GROWING CROPS & PLANTS BY ELECTRICITY.

Explaining what has been done on a practical scale.

BY

E. C. DUDGEON.

WITH 12 ILLUSTRATIONS.

London:
S. RENTELL & Co., Ltd.,
36, MAIDEN LANE, STRAND, W.C.

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PREFACE

THE subject of Electro-culture has now reached a stage at which it is of real interest to the man-in-the-street. This little book is intended to serve a double purpose: to interest the general reader, and at the same time to give the farmer, the market-gardener, and the amateur horticulturist, a clear idea of what has been and is being done in the application of Electricity to growing plants.

The author is indebted to Charles R. Gibson, F.R.S.E., for suggestions made in reading over the MS. of this small work; also to Miss Young, of Lincluden, and to William Aitken for some of the illustrations.

CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

THE problem of food supply is one of very considerable importance to Great Britain, which if at war with foreign powers might at any moment have only its own resources to rely upon, therefore, if science discovers new means by which our dependence upon imported foodstuffs can be in any way lessened, it is only right that these discoveries should be applied to practical purposes and given a fair trial. Much has been done, and much yet remains to be done, to solve the problem of how to make our land more productive, but research work done by agricultural colleges has been of great value in this direction. Electro-culture points to the possibility of obtaining a very considerable increase in our most important crops; this has been clearly shown by practical experiments. The subject is still in its infancy, and there remains much to be learnt about it; many theories have been advanced, but they still require careful and tedious research on the part of the scientist to either confirm or reject, but natural inference from trials already made is that many of them are more likely to prove true. In any case the lack of an efficient theory does not debar the practical application of electricity. The rapid advance of electrical science within recent years indicates that we have little conception of the extent to which it may be developed in the future. Indeed, it is only now that we are beginning to realise the immensely important part which electricity plays in the Universe. There is no branch of science into which the subject of electricity does not enter, and we are familiar with the manifold applications of electricity in everyday life. It is of interest to think of its application in medical science, for here we find it stimulating the whole human system; and the botanist has shown us that plant life is, after all, "very human." The plant has an organic system: it breathes, feeds and digests its food. It has even been suggested that plants have nerves, and scientific papers have been written by eminent men on such subjects as "The Consciousness of Plants." Our present interest will be to see what has been done by applying electricity to plant life.

Placing an insulator upon one of the poles to carry electric discharge wire. The pole is fifteen feet high and the top portion of the insulator is about ten inches in diameter.

Growing Crops and Plants by Electricity.

CHAPTER I

WHO SUGGESTED THE IDEA OF GROWING PLANTS BY ELECTRICITY ?

ALTHOUGH it is only within recent years that practical experiments have been made in electro-culture, the idea is by no means new. So far back as 1746 an Edinburgh physician electrified two myrtle trees and found that " they put forth small branches and blossoms sooner than other shrubs of the same kind which had not been electrified."

Not long after this a French scientist made similar experiments on a number of plants, all of which flourished under the electric influence. We find other records of experiments made from time to time, but the real beginning of the practical electro-culture dates from 1885. In that year the late Professor Lemstrom, of Sweden, made his first practical experiments.

During his travels in the Polar regions the attention of Professor Lemstrom, as well as that of other travellers, was attracted by the remarkable development in the vegetation of those parts as compared with that of more Southern regions ; not only did the plants come to maturity in less time, but the scent and cclour of the flowers, and the freshness of the green were striking to the most casual observer. Everyone knows that vegetables, cereals, flowers, and in fact, all forms of vegetation require a good soil, and a sufficient supply of heat and moisture to cultivate them with any success ; in the Polar regions both the illuminating and heating effects of the sun are very low, even though the days are long, therefore an explanation of this development had to be sought. Professor Lemstrom, in his book treating of the subject of these investigations, says : " For several reasons I was induced to search for the cause in electrical currents, the effect of which occurs in the Polar light and which are going from the atmosphere to the earth and vice versa." He then proceeds to give the following reasons for these deductions.

