 365 days. One lot was in the ordinary condition of stored seeds; the other lots were dried over chemicals until no further loss in weight occurred. Of the latter, the seed coat of one lot was perforated, while in the other the seed coat was not modified. In all cases when the seed coats were perforated, there was a loss in germinating power while in dry seeds, just as long as the seed coats remain impermeable, the liquid and vapors had no effect.

T. Taubenhause (129) in 1908 treated both old and fresh seeds with ether to determine their germination.

Seeds of tomato, turnip, cucumber, muskmelon, asparagus, cabbage and wheat were tested. He found that ether invigorated old seeds, since about one-half of the old seeds germinated when etherized, and only one-third of the check seeds of the same kind started. Etherization appears to hasten germination of all seeds tested. Seedlings from etherized seeds were stronger than those from normal seeds. He also says: "A hot house at 75° F. was necessary to accomplish this as no results were secured at medium temperature."

The Physiological or Immediate Effect
of Artificial Agents upon Plants.

There have been many expressions of opinions and much written concerning the physiological effect of artificial agents upon plants. The question as to the true effect of these agents upon plants has not as yet been settled as there has been but very little actual experimental work done to substantiate the many views given.

Claude Bernard (19) came to the conclusion that anesthetics had the same physiological effect upon plants as on animals, since the higher forms of life were the first to succumb to the fumes of ether. He thought that anesthetics caused a coagulation of the protoplasm. This view was perhaps the first one put forth as Aymard(11) and Johannsen (73a) give Bernard the credit of being the first one to discover the influence of anesthetics upon

plants. Dubois (43) in 1891 found that when succulent plants were subjected to ether fumes, large drops of water formed on the surface of the leaves. He concluded that this was due to a withdrawal of water from the protoplasm very similar to that which occurs when freezing takes place. Johanssen (73a) disagrees with Dubois; he says this dehydration occurs only when plants have been exposed to ether long enough to injure the tissue. Dubois' results, however, have been accepted by later writers and experimenters. Aymard (11) in 1903 emphatically supports this view; in support of his opinion he cites an experiment in which lily-of-the-valley pips when treated with a dehydrating agent like phosphoric anhydrid forced even more quickly than when treated with ether. Stuart (125) in 1910 also favors this theory. In speaking of anesthetics he says: "Their effect upon the plant is to arrest growth, extract moisture from the cell protoplasm and through these physiological derangements impart a severe shock to the whole plant which, when removed, causes a decided growth." He also sets forth the view that toxic substances like acetone, alcohol, etc., and non-toxic agents like freezing, vacuum treatments and desiccation cause growth in the same way.

Molisch (98) in 1908, showed that by soaking in warm water the flowering branches or rooted trees or shrubs of woody plants, for from 9 to 12 hours, even great-

er growth is produced than when ether is used. Stuart says: "Hot water imparts a distinct shock to the cell protoplasm and tissue and acts as a solvent in softening up the winter protecting scale inclosing the leaf and flower buds."

Howard (65) in 1915, found, by weighing several lots of twigs before and after etherization, that there was no appreciable loss due to etherization. He concludes therefore that etherization does not cause desiccation. He found that treatments such as etherization, warm water bath, alcohol bath, hydrochloric acid bath, drying, mechanical injury, etc., when applied during the early winter, increased the amount of readily soluble reducing sugars within 24 hours after applications were made.

Drude, Nauman and Ledien (41) in 1903 advanced the theory that ether and chloroform checked some of the changes within the plant while at the same time respiration was increased.

Beltz (18) thought that etherization caused an enlargement of the cells such as occurs in the spring. Iraklionow (68) in 1911 found that warm water caused an increased respiration in potato tubers. He believed that the breaking of the rest period by means of warm water is a simultaneous action of the high temperature and the water and that the warm bath influences enzymes, chiefly oxidases. The enzymes are liberated and act as a lubri-

cant in hastening the reactions necessary for life.

Müller-Thurgau (100) in 1883 found an accumulation of sugar in potato tubers stored at zero degrees C.

The experiments of Butler (27) in 1912, and Appleman (5) in 1914 confirm these results. At this temperature Müller-Thurgau explains that protoplasmic activities are much depressed, hence the fermentation processes produce more sugar than can be used: therefore, the accumulation.

When these potatoes were removed to a warm room respiration was increased, due, he thinks, to the large amount of sugar that was placed at the disposal of the protoplasm. Howard (61) says: "The foundation principle to be worked from is whether a given agency as ether, drying, etc., will cause the formation of sugar in a plant."

Hempel (60) in 1911, after extensive investigations of the effect of etherization on plant metabolism, recognizes three stages of narcotization:

(1) Exciting phase, produced by small doses for short duration, in which the normal processes of plant activity were accelerated.

(2) Narcosis proper, produced by small doses for protracted periods, or by enlarged doses for short duration, characterized by a retardation of the normal processes of plant activity.

(3) Toxic phase, where large doses are used for

long exposures, which produce all phenomena characteristic of the death of the plants.

Klebs (79) is of the opinion that ether is an important factor in liberating enzymes which convert these accumulated foods into favorable forms thus causing growth.

Howard (65) in 1915 states that all artificial anesthetic agents merely act as stimulants to the enzymes which are induced to become active or "are stimulated into greater activity by treating the plant with ether and other agents."

Osterhaut (105) 1913, has shown that the first action of such substances as anesthetics is to lower the permeability of the protoplasm to salts. Thus it is quite possible that evaporation may be hindered both by a physiological alteration in the protoplasmic surface and by a purely physical retardation of the water molecule by the heavy vapor.

Atkins (9a), 1913, found that anesthetics greatly increased permeability of the cell wall for cell sap is much more readily leached out after their application. It must, however, be considered whether these are toxic and irreversible as distinct from true anesthetic effects, which are reversible. To decide this important question, Osterhaut performed several experiments and showed that the decrease in permeability is easily reversible, whereas the increase is not. The facts all favor the view that the

true anesthetic action is due to decrease in permeability.

W. J. Beltz (18) says: "Ether occasions extension of cells through exterior excitation. The extension produces an enlargement of cell capacity in the same manner as that produced on plants by sun in spring time."

Drude (42) says: Ether effects plants by checking some of the changes within the plant cell while at the same time increasing respiration. Too strong doses kill plants. Sufficient but not too weak quantities hasten metabolism."

J. Fisher (48) states: "Treatment with ether must always be given plants which have not lost or are losing their leaves. In general, it is only in the after-resting stage that etherization is of practical value."

Maumene (93) says: "The cause of action of anesthetics on plants is a matter of theory and may be due to an acceleration of the order of growth, or the phenomena may be the suspension of an arrest which has occurred in the natural growth."

On the other hand, ether may be merely an excitant. The vapors may have a momentary effect although they produce extreme stimulation, shorten period of repose and inaugurate vegetation.

Aymard (10) thinks ether or anesthetics act on vegetable tissue as dehydrating agents.

Gerrassimow (65a) found that ether caused in-

creased growth of Spirogyra due to a stimulation of the cell nucleus.

Latham (81) found an increased economy in the metabolism after increased growth of chloroformed fungi.

According to Butkewitsch (65) ether vapor dissolves starch in the leaves. Lepeschkin (65a) found that the osmotic pressure of Spirogyra cells which remained in 0.05 per cent to 1 per cent chloroform, or in 2.5 per cent ether solution, for some time was increased by 0.1 to 0.5 atmospheres. Zaleski (65a) showed that etherization increased the protein regeneration in the cotyledon of Lupinus seedlings, diminishing the loss of glucose and causing a greater movement from endosperm into the growing plant.

Johannsen (65b) and Overton showed clearly that desiccation cannot be caused by the mild doses of ether which are effective in breaking the rest period. Johannsen (74) believed that etherization might either affect the vegetative activity, or it might unfavorably influence the obstacles or inhibiting factors of growth. He explained that small doses of ether were apt to favor vegetative activity, while larger ones such as are given when the rest period is to be broken, weaken or devitalize those factors which are inhibiting growth, thereby indirectly favoring growth.

Some writers think that etherization performs

the same function to plants that freezing does, while others claim that it does not. Howard (65) rather supports the former view.

Klebs (78) points out that a combination of high temperature and humidity favor fermentation and thought it probable that the influences of ether could be traced to this factor.

A. Fisher (49) claimed that the resting buds of trees cannot be made to grow until a certain minimum of the insoluble starch has been changed "to easily respired, and therefore energy yielding, material." However, some other writers do not think the presence of sugar is the determining factor.

Application of Anesthetics.

The kind of plants which have been largely used heretofore for experimental purposes and also in a commercial way are principally flowering shrubs such as lilacs, deutzias, spiraeas, viburnums and azaleas. With few exceptions all of the foreign experimenters have dealt with flowering plants and have based the measure of their success with anesthetics on the relative increase in earliness of blooming.

So far as known to the writer, little, if anything, has been done with perennial plants grown for their edible parts, more particularly with those having fleshy underground roots and crowns. There is a great lack of

experimental data on this subject.

Normally plants will not start into growth until they have entered into the after rest period. The largest measure of success therefore in the use of anesthetics must necessarily come from plants subjected to the influence of ether or chloroform during the early or middle rest period. If one is forcing plants, according to Johannesssen, he must pay particular attention to the different phases of the rest period of each kind of plant used. These phases he divides into the "early rest, middle rest and after rest."

The process of treatment is a comparatively simple one. Plants which are to be treated are subjected to the vapor of ether in an air-tight receptacle for from 24 to 72 hours, depending upon the earliness or lateness of the treatment and the temperature. Owing to the great density of the ether fumes, the anesthetics used should be poured through an opening in the top of the receptacle into an open vessel suspended beneath.

The amount of ether to use per cubic foot of air space should be largely governed by temperature, moisture, season of year and kind of plant to be treated. The higher the temperature and the later the season, the more violent is the effect of the anesthetic; hence the amount and time of exposure to ether or chloroform may be said to vary inversely with the temperature and the season when

treatment is given.

Considerable variation occurs in the amounts recommended by different writers on the subject. Johannsen (74) advises the use of the following number of cubic centimeters of ether per forty gallons of air space (approximately 6.2 cubic feet):

Azaleas.....	49-56 cc
Viburnum opulus....	53-59 cc
Amygdalus Persica.....	42-53 cc
Prunus triloba.....	42-53 cc
Spiraea.....	45-53 cc
Deutzia.....	45-56 cc
Lilacs.....	42-56 cc

Drude, Ledien and Nauman (42) recommended as a normal dose during October, 50-60 grams of ether per hectoliter of air space (approximately 3.5 cubic feet). The normal dose for November is claimed to be 40 grams (57 cc) but during the latter part of the month even this amount is thought to be too great. In October, treatment of 48 hours is recommended, while still later on 24 hours perhaps is sufficient. "Plants were killed when subjected to 40 grams per hectoliter for four days. When 60 grams were used the plants were killed in two days." Quite as much variation has been noted in the amounts recommended by other writers as in the two just noted.

Apparently there is greater latitude in the

amount of ether that plants will stand than is currently believed by those who have practiced its use, and, incidentally, this is one of the problems the writer tries to determine more specifically.

The Influence of Varying Amounts of Carbon Dioxide
in the Air on the Mode of Growth of Plants.

The writer does not find that a great deal of work has been done along this line, but finds a few experiments that have been made and are well worth noting.

In 1898-1899 Brown and Escombe (23) found that in increasing the carbon dioxide content of air, an increase was noted in the photosynthetic power of the leaf in nearly the same proportion. In all cases where the illumination of the leaf was good, the photosynthesis was somewhat in excess of what might be expected from the increased amount of carbon dioxide which was attributed to an excess of ordinary moisture in the air, but later similar results were obtained with insufficient illumination.

Seedling plants were inclosed in a vessel and subjected to varying amounts of carbon dioxide. There appeared to be a slight diminution in the increase of dry matter and a less development of leaf area. There were also certain morphological differences.

The effect of an increased amount of carbon dioxide became most apparent within a week or ten days of

the beginning of the experiment.

A marked difference was noted in the habit and general appearance of the plants, owing to a stimulation of axial growth accompanied by a more or less shortening and thickening of the internodes. As it appeared evident the increased photosynthesis did not contribute to the increase of dry matter of the plant, it is concluded that the transformation, translocation and metabolism of the leaf reserves could not keep pace with the increased tendency to produce an extra amount of plastic material from the atmosphere. Without exception all the plants experimented with seemed to be best adapted to the atmosphere containing the ordinary proportion of carbon dioxide.

The response made to slight increase in this amount appears unfavorable to the growth and reproduction of the plants and it is believed that the comparatively sudden increase in the carbon dioxide in the air, to an extent of two to three times the normal amount, would result in the speedy destruction of nearly all our plants.

Demoussy (38) grew some lettuce under bell jars through which was forced five times the normal amount of carbon dioxide; at the end of 24 days plants in the air weighed only 21 and 24 grams, respectively, while plants which had been treated with carbon dioxide weighed 50 and 60 grams, respectively.

J. B. Farmer and S. E. Chandler (47) report that an excess of carbon dioxide checks the growth of inter-

nodes while prolonging the period of growth. The leaf area is more or less reduced by checking growth of leaves at an early stage. The absolute number of stomata per unit area of leaf surface is considerably increased although the relative proportion of stomata to the number of epidermal cells remains practically constant. The anatomical structure of the leaf is not materially altered.

In the stem xylem areas are less outlined but the phloem shows no alteration. As a rule, there is a considerable increase of starch and a diminution of the amount of tannin and crystals of calcium oxalate.

No alteration could be detected in the roots as a consequence of the increase of carbon dioxide content of the air.

These results differ very much from those obtained by Teodoresco⁽¹³¹⁾ but the difference is perhaps due to slight differences in the experiment.

F. E. Lloyd (88) states that carbon dioxide at high pressure causes artificial ripening of the persimmon which is due to the associated colloid and the physiochemical conduction of the colloid and its consequent behavior toward tannin. Possibly the function of carbon dioxide in this relation may be due to the hastening of the secretion or the activity of a responsible enzyme.

Teodoresco (130) compared plants which had been grown in an atmosphere entirely purified from carbon dioxide,

with others grown in air containing an amount varying from 1.5 to 2 per cent of this gas. He found that under these conditions plants treated with excessive carbon dioxide grew more luxuriantly and exhibited more complete internal differentiation than those deprived of this source of carbon.

Influence of Oxygen on Plant Growth.

A. J. Nabokich (102) claims that resting cells and mature parts of plants with a reduced metabolic assimilation are able to remain a long time without injury in an oxygen-free atmosphere, but that on the contrary young growing cells in the absence of oxygen soon succumb with the typical symptoms of poisoning of the protoplasm resulting from certain metabolic assimilation products. The more vigorously the plants manifest their capacity for growth and metamorphism of organic substances, the more energetically the poisoning occurs. Air with its normal gas content seems to be an unfavorable medium for the growth of young plants. The growth occurs energetically in rarified atmospheres in gas mixture containing small amounts of oxygen and in water in which insignificant amounts of air are dissolved.

Weak concentrates of oxygen materially increased the activity of the protoplasm and therefore the growth of the tissues, while appreciable quantities of this gas checked cell activity thereby hindering and

stopping their growth.

N. Zaleski (138) says: "Oxygen plays no direct role itself in the formation of proteids from amino acids in plants but may do so indirectly. In the absence of oxygen, proteid formation does not occur and therefore probably all living processes of green plants depend on the presence of oxygen."

EXPERIMENTS TO DETERMINE THE INFLUENCE OF CARBON DIOXIDE
AND OTHER CHEMICALS ON ROOT AND VEGETATIVE GROWTH
OF HARD AND SOFT WOOD CUTTINGS AND ON PER CENT
GERMINATION AND AFTER GROWTH OF SEEDS.

The material available made it possible to conduct the experiments along the following lines:

I. To determine if artificial agents, such as ether, may be used to induce early root formation and vegetative growth of plants and cuttings.

(1). To determine the continued effect on hard wood cuttings treated with ether and placed under the following conditions:

- a. Hard wood cuttings immediately placed in cutting bed in greenhouse where night temperature averaged about 60° F., and day temperature about 70° F.
- b. Hard wood cuttings placed in damp sawdust in a cool basement room.
- c. Hard wood cuttings placed outside in a coldframe.

(2). To determine the continued effect of ether on young growing herbaceous plants; also on soft wood cuttings which were placed in sand in the greenhouse, the temperature of which was kept at about 75° F.

II. To determine the effect of carbon dioxide

on vegetative growth and reproductive activity of young growing herbaceous plants.

III. To determine the effect of oxygen and carbon dioxide on the per cent germination of seeds of various kinds of field and garden plants.

IV. To determine the influence of ether and other factors on the carbon dioxide production of some of the herbaceous plants.

V. To determine effect in hastening root formation of hard wood cuttings of some of the common varieties of fruits, of placing terminal buds down in sand in the incubator located in the greenhouse.

VI. To determine the effect of liquid taka-diastase on:

- (1) Per cent germination of various kinds of seeds.
- (2) Root growth and vegetative activity of plants.

General Statement in Regard to Hard Wood Cuttings.

The methods commonly used in propagating poma-ceous fruits are, for the most part, very expensive. Then again, a large number of the woody plants cannot be grown successfully from cuttings because they fail to root even under the best treatment.

One of the main objects of this experiment was to induce these and other plants to form roots and acceler-

ate vegetative growth by the use of the artificial agent, ether. A method of treatment that would bring about this result would be of great economic importance to the commercial nurserymen.

If a method could be perfected whereby ether or other artificial agents could be successfully used in growing these plants from cuttings, the cost of propagation would be greatly reduced.

The only operations necessary then would be to procure the wood in the fall, make the cuttings, give them the necessary artificial treatment, store them away packed in some material such as damp sawdust, in a cool cellar or outside in a callus pit, and finally transfer them to the nursery rows as soon as weather conditions become favorable. This method, as well as the one now in common use, would entail some expense but if the new method should prove of economic value, it would be much less expensive than the one now in common practice.

Such an artificial method of treating cuttings would effect a similar saving in the case of graftage, which method is most commonly practiced in the propagation of our pome fruits. The cost of obtaining and storing cuttings under the desired method would be no greater than the cost of obtaining and storing scions under the present method of treatment. The expense of purchasing and applying the artificial agent to be used under the desired treat-

ment would be counter-balanced by the cost of wax and tying material used under the system now commonly practiced. Not only the nurserymen but the growers and planters as well would profit greatly by such a discovery. They could then purchase or raise the trees at a much lower rate than they are at present paying. It would not only save time but labor and money.

This particular part of the work is, to some extent, similar to the work done by Corriveau (31a) only it is concerned more with the after effects of the artificial agent, and the physiological changes involved than with just merely breaking the rest period, with which he was most vitally concerned.

Hard Wood Cuttings Used.

- (a) Pyrus malus, Linn., var. Jonathan, Ben Davis, Delicious, Gano.
- (b) Pyrus communis X Pyrus Sinensis, var. Kieffer.
- (c) Prunus Persica, Sieb., var. Elberta.
- (d) Liriodendron Tulipifera, Linn., Tulip Tree.
- (e) Acer Saccharinum, Linn., Soft Maple.
- (f) Ligustrum vulgare, Linn., Privet.
- O (g) Prunus cerasifera, Marianna Plum.

Method of Collecting Material.

The first object in view was to secure as nearly uniform samples as possible. Only one year twigs - i.e.,

the growth that had matured during the season of 1916 - were used. The reasons for selecting this material were: first, it would callus and form roots and the vegetative wood would be more tender than older wood; second, it had not been exposed to environmental influences for so long a time and hence had not had as much opportunity to become changed. All the cuttings were taken from the tops of the trees where all were subjected to the same environmental conditions.

Only well matured twigs, with perfectly developed buds were used.

The collection from each tree was kept separate until divided into experimental lots.

For each treatment ten cuttings were used, ten to be etherized and ten used as check. As the cuttings were to be placed under four different environments - sawdust in cool basement, sawdust in cold storage, sand in greenhouse, and sand in coldframe - there was a total of eighty cuttings for each kind used. Since there were ten different species or varieties of hard wood cuttings used, there was a grand total of eight hundred cuttings. The material was secured on October 12-15.

After the material was secured, cuttings from 12 to 16 cm. were made using only the tips of twigs for these. The samples were then given the following treatments; All the cut surfaces of the cuttings were placed down and the terminal buds up. A bunch of cuttings was

held loosely between the hands and then struck lightly on the table, until all cut ends occupied the same plane.

Apparatus and Methods Used in the Experiment.

The general appearance of the apparatus used in etherizing the cuttings is shown in Plate A.. This is merely a liter specimen jar provided with a clamp screw and rubber washer, by means of which the jar could be made air tight.

The cuttings to be etherized were put in the jar, and the whole part of the cuttings etherized by adding commercial sulphuric ether, at the rate of 0.5 cc per liter of air space. The lid was immediately put in place and securely clamped. Special care was taken in adding the ether that none came in direct contact with any of the cuttings. In all treatments the cuttings were subjected to ether fumes for 48 hours.

After the preliminary treatments were administered one lot of cuttings was placed in a cool, north basement room, inverted in moist saw dust; one lot was placed outside, inverted in a large frame of sand. The frame was about 10 feet long and 8 feet wide, containing about 2 feet of sand. During the cold weather of winter, this frame was covered with hay to prevent the sand from freezing. A third lot was removed to a warm greenhouse where the average night temperature was about 60° F., and the average day temperature about 70° F., and set in a well made cutting bed.

A

ETHERIZING CHAMBER

The fourth lot was removed to cold storage down town.

The results obtained by the exposure of the hard wood cuttings to the fumes of ether and placed under four different environments are given in the following tables.

Tables Showing Comparative Results in Number of Cuttings Callused, Number Showing Root and Vegetative Growth and Number Failing to Respond to Treatment of Sulphuric Ether After Being Placed in Cold frame, in Cutting Bed in the Greenhouse and Storage in Moist Sawdust Held in Common and Cold Storage, Collected on Dates From October 12 to 15, 1916.

Date of Obser- va- tions	Stored in Sawdust						Stored in Sand					
	Cellar			Cold Storage			Greenhouse			Outside		
	N	N	N	N	N	N	N	N	N	N	N	N
	o	o	o	o	o	o	o	o	o	o	o	o
	D	C	S	D	C	S	D	C	S	D	C	S
	e	a	t	e	a	t	e	a	t	e	a	t
	a	l	a	a	l	a	a	l	a	a	l	a
	d	l	r	d	l	r	d	l	r	d	l	r
		u	t		u	t		u	t		u	t
		s	e					s	e		s	e
		e	d					e	d		e	d
		d						d			d	
<u>Pyrus Malus, Linn., var. Jonathan</u>												
30	ether	0	0	0	0	0	0	0	0	0	0	0
Oct.	check	0	0	0	0	0	0	0	0	0	0	0
15	ether	0	0	0	0	0	0	0	0	0	0	0
Nov.	check	0	0	0	0	0	0	0	0	0	0	0
18	ether	0	0	0	0	0	0	0	0	0	0	0
Dec.	check	0	0	0	0	0	0	0	0	0	0	0
14	ether	0	1	0	0	0	0	0	1	0	0	0
Jan.	check	0	4	0	0	0	1	1	1	0	0	0
28	ether	1	3	6	3	3	2	0	5	6	2	3
Feb.	check	1	8	0	1	4	0	0	7	0	1	2

A study of the above data shows that callusing started about two months after treatment. The check material placed in sawdust in cellar was the first to start callusing. The cuttings etherized and placed in sand in the greenhouse were the

first to start vegetative growth. This occurred on January 14. A much larger percentage of both treated and untreated material showed greater activity when placed in sand in the greenhouse. Only two cuttings each in sawdust in cold storage and sand on the outside showed any response to vegetative growth up to the last examination on February 28. Those in sand on the outside showed the least response to treatment of any of the cuttings placed under different environments.

None of the treatments employed induced rooting of the cuttings. The results show that artificial treatment delays callus formation and in every case causes greater and quicker vegetative growth.

The results obtained by treating Jonathan cuttings and placing them under different environments show that artificial agents are of no use in hastening callus and foot formation, but do give greater and earlier vegetative growth.

Pyrus Malus, Linn., var. Ben Davis

30	ether	0	0	0	0	0	0	0	0	0	0	0	0
Oct.	check	0	0	0	0	0	0	0	0	0	0	0	0
15	ether	0	0	0	0	0	0	0	0	0	0	0	0
Nov.	check	0	0	0	0	0	0	0	0	0	0	0	0
18	ether	0	0	0	0	0	0	0	0	0	0	0	0
Dec.	check	0	0	0	0	0	0	0	0	0	0	0	0
14	ether	0	1	0	0	0	0	0	0	1	0	0	0
Jan.	check	0	4	0	0	0	0	1	1	1	0	0	0
28	ether	1	3	6	3	3	2	0	5	6	2	3	2
Feb.	check	1	8	0	1	4	0	0	7	0	1	2	0

In this case callus formation started some earlier than in the case of the Jonathan.

The check material placed in sawdust in cellar was again first to callus, while that put in sand in the greenhouse

showed the greatest activity and response to artificial treatment. Observation of the above table shows that in neither of the four environments did artificial agents hasten callus formation, but did accelerate vegetative growth.

Pyrus Malus, Linn., var. Gano

30 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct. check	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov. check	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ether	0	0	0	1	0	0	0	0	0	0	0	0	0
Dec. check	0	2	1	1	0	0	0	0	0	0	1	0	0
14 ether	0	0	3	1	0	0	0	0	0	0	0	1	1
Jan. check	0	3	0	0	2	1	0	3	2	0	1	0	0
28 ether	3	2	6	2	2	7	1	4	7	2	4	4	4
Feb. check	0	5	1	1	8	1	0	7	1	1	6	1	1

In this case vegetative growth started earlier than in either the Jonathan or Ben Davis. This occurred in sawdust in the cellar on treated cuttings. Otherwise the results are comparable to those secured with Jonathan and Ben Davis.

Pyrus Malus, Linn., var. Delicious

30 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct. check	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov. check	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec. check	0	0	0	0	0	0	0	0	0	0	0	0	0
14 ether	1	0	2	0	0	0	0	3	3	0	0	0	0
Jan. check	0	0	1	0	1	0	0	4	4	0	1	0	0
28 ether	0	3	5	0	2	5	0	4	8	0	2	3	3
Feb. check	1	3	1	1	3	1	0	5	6	0	3	1	1

Callusing and vegetative growth took place with the cuttings placed in sand in greenhouse in about 45 days - much earlier than with the cuttings placed under the other environments. The activity of both check and treated specimens in callusing and vegetative growth was much greater under this environment than under the others. Again the check in all

four conditions showed greater callusing than the treated.

Prunus cerasifera var. Marianna

30	ether	0	0	0	0	0	0	0	0	0	0	0	0
Oct.	check	0	0	0	0	0	0	0	0	0	0	0	0
15	ether	0	0	0	0	0	0	0	0	0	0	0	0
Nov.	check	0	0	0	0	0	0	0	0	0	0	0	0
18	ether	0	0	0	0	0	0	0	0	0	0	0	0
Dec.	check	0	0	0	0	0	0	0	0	0	0	0	0
14	ether	0	1	2	0	0	0	0	2	0	0	0	0
Jan.	check	0	2	0	0	1	0	0	3	0	0	2	0
28	ether	1	3	3	0	3	3	0	4	5	0	2	4
Feb.	check	0	4	1	0	5	1	0	6	3	0	3	2

Callusing started with the cuttings in sawdust and sand in greenhouse in about 15 days after treatment. Vegetative growth started in about 3 months. The cuttings in sand in greenhouse showed more vegetative growth than any of the others. In every case greater callusing took place with the check quicker than with the treated.

Ligustrum vulgare (Privet)

30	ether	0	0	0	0	0	0	0	0	0	0	0	0
Oct.	check	0	0	0	0	0	0	0	0	0	0	0	0
15	ether	0	0	0	0	0	0	0	0	0	0	0	0
Nov.	check	0	0	0	0	0	0	0	0	0	0	0	0
18	ether	0	0	0	0	0	0	0	0	0	0	0	0
Dec.	check	0	0	0	0	0	0	0	0	0	0	0	0
14	ether	0	0	0	0	0	0	0	2	0	0	1	0
Jan.	check	0	1	0	0	0	0	0	5	0	0	2	0
28	ether	0	3	4	0	2	2	0	5	5	0	3	2
Feb.	check	0	4	1	0	4	1	0	6	2	0	4	1

The cuttings of Privet showed very little effect at the time of last observation. Callusing took place in about 3 months after putting the cuttings out. Vegetative growth began in about 4 months, and was greater in sand in greenhouse than with cuttings in the other three environments. It showed least, however, with the cuttings in sawdust in cold

storage. Callusing showed more in the checks than with the treated cuttings, in every case.

Acer Saccharinum, Linn. (Soft Maple)

30 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct. check	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov. check	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec. check	0	0	0	0	0	0	0	0	0	0	0	0	0
14 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Jan. check	0	1	0	0	0	0	0	0	0	0	0	1	0
28 ether	2	3	2	0	4	4	1	1	6	2	1	2	2
Feb. check	1	5	0	0	5	2	0	6	2	1	4	0	0

The first callusing took place about $2\frac{1}{2}$ months after cuttings were made. This occurred first with the check of the cuttings placed in sawdust in the cellar, and in sand on the outside. Vegetative growth started about 4 months after cuttings were made and put out. It was most active with the cuttings placed in sand in the greenhouse. The vegetative growth was more active with the treated cuttings than with any of the others in the four different environments.

Pyrus communis x Pyrus sinensis, var. Kieffer

30 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct. check	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ether	0	4	0	0	3	0	0	7	0	0	5	0	0
Nov. check	0	5	0	0	4	0	0	3	0	0	6	0	0
18 ether	0	5	0	0	3	0	0	8	0	0	5	0	0
Dec. check	0	6	0	0	5	0	0	9	0	0	6	0	0
14 ether	1	5	2	1	4	1	0	8r	4	0	6	2	2
Jan. check	1	6	0	0	6	0	0	9	2	0	7	0	0
28 ether	1	5r	3	0	4	5	1	8r	6	1	7	4	4
Feb. check	1	6	0	0	6	2	0	9	3	0	8	2	2

Those marked r, rooted.

Both treated and untreated cuttings, in all four environments, started callusing in about 15 days. However, the callus was more pronounced in the case of the cuttings in sand in the greenhouse. The cuttings of the checks were callused more in every case than the treated cuttings. Vegetative growth started in about 2 months in all four conditions, but a greater amount of growth took place in the case of the cuttings in sand in the greenhouse. There was less vegetative growth with cuttings placed in sawdust in cold storage than with any of the cuttings of the four different environments. Root growth started with the cuttings in sand in the greenhouse in January and with those in sawdust in the cellar in February.

Prunus Persica var. Elberta

30 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct. check	0	0	0	0	0	0	0	0	0	0	0	0	0
15 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov. check	0	0	0	0	0	0	0	0	0	0	0	0	0
18 ether	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec. check	0	0	0	0	0	0	0	0	0	0	0	0	0
14 ether	1	0	0	2	0	0	2	0	0	1	0	0	0
Jan. check	3	0	0	0	1	0	1	0	0	1	0	0	0
28 ether	1	2	5	5	3	6	2	3	6	3	2	4	4
Feb. check	3	4	1	2	5	2	0	5	1	1	1	0	0

Callusing showed up on the check cuttings in sawdust in cold storage about 2½ months after being put out. It did not appear, however, on any of the others for about 4 months. A higher percentage than usual died in the case of the treated cuttings of all environments. Again callus-

ing took place with the treated material. In this case the vegetative growth was greatest in sawdust in cold storage, but appeared about the same time in every condition of environment.

Liriodendron Tulipifera, Linn., Tulip Tree

30	ether	0	0	0	0	0	0	0	0	0	0	0	0
Oct.	check	0	0	0	0	0	0	0	0	0	0	0	0
15	ether	0	0	0	0	0	0	0	0	0	0	0	0
Nov.	check	0	0	0	0	0	0	0	0	0	0	0	0
18	ether	0	0	0	0	0	0	0	0	0	0	0	0
Dec.	check	0	0	0	0	0	0	0	0	0	0	0	0
14	ether	1	0	0	0	0	0	0	1	0	0	5	0
Jan.	check	0	2	0	0	2	0	0	3	0	0	2	0
28	ether	0	2	6	0	3	3	0	2	6	0	3	3
Feb.	check	1	3	4	0	1	1	0	5	5	0	3	1

The first callusing of treated cuttings took place with those in sand in the outside and sand in the greenhouse. Check cuttings were the first to callus as usual. This occurred about $2\frac{1}{2}$ months after the cuttings were put out. Vegetative growth started about 4 months after cuttings were made and treated. The treated cuttings placed in sand in the greenhouse showed greater response to treatment than any of the treated cuttings. But the treated cuttings were more active in every case than were the checks.

Hard wood cuttings of the above were made October 12 to 15, treated and then placed under the four different environments - namely, sand in greenhouse, sawdust in cellar, sawdust in cold storage, and sand on the outside.

These were left in the places designated until February and then examined. All cuttings that were callused

or showed root growth were transferred to an incubator in the greenhouse. This incubator is about 3 feet wide and 6 feet long, closed over the top with glass, and having a shelf about two-thirds the way to the top holding about 8 inches of sand. Underneath this shelf is placed a thermostat which keeps the temperature constantly at 80° F.

The cuttings remained in the incubator from February 29 to March 28. Observation was made March 25 to determine if there had been additional root growth and also to observe the additional foliage growth.

The treated cuttings in every case showed luxuriant vegetative growth except in the case of Ligustrum vulgare which showed some growth but not nearly so much as the other cuttings. The treated cuttings that had previously been in sand in the greenhouse showed greatest vegetative growth. The checks in every case had made some vegetative growth but not so much as the treated ones.

About two-thirds of the treated cuttings of Prunus Persica var. Elberta died when transferred to the incubator, showing that the ether treatment was too strong for this variety when placed in conditions of high temperature.

The foliage growth in all cases was principally confined to the terminal buds.

There was no root growth except in the case of Pyrus communis x Pyrus Sinensis var. Kieffer. In addition

PLATE 13

Cuttings of Kieffer pear and Jonathan apple made October 12-15 and exposed in closed jar to fumes of sulphuric ether at the rate of 0.5 cc of ether per liter of air for 48 hours. Lots 1, 2, 3 and 4 were stored in moist sawdust in basement. Lots 5 and 6 stored in frame of sand on outside. The cuttings remained in these environments until February 29, then were transferred to sand in incubator located in greenhouse. Observations made March 25.

KIEFFER PEAR (Pyrus communis x Pyrus sinensis)

(Upper Figure)

Lots 1 and 2 stored in moist sawdust in basement.

Fig. 1 Check. Growth well started.

" 2 Etherized. Note accelerated foliage growth.

KIEFFER PEAR (Pyrus communis x Pyrus sinensis)

(Central Figure)

Lots 3 and 4 stored in sand in the coldframe.

Fig. 3 Check. Growth just starting.

" 4 Etherized. Note excess foliage growth.

JONATHAN APPLE (Pyrus Malus, Linn).

(Lower Figure)

Lots 5 and 6 stored in moist sawdust in basement.

Fig. 5 Check. Growth not started.

" 6 Etherized. Growth well started.

13

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PLATE 14

Cuttings of Delicious apple, Ben Davis apple and Elberta peach. Made October 12-15 and exposed in closed jar to fumes of sulphuric ether at the rate of 0.5 cc per liter of air for 48 hours. Lots placed in moist sawdust in basement until February 29, then transferred to sand in incubator located in the greenhouse. Observation made March 25.

Pyrus Malus, Linn., var. Delicious.

(Upper Figure)

Fig. 1 Check. Showing no growth.

" 2 Etherized. Note accelerated foliage growth.

Pyrus Malus, Linn., var. Ben Davis.

(Central Figure)

Fig. 3 Check. Growth just starting.

" 4 Etherized. Note excess foliage growth.

Prunus Persica var. Elberta.

(Lower Figure)

Fig. 1 Check. Note foliage well started.

" 2 Etherized. Treatment too severe.
Cuttings slightly injured.

14

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to the ones that were rooted when transferred to the incubator, there were four more that showed root growth.

The results obtained by treating the above named cuttings with the artificial agent, ether, in the early fall, show that the artificial agent is not effective in hastening callus formation or root growth in any case except with Pyrus communis x Pyrus Sinensis var. Kieffer. These cuttings showed hastening of root growth when placed in sand in the greenhouse.

Reference to Plates 13 and 14 will show the vegetative growth in both check and treated material.

EFFECT OF ETHER UPON SOFT WOOD CUTTINGS.

The object of this experiment was to note the effect of ether upon soft wood cuttings. In making the exposures (a) ether was applied at the rate of 0.5 cc per liter of air for exposures at different lengths of time; and, (b) at different strengths for the same duration.