"The Physiology of plants," he points out, "gives a satisfactory explanation of the functions which most organs have to perform and good reason for their existence in varying forms;" he proceeds to argue that the needle-like shape of the leaves of the fir trees, and beard on the ears of most cereals might well be the means of transmitting small electric charges through the plants, and to verify this argument he proved the presence of electricity round the plants by means of fine metal points, and with a specially contrived apparatus he even managed to register the amount.

Upon returning to Finland, in 1886, Professor Lemstrom commenced his experiments and the result was that the percentage of crops grown under the influence of the electrified wires was greatly in excess of those in the unelectrified area.

These experiments were followed up in 1904 by Mr. J. E. Newman, of Gloucester, England. Mr. Newman erected an apparatus at Salford Priors, near Evesham, in Gloucestershire, the property of Mr. Raymond Bomford. The apparatus which was designed and patented by Sir Oliver Lodge, is extremely easy to manage. It consists of a large induction coil with spark gaps, five vacuum globes through which one current, the positive, is guided to the overhead wires in the field, the negative being connected to the earth.

Two different kinds of electricity—positive and negative—are always attracted by each other and endeavouring to meet, so that in the arrangement of separating the two electricities when coming from the coil, they are continuously striving to reach each other through the air that separates them, thus causing a discharge of electricity in the air space between the overhead wires and the earth. This is just what happens in a thunderstorm, when two heavily charged clouds of opposite signs approach each other, and when the distance between them is short enough for the electricity to jump across, they discharge and a flash of lightning is the result.

The coil requires quite a small current of electricity to excite it, which can easily be applied if there is a convenient main in the neighbourhood, otherwise it is necessary to have a small engine and dynamo. The apparatus must be kept in a perfectly water-tight house or shed, the dimensions of which do not require to be more than 12ft. by 9ft. A system of poles is arranged round the field or fields to be electrified, one to the acre being sufficient (see photograph at page 3). Each pole is surmounted by a very powerful porcelain insulator and round these insulators the main wire is fixed (No. 18 ordinary galvanised wire), and extends round the outside of the area to be cultivated. Stretched from these

Cattle peacefully and harmlessly grazing below the electric discharge wires.

wires across the field are much finer ones, at intervals of about 30ft. making a complete network above the ground. To allow of carting to be carried on after the wires are put up, they are generally placed at a height of about 15ft. above the ground. The moment the coil is excited the overhead system becomes charged at a very high pressure, and the electric discharge immediately commences.

CHAPTER II

A BRIEF REVIEW OF SOME EXPERIMENTS

In the summer of 1902 Professor Lemstrom erected an electric installation at Durham College—the crops experimented on were strawberries, potatoes, mangolds, peas and sugar beets, but as the apparatus was not in complete working order he was unable to apply the discharge until nearly the end of May. During the whole period of the experiment exceptionally wet weather was experienced, and as it is useless to work the apparatus during rain, he was only able to apply the discharge for about 50 hours in 132 days; but in spite of these disadvantages germination and vegetation were distinctly better on the experimental fields than on the control fields. The following tables show the increase per cent.:—

Crop.	Increase per cent.
Strawberries	37.0
Potatoes (1st)	31.1 } Average 23.3
Potatoes (2nd)	15.4 }
Mangolds	25.0
Peas	20.0
Sugar Beet	No difference; but analysis showed slight increase of sugar.

In the same year an experiment was carried on near Breslau, in Germany—the weather throughout was very similar to that at Durham College, Newcastle. Results were as follows:—

Crop.	Increase per cent.
Strawberries	50.1
Carrots	13.1
Potatoes (1st)	13.8
Potatoes (2nd)	17.4 average 20.8
Potatoes (3rd)	30.3
Oats (1st)	40.7
Oats (2nd)	4.5 average 22.6
Barley (1st)	6.9
Barley (2nd)	14.2 average 10.6

Non-electrified wheat grown at Salford Priors, Evesham, with measuring board, showing the considerable difference in height of crop when compared with board of the same dimensions in the electrified area.

An electrified field of wheat grown at Salford Priors, Evesham, with measuring board showing comparison with the unelectrified crop, in the illustration facing this.