Since there has been such a diversity of opinion among writers on the amount of ether one should use in treating plants, at certain times, the writer performed this experiment with the view of ascertaining to some degree, the correct amount of ether one should apply, and the length of exposure when applied at a certain rate. This study was made with reference to the treatment of cuttings of some of the herbaceous plants.

Description of Cuttings.

Material used in this experiment was taken as soft wood cuttings from just previous to first early autumn frost. The mother plants were grown to maturity in the field from small potted plants propagated and grown in the greenhouse until time for spring setting.

In general the cuttings were from well matured, thriftily grown, healthy, vigorous plants.

On October 4, 5 and 6, ten soft wood cuttings of each of fourteen different species and varieties were made. The cuttings of each variety were divided into two

equal lots, each lot being placed in a separate specimen jar. One lot was then exposed to the fumes of a measured quantity of sulphuric ether for a definite period, also a variable quantity of ether for periods of varied duration, while the other lot was left untreated to serve as a check for the etherized lot.

The varieties of plants used in the preparation of the cuttings, the method of treatment, and the results secured, together with notes taken on November 11, at which time the observations were made, follow.

Large Alternanthera (Telanthera versicolor, Regels).

Table 1, Pl. 1 & 2

1-a. The exposure of Large Alternanthera for 30 minutes at the rate of 0.5 cc per liter of air gave the maximum amount of foliage growth. In this case the 15 minute exposure was inferior to that of the check in both root and foliage growth. The foliage of these cuttings was slightly burned and the root growth was very poor. The root and foliage growth of the check appeared normal. The 1 and 2 hour exposures at the same rate as the 15 minute exposure were inferior in root and foliage growth to that of the 30 minute treatment. The exposure for 3 hours at the same rate was entirely too severe, as all the cuttings in this lot were severely burned.

PLATE 1 & 2

LARGE ALTERNANTHERA (Telanthera versicolor, Regels)

Six sets of 5 cuttings each were exposed to the fumes of sulphuric ether at the rate of 0.5 cc of ether per liter of air. The time of exposure varied for each set.

- Fig. 1 Check cuttings. Showing normal foliage and root growth.
"	2	Exposed 15 min.	Showing slight injury to foliage.
"	3	" 30 "	Note accelerated root and foliage growth.
"	4	" 60 "	Leaves smaller than 3.
"	5	" 120 "	Leaves larger and more turgid than 4.
"	6	" 180 "	Foliage badly injured due to too long exposure.

Large Alternanthera (Telanthera versicolor, Regels)

Table 1, Pl. 3 & 4

1-b. The 15 minute exposure of Large Alternanthera, at the rate of 1 cc per liter of air gave a maximum amount of root and foliage growth. The roots were longer and more numerous than the roots of any of the other lots. The check was very poorly rooted and foliage of two of the cuttings was slightly injured. The 30 minute and 1 hour exposures at the rate of 1 cc per liter of air were inferior to that of the 15 minute exposure, but the cuttings apparently were normal in both root and foliage growth.

Dwarf Green Alternanthera (Telanthera amoena, Regels)

Table 2, Pl. 3 & 4

2. The exposure of Dwarf Green Alternanthera for 15 minutes at the rate of 0.5 cc per liter of air was slightly superior to the cuttings of all the other lots in root and foliage growth. The roots were longer and more numerous. The 30 minute and 1 hour exposures at the same rate were normal and healthy, but apparently the treatment did not have the accelerating effect as in the 15 minute treatment. The check appeared normal in every way.

Rose Geranium (Pelargonium quercifolium, Bailey)

Table 2, Pl. 5

3. Exposure of Rose Geranium for 30 minutes at the rate of 0.5 cc ether per liter of air gave best results. Cuttings, both treated and untreated, were in good condition

PLATE 3 & 4

(Upper Figure)

LARGE ALTERNANTHERA (Telanthera versicolor, Regels)

The four sets of 4 cuttings each were exposed to the fumes of sulphuric ether at the rate of 1 cc per liter of air. The time of exposure was varied for each set.

Fig. 1 Check cuttings. Note lack of root growth.

"	2	Exposed 15 min.	Showing accelerated root and foliage growth.
"	3	" 30 "	Showing accelerated root and foliage growth.
"	4	" 60 "	Length of exposure too severe.

PLATE 3 & 4

(Lower Figure)

The four sets of 4 cuttings each were exposed to the fumes of sulphuric ether at the rate of 1 cc per liter of air. Time of exposure was varied for each set.

Fig. 1 Check cuttings. Showing normal foliage and root growth.

"	2	Exposed 15 min.	Note accelerated root growth; they were greater in number and longer than check.
"	3	" 30 "	Normal foliage and root growth.
"	4	" 60 "	Normal foliage and root growth.

HERB. IMP. VIENNA

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4

PLATE 5

ROSE GERANIUM (Pelargonium hortorum, Bailey).

The six sets of 4 cuttings each were exposed to the fumes of sulphuric ether at the rate of 0.5 cc of ether per liter of air. The time of exposure was varied for each set.

- Fig. 1 Check cuttings. Note small amount of root growth.
"	2	Exposed 15 min.	Note accelerated root growth over the check.
"	3	" 30 "	Note excess of root and foliage growth. The roots were longer and more fibrous.
"	4	" 60 "	Note decrease in amount of root growth.
"	5	" 120 "	Two of the cuttings slightly injured.
"	6	" 180 "	Length of exposure too severe.

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in so far as root and foliage growth was concerned. However, the 30 minute treatment induced a greater number of roots slightly longer than those resulting from the 15 minute treatment. The foliage growth of the two was about the same. The foliage growth of the 15 minute treatment, as well as the root growth, was superior to that of the check in general appearance, vigor and growth. The leaves of the check had a slightly yellow tinge and looked somewhat unhealthy. Root growth of the plants was very poor, roots being short and very few in number. Exposure for more than 1 hour was too severe. The cuttings were so severely injured they failed to recover.

Coleus (Coleus Verschaffeltii, Linn.)

Table 3, Pl. 6

4. Exposure of Coleus at the rate of 1 cc for 2 hours was entirely too severe. One of the cuttings was dead and the remainder were badly injured. This plant is too tender and succulent for this length and rate of exposure. The control cuttings were all well rooted and the foliage growth appeared normal in every respect.

Cigar Plant (Cuphea ignea, D.C.)

Table 3, Pl. 6

5. The exposure of the cigar plant for 15 minutes at the rate of 1 cc per liter of air gave the maximum amount of root and vegetative growth. The 30, 60 and 90 minute exposures, at the same rate, were poorly rooted but

PLATE 6 & 7

(Upper Figure)

COLEUS (Coleus Verschaffeltii, Linn.)

The four sets of 4 cuttings each were exposed to fumes of sulphuric ether in varied quantities for a period of 2 hours.

- Fig. 1 Check cuttings. Normal root and foliage growth.
"	2	1 cc exposure.	All cuttings badly injured.
Leaves and stems severely burned.
"	3	1.25 cc "	Quantity of ether and length of exposure too severe.
"	4	1.5 cc "	Quantity of ether and length of exposure too severe.

PLATE 6 & 7

(Lower Figure)

*CIGAR PLANT (Cuphea ignea, D.C.)

The two sets of 4 cuttings each were exposed to the fumes of sulphuric ether at the rate of 1 cc per liter of air for a period of 15 min.

- Fig. 1 Check. Normal root and foliage growth.
"	2	Exposed 15 min.	Note accelerated root and foliage growth.

*Only 2 of the 5 sets photographed.

7

2

1

3

2

1

4

6

PLATE 8 & 9
(Upper Figure)

MEADOW SAGE (Salvia farinacea, Benth.)

The two sets of 4 cuttings each were exposed to the fumes of sulphuric ether at the rate of 0.5 cc of ether per liter of air for 15 minutes.

- Fig. 1 Check cuttings. Poorly rooted, foliage normal.
" 2 Exposed 15 min. Note lack of root growth.
Treatment too severe.

PLATE 8 & 9
(Lower Figure)

LARGE LANTANA (Lantana camara, Linn.)

The two sets of 4 cuttings each were exposed to fumes of sulphuric ether at the rate of 0.5 cc per liter of air for 15 minutes.

- Fig. 1 Check cuttings. Note lack of roots.
" 2 Exposed 15 min. Note accelerated root and foliage growth.

PLATE 10

ROSE GERANIUM (Pelargonium hortorum, Bailey).

The five sets of 4 cuttings each were exposed to the fumes of sulphuric ether at the rate of 1 cc per liter of air. The time of exposure was varied for each set.

Fig. 1	Check cuttings.	Poorly rooted but normal foliage growth.
" 2	Exposed 15 min.	Poorly rooted but normal foliage growth.
" 3	" 30 "	Poorly rooted but normal foliage growth.
" 4	" 60 "	Note accelerated root and foliage growth.
" 5	" 120 "	Cuttings badly injured. Length of exposure too long.

10

the foliage growth was equally as vigorous. The check cuttings were equal to any of the treated cuttings in foliage growth, but were slightly inferior in root growth to the 15 minute exposure at the rate of 1 cc per liter of air.

Meadow Sage (Salvia farinacea, Benth).

Table 3, Pl. 8

6. Meadow Sage exposed for 2 hours to ether at the rate of 0.5 cc per liter of air had a detrimental effect so far as root growth was concerned. None of the cuttings of this exposure were rooted, but the foliage growth appeared normal and healthy. Three of the five cuttings of the check were medium well rooted; two of them failed to take root. The foliage growth on all the cuttings of this run of checks were normal and healthy.

Large Lantana (Lantana camara, Linn).

Table 4, Pl. 9

7. Large Lantana exposed for 2 hours at the rate of 0.5 cc per liter of air caused a very marked acceleration of root and vegetative growth. These cuttings were medium well rooted. The foliage of the check appeared normal and healthy but none of them took root.

Rose Geranium (Pelargonium quercifolium, Bailey)

Table 4, Pl. 10

8-a. Rose Geranium exposed for 1 hour at the rate of 1 cc per liter of air gave a greater amount of root growth than any of the other exposures at the same rate.

Exposure at the same rate for $1\frac{1}{2}$ hour was too severe, as two of the plants died and the foliage of two of the remainder was seriously injured. However, the three living ones were medium well rooted. Apparently there was no difference in root or foliage growth of the 15 and 30 minute treatments at the rate of 1 cc per liter of air, to that of the check. None of the treated cuttings at the above rate appeared so vigorous in root and foliage growth as the 15 and 30 minute exposures at the rate of 0.5 cc per liter of air on the same variety of cuttings in a previous treatment.

Rose Geranium (Pelargonium quercifolium, Bailey).

Table 4, Pl. 11a.

8-b. Exposure of Rose Geranium at the rate of 0.75 cc per liter of air for two hours was entirely too severe for this variety. The treated cuttings were all very severely injured. In no case except the check did the cuttings take root. Treatment of 1.25 cc for 2 hours killed three of the five cuttings. Exposure of 1.5 cc for 2 hours killed all the cuttings. The check was poorly rooted.

Coleus (Coleus Verschaffeltii, Linn.)

Table 5, Pl. 11b

9. Exposure of Coleus at the rate of 0.5 cc for one hour gave superior root and vegetative growth over the 15 minute exposure or the check. Exposure, however, for

PLATE 11a

ROSE GERANIUM (Pelargonium hortorum, Bailey)

The four sets of 4 cuttings each were exposed to fumes of sulphuric ether in varied quantities for a period of 2 hours.

- Fig. 1 Check cuttings. Note the normal foliage but poor root growth.
"	2	0.75 ^{cc} exposure.	Showing very severe injury.
"	3	1 cc "	Severely burned.
"	4	1.25 cc "	All practically dead.

PLATE 11b

COLEUS (Coleus Verschaffeltii, Linn.)

The five sets of 4 cuttings each were exposed to the fumes of sulphuric ether at the rate of 0.5 cc per liter of air. The time of exposure was varied for each set.

- Fig. 1 Check. Note small number of leaves and roots.
"	2	Exposed 15 min.	Showing accelerated foliage growth but very poor root growth.
"	3	" 30 "	Note increased root growth.
"	4	" 60 "	Showing maximum root and foliage growth. Roots long and fibrous.
"	5	" 120 "	Note decrease in root and foliage growth.

Photograph made on Nov. 11.

111 (b)

2 hours at the same rate gave splendid results as far as root growth was concerned, yet the foliage growth did not look as healthy as the foliage exposed for 1 hour. Apparently there was no difference between the check and the 15 minute exposure; both were poorly rooted. One of the check cuttings was dead and the leaves of two of the others were slightly injured.

Marguerite (Chrysanthemum frutescens, Bailey).

Table 5

10. Exposure of standard strength of ether fumes was too severe for Marguerite cuttings. Since the plant is very tender and succulent, a smaller quantity of ether than the standard strength necessarily must be used if favorable results are to be expected. The check was medium well rooted and foliage growth appeared normal and healthy.

Large Lantana (Lantana camara, Linn.)

Table 5

11. An exposure of Large Lantana for 15 minutes at the rate of 0.5 cc per liter of air gave superior results to any of the other treatments, as far as foliage growth was concerned. A 30 minute exposure at the rate of 0.5 cc gave superior root growth in that the roots were longer and greater in number than those developed as a result of the 15 minute treatment. In the 30 minute exposure more of the plants were dead than in the case of the 15 minute treatment. When duration of time was increased to 1 hour practically

the same results followed as in the exposure of 30 minutes at the same rate, except the loss in number of cuttings was greater. Doubling length of time of exposure to the 0.5 cc strength killed nine of the ten cuttings. The one remaining was so badly injured that it barely produced root.

Salvia (Salvia splendens).

Table 6.

12. *Salvia* cuttings exposed for 15 and 30 minutes at the rate of 0.5 cc per liter of air, gave superior root growth in that the roots were longer and better developed than on the control lot. Apparently there was no difference resulting from the 15 or 30 minute treatments as indicated by root and foliage growth. The ten checks were poorly rooted. The leaves of two of these cuttings were slightly unhealthy. The general appearance indicated an exhaustion of a reserve of food previous to rooting.

Chrysanthemum (Chrysanthemum hortorum).

Table 6

13. Every period of exposure at the rate of 0.5 cc per liter of air proved detrimental to *Chrysanthemum* cuttings. Eight of the ten cuttings of the 15 minute treatment were dead. The leaves on the others were slightly injured and the plants were poorly rooted. If favorable results are to be secured in treating *Chrysanthemum* cuttings with ether, a smaller quantity than 0.5 cc per liter of air for a period of short duration must be used.

Cigar Plant (Cuphea ignea, D.C.)

Table 7

14-a. One hour exposure of the cigar plant at the rate of 0.5 cc per liter of air produced superior results in root and foliage growth than a larger quantity of ether. The check was medium well rooted and the foliage growth was good, yet not so vigorous in appearance.

Cigar Plant (Cuphea ignea, D. C.)

Table 7

14-b. Cigar Plant exposed for one hour at the rate of 0.5 cc per liter of air showed the maximum amount of foliage and root growth. Both root and foliage growth were vigorous and healthy. The 15 and 30 minute and the 1 hour exposures were of equal efficiency relative to root growth, yet as a result of the 1 hour exposure, the foliage growth was not as vigorous. The leaves were larger and of a deeper green color than possessed by the check. This plant responds to treatments of ether more favorably than any of the varieties utilized in these experiments.

Blue Sage (Salvia patens, Linn.)

Table 7

15. Exposures of Blue Sage for 15 minutes at the rate of 0.5 cc per liter of air, and for 30 minutes at the rate of 1 cc per liter of air, had a very detrimental effect as far as root growth was concerned. These cuttings did not take root, yet the tops remained normal and healthy.

The check was slightly rooted, and the foliage growth apparently normal. In the exposure for 15 minutes at the rate of 1.5 cc, the leaves were very badly injured, the injury resembling that of frost. Eight of the ten cuttings were dead; the remaining two failed to take root.

Exposure for 15 minutes at the rate of 1.75 cc per liter of air killed all of the cuttings. A study of the table shows that in every case ether had a detrimental effect on this plant.

Sweet Alyssum (Alyssum Maritimum, Lam.)

Table 8

16. The exposures of Sweet Alyssum for 15 and 30 minutes at the rate of 0.5 cc per liter of air gave an increased root growth over that of the check. Apparently there was no difference between the foliage growth of the two lots. The check was very poorly rooted. Cuttings of the 15 and 30 minute exposures were fairly well rooted. Exposure for 1 hour at the rate of 0.5 cc per liter of air slightly injured the leaves. The root growth was also very poor.

Artillery Plant. (Pilea Serpyllifolia, Wedd.)

Table 8

17. The Artillery Plant exposed to ether for 15, 30, 60 and 120 minutes at the rate of 0.5 cc per liter of air responded less than the check in root and vegetative growth. All the treated cuttings rooted very poorly. The check cuttings gave slightly better results. The leaves on the cuttings of the 1 hour exposure at the rate of 0.5 cc per liter of air

were slightly injured. Those on the $1\frac{1}{2}$ hour exposure at same rate were badly injured. The results of this experiment show that ether at the above rate for the period of exposure used should not be recommended for this plant.

White Geranium (Pelargonium hortorum, Bailey)

Table 9

18-a. White Geranium exposed for 1 hour at the rate of 0.5 cc per liter of air gave the maximum amount of root and vegetative growth and much superior to that of the check in that the roots were longer and greater in number. The foliage growth of the check was apparently healthy, yet the cuttings were very poorly rooted. The exposure for $1\frac{1}{2}$ hours at the rate of 0.5 cc per liter of air slightly injured the leaves but was followed by excellent root growth. In this exposure three of the ten plants were badly injured.

White Geranium (Pelargonium hortorum, Bailey)

Table 9

18-b. White Geranium exposed for 15, 30 and 60 minutes at the rate of 1 cc per liter of air gave about the same results as that of the check in both root development and foliage growth. Exposure for $1\frac{1}{2}$ hours at the same rate slightly injured the leaves. Results would indicate that ether used at the above rate, and for these periods of exposure, should not be recommended for this plant, as results were not superior in any way to that of the check.

TABLE 1

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Exposure

Large Alternanthera 1-a (Telanthera versicolor, Regels) Pl. 1 & 2

No. Lot	Amount of Ether cc	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	Ck.	Ck.	0	5	1	All plants in good condition.
2	0.5	15	0	4	1	Two plants slightly injured.
3	0.5	30	0	5	3	All plants in good condition.
4	0.5	60	0	5	3	All plants in good condition.
5	0.5	120	0	5	2	All plants in good condition.
6	0.5	180	2	1	1	All plants badly injured

Large Alternanthera 1-b (Telanthera versicolor, Regels) Pl. 3 & 4

1	Ck.	Ck.	2	1	1	All in fair condition.
2	1	15	3	2	1	Leaves slightly injured on all.
3	1	30	2	1	1	Leaves badly injured on all.
4	1	60	3	0	0	Leaves badly injured on all.
5	1	120	5	0	0	All dead.

TABLE 2

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Duration.

Dwarf Green Alternanthera (Telanthera amoena, Regels) Pl. 3 & 4

No. of Lot	Amount ether cc	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	Ck.	Ck.	0	5	2	All in fair condition
2	0.5	15	0	5	3	Accelerated root and foliage growth
3	0.5	30	0	5	2	All plants in good condition
4	0.5	60	0	5	2	All plants in good condition
5	0.5	120	0	5		All plants in good condition

Rose Geranium (Pelargonium hortorum, Bailey) Pl. 5

1	Ck.	Ck.	1	4	1	Leaves on two appeared yellow
2	0.5	15	0	5	3	All in good condition
3	0.5	30	0	5	4	All in good condition
4	0.5	45	1	4	1	One of four living, slightly injured
5	0.5	60	1	4	2	Two of four living, badly injured
6	0.5	120	1	3	1	All badly injured

TABLE 3

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Duration

Coleus (Coleus Verschaffeltii, Linn) Pl. 6 & 7.

No. of Lot	Amount ether cc	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	Ck.	Ck.	0	5	4	All in good condition
2	1	120	1	4	1	All badly injured
3	1.25	120	3	1	1	All badly injured
4	1.5	120	5	0	0	Dead
5	1.75	120	5	0	0	Dead

Cigar Plant (Cuphea ignea, D.C.)

1	Ck.	Ck.	0	10	2	All in good condition
2	1	15	0	8	3	All in good condition
3	1	30	0	9	1	All in good condition
4	1	60	0	9	1	All in good condition
5	1	90	0	4	1	All in good condition
6	1	120	3	6	1	Leaves and stems slightly injured

Meadow Sage (Salvia farinacea, Benth) Pl. 8 & 9

1	Ck.	Ck.	1	3	1	All plants in good condition
2	0.5	15	0	0	0	All plants in good condition

TABLE 4

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Duration

Large Lantana (Lantana camara, Linn.) Pl. 8 & 9

No. of	Amount ether cc	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	Ck.	Ck.	0	0	0	All in good condition
2	0.5	15	0	5	1	All in good condition

Rose Geranium 1-a (Pelargonium hortorum, Bailey) Pl. 10

1	Ck.	Ck.	0	4	2	All cuttings in good condition
2	1	15	0	5	2	All cuttings in good condition
3	1	30	0	5	2	All cuttings in good condition
4	1	60	0	5	4	All cuttings in good condition; had leaves of darker green color
5	1	120	2	5	3	Foliage slightly injured

Rose Geranium 1-b (Pelargonium hortorum, Bailey) Pl. 11a

1	Ck.	Ck.	1	4	1	Two plants slightly injured
2	0.75	120	1	0	0	All badly injured
3	1	120	1	0	0	All badly injured
4	1.25	120	3	0	0	All badly injured
5	1.5	120	5	0	0	Dead

TABLE 5

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Duration

Coleus (Coleus Verschaffeltii, Linn.) Pl. 11b

No. of Lot	Amount ether	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	Ck.	Ck.	1	3	1	Two slightly injured
2	0.5	15	0	4	1	All in good condition
3	0.5	30	0	5	3	All in good condition
4	0.5	60	0	5	4	All in good condition
5	0.5	120	0	5	3	Slightly injured

Marguerite (Chrysanthemum frutescens, Bailey).

1	Ck.	Ck.	0	7	2	All in fair condition
2	0.5	15	10	0	0	All dead
3	0.5	30	10	0	0	All dead
4	0.5	60	10	0	0	All dead
5	0.5	120	10	0	0	All dead

Large Lantana (Lantana camara, Linn).

1	Ck.	Ck.	0	0	0	All in fair condition
2	0.5	15	0	5	1	All in fair condition
3	0.5	30	3	1	2	All not dead in fair condition
4	0.5	60	5	5	1	All not dead in fair condition
5	0.5	120	9	1	1	Leaves slightly injured

TABLE 6

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Duration

Salvia (Salvia splendens, Ker-Gawl)

No. of Lot	Amount ether cc.	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	Ck.	Ck.	6	4	1	Leaves slightly in- jured
2	0.5	15	3	7	2	All not dead in good condition
3	0.5	30	6	4	2	All not dead in good condition
4	0.5	60	8	2	1	Leaves all badly in- jured
5	0.5	120	7	3	0	Leaves all badly in- jured

Chrysanthemum (Chrysanthemum hortorum)

1	Ck.	Ck.	2	5	2	Leaves not very healthy
2	0.5	15	8	2	2	Leaves slightly in- jured
3	0.5	30	6	4	1	Leaves slightly in- jured
4	0.5	60	8	2	1	Leaves slightly in- jured
5	0.5	120	10	0	0	Dead

TABLE 7

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Duration

Cigar Plant 1-a (Cuphea ignea, D.C.)

No. of Lot	Amount ether cc	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	Ck.	Ck.	0	10	3	All in good condition
2	0.5	60	0	10	4	All in good condition
3	0.75	60	0	10	3	All in good condition
4	1.	60	0	10	1	All in good condition
5	1.5	60	8	2	1	All badly injured

Cigar Plant 1-b (Cuphea ignea, D.C.)

1	Ck.	Ck.	0	10	3	All in good condition
2	0.5	15	0	10	4	All in good condition
3	0.5	30	0	10	4	All in good condition
4	0.5	60	0	10	4	All in good condition
5	0.5	120	5	5	3	Those living badly injured

Blue Sage (Salvia patens, Linn.)

1	Ck.	Ck.	3	5	1	All in fair condition
2	0.5	15	0	0	0	All in fair condition
3	1.	15	0	0	0	All in fair condition
4	1.5	15	8	0	0	Leaves badly injured
5	1.75	15	10	0	0	Dead

TABLE 8

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Duration

Sweet Alyssum (Alyssum maritimum, Lam.)

No. of Lot	Amount ether cc	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	Ck.	Ck.	0	10	1	All plants in fair condition
2	0.5	15	0	10	2	All plants in fair condition
3	0.5	30	0	10	2	All plants in fair condition
4	0.5	60	0	10	1	Leaves on all slightly injured
5	0.5	90	0	3	1	Leaves more severely injured than on 4

Artillery Plant (Pilea serpyllifolia, Wedd.)

1	Ck.	Ck.	0	8	2	All plant in fair condition
2	0.5	15	0	10	1	All plants in fair condition
3	0.5	30	0	10	1	All plants in fair condition
4	0.5	60	1	9	1	Leaves slightly injured
5	0.5	90	7	3	1	Leaves badly injured

TABLE 9

Showing Results with Different Varieties of Soft Wood Cuttings
Exposed to Sulphuric Ether in Varied Quantities
During Different Periods of Duration

White Geranium (Pelargonium hortorum, Bailey)

No. of Lot	Amount ether cc	Time min.	No. dead	No. rooted	Rank in rooting	Condition of Plant
1	0.5	15	0	3	1	All in good condition
2	0.5	30	0	6	2	All in good condition
3	0.5	60	1	9	4	All not dead in good condition
4	0.5	90	3	7	3	Leaves slightly injured
5	Ck.	Ck.	1	9	2	All not dead in good condition

White Geranium (Pelargonium hortorum, Bailey)

1	1	15	1	9	3	Those not dead in good condition
2	1	30	3	7	3	Those not dead in good condition
3	1	60	1	9	3	Those not dead in good condition
4	1	90	4	6	2	Leaves slightly injured.
5	Ck.	Ck.	0	10	2	All in good shape

Explanation of figures in column marked "rank in rooting."

- No. 1 - poorly rooted
- " 2 - slightly rooted
- " 3 - medium well rooted
- " 4 - well rooted

TABLE 10

showing Quantity of Anesthetic and Time of Exposure Recommended
for the Following Soft Wood Cuttings

Plant	Time of Exposure	Amount Ether to Use per Liter of Air
<i>Telanthra versicolor</i> , Regels	15 min.	0.5 cc
<i>Telanthra amoena</i> , Regels	120 "	0.5 cc
<i>Telanthra Beetzichiana</i> , Regels	120 "	0.5 cc
<i>Pelargonium quercifolium</i> , Bailey	45 "	1. cc
<i>Coleus Verschaffeltii</i> , Linn	60 "	0.5 cc
<i>Salvia Patens</i> , Ker-Gawl	No results as good as check	No results as good as check
<i>Lantana camara</i> , Linn.	30 min.	0.5 cc
<i>Chrysanthemum frutescens</i>	No results as good as check	No results as good as check
<i>Salvia splendens</i> , Ker-Gawl	30 min.	0.5 cc
<i>Chrysanthemum hortorum</i> ,	15 "	0.5 cc
<i>Cuphea ignea</i> , D. C.	60 "	0.5 cc
<i>Alyssum maritimum</i> , Lam.	30 "	0.5 cc
<i>Pilea serpyllifolia</i> , Wedd	No results as good as check	No results as good as check
<i>Pelargonium hortorum</i> , Bailey	90 min.	0.5 cc

Summary

1. Soft wood cuttings of herbaceous plants are susceptible to fumes of ether.

2. The influence of anesthetics varies with temperature and humidity.

3. The physiological condition of plant and the succulence of stem are also factors that must be considered when applying ether as an accelerator.

4. In general the higher the temperature, within a maximum, the smaller the quantity of anesthetic required.

5. In general under average normal temperatures, the greater the humidity, the less proportionate effect a given quantity of anesthetic produces on the green growing plant.

6. Vegetative growth of leaves and stems was accelerated in Telanthera versicolor, Regels, Telanthera amoena, Regels, Pelargonium quercifolium, Bailey, Coleus Verschaffeltii, Linn., Cuphea ignea, D.C., Lantana camara, Linn., and Pelargonium hortorum, Bailey.

7. Root formation was accelerated in Telanthera versicolor, Regels, Telanthera amoena, Regels, Pelargonium quercifolium, Bailey, Coleus Verschaffeltii, Linn., Cuphea ignea, D. C., Lantana camara, Linn., Pelargonium hortorum, Bailey, Salvia splendens, Ker Gawl, and Alyssum Maritimum, Lam.

8. The greatest accelerated effect is secured without injury to the cutting.

9. The varieties of plants do not respond to equal quantities of anesthetic applied for the same period of time, nor to larger doses during longer or shorter duration.

10. In general exposure of soft wood cuttings to the fumes of ether has a decided beneficial effect on the rooting of soft wood cuttings.

11. In general the weaker doses of ether applied during a longer period of time under low temperature, and a reduced humidity, have a less detrimental, a greater beneficial and a more lasting effect than stronger doses applied under similar conditions.

THE EFFECT OF ETHER UPON THE TISSUE OF SOFT WOOD CUTTINGS.

There has been a great diversity of opinion among experimenters as to the physiological effect of anesthetics upon plants. Some believe anesthetics act as a dehydrating agent, others that such action as drying and freezing do no injury to the plant tissue, while others believed dehydration takes place with plants treated with ether only when plant tissue has been injured. According to Howard (61) Johannsen and Overton support this latter view very vigorously. Stuart supports the view that ether causes a desiccation of plant tissue, but does not state that plant cells necessarily will be injured before desiccation takes place. In order to come to some definite conclusion as to which of the above views is correct, the writer performed an experiment, to determine whether plants exposed to anesthetics for a certain length of time, at a certain rate of ether per liter of air, lost or gained in weight.

On November 26, ten cuttings of several species and varieties of soft wood cuttings were made. Each variety was divided into several lots of ten cuttings each. Each lot was placed in a separate specimen jar. From three to seven lots of each variety were subjected to the fumes of ether at a definite rate per liter of air for a certain time while one lot of each variety was left untreated to serve as

a check. The results are given in Tables 11, 12, 13, 14 and 15, which are appended to this section.

Soft Wood Cuttings Used.

(a) <u>Chrysanthemum frutescens</u>	40 cuttings
(b) <u>Salvia patens</u> , Ker Gawl	40 "
(c) <u>Coleus Hybrida</u> ,	65 "
(d) <u>Lantana camara</u> , Linn	40 "
(e) <u>Telanthera Versicolor</u> , Regels	40 "

All cuttings were carefully weighed immediately following preparation, then treated and reweighed. The checks were held in a specimen jar in a manner identical with those treated. After they were treated and weighed, all were put in a sand bed in the greenhouse, kept at a temperature of about 75° F.

A study of the following tables shows that in every case where the cuttings were slightly injured, severely injured or killed, the plants lost in weight. The loss in weight runs in direct proportion to the degree of injury. These results seem to be comparable to Johannsen's ideas, that ether acts as a desiccating agent only when the plant tissue has been injured or killed. The greater the injury, the greater the loss in weight. Where there was no injury, the cuttings either weighed the same as in the first weighing or gained slightly in weight. The injury to the cuttings was either the result of too long exposure for the amount of ether used, or to an excess of ether. The in-

jury resembled that of frost, the leaves blackened and wilted down, and in case of severe injury the cuttings later died.

These cuttings were observed again on November 30, and in every treatment where they were badly injured, they had died or were so near dead they did not take root.

It was noticed that when the plants were treated to the extent that they were badly injured, the receptacle in which they were treated contained considerable moisture on the sides and bottom - a greater amount than one would suspect due to transpiration. In one or two cases the Marguerite cuttings in particular were badly injured and had a considerable quantity of water in the bottom of the jar.

This leads to the conclusion that where the tissues of the plant are injured, the cell walls are rendered pervious and thus give off their water content. That where the tissues are not injured the cells retain their contents and consequently do not lose in weight in the time exposed, to an appreciable amount.

These results are contrary to a great many views set forth by some of the writers on the subject of physiological effect of anesthetics upon plants - i.e., that anesthetics have the same influence on plants as drying and freezing, in that it induces desiccation of the living tissue.

TABLE 11

Soft Wood Cuttings Etherized to Determine Whether They Lost or Gained in Weight.

Every exposure 2 hours unless otherwise stated in tables.

Marguerite (Chrysanthemum frutescens)

No. of Lot	Amount of ether cc	Wt.in grams before treating	Wt.in grams after treating	Loss	Gain	Remarks
1	1	13.3	13.3	0	0	All plants in good condition
2	1.25	12.4	12.3	.1	0	Leaves on all slightly injured
3	1.5	13.0	12.7	.3	0	Very badly injured, later died
4	Ck.	12.4	12.5	0	.1	All in good condition

Marguerite (Chrysanthemum frutescens)

1	0.5	9.6	9.65	0	.15	All plants in good condition
2	1	10.2	10.2	0	0	All plants in good condition
3	1.25	10.7	10.5	.2	0	Four of the five badly injured
4	Ck.	9.6	9.6	0	0	All in good condition

Blue Sage (Salvia patens, Ker Gawl)

1	1	11.1	11.1	0	0	All in good condition
2	1.25	7.7	7.5	.2	0	Three of the five plants slightly injured.
3	1.5	7.5	7.4	.1	0	Four of five plants slightly injured
4	Ck.	5.5	5.5	0	0	All in good condition

TABLE 12

Soft Wood Cuttings Etherized to Determine Whether They Lost
or Gained in Weight

Every exposure 2 hours unless otherwise stated in tables

Blue Sage (Salvia patens, Ker Gawl)

No. of Lot	Amount ether cc	Wt.in grams before treat- ing	Wt.in grams after treat- ing	Loss	Gain	Remarks
1	0.5	7.5	7.5	0	0	All in good condition
2	1	7.1	7.15	0	.05	All in good condition
3	1.25	7.4	7.1	.3	0	All badly injured
4	Ck	8.2	8.25	0	.05	All in good condition

Coleus (Coleus Hybrida)

1	0.5	19.5	19.5	0	0	All in good condition
2	0.75	19.2	19.25	0	.05	All in good condition
3	1.	19.0	18.9	.1	0	All slightly injured
4	1.25	18.8	18.6	.2	0	Leaves badly injured
5	1.5	19.1	18.85	.25	0	Leaves and stems badly injured
6	2.	19.6	19.4	.2	0	Leaves and stems badly injured
7	Ck.	19.4	19.4	0	0	All in good condition
8	Ck.	18.4	18.45	0	.5	All in good condition

TABLE 13

Soft Wood Cuttings Etherized to Determine Whether they Lost
or Gained in Weight

Every exposure 2 hours unless otherwise stated in tables

Large Alternanthera (Telanthera Versicolor, Regels)

No. Lot	Amount of ether cc	Wt.in grams before treat- ing	Wt.in grams after treat- ing	Loss	Gain	Remarks
1	0.5	15.2	15.2	0	0	All plants in good condition
2	1.	14.7	14.5	.2	0	All plants in good condition
3	.75	14.	13.9	.1	0	Leaves on all slightly injured
4	Ck.	15.3	15.3	0	0	All in good condition

Large Alternanthera (Telanthera Versicolor, Regels)

1	1	16	15.9	.1	0	Leaves and stem slightly injured
2	1.25	13.9	13.6	.3	0	Leaves and stem badly injured. (died)
3	1.5	15.2	14.8	.4	0	Leaves and stem badly injured. (died)
4	Ck.	14.1	14.13	0	.03	All plants in good condition

TABLE 14

Soft Wood Cuttings Etherized to Determine Whether they Lost
or Gained in Weight

Etherized with 1 cc.

Coleus (Coleus Hybrida)

No. of Lot	Time min.	Wt.in grams before treat- ing	Wt.in grams after treat- ing	Loss	Gain	Remarks
1	15	13.5	13.5	0	0	All plants in good condi- tion
2	30	14.6	14.65	0	.05	All plants in good con- dition
3	60	14.9	14.08	.1	0	Three of five plants slightly injured
4	120	16.7	16.4	.3	0	All slightly injured

TABLE 15

Soft Wood Cuttings Etherized to Determine Whether they Lost
or Gained in Weight

Exposed 2 hours.

Large Lantana (Lantana camara, Linn.)

No. of Lot	Amount of ether cc	Wt.in grams before treat- ing	Wt.in grams after treat- ing	Loss	Gain	Remarks
1	0.5	12.2	12.2	0	0	All plants in good condition
2	0.75	13.9	13.95	0	.05	All plants in good condition
3	1.	11.1	10.9	.2	0	Two of five slightly injured
4	1.25	14.5	14.4	.1	0	Three of five slight- ly injured
5	1.5	13.6	13.1	.5	0	All badly injured
6	1.75	12.7	12.3	.3	0	All badly injured
7	2	13.8	13.2	.6	0	Four of five plants dead
8	Ck.	12.5	12.5	0	0	All in good condition

GROWTH OF COLEUS VERSCHAFFELTII, LINN.,
FOLLOWING TREATMENT WITH ETHER.

The object of this experiment was to show the after effects of sulphuric ether on Coleus Verschaffeltii following treatment with ether at the rate of 0.5 cc per liter of air.

On October 5, twenty cuttings of Coleus Verschaffeltii were prepared and divided into five lots of four cuttings each. Lot 1 served as a check; lot 2 was subjected to the fumes of ether for 15 minutes; lot 3, for 30 minutes; lot 4, for 60 minutes; lot 5, for 120 minutes.

Each lot of cuttings was set immediately following treatment in the sand bed in the greenhouse, in a temperature of about 75° F. They were examined on November 11, weighed and a photograph taken of the plants. At this time the plants were set in 4 inch pots and held in the greenhouse where they were allowed to grow until December 21 when a second observation was made and another photograph of the plants taken; also the number of leaves, weight of leaves, stem and root were recorded.

It will be noted from inspection of Pl. 12 showing the effects of the treatment after being exposed to periods of different duration, that there is a marked

PLATE 12

COLEUS (Coleus Verschaffeltii, Linn.)

The five sets of 4 cuttings each were exposed to fumes of sulphuric ether at the rate of 0.5 cc per liter of air. The time of exposure varies for each lot.

Fig. 1 Check. Note small number of leaves and roots.

"	2	Exposed 15 min.	Showing accelerated root and foliage growth.
"	3	" 30 "	Note increased root growth.
"	4	" 60 "	Showing maximum root and foliage growth.
"	5	" 120 "	Showing slight decrease in root and foliage growth.

Photograph made 40 days after the first photograph.

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difference in root growth. Exposures for 30, 60 and 120 minutes were especially effective in accelerating root growth. The maximum amount of root growth was obtained with the 1 hour exposure; the minimum amount of root growth, as well as of foliage growth, took place with the checks. The roots on the plants exposed for the greater length of time seem to be confined more to the tip end of the cuttings. There was a greater number of roots on the side of the stem with the cuttings exposed to the periods of shorter duration. There apparently was no difference in the general healthfulness of the plants of the different lots. The leaves on the plants of the check lot were smaller and fewer in number than on any of the treated lots. The stems of the plants in the lot exposed to the ether for 1 hour were much larger than the stems of the plants of any of the other treated lots. The treated plants were stockier, bushier in appearance and had developed a larger number of branches than the plants of the untreated lot. The table shows that the number of leaves, weight of leaves, stem and root increased in direct proportion to the time of exposure, the 1 hour exposure being the maximum.

A study of the table shows that accelerated growth of plants due to exposure to anesthetics is permanent instead of temporary, and that the treated plants maintain their increased weight over the untreated plant as they increase in size, due to growth.

TABLE 16

Showing Weight of Coleus Verschaffeltii Treated with Sulphuric Ether at the Rate of 0.5 cc per Liter of Air, at the time of First Photographing Nov. 11; also Number of Leaves, Weight of Leaves, Stem and Root at Time of Second Photographing Dec. 21.

Wt. of plant at time of first photographing November 11		Wt. of plant at time of second photographing December 21	
Time etherized	Wt. in grams		Wt. in grams
Ck.	11.7		15.9
15 min.	16.4		26.3
30 "	17.3		27.9
60 "	18.5		29.5
120 "	19.8		30.4

Time of Second Photographing				
Time etherized	No. of leaves	Wt. of leaves in grams	Wt. of stem in grams	Wt. of root in grams
Ck.	94	6.3	9.45	.2
15 min.	184	12.0	14.0	.3
30 "	222	13.1	15.5	.9
60 "	180	13.2	14.0	.7
120 "	253	14.9	14.8	.7

EFFECT OF ETHER UPON YOUNG ACTIVELY GROWING
TOMATO PLANTS (LYCOPERSICUM ESCULENTUM)

The object of this experiment was to note the effect of ether upon young actively growing tomato plants, used at the rate of 0.5 cc per liter of air for a definite length of time.

On February 1, four tomato plants the same age, about 8 inches high, and as nearly uniform in shape as possible, were selected from a lot that had been grown in 6 inch pots in the greenhouse. Each of these plants was placed in a 5 liter specimen jar and ether was added to two of the jars, at the rate of 0.5 cc per liter of air. Each of these jars was immediately closed air tight. The other two were closed in the same manner and served as controls. These four jars were then labeled as to treatment and set on a table in the greenhouse where the day temperature was kept at about 74° F., and night temperature about 60° F.

Results.

On February 5 the first observation was made. On the two plants that had been treated with ether, adventitious roots could be seen breaking through the surface all along the stem, while the checks showed no indication of such growth. On February 9 the second observation was made and a photograph was taken of one of the treated and

one of the untreated plants. At this time the adventitious roots on the two plants that had been previously treated with ether were much longer and new roots were breaking through the surface of the stems and branches. The untreated plants showed no signs of adventitious growth.

In addition to the accelerated growth of adventitious roots, there was a very marked difference between the two sets in regard to general habit and appearance; the treated plants were taller and the leaves were of a darker green color. The new leaves toward the apex of the treated plants were some smaller and more curled than those on the untreated ones. The distance between the internodes and the size of the stem was about the same on both treated and untreated plants. (See Pl. 15). At this date the plants were removed from the specimen jars and the pots containing the plants were buried in sand which was kept at about 75° F. These were then let grow until mature or until they were in full blossom, which was about eight days earlier than the untreated plants. The general characteristics of the blossoms of both treated and untreated plants were very similar, except those of the treated ones were larger.

After the treated plants were out of the specimen jars a few days, they returned to their normal color or the color of the untreated ones.

The results of this experiment show that ether causes a very marked accelerative growth and earlier flowering by about a week on the Lycopersicum esculentum.

PLATE 15

TOMATO PLANT (Lycopersicum Esculentum)

Exposed in closed jar to fumes of sulphuric ether for five days.

Fig. 1 Etherized. Accelerated foliage and adventitious root growth.

" 2 Check. No adventitious root growth.

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EFFECT OF CARBON DIOXIDE
UPON YOUNG GROWING RAPHANUS SATIVUS.

The object of this experiment was to determine the relative influence of varying amounts of carbon dioxide on Raphanus sativus to alternate exposures of periods of 12 hours duration, the periods extending from 6 A.M. to 6 P.M.

On January 15, six radish plants of the same age, about 6 inches tall, with fleshy roots about three-fourths to one inch in diameter, and as uniform in shape and size as possible to select from a large number grown singly in 5 inch pots held in the greenhouse, were selected. These plants were divided into two lots of three plants each and treated according to the following schedule.

Lot I.

1. Check - plant enclosed in the jar during the night and held in the open during the day.
2. Exposed during the night, in a closed jar, to the action of carbon dioxide 6 to 10 times that of the normal atmosphere, and held in a normal atmosphere during the day.
3. Exposed, during the night, in closed jar that had atmosphere displaced by the in-

troduction of chemically prepared carbon dioxide, but exposed during the day to normal atmosphere.

Lot. II.

4. Check - plant enclosed in jar during day and in open at night.
5. Exposed, during the day, to carbon dioxide 6 to 10 times that of normal atmosphere, and during the night to normal air.
6. Exposed, during the day, in closed jar having atmosphere displaced by carbon dioxide, and exposed, during the night, to normal air.

Each of these plants was placed in a 3 liter specimen jar provided with a clamp screw and rubber gasket, by means of which the jar could be made air tight.

The air was displaced by attaching a rubber tube to an iron cylinder containing carbon dioxide; the other end was then placed in the jar containing the plant. The carbon dioxide was turned on and allowed to run in for a time sufficient to displace the air. The jar was then closed immediately and made air tight. Carbon dioxide was supplied to the jar containing the plant that was to be exposed to 6 to 10 times that of normal air, in a like manner.

The jars containing the plants were kept in the

greenhouse with a night temperature of about 60° F., and a day temperature of about 70° F.

On the third day following the inauguration of the experiment, the first observation was made. Plant 3 was dead, and plant 6 was badly injured. The leaves of the latter plant were of normal color but were slightly wilted. Plants 2 and 5 appeared vigorous and healthy. Plants 1 and 4 were also normal in every respect.

On January 23 a second observation was made. Plant 6 was dead, and plant 2 was slightly injured. The leaves of the latter were slightly discolored on the margin. Plant 5 appeared vigorous and healthy, and the leaves were of a darker green color and showed accelerated growth over the check of the same lot. Apparently there was no difference between plants 1 and 2.

The plants were now removed from the large jars in which the exposures were made, and the pots plunged in sand in the greenhouse. Here these remained until maturity or until in full bloom. Plant 5 produced flowers five days earlier than plant 2, and seven days earlier than either of the checks. Both of the treated plants flowered more abundantly than the checks, yet the blossoms on plant 5 were greater in number and much larger than those on plant 2. There was a marked difference in the habit and general appearance of the two treated plants when compared with the two checks. The leaves of the treated plants were smaller,

greater in number, somewhat curled and of a darker green color than the untreated ones. There was not much difference in the general appearance and habit of the two treated plants, the most noticeable being a larger top and a greater number of flowers for plant 5.

The results of this experiment apparently warrant the conclusion that young growing radish plants soon die when enclosed in a jar, in which the air had been displaced by carbon dioxide, for 12 hours then alternated with an exposure to normal air for a similar period. That carbon dioxide greatly accelerated the growth of young radish plants exposed in a closed jar, for alternate periods of 12 hours duration (night and day), to an atmosphere enriched with carbon dioxide 6 to 10 times that of normal air. Accelerated growth was most marked when the radish plant was exposed during the day in a closed jar to an atmosphere enriched in carbon dioxide 6 to 10 times that of normal air, and exposed at night to normal air. The check radish plant enclosed in a jar during the day and in the open at night had a healthier appearance and was greener in color, but was no larger than the check kept in a closed jar during the night and in the open during the day.

THE INFLUENCE OF CARBON DIOXIDE ON THE PER CENT GERMINATION
OF SOAKED SEEDS OF VARIOUS KINDS OF FIELD AND GARDEN PLANTS.

The factors influencing the development of soaked seeds and the nature of the impetus which results in germination are still, in most respects obscure. The large range of cases of delayed or non-germination of dry seeds which, to all appearances, were in good condition for germination, has been the basis of considerable research.

Kidd (76) showed that high pressures of carbon dioxide in the atmosphere retarded or inhibited the germination of some seeds. The seeds used in his experiments fell into two classes. In the first class the seeds germinated at once, after removal from the inhibitory carbon dioxide pressure. In the second class the inhibition continued indefinitely after the removal of the inhibitory carbon dioxide pressure, and was terminated only by complete drying or re-wetting, or by the removal of the testa. In this class a lower degree of permeability of the testa to gases by the action of carbon dioxide is indicated. A change which would result, (1) in a reduction in the amount of oxygen reaching the embryo; (2) a relative rise in the actual carbon dioxide pressure in the embryo tissues. The condition of prolonged inhibition after removal to the air was suggested as being the condition of seeds often met

with in nature, the germination of which is often delayed in spite of suitable conditions of temperature and moisture.

By taking into consideration the above experimental data, the writer performed this experiment to ascertain the effect of carbon dioxide on the per cent germination of soaked seeds of a large number of field and garden plants.

On December 4, forty-three varieties of seeds were selected for treatment. Lots of each variety were subjected to four different treatments as follows:

1. Soaked 3 hours, exposed to carbon dioxide for 24 hours, and planted immediately.
2. Soaked 3 hours, held in closed jar 24 hours, and planted immediately.
3. Dry, planted.
4. Soaked 3 hours and planted immediately.

As noted, the 43 varieties of seeds were each divided into four lots. Seventeen varieties contained 25 seeds in each lot, while the remainder contained 50 seeds in each lot. The plan was to use a smaller number of the larger seeds, and a greater number of the smaller seeds. The jar in which these seeds were exposed to carbon dioxide was a 12 liter specimen jar, provided with a clamp and rubber gasket by means of which the jar could be made air tight.

Treatment 1. In the first treatment the seeds were placed in test tubes and soaked in tap water for 3

hours. The tubes containing the seeds were then put in a small wire basket and placed in the specimen jar. One end of a rubber tube was attached to an iron cylinder containing carbon dioxide; the other end was placed in the specimen jar. The carbon dioxide was turned on and allowed to run long enough to displace all of the air. After the seeds remained in the jar 24 hours they were planted in a sand-bed in the greenhouse.

Treatment 2. Seeds were placed in test tubes the same as in Treatment 1, then soaked 3 hours, after which they were put in a wire basket and placed in the specimen jar, which was closed for 24 hours after which the seeds were planted in a sand-bed in the greenhouse, as described above.

Treatment 3. Seeds were planted dry in sand-bed in the greenhouse.

Treatment 4. Seeds were put in test tubes the same as in Treatments 1 and 2 and covered with tap water for 3 hours. This was done 3 hours before time to plant the seeds from Treatments 1 and 2. The lots of seeds variously treated were planted at the same time.

The day temperature of the greenhouse was kept at about 70° F., and the average night temperature about 60° F. The sand in which the seeds were planted was kept at about 75° F.

On December 14 the first observations were

made as to per cent of germination. Apparently there was no difference in the time of germination of the lots of the same kind of seeds receiving the four different treatments, except in case of the lots of dry seeds which was delayed about a day in coming through the sand. The lots treated with carbon dioxide germinated at the same time as those soaked 3 hours and then held in closed jar for 24 hours; also the lot soaked 3 hours and planted immediately.

At the time the seedlings from the dry seeds had been above the ground for three or four days one could not observe a difference in size from the same variety receiving other treatment.

TABLE 17

Showing Per Cent Germination of Different Kinds
of Field and Garden Seeds After Being Exposed
to Carbon Dioxide

Variety	Per Cent Germination			
	(25 seeds used)			
	(1)	(2)	(3)	(4)
<i>Zea Mays</i> , Linn.	96	84	56	60
<i>Phaseolus vulgaris</i> , Linn.	84	76	72	60
<i>Phaseolus lunatus</i> , Linn.	12	24	32	8
<i>Helianthus annuus</i> , Linn.	96	92	100	96
<i>Lupinus albus</i> , Linn.	92	96	92	84
<i>Lupinus luteus</i> , Linn.	4	4	0	0
<i>Trifolium</i> , sp.	16	8	0	0
<i>Zea Mays</i> , Linn.	96	100	80	64

<i>Phaseolus vulgaris</i> , Linn.	100	100	72	48
<i>Pisum sativum</i> , Linn.	96	92	52	62
<i>Pisum sativum</i> , Linn.	36	36	0	4
<i>Citrullus vulgaris</i> , Schrad.	84	100	0	0
<i>Andropogon Sorghum</i> , Piper	52	84	36	68
<i>Zea everta</i> , Sturt.	100	96	100	100
<i>Citrullus vulgaris</i> , Schrad.	8	24	0	0
<i>Vigna sinensis</i> , Endl.	24	68	60	24
<i>Vicia sativa</i> , Linn.	40	16	76	78
(50 seeds used)				
<i>Triticum sativum</i> , Lam.	96	90	96	96
<i>Hordeum vulgare</i> , Linn.	74	72	96	76
<i>Vicia sativa</i> , Linn.	4	30	18	4
<i>Citrullus vulgaris</i> , Schrad.	38	44	0	0
<i>Avena sativa</i> , Linn.	86	94	98	92
<i>Trifolium hybridum</i> , Linn.	72	54	76	80
<i>Petroselinum hortense</i> , Hoffm.	0	0	0	0
<i>Licopersicum esculentum</i> , Mill.	48	36	56	62
<i>Andropogon Sorghum</i> , Piper	20	20	14	20
<i>Oryza</i> , sp.	8	26	0	0
<i>Andropogon Sorghum</i> , Piper	32	28	0	6
<i>Brassica oleracea</i>	66	54	74	62
<i>Secale cereale</i> , Linn.	0	10	0	0
<i>Trifolium Pratens</i> , Linn.	64	64	48	42
<i>Brassica oleracea</i> , Linn.	20	48	60	32
<i>Medicago sativa</i> , Linn.	80	76	66	60

<i>Trifolium incarnatum</i> , Linn.	10	32	38	38
<i>Panicum crus-galli</i> , Linn.	62	60	40	62
<i>Andropogon sorghum</i> , Piper	3	1	0	0
<i>Raphanus sativus</i> , Linn.	42	50	54	98
<i>Lespedeza striata</i> , Hook. and Arn.	26	34	0	0
<i>Brassica rapus</i> , Linn.	80	96	96	92
<i>Cucumis melo</i> , Linn.	70	60	8	0
<i>Trifolium Repens</i> , Linn.	62	84	78	34
<i>Hibiscus esculentis</i> , Bailey	76	80	72	62
<i>Cucumis sativus</i> , Linn.	12	42	14	10
<hr/>				
	Average	50.8	55.5	47.8 41.7

1. Soaked 3 hrs., carbon dioxide 24 hrs., planted.
2. Soaked 3 hrs., closed jar 24 hrs., planted.
3. Dry, planted.
4. Soaked 3 hrs., planted

A study of the above table shows by taking the average per cent of all the lots soaked, those that had been soaked for 3 hours and kept in closed jar for 24 hours, ranked higher in average per cent of germination than any of the other lots. The lot giving the second highest average per cent germination was soaked 3 hours, exposed to carbon dioxide 24 hours and planted immediately. The third highest average per cent of germination were those planted dry and without treatment. The lowest average was produced when soaked for 3 hours and planted immediately. The writer cannot understand why lots of dry seed receiving no treatment should give a higher average per cent germination

than lots of the same kind of seeds soaked for 3 hours and planted immediately. Perhaps one reason why a higher average percentage of all seeds was not obtained was possibly due to the seeds being a little old.

It will be noted that not only did the lots treated with carbon dioxide show a higher average per cent germination than the lot planted dry, and the lots soaked 3 hours and planted, but germinated just as soon as any of the lots of the same kind of seed differently treated. Consequently one would conclude that none of the varieties tested in this experiment come in the class where the inhibition continued indefinitely after the removal of the inhibitory carbon dioxide pressure.

EFFECT OF OXYGEN ON GERMINATION OF SEEDS.

The object of this experiment was to determine the influence of oxygen on the per cent germination of dry and soaked seeds.

On December 18 fifteen different kinds of seeds were selected for treatment. Each kind of seed was divided into four lots of 50 each. Lot 1 was soaked in tap water for 6 hours, exposed to oxygen for 24 hours and planted. Lot 2 was soaked in tap water for 6 hours and planted. Lot 3 was dry and exposed to oxygen 24 hours and planted. Lot 4 was planted dry. The lots exposed to oxygen were put in large glass tubes and placed in a 5 liter specimen jar with

lid and rubber gasket. One end of a rubber tube was then attached to an iron cylinder containing oxygen and the other end placed in the specimen jar. The oxygen was turned on and let run long enough to displace the air. The jar was then immediately closed. After the seeds remained in the specimen jar for 24 hours they were planted in the sand in the greenhouse, where the day temperature was held at about 70, and the night temperature about 60° F.

The seeds that were soaked were placed in large glass tubes and covered with tap water 6 hours before the 24 hours expired in Lots 1 and 2. This was done so that all the seeds could be planted immediately after each treatment and as nearly as possible at the same time. The sand in which the above seeds were planted was kept at a temperature of about 75° F.

The results of the test are arranged conveniently in the table appearing on the next page.

TABLE 18

Showing Per Cent Germination of Different Kinds
of Seeds Under Four Different Treatments.

Kind of Seed	Per Cent Germination			
	(1)	(2)	(3)	(4)
<i>Zea everta</i> , Sturt.	100	98	100	100
<i>Zea Mays</i> , Linn.	98	100	96	100
<i>Helianthus annus</i> , Linn.	98	98	100	98
<i>Lupinus albus</i> , Linn.	100	96	98	100
<i>Pisum sativum</i> , Linn.	100	1000	100	100
<i>Phaseolus vulgaris</i> , Linn.	96	98	98	100
<i>Avena sativa</i> , Linn.	100	100	100	100
<i>Phaseolus vulgaris</i> , Linn.	96	98	96	98
<i>Vigna sinensis</i> , Endl.	100	96	94	100
<i>Hordeum vulgare</i>	98	100	100	98
<i>Zea Mays</i>	98	100	100	100
<i>Raphanus sativus</i> , Linn.	92	98	96	94
<i>Citrullus vulgaris</i> , Schrad.	94	100	92	98
<i>Brassica rapus</i> , Linn.	100	94	96	100
<i>Triticum sativum</i> , Lam.	98	100	100	100
Total average per cent	97.8	97.7	97.7	99.06

1. Soaked 6 hrs., oxygen 24 hrs., planted.
2. Soaked 6 hrs., planted.
3. Dry, exposed to oxygen 24 hrs., planted.
4. Dry, planted.

The soaked seeds of lots 1 and 2 germinated at approximately the same time. Lot 1 which had been exposed to oxygen in addition to being soaked gave approximately the same average per cent of germination.

The dry lots germinated about one day later than the soaked. However, there was no difference in time of germination between the soaked lots. The average per cent of germination of all seeds in these two lots was approximately the same. Lot 3 germinated an average of 97.7 per cent, lot 4, 99. One could not tell the difference in size or vigor of the plants from the soaked or the dry seeds of the same variety, four or five days following the date the dry seeds pushed through the sand.

A study of Table 18 shows the reasons the writer would not recommend an exposure of soaked seeds to oxygen previous to planting.

INFLUENCE OF ETHER AND OTHER FACTORS UPON THE PRODUCTION OF CARBON DIOXIDE BY MUSA CAVENDESHII.

An exposure to the fumes of ether judiciously planned and of a measured volume, applied at the proper time for the particular plant treated, has been found by many experimenters to increase respiration and hasten metabolism favorable to a very marked acceleration in growth; also, that a rise to an optimum temperature increases respiration.

With this idea the writer performed an experiment to determine the effect of ether upon the amount of carbon dioxide produced by Musa Cavendeshii.

Musa Cavendeshii growing in a box 1 foot square, having attained a height of $2\frac{1}{2}$ feet, was placed in a galvanized tub. A piece of heavy canvas was then dipped in paraffin and cut to fit over the top of the tub enclosing the base of the plant. The lower edge of the canvas was tied tightly in order that air could not escape from the box. The canvas in contact with the stem of the plant was also paraffined in order that no air could enter from without, thus preventing evaporation other than through the plant. The glass container in which the plant was to be placed was $7 \times 3\frac{1}{2} \times 3\frac{1}{2}$ feet in dimensions.

The temperature within the container was regulated by a thermostat. The humidity and temperature of the container were recorded by means of a hygrograph and a thermograph.

The plant was watered by means of a rubber tube connected at one end to a stop-cock funnel extending through a hole in the top of the container, the other end terminating in the box containing the plant. Ether was added through a stop-cock funnel projecting through a hole in the top of the cage opposite the funnel through which the water entered.

The introduction and removal of the air within the container was accomplished through an iron pipe extending horizontally through the sides about 1 foot above the base. The exterior end of the pipe was fitted with a cut-off so

that the air could be changed at any desired time.

The carbon dioxide content of the atmosphere was measured by a duplicate of the apparatus originated in 1905 by Brown & Escombe¹, and described in an article by them entitled "The New Method for the Determination of Atmospheric Carbon Dioxide, Based on the Rate of its Absorption by a Free Surface of a Solution of Caustic Alkali." This apparatus consisted of a glass cylinder about 15.5 cm. long and 6.8 cm. wide, closed with a soft rubber plug with a central perforation through which a short tube of 2.5 cm. diameter is passed and extending into the cylinder below, provided with a lateral tube connected to an aspirator. The upper part of the tube is closed with a cork through which is passed a narrow but much smaller tube terminating below in a funnel of a width slightly less than that of the cylinder. The mouth of this funnel was closed with a perforated porcelain disc luted with paraffin. By means of the aspirator air is drawn through the side tube, down the narrow tube, passed through the perforated plate, and impinged as a turbulent stream on the surface of the absorbing solution of caustic soda.

In order to distribute the air more completely a small cone of paraffin was supported on a needle of suf-

¹ Brown & Escombe, Proc. Roy. Soc. London, B 76, 1905, pp.112-119.

PLATE 17

ETHERIZATION RECEPTACLE

1. Hygrograph
2. Thermostat
3. Thermograph

Note Musa Cavendeshii under treatment.

ficient length that when fastened to the porcelain plate the top of the cone of paraffin came within one-eighth inch of the opening in the stem of the funnel. The funnel was adjusted about 1 cm. from the surface of the liquid in the cylinder.

Hart's method of double titration was used for determining the carbon dioxide absorbed by the alkali. This method requires the addition of phenol-phthalein indicator to the caustic soda, and acidulation by hydrochloric acid until the pink color fades to a trace. This marks the point of complete conversion of the neutral into the acid carbonate or, more strictly speaking, the point at which the liberation of the first trace of carbon dioxide takes place. This is the starting point of the true titration process. Methyl-orange is then added and followed 1/10 normal hydrochloric acid until the acid carbonate is decomposed. The volume of the 1/10 normal acid requisite to produce this effect is the measure of the carbon dioxide displaced.

This method is quite independent of the relation of the total acid equivalent of the alkali before and after absorption of carbon dioxide, the determination of carbon dioxide absorbed merely depending on the amount of dilute acid required in each case between the first reaction with phenol-phthalein. To avoid an undue increase in volume of liquid undergoing titration which would diminish the sensitiveness of the reaction, it was advisable to use

in the early stages of the first titration an acid of a strength varying, according to circumstances, between normal and $1/6$ normal (until the pink color becomes somewhat faint). This is then followed by $1/10$ normal acid to the complete disappearance of the color.

The caustic soda solution should be made from metallic sodium since a trace of alumina as iron interferes with the sharpness of the second titration, a 4 per cent caustic soda solution should be used. If precautions are taken the method is sensitive to extremely small differences in carbon dioxide content of the soda solution.

Contrary to what might be expected from the perfect absorbent nature of the caustic soda solution and the known laws of gaseous diffusion, the amount of carbon dioxide by unit area of liquid surface, exposed for a unit of time, ceases sensibly to increase when a comparatively slow velocity of the moving air current has been reached. This, however, only holds good when the proportion of carbon dioxide in the air stream is maintained quite constant, any slight variation in amount at once affecting the ratio of absorption.

It was found that for dilutions of carbon dioxide lying between 0.6 part and 6 parts per 10,000 of air, the rate of absorption of the carbon dioxide is strictly proportional to its partial pressure.¹

¹Phil. Trans., B. 1900, vol. 193, p. 278.

So accurately is this the case that the above described apparatus may be used for determining the varying amounts of carbon dioxide in air without the necessity of measuring the volume of air through the apparatus. It is only necessary to pass the air over the absorbing surface at a sufficient rate to insure maximum absorption in order to compare the amount of absorption for a given time with that produced from air of a known content of carbon dioxide, a process of standardization which is done once for all with the apparatus. The ratios of the absorptions give at once the ratios of the partial pressures of the carbon dioxide in the two cases.

The difference between partial pressure and rate of absorption are largely due to difference of temperature. By a series of experiments carried out by Brown & Escombe¹ they found that within the experimental limits the coefficient of absorption varies directly with the temperature, and that an increase of temperature of 1° C. corresponds to an increase of 0.0018 in the absorption coefficient. Hence the value of this coefficient for any temperature to within the limits of 13.7° C., and 23.7° C. was represented by $(0.0356 \text{ plus } t^{\circ} \times 0.0018)$, 0.0356 being the coefficient of absorption at 0° C., as determined by extra polation.

¹Phil. Trans., B. 1900, Vol. 193, p.278.

The volume of carbon dioxide contained in 10,000 volumes of dry air should be given by the formula

$\frac{A}{0.0356 \times t^0} \times 0.00118$ where A represented the carbon dioxide absorbed per square centimeter of surface per hour, at temperature t^0 , from an air-stream which is drawn over the absorbing liquid at a sufficient rate to insure the limit of maxima absorption being reached, A being stated in terms of cubic centimeter at normal temperature and pressure.

Brown & Escombe¹ by a series of experiments established the fact that with this special form of apparatus and with amounts of carbon dioxide not exceeding 14 parts per 10000 parts of air, a velocity current of about 150 liters per hour was sufficient to insure a maximum rate of absorption.

The aspirator mentioned above used in this experiment consisted of a suction pump attached to the hydrant. A rubber tube connecting the pump with the apparatus containing the caustic soda was located near and attached to the inlet pipe of the container by means of a rubber tube.

This suction pump had sufficient power to impel a much greater velocity of the current of air per hour over the caustic soda solution than was necessary to secure the maximum amount of carbon dioxide absorption.

¹Proc. of Roy. Soc. of London, Vol. 76 B, 1905, p.115.

On March 17 and 18 six determinations of carbon dioxide content of dry air were made; one in the early part of the day, another near noon and a third in late afternoon. The average of the six determinations was found to be 3.08 parts carbon dioxide per 10000 (see Table 19). This data was used as the basis of comparison of carbon dioxide content of the air in the cage containing Musa Cavendeshii.

TABLE 19

Showing Carbon Dioxide in Parts per 10,000 of Dry Air

No. of Deter.	Date	Temp.	Time sample taken	Carbon dioxide in parts per 10,000 of air	Total Amt. carbon dioxide in container
1	Mar. 17	23.8	8-9 A.M.	3.19	77.45
2	" "	25.0	10-11 A.M.	3.01	73.08
3	" "	25.5	2-3 P.M.	3.10	75.26
4	" 18	22.5	8-9 A.M.	3.0	72.84
5	" "	23.8	10-11 A.M.	3.18	77.21
6	" "	25.0	2-3 P.M.	3.05	74.05
Average				3.08	74.98

On March 19 at 8 A.M. the tub containing the plant was placed in the container, which was then closed and made air tight. Four carbon dioxide determinations of the air in the container were made on this date. Again one was made in the morning, one near noon and one in the afternoon.

On March 20, four more determinations were made

at approximately the same periods of the morning, noon and afternoon. (See Table 20) .

TABLE 20

Showing Carbon Dioxide Given Off in Parts Per 10,000
at Different Periods of Exposure of Musa Cavendeshii
Enclosed in Glass Container

No.of Deter.	Date	Humid- ity	Temp.	Time Recep- tacle was closed	Time sample of air was taken	Carbon dioxide per 10,000 of air	Total carbon diox- ide content of receptacle
1	Mar.19	73	25°C.	8 A.M.	8-9 AM	3.20	77.69
2	" "	70	27 "	8 A.M.	11-12"	2.88	69.264
3	" "	63	32 "	8 A.M.	2-3 PM	2.82	68.46
4	" "	54	28 "	8 A.M.	4-5 "	2.71	65.79
5	" 20	74	24 "	8 A.M.	8-9 AM	3.28	79.63
6	" "	68	25 "	8 A.M.	10-11"	2.75	66.77
7	" "	62	28 "	8 A.M.	12-1PM	2.71	65.79
8	" "	60	31 "	8 A.M.	2-3 "	2.65	63.24
Average						2.87	69.80

Immediately following the last determination the container was opened and again closed on March 22 at 8 A.M. Sulphuric ether was immediately introduced at the rate of 0.5 cc per liter of air. Four determinations of carbon dioxide content of the air were made on this date at 9 and 11 A.M. and at 1 and 3 P.M., respectively. (See Table 21).

A study of Table 19 shows that the average of the six determinations made daily during a period of two days, is 3.08 parts of carbon dioxide per 10,000 parts of dry at-

mosphere of a temperature ranging from 22.5 to 25° C. This would make the total carbon dioxide content of the atmosphere in the container 74.98 cc under normal conditions.

TABLE 21

Showing Carbon Dioxide Given off at Different Periods of Exposure of Musa Cavendeshii Enclosed in Glass Container and Treated with Ether at the Rate of 0.5 cc per Liter of Air

No. of Deter.	Date	Humidity	Temp.	Time receptacle was closed	Time sample of air was taken	Carbon dioxide in parts per 10,000 of air	Total carbon dioxide content of receptacle
1	Mar. 22	71	25° C	8 A.M.	9-10 A.M.	3.21	77.93
2	" "	68	28	8 A.M.	11-12 A.M.	2.98	72.37
3	" "	61	32	8 A.M.	1-2 P.M.	2.85	69.19
4	" "	55	29.5	8 A.M.	3-4 P.M.	2.78	67.49
5	" 23	74	24	8 A.M.	8-9 A.M.	3.24	78.66
6	" "	70	26.5	8 A.M.	10-11 A.M.	2.95	71.62
7	" "	63	31.5	8 A.M.	1-2 P.M.	2.88	69.92
8	" "	57	30.6	8 A.M.	3-4 P.M.	2.82	68.46
Average						2.99	72.59

The average carbon dioxide content per 10,000 parts of dry air or the total carbon dioxide content of the receptacle which is 74.98 cc will hereafter be used as a basis of comparison with the carbon dioxide content of the receptacle containing the plant under treatment.

Table 20 shows that by keeping Musa Cavendeshii enclosed in the receptacle for a period of about two days under a temperature ranging from 24 to 32° C., the plant reduced the average carbon dioxide content of the receptacle by 2.39 cc.

To secure this data eight determinations were made - two in the morning and two in the afternoon for two successive days. The carbon dioxide content of the receptacle was less in every determination made than that of normal air except those made early in the morning of each day. The determinations 8 to 9 A.M. showed a slight increase over that of normal air, the increase being 5.38 cc of carbon dioxide on the morning of March 19 and 6.35 cc on the early morning of March 20. There was a very marked decrease in the carbon dioxide content of the receptacle during successive hours of the days, the decrease ranging from 78.66 cc of carbon dioxide in the early morning to 68.46 cc in the afternoon of the same day. This decrease in carbon dioxide content of the receptacle from the early morning to late afternoon was due to the plant being exposed to a very favorable condition of light, temperature and moisture favoring maximum photosynthesis. Constructive metabolism was apparently increased, thus probably but not necessarily, requiring a larger per cent of carbon dioxide in processes of plant activity. If the photosynthetic rate of the plant is increased resulting in anabolic activity

of the plant, a decrease in carbon dioxide content would necessarily follow.

The increase of carbon dioxide as determined for early morning was due to oxidation accompanying vegetative activity of the plant during the night, thus increasing the carbon dioxide content above that of normal air.

Table 21 shows that the plant exposed to fumes of sulphuric ether at the rate of 0.5 cc per liter of air, gave very similar yet more marked relative results, to the carbon dioxide given off even when it was placed under the same condition minus the exposure to ether. There were eight determinations made - one early in the morning, one near noon, one early after noon, and a fourth late in the afternoon for each of two successive days. The carbon dioxide content of the receptacle increased with each determination made with the exception of the first, made on the morning of March 23. This first determination showed .97 cc of carbon dioxide less than the highest determination made where the plant was under similar conditions, yet not under the influence of ether. The temperature ranged from 24 to 32° C.

Each of the four determinations made during the day showed a slightly less carbon dioxide content than the one just preceding it. This difference is believed to be due to the plant being under very favorable conditions of

light, temperature and moisture favorable to photosynthetic processes and that the anabolic activity of the plant was at its maximum, thus constantly drawing on the surrounding air for its source of carbon dioxide.

Summary.

A study of the data included in the tables apparently warrants the following general conclusions.

1. The carbon dioxide content of air within the container remains normal and constant.

2. Musa Cavendeshii enclosed within the container produced an increase of carbon dioxide during the night and a decrease during the day, the decrease becoming more perceptible during the later hours of the day.

3. The exposure of the plant to fumes of sulphuric ether increased the per cent of carbon dioxide, yet the normal increase and decrease corresponded in general with those accompanying the normal plant.

Result of Increasing the Carbon Dioxide Content of Air
in Receptacle Containing Musa Cavendeshii.

On the morning of February 25 the receptacle containing Musa Cavendeshii was closed and made air tight. Chemically prepared carbon dioxide was introduced to the amount of six times that of normal air. Observations were made on the afternoon of the 25th and morning of the 26th and no results could be detected. On the afternoon of the 26th more carbon dioxide was introduced to increase the amount to fourteen times that of normal air. Observations were made on the morning and afternoon of the 27th and no results could be detected except a very marked increase in moisture content.

On the morning of February 28 the carbon dioxide content was increased to fifty-four times that of normal air. On March 5 the last observation was made. The one influence that could be detected was that the leaves of the plant were of a much darker green color than normally, and a marked increase in moisture content. The hydrograph reading increased from 71 to 80.

The writer believes that before very marked results could be detected after treating Musa Cavendeshii for a few hours, the quantity of carbon dioxide would have to be increased possibly two hundred times that of normal air.

THE EFFECT OF PLACING THE TERMINAL BUD DOWN IN SAND IN
THE INCUBATOR IN THE GREENHOUSE, IN HASTENING ROOT
FORMATION OF HARD WOOD CUTTINGS OF SOME OF THE COM-
MON VARIETIES OF FRUITS.

During these investigations the writer had observed that some varieties of hard wood cuttings when placed with the terminal bud downward in a cutting bed in the greenhouse, where the temperature and moisture were suitable for normal growth, callused much sooner than those of the same variety placed in the normal way of setting cuttings. This experiment was performed with the object of ascertaining to what extent root formation was hastened in some of the common varieties of our orchard fruits, by placing the cuttings with the terminal bud down in sand in the incubator in the greenhouse held at a temperature of 80° F.

This incubator is about 3 feet wide and 6 feet long, closed over the top with glass and having a shelf about two-thirds the way to the top, holding approximately 8 inches of sand. Underneath this shelf was placed a thermostat, controlling an electric stove.

On January 29, ten cuttings each of 1 and 2 year old wood were made of the following varieties: Kieffer pear, Jonathan, Ben Davis and Delicious apples, and of 1

year old wood of Elberta peach, gooseberry, currant and Norton and Neosho grapes.

The cuttings of each variety of both 1 and 2 year old wood were divided into two lots of five cuttings each. Both lots of each variety were placed in sand in the incubator, one in a normal position, while the other was placed with the terminal buds down.

On February 7 the first observation was made. It was found that none of the cuttings of a variety placed in the normal position had callused, with the exception of the lots of cuttings of 1 year old wood of Kieffer pear and Elberta peach, and of these cuttings both lots were slightly callused. The cuttings of all varieties having the terminal buds placed downward had callused to some extent, except those of the Norton and Neosho grapes. The callusing in every case soon after forming, turned to a deep chlorophyll green color.

On February 25 all the cuttings of each variety that were placed with terminal buds down were taken up and set in the normal way of setting cuttings. A study of the callusing showed that none of the cuttings that were originally set in normal position had taken root except three Kieffer pear and two Elberta peach. Some of every variety of cuttings, and in most cases all of each variety were well rooted, that originally had their terminal buds turned down and later set in their normal position.

The result of this experiment would warrant the conclusion that callus formation and root growth of the cuttings of some of the varieties of our common fruits may be hastened several days by placing the terminal buds down when set in the callus pit, until the root end had callused, then turning them to their normal position. The writer believes that this practice could be made of commercial value.

TABLE 22

Showing Degree of Callusing of Hard Wood Cuttings Set in Sand in Incubator in the Greenhouse, One Lot with Terminal End Down and Another Lot in Normal Way; also Number Rooted 18 Days After Callusing and Returning to Normal Position

Variety	Age of wood	Degree of callusing of cuttings set in sand		No. of cuttings rooted 18 days after being turned to normal position	
		normal	with terminal buds down	normal	reverted
Kieffer	1 yr.	very little	all callused well	3	5
"	2 "	none	4 well callused	none	5
Elberta	1 "	very little	4 med.well rooted	2	4
Jonathan	1 "	none	all med.well callused	none	5
"	2 "	none	all callused some	none	5
Ben Davis	1 "	none	all callused some	none	4
" "	2 "	none	all callused some	none	5
Delicious	1 "	none	all well callused	none	5
"	2 "	none	all well callused	none	3
Gooseberry	1 "	none	all med.well callused	none	2
Currant	1 "	none	4 med.well callused	none	3
Norton Grape	1 "	none	none	none	none
Neosho	" 1 "	none	none	none	none

EFFECT OF LIQUID TAKA-DIASTASE
ON THE PER CENT GERMINATION OF SEEDS
AND THE CONTINUED INFLUENCE ON THE PLANTS.

Diastase acts as a ferment converting starch into dextrin and sugar (usually found in germinating grains and in animal fluids, as saliva). Taka-diastase is said to liquefy 150 times its weight of starch in a comparatively short time. The writer having this fact in mind, performed this experiment with the object in view of determining the role taka-diastase would play on:

- (a) Per cent germination of various kinds of seeds.
- (b) The continued effect, if any, upon the growing plant.

On February 4, twelve varieties of seeds were selected for treatment. Each kind was divided into three lots of 50 seeds each. Lot 1 was soaked in tap water for 6 hours and planted. Lot 2 was soaked in liquid taka-diastase at a strength of 5 cc of the powder dissolved in 200 cc of distilled water. Lot 3 was dry. The seeds were planted immediately in sand in the greenhouse under a day temperature of about 70° F., and a night temperature of about 60° F. The temperature of the sand was held at about 75° F.

On February 13 the first observation was made.

Lots 2 of the same kind of seeds that were soaked in taka-diastase gave nearly the same average per cent germination as Lots 1 of the same kind of seed that had been soaked in tap water. Lot 3, planted dry, was about one day behind the soaked lots in pushing through the sand.

On February 26 a second observation was made. At that time the plants were about 6 inches high. No difference of any lot could be detected. The plants were then removed from the sand, and it was found that in no case was there a noticeable difference in root growth between the seedlings from the treated and untreated seeds.

The results obtained do not warrant the soaking of seeds in either water or taka-diastase or both. The following table shows the results of the experiment.

TABLE 23

Showing Comparative Results in Per Cent Germination
and After Effects on the Growth of Plants for Different
Kinds of Seeds Planted Dry and Soaked in Liquid
Taka-diastase at a Strength of 5 to 200.

Kind of Seed	Per Cent Germination		
	(1)*	(2)*	(3)*
<i>Avena Sativa</i> , Linn.	98	100	100
<i>Cucumis melo</i> , Linn.	98	96	100
<i>Cucumis sativus</i> , Linn.	100	100	100
<i>Trifolium incarnatum</i> , Linn.	96	94	98
<i>Raphanus sativus</i> , Linn.	100	100	94
<i>Licopersicum esculentum</i> , Mill.	98	100	98
<i>Secale cereale</i> , Linn.	100	100	100
<i>Zea Mays</i> , Linn.	94	98	98
<i>Helianthus annus</i> , Linn.	100	100	100
<i>Lupinus albus</i> , Linn.	98	96	96
<i>Phaseolus vulgaris</i> , Linn.	100	98	98
<i>Citrullus vulgaris</i> , Schrad.	98	100	92
Average	98.3	98.5	97.8

*1. Soaked in tap water 6 hrs. and planted.

2. Soaked in liquid taka-diastase at strength of 5-200.

3. Planted dry.

EFFECT OF LIQUID TAKA-DIASTASE ON SOFT WOOD CUTTINGS.

The object of this experiment was to determine the effect of various strengths of taka-diastrase in liquid form on different species and varieties of soft wood cuttings, exposed for different periods of time.

On January 16 cuttings of the following plants were made:

20 cuttings	Large Alternanthera	(Telanthera versicolor, R Regels.)
60	"	Dwarf Alternanthera (Telanthera amoena, Regels)
20	"	Meadow Sage
50	"	Rose Geranium (Pelargonium quercifolium, Bailey)
20	"	White Geranium (Pelargonium hortorum, Bailey)
40	"	Coleus (Coleus Hybrida)
20	"	Dwarf Red Salvia (Telanthera Beetzichiana, Regels)

These cuttings were divided into lots of 10 each. One lot was planted as a control, while merely the cut ends of the remaining were soaked, for different periods of time, in a solution of taka-diastrase of various strengths. After the cuttings were made each lot was held loosely in the hand and struck lightly on the table until all the cut ends occupied the same plane. The lots to be treated were placed in battery jars containing about one-half inch of taka-diastrase solution of the desired strength. After these cuttings had remained in the solution for the scheduled length of time,

they were moved immediately and set in moist sand in a cutting bed in the greenhouse. The control lots were set at the same time and in a like manner. The sand in which the cuttings were placed was kept at a temperature of about 75° F.

On February 15 an examination was made and the following observations noted. In no case except that of Coleus exposed to taka-diastase at a strength of 1-100 were favorable results secured. In this case stems were uniformly larger than those in the control lot. However, there was no noticeable difference between this lot and the control in the general characteristics of the leaf growth. The leaves in both cases were of a normal shape and size. In most cases where the stronger solutions were used, taka diastase had a detrimental effect in that it either killed the plant or injured it to such an extent that some of the leaves were burned on the margins, and slightly yellow in color.

The following table shows the kind of plant, rate of treatment, time and the effect of treatment on the ten cuttings made from each variety of plant used in this test.

TABLE 24

Plants Treated with Variable Amounts of Taka-diastase
Dissolved in Different Volumes of Water

Kind of Plant	Rate of treatment	Time min.	Effect of Treatment
Telanthera versicolor, Regels	Ck.		Well rooted
Telanthera versicolor, Regels	1-100	15	Well rooted; no effect on foliage growth, about the same as check
Farinacea	Ck.		Med. well rooted; normal foliage growth
Farinacea	1-100	15	All dead
Pelargonium hortorum, Bailey	Ck.		Med. well rooted; normal amount foli- age growth. Appeared healthy
Pelargonium hortorum,	1-100	15	Very poorly rooted Foliage about same as check
Telanthera amoena, Regels	Ck.		Med. well rooted. Normal foliage growth; plants appeared healthy
Telanthera amoena, Regels	5-100	15	Very poorly rooted. Good foliage growth Plants appeared healthy. No differ- ence from check
Telanthera amoena Regels	5-200	15	Poorly rooted. Leaves had a tinge of yellow and were slightly injured
Telanthera amoena Regels	5-300	15	Poorly rooted. Leaves yellow but showed normal amount of growth

Table 24 contd.

Telanthera amoena, Regels	5-400	15	Med. well rooted. Normal amt. foliage growth. Appeared healthy. No differ- ent from check
Telanthera amoena, Regels	5-500	15	Med. well rooted. Normal amt. foliage growth. No differ- ent from check
Telanthera Beetzichiana, Ck. Regels			Poorly rooted. Two died. Poor foliage growth; foliage slightly injured
Telanthera Beetzichiana, Regels	5-400	15	Poorly rooted; five dead. Others badly injured
Coleus Hybrida	Ck.		Well rooted, good foliage growth. Appeared healthy
Coleus Hybrida	1-200	15	Normal foliage growth; looked same as check.
Coleus Hybrida	1-100	15	Stems larger than check; no difference in size of leaves or general character.
Coleus Hybrida	5-200	15	All dead
Pelargonium querci- folium, Bailey	Ck.		Med. well rooted. Normal amt. foliage growth.
Pelargonium querci- folium, Bailey	1-200	60	Med. well rooted. No difference in foliage from check.
Pelargonium querci- folium, Bailey	2-200	60	Med. well rooted. Foliage slightly in- jured. Appeared yellow.
Pelargonium querci- folium, Bailey	3-200	60	Poorly rooted. Four dead. Leaves -yellow
Pelargonium querci- folium, Bailey	4-200	60	✓ all dead

The table shows that no treatment or exposure to taka-diastrase has a favorable effect on the root growth of the plant. In cases where the strong solutions were used, the cut end died back as far as the solution came in contact with the cutting. The results of this experiment with taka-diastrase show that this agent cannot be recommended as a treatment for soft wood cuttings useful in the acceleration of roots or an increased vegetative growth.

EFFECT OF LIQUID TAKA-DIASTASE
UPON YOUNG GROWING BEET PLANTS (BETA VULGARIS).

The object of this experiment was to determine the effect of taka-diastrase of different strengths upon young actively growing beet plants.

On February 8, twenty-four beet plants the same age, about 6 inches high and as nearly uniform in shape as possible were selected from the lot that had been grown in 6 inch pots in the greenhouse. These plants were divided into 6 lots of four plants each. These were labeled as follows:

- Lot 1. Control
- " 2. 1-200
- " 3. 1-150
- " 4. 1-100
- " 5. 1-50
- " 6. 1-25

The pots were then plunged in sand in the greenhouse to control as effectively as possible the evaporation from the surface of the porous pots. Solutions of taka-diastase at various strengths were then made up as follows:

Quantities of 1 gram each of taka-diastase were dissolved in 25, 50, 100, 150 and 200 cc of distilled water, respectively. These solutions were added to the pot by pouring over the surface of the soil in the same manner one would commonly in watering a plant, at the rate of 100 cc per day for 15 days. Pot 1 was run as a control.

On February 23 the first observations were made. There was a very conspicuous difference in growth between the control and the treated plants. The leaves and roots of lot 1 were very much smaller than the leaves of any of the treated ones. The plants were removed from the pots and the dirt carefully washed from the roots. The number of leaves, weight of leaves and roots were taken.

TABLE 25

Showing Number of Leaves, Weight of Leaves, and Weight of Root of Young Actively Growing Beet Plants Following Treatment with Taka-diastase in Liquid Form, from Feb. 8 to Feb. 23.

No. of plant	Strength of solution	No. of leaves	Wt. of leaves grams	Wt. of root grams	Total Wt. of plant grams
1	Ck.	92	21.790	14.204	36.030
2	1-25	85	45.070	48.890	93.960
3	1-50	103	37.01	46.370	83.380
4	1-100	67	25.895	37.850	63.745
5	1-150	92	21.790	31.200	52.990
6	1-200	99	21.650	27.935	49.585

The table shows that the weight of leaves and roots increased in direct proportion to the increase of the concentration of the solution with which they were treated. The maximum weight of leaves and roots was reached in Lot 2 which was treated with the stronger solution, 1-25. The foliage growth of Lots 2 and 3 were darker in color, more succulent, roots were larger in diameter, shorter, and contained a larger number of fibrous roots than the plants of any of the other lots.

PLATE 16

BEET (Beta vulgaris)

The six lots of 4 plants each were treated for 15 days with variable strengths of liquid takadiastase.

Fig. 1	Check.	Normal root and foliage growth.
" 2	1-25.	Note accelerated root and foliage growth.
" 3	1-50.	Showing maximum root growth.
" 4	1-100.	Note increase in foliage and decrease in root growth.
" 5	1-150.	Showing marked decrease in foliage growth.
" 6	1-200.	Note further decrease in root growth.

Fig. 1. Root of *Aspidopteryx peruviana* or the
root of *Aspidopteryx* from these roots.

CONCLUSIONS

First. Artificial treatments with ether cannot be economically applied on a commercial scale to hasten callus and root formation of dormant hard wood cuttings yet are serviceable in hastening foliage growth.

Second. Ether applied as fumes accelerates foliage and root growth of soft wood cuttings but does not hasten the time of rooting.

Third. Desiccation of soft wood cuttings when exposed to ether is the result of injury of the cells of the plant.

Fourth. Exposure of the young growing tomato plant to fumes of sulphuric ether accelerates foliage growth, hastens maturity and increases the number and size of the blossom.

Fifth. Carbon dioxide does not have an inhibitory or accelerative action upon germination of soaked seeds of many of the field and garden plants when planted immediately after exposure.

Sixth. Exposure of dry or soaked seeds to oxygen, previous to planting produces no visible action or results upon the seed or the seedling.

Seventh. The soaking of seeds in a strong solution of taka-diastase does not influence germination or the growth of the plants from these seeds.

Eighth. Due to an injurious action, liquid taka-diastase cannot be recommended in any strength for the treatment of soft wood cuttings for the purpose of accelerating root development or vegetative activity.

Ninth. Carbon dioxide hastens maturity, accelerates foliage growth and increases the size of the blossom of young growing radish plants when exposed in a closed jar, during alternate periods of 12 hours duration, night and day, to an atmosphere enriched with carbon dioxide 6 to 10 times that of normal air. Young growing radish plants soon die when enclosed in a jar in which the air had been displaced by carbon dioxide, 6 A.M. to 6 P.M., even when exposed to normal air during alternate periods of 12 hour duration.

Tenth. Musa Cavendeshii (Banana) enclosed within a glass receptacle increases the carbon dioxide content of the air during the night and corresponding decrease during the day, the decrease becoming more perceptible during the later hours of the day. The exposure of this plant to the fumes of sulphuric ether at the rate of 0.5 cc per liter of air resulted in an increased per cent of carbon dioxide, yet the normal increase and decrease corresponded in general with those accompanying the normal plant.

Eleventh. Young actively growing beet plants are accelerated in root and foliage growth by the application of taka-diastase as a liquid fertilizer.

Twelfth. Callus formation and root growth of

some of the varieties of our common fruits may be hastened several days by placing the terminal buds down when set in the callus pit, later when the root end had callused and the tissue become green in color, turning them to a normal position. This practice might possibly prove to be of value in the rooting of cuttings prepared on a commercial scale.

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BIBLIOGRAPHY

1. American Gardening Ether and chloroform in forcing.
Amer. Gard. 24:165-66, 1903
2. American Florist Vol. 18, No. 720, pp.319-321 1902
Vol. 27, No. 986, pp.1051-1052 1906
3. Appleman, C. O. Some observations on catalases
Bot. Gaz. 50:182-192 1910
4. _____ Relation of catalase and oxidases
to respiration in plants
Md. Sta. Bul. No. 191 Sept. 1915
5. _____ Study of the rest period in potato
tubers
Md. Sta. Bul. 183, pp.181-226 1914
6. Armstrong, H.E. & E.F. Pt. III
The function of harmones in stimu-
lating enzymic change in relation
to narcosis and the phenomena of
degenerative and regenerative
change in living structure
Proc. Roy. Soc., B. 82-588 1910
7. _____ The stimulation of plant growth
Journ. Roy. Hort. Soc. 1912,
No. 1, pp.17-21.
8. Arloing, M. See Howard
Research Bul. No. 1, p. 20
9. Askenasy, E. See Pfeffer's Physiology of Plants
Vol. 11, pp. 205-206; 213-214
- 9a. Atkins, Researches in Plant Physiology.

10. Aymard, J. fils Forcing by ether in France
Le Jardin.
Abs. Fl. Exc. 15:539 1903
11. _____ Les Anesthetiques et le Forcage
des Plantes
Libr. Hort., Paris pp. 1-68, figs.4
Abs. Exp. Sta. Rec. 16:666 1905
12. _____ Etherization of plants
Jour. de la Soc. Nat. D.'Hort
May 1904
13. Bailey, L. H. The Nursery Book
The Macmillan Co., New York 1913
14. Beal, W. J. The vitality of seeds buried in
the soil
Rpt. Mich. St. Bd. Agr. 1915,
pp. 218-219.
15. Becquerel, P. The permeability of seed coats of
certain seeds to gases.
Exp. Sta. Rec. 16, No. 9, p.881 1905
16. Bellair, G. Des Effects de l'etherization des
plante pour leur forcage
(A review of the book by J. Aymard
fils)
Rev. Hort. 76, No. 14, Paris, 1904,
pp.333-335
17. _____ Forcing lilacs after preliminary
etherization
Rev. Hort. 76:84; 333-335 1904
Abs. Exp. Sta. Rec. 15:972 1904
18. Beltz, W. J. The effects of etherization on plants
Le Jardin 19:26-27 1905
Abs. Exp. Sta. Rec. 16:978 1905
19. Bernard, Claude See Corriveau
Thesis, Univ. of Mo., 1916, p.18
Effect of rest period breaking
agencies upon hard wood cuttings.

20. _____ See Aymard, pp.12; 23-24
Experiments to determine effects of
ether upon plants
Exp. Sta. Rec. 16:159
21. Bolle, J. Experiments to determine the effects
of ether and chloroform upon plants
Ztschr.-Landw.-Versuchw.-Oester. 7,
pp.182-3, fig. 2, 1904
Abs. Exp. Sta. Rec. 16:159 1904
22. Bos, A. See Howard(65)
23. Brown & Escombe Influence of varying amounts of
carbon dioxide on photosynthesis
Proc. Roy. Soc. London, 70, No. 464,
pp. 397-413, pls. 6, 1902
Abs. Bot. Centbl. 90, No. 11, pp.293-4
1902
24. _____ Variations in the amount of carbon
dioxide in the air of Kew, 1898-1901
Proc. Roy. Soc. London, p.118.
25. Brocq-Rousseau Presence of amylase in old seeds
Red. Acad. Sci., Paris 148, No. 6,
pp. 359-361, 1909
26. Butel, M. Forcing strawberries with ether
Jour. Soc. Nat. Hort., France 7,
pp. 27-191, 1906
Abs. Gard. Chron. 3 ser., 41, 1063
p.302, 1907
27. Butler, O. A note on the significance of sugar
in tubers of Solanum tuberosum
Bul. Torrey Bot. Club, 40:110, 1913
- 27a. Butkewitsch See Howard (65) Res. Bul. 21, p.9
28. B., F. W. Etherizing lilacs before forcing
Am. Fl. 19:685, 1902
Abs. Gard. Chron. 32:475, 1902

29. Charmeux, F. Tests of etherization for grape vines
Exp. Sta. Rec. 16:158
30. Copeland, E. B. Chemical stimulation and the evolution
of carbon dioxide
Bot. Gaz. 35:83-98
31. Corbett, L. C. The development of roots from cuttings
W. Va. Sta. Rpt. 1896, pp. 196-199
- 31a. Corriveau, P.E. The effect of rest period breaking
agencies upon hard wood cuttings.
Thesis, Univ. of Mo., 1916.
32. Crocker, Wm. Mechanics of dormancy in seeds
Jour. of Bot. Vol. 3, No. 3, 1916.
33. _____ Role of seed coats in delayed germina-
tion.
Bot. Gaz. Vol. 42, pp.265-291, 1906
34. _____ Longevity of seeds
Bot. Gaz. 47, 1909.
35. _____ Germination of seeds of water plants
Bot. Gaz. 44, 1909.
36. Cugini, G. See Howard (61)
Res. Bul. 1, p. 20.
37. Czapek The anti-ferment reaction in tropistic
movements of plants
Ann. Bot. Vol. 19, pp.75-98, 1905.
38. Demoussy, E. The growth of plants in atmosphere
in carbon dioxide.
Compt. Rend. Acad. Sci., Paris, 139,
No. 21, pp. 883-885, 1904.
39. Detmer, W. See Howard (61)
Res. Bul. 1, p. 20.

40. Dixon, H. H. On the effects of stimulation and
 anesthetic gases on transpiration.
 Preliminary note.

Proc. Roy. Irish Acad. Dublin, III,
ser. Vol. 4, 1896.
41. Drude, O. See Howard (61)
 Res. Bul. 1, p. 19.
42. Drude, O. Experiments and observations in the
 Ledien, F. Government Botanical Gardens at Dresden
 Naumann, A.

Sep. Jahresber. Flora, Dresden, 7:21,
pls. 6.
Abs. Exp. Sta. Rec. 16:665-666, 1905.
43. Dubois, R. See Corriveau (31a).
44. Duggar, B. M. Plant Physiology

Chapter on Growth, pp.304-341

The Macmillan Co., N.Y., 1912.
45. Effront, J. Enzymes and their applications.

(Transl. by Samuel C. Prescott)

John Wiley & Sons, N. Y., 1902.
46. Ewart, A. J. Effect of oxygen on fermentative activity.

Pfeffer's Plant Physiology, Vol. 1,
pp.547-554.
47. Farmer, J. B. Influence of an excess of carbon dioxide
 Chandler, S. E. in the air on the form and internal
 structure of plants.

Proc. Roy. Soc. London, 70, No. 464,
pp. 413-424, fig. 5, 1902.
48. Fischer, J. The forcing of plants by ether.

(Transl. from a memoir by W. Johannsen
of Copenhagen).

Am. Gard. Vol. 21, No. 283, pp.358-360
1906 No. 284, pp.372-374
49. Fisher, A. Beitrage zur Physiologie der Holzgewachse

Jahrb. f. wiss. Bot. 22, pp. 73-80, 1891.

50. Fulton, S. H. Effect of oxygen on fruits
U. S. D. A., Bureau Plant Industry
Bul. 108, p. 28.
51. Gardeners' Chronicle (Editorial)
The use of electric light and of
ether in forcing plants.
Gard. Chron. 31:144-145, 1902.
52. Gardening, 11, No. 248:121, 1903.
53. Giglioli, J. Latent viability in seeds.
Researches in Plant Physiology by
Atkins, pp. 137-147.
- 53a. _____ See Howard (61).
54. Green, J. R. Influence of light on diastase
Ann. of Bot. Vol. VIII, pp.370-373,
1894.
55. Harms, F. Etherizing lilacs for early forcing
Moller's Deut. Gart. Ztg. 17:8-11,
figs. 3, 1902.
Abs. Exp. Sta. Rec. 14:149.
56. _____ Ether in forcing plants.
Le Jardin, 1902.
Abs. Gard. Chron. 32:379, 1902.
57. Harris, F. Forcing etherized plants.
Le Jardin, 1902.
Abs. Am. Fl. 19:726, 1902.
58. Heckel, E. Effect of anesthetics on motile
stamens.
vines, Plant Physiology, pp.549-551.
- 58a. _____ See Howard (61).

59. Heinicke, A. J. Physiological changes occurring in plant tissue as a result of the stimuli administered to break the rest period.

Thesis, Univ. of Mo. 1914.
60. Hempel, Jenny Investigations on the effect of etherization on plant metabolism.

Exp. Sta. Rec. 26:127, 1911.
61. Howard, W. L. An experimental study of the rest period in plants. The winter rest.

Research Bul. 1, Mo. Exp. Sta. April 1910.
62. _____ An experimental study of the rest period in plants. The summer rest of bulbs and herbaceous plants.

Research Bul. 15, Mo. Exp. Sta., April 1915.
63. _____ An experimental study of the rest period in plants. Pot grown woody plants.

Research Bul. 16, Mo. Exp. Sta., April 1915.
64. _____ An experimental study of the rest period in plants. Seeds.

Research Bul. 17, Mo. Exp. Sta., April 1915.
65. _____ An experimental study of the rest period in plants. Physiological changes accompanying breaking the rest period.

Research Bul. 21, Mo. Exp. Sta., June 1915.
- 65a. _____ Res. Bul. 21, Mo. Exp. Sta., p. 9.
- 65b. _____ " " " " " " p. 8.
66. Howitt, J. E. Forcing plants by means of ether.

Cornell Countryman 3, No. 8, pp. 187-188, May 1906.

67. Hutchinson, J. Tried to force by ether and failed.
Am. Gard. 24:702. 1903.
Abs. Exp. Sta. Rec. 15:682. 1904.
68. Iraklionow, P.P. Effects of warm baths on respiration and germination of resting plants.
Exp. Sta. Rec. 27:220. 1911.
69. Irving, Annie A. The effect of chloroform upon respiration and assimilation.
Ann. Bot. Lond. 25, No. 100, pp. 1077-1099. 1911.
70. Jannock, T. The etherization of plants.
Gard. Chron. 3d ser. 34:240. 1903.
Abs. Exp. Sta. Rec. 15:367 1903.
71. Jessenko, F. A new method of shortening the rest period of woody plants.
Gard. Chron. 3 ser. 50, No. 1286, p. 131. 1911.
72. _____ New treatments for shortening the rest period of woody plants.
Exp. Sta. Rec. 28:837.
73. Johannsen, W. The forcing of plants by ether.
Transl. from Dr. Johannsen's Memoirs by J. Fischer.
Am. Gard. 21:358-360, 1900.
- 73a. _____ See Corriveau (31a)
Thesis, p. 18
74. _____ Etherization and chloroforming of dormant plant parts.
Norsk. Havetidende 18:194-203, figs. 5, 1902.
Abs. Exp. Sta. Rec. 14:1074-1075, 1903.
75. Jost, L. Lectures on plant physiology.
(especially lectures XXVII, XXVIII, pp. 340-367).
Transl. by R. J. Harvey Gibson, Oxford.

76. Kidd, Franklin The controlling influence of carbon dioxide in the maturation, dormancy and germination of seeds.

Proc. Roy. Soc. London, B. 87, pp. 408-421; 609, 1913-14.
77. Kirk Treatment of plants with ether.

Transl. from Dannebrog of a lecture by Dr. Johannsen.

U. S. Consular Rpt. of Danish Consul at Copenhagen, May 8, 1897.
78. Klebs, G. Alterations in the development and form of plants as a result of environment.

Proc. Roy. Soc. London, Ser. b 82, No. 559, pp. 547-558, 1910.
79. _____ Uber die Rhythmik in der Entwicklung der Pflanzen.

Stzr. Heidelb. Akad. Wiss. 23, 1911. Abs. Exp. Sta. Rec. 27:522.
80. Kostytschew, S. On the influence of fermentation products and phosphates upon respiration in plants.
Scheloumow, A.

Exp. Sta. Rec. 86:627.
81. Latham, M. E. Stimulation of sterigmatocystis by chloroform.

Bul. Torrey Bot. Club 32, pp. 337-351, 1905.
82. Lauren, W. See Howard, Res. Bul. 1, p. 21.
83. Leblanc, Ch. Bul. de la Soc. Cont. d'Hort. de Nancy, p. 39, 1902.
Le Jardin, p. 124, fig. 3, 1902.
84. Ledien, F. The ether treatment of lilacs in the trade.

Gartenwelt 6:219-221, 1902.
Abs. Exp. Sta. Rec. 14:359, 1902.
85. _____ Further developments of etherization in the forcing of lilacs.

Exp. Sta. Rec. 18:444.

86. Lemoine, E. The use of ether and chloroform for the forcing of shrubs and of lilacs in particular.
Journ. Roy. Hort. Soc. 28, Pt. 1 & 2, pp.45-51, 1903.
Gard. Chron. 33:142-143, 1903.
(Transl. by Rev. W. W. Wilks).
Abs. Gardening 11:229-230, 1903.
Abs. Exp. Sta. Rec. 15:682, 1904.
87. Lewis, C. I. Forcing bulbs by means of ether.
Cornell Countryman 3, No. 8, pp. 190-191, May 1906.
88. Lloyd, E. F. Carbon dioxide at high pressure and the artificial ripening of persimmons.
Sci. 34, 924 (232). 1911.
89. Lochot, J. The action of ether vapor in forcing plants.
Rev. Hort. 76:250-252, 1904.
Abs. Exp. Sta. Rec. 16:268-269, 1904.
90. Macchiati, L. See Howard, Res. Bul. 1, p. 20.
91. Marble, Flora P. Ether forcing without a greenhouse.
Gard. Mag. 2:64-65, figs. 7, 1905.
Abs. Exp. Sta. Rec. 17:763, 1906.
92. Matthaei, C. C. Effect of temperature on carbon dioxide assimilation.
Ann. Bot. 16, p. 59, 1902.
93. Maumene, A. The ether forcing process.
Am. Gard. 23:238-239, 1902.
(Transl. from La Nature)
Abs. Exp. Sta. Rec. 14:149, 1902.
94. _____ Forcing etherized plants.
Le Jardin 18:42-43, 1904.
Abs. Exp. Sta. Rec. 15:775-776, 1904.

95. _____ Forcing plants by ether.
Le Jardin 18:20-22, 1904.
Abs. Exp. Sta. Rec. 16:269, 1904.
96. _____ Etherization in forcing.
Le Jardin 19:44-46, 1905.
Abs. Exp. Sta. Rec. 16:978, 1906.
97. _____ Ether for plant forcing.
Rev. Scien. 1903.
Abs. Public Opinion 1903.
Fl. Rev. 12:964-965 1903.
98. Molisch, E. Forcing plants by warm baths.
Sci. Amer. Supp. 66, No. 1714,
p. 298, 1908.
99. Müller-Thurgau, H. & O. Schneider-Orelli
Life processes in resting portions
of plants.
Exp. Sta. Rec. 30, p.725.
100. _____ Beitrag zur Erklärung der Ruheperiode
der Pflanzen.
Landw. Jahrb. Bd. XIV, 1883.
(See Howard Res. Bul. 1, p.22)
101. McCollum, ✓ On forcing plants.
Ariz. Sta. Rpt. 1909, pp. 584-586.
102. Nabokich, A. J. Influence of oxygen on plant growth.
Bot. Centbl. Beihefte 26, 1, abr.
No. 1, pp. 7-149, 1910.
103. Naumann, A. See Drude, O.
104. Noel, P. The artificial retarding of plants.
Exp. Sta. Rec. 21:725.
105. Osterhaut The effect of certain poisonous gases
on plants.
Univ. Cal. Pub. Bot. 3:339-340.

106. Pfeffer, W. Physiology of plants, Vol. II.
Trans. by E. J. Ewart, Oxford, 1903.
107. Pollitt, J. The influence of electricity and
anesthetics upon plants.
Jour. Dept. of Agr., W. Australia,
15:451-454.
108. Portheim, L. von Studies on the rest period of woody
Kuhn, O. plants.
Exp. Sta. Rec. 32:437.
109. Rade, K. Experiments with ether in the forcing
of lilacs.
Moller's Deut. Gar. Ztg. 19:50-52,
figs. 3, 1904.
Abs. Exp. Sta. Rec. 15:775, 1904.
110. Richards, H. M. The influence of carbon dioxide and
McDougal other gases on plants.
Torrey Bot. Club 31, p.57.
111. Richter, O. Differences in chemical composition
between plants exposed to an atmos-
phere of narcotics and those in air.
Exp. Sta. Rec. 27:130.
112. Rose Delayed germination in economic seeds.
Bot. Gaz. 59.
113. Russell, W. The survival of plant tissue after
freezing.
Comptes rendu. Acad. Sci. Paris,
158, No. 7, pp.508-510, 1914.
114. Sachs, J. Physiology of plants.
Trans. by Marshall Ward, Oxford 1887.
Lecture XXI.
115. Sandsten, E. P. The effect of ether in water and in
vapor form upon tubers, bulbs and
growing plants.
Minn. Bot. Studies, June 1898.

116. _____ The influences of gases and vapors upon the growth of plants.
Minn. Bot. Stud. 2 ser. 1, 1898.
117. Schneider, A. Researches on the influence of anesthetics on transpiration.
Minn. Acad. Sci. 17, 1892.
118. Schnurbusch Die Gartenwelt, p. 160, 1901.
Abs. Am. Fl. 25:858-59, 1905.
119. Shull, C. A. Role of oxygen in germination.
Bot. Gaz. 1914.
120. _____ Oxygen minimum and germination of Xanthium seeds.
Bot. Gaz. Vol. 52:455-577, 1911.
- 120a. _____ The semi-permeability of seed coats.
Bot. Gaz. 56:169, 1913.
121. Sorauer, P. A treatise on the physiology of plants. 1895.
Trans. by F. E. Weiss.
pp. 175-183; 207-213.
Longmans Green & Co.
122. Stuart, W. Etherization as an aid in rhubarb forcing.
Vt. Sta. Rpt. 1904, 442-445.
Abs. Exp. Sta. Work, Vol. 2, No. 11, pp. 294-297, fig. 1, 1905.
Exp. Sta. Rec. 17:250, 1905.
Abs. Am. Fl. 25:858-859, 1905.
123. _____ The use of anesthetics in the forcing of plants.
Vt. Sta. Rpt. 1906, pp. 279-293.
124. _____ The etherization of plants for forcing purposes.
Trans. Mass. Hort. Soc. Pt. 1, pp. 67-87.
1909.

125. _____ The ^Role of anesthetics and other agents in plant forcing.
Vt. Exp. Sta. Bul. No. 150, March 1910.
126. Tassi, F. See Howard, Res. Bul. 1, p. 20.
127. Taubenhaus, J. Etherizing white Roman hyacinths.
Cornell Countryman, 4, No. 8,
pp. 254-257, 1907.
128. _____ Ether and the forcing of bulbs.
Cornell Countryman, 5, No. 2, pp. 55-57.
1907.
129. _____ Ether and the germination of seeds.
Cornell Countryman, 5, No. 6, p. 201.
1908
130. Teodoresco, E. C. Influence of an excess of carbon dioxide, etc.
Exp. Sta. Rec. 10:610.
131. _____ Influence de l'Acide carbonique sur la forme et la structure des plantes
Rev. Gen. de Botanique Vol. II, 1899
Proc. Roy. Soc. London, Vol. 70,
pp. 422-423, 1902.
132. Townsend, C. O. The effect of ether vapor upon the germination of seeds and spores.
Bot. Gaz. 27:458-466, 1899.
133. U. S. Dept. Agr. Bureau Chemistry Bul. 107 (revised)
p. 49.
- 133a. _____ The use of ether in forcing rhubarb.
Farmers' Bul. No. 233:18-21.
134. Villebenoist, J. Sur le forçage des lilas.
Rev. Hort. Paris, 75, No. 4, p. 91, 1903.
- 134a. Waugh, F. A. Artificial use of enzymes in germination.
Vermont Rpt. 1898.

135. Weber, F. Shortening the rest period of shoots
by wounding and injection of water.
Exp. Sta. Rec. 25:642; 27:221.
136. Wiggans, C. C. Rest Period of seeds.
Thesis, Univ. of Mo., 1913.
137. Zaleski, W. Role of oxygen in the formation of
proteids in plants.
Exp. Sta. Rec. 23:29.

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