About 8 acres were experimented upon in Sweden in the summer of 1902 by Baron Theodore Adelsvard, and the following results were obtained :—

Crop.	Increase per cent.
Mislin (barley, oats, peas, &c.)	20.9
Beets (cattle food)	26.5
Carrots	2.9

Much damage was done to the crops by rain and low temperature so that the results obtained were not satisfactory.

Experiments were repeated at all three places in 1903. At Durham College the conditions were somewhat varied by watering one half of the electrified area and not the other. The comparison is of considerable interest.

Crop.	Increase per cent.	
	Crop Watered.	Unwatered.
Turnips	99.0	49.5
Sugar Beets	40.0	49.6
Mangolds	0.2	33.2
Potatoes	30.8	65.5
Peas	28.1	7.9
Beans	8.3	12.0
Rye Grass	129.7	97.4
Clover	13.3	16.5

From the above table it will be noticed that turnips, peas, rye grass and clover benefited by the watering; upon the other crops Professor Lemstrom considered it had an injurious effect. He further observed that with turnips and sugar beet the excess of leaves was equal to that of roots, while with mangold it was different, and the stalks of the peas and beans were far more developed than the fruit.

In Germany the results of trials in 1903 varied somewhat in comparison with the previous year's trial. The increased percentage of barley was considerably more, in that of potatoes less. In Sweden, owing to rain and irregularities in the working of the apparatus the trial was scarcely a fair one, but in spite of that there was a percentage of 19.5 on the rye and the quality of the corn upon analysis was improved. The following table of the analysis of some of the crops grown at Atnidaberg, Sweden, shows that the electric charge produced a considerable increase in some of the most important ingredients.

Crop.	Increase per cent.		
	Proteid Matter.	Nitrogen.	Albumen.
Rye	19.0	19.2	14.3
Barley	12.4	1.2	
Oats	4.2	6.6	8.1

Mr. J. E. Newman's Experiment.

In 1906 Mr. Newman commenced his experiments at Evesham, Worcestershire, of which the following tables give the result :—

1906.

Crop.	Increase per cent.
Wheat, Canadian Red Fife	39.0
Wheat, English Red Queen	29.0
Barley	5.0

The barley crop was very irregular which was attributed to the previous treatment of the field.

1907.

Crop.	Increase per cent.
Wheat, Red Fife	29.0 Which made an increase of 9.4 bushels per acre.
Mangolds	18.0

1908.

Crop.	Increase per cent.
Wheat	24.3

An increase of over five bushels per acre over the control crop.

1909.

Crop.	Increase per cent.
Wheat, Red Fife	23.0

1909, Scotland.

Mr. Low's Experiment at Balmakewn, Kincardineshire.

Crop.	Increase per cent.
Oats Turnips	$6\frac{1}{2}$ grain. 8 Straw. Small Increase

The season was exceptionally dry and the soil light, so that the conditions were not favourable to the discharge.

During the year 1909 some trials in electro-culture, of an exceptionally interesting character, were conducted at Dahlem, in Germany.

The experimental ground was divided into four plots ; a certain number of plants were adopted as standards, among them being spinach, radish, cabbage and lettuce. These were grown under normal conditions. The same variety of plants in another plot were exposed to intensified atmospheric electricity by means of currents on overhead wires. A third group was treated with high tension electricity, while a fourth was covered with a wire cage arranged so as to exclude all the natural electricity in the atmosphere. The following table gives the results obtained from each of the plots.

I	II	III	
Standard.	Intensified Atmospheric Electricity.	High Tension Electricity.	
		Weak Current.	Strong Current.
100 per cent.	115 to 140 per cent.	100 to 125 per cent.	90 to 105 per cent.

IV
Atmospheric Electricity Excluded.
85.5 per cent.

CHAPTER III

THE AUTHOR'S EXPERIMENTS

THE first experiment conducted by the author was at Lincluden, Dumfries. This experiment (1910) was on almost too small a scale to be called a fair trial, the experimental area being only about a quarter of an acre. A plot of 60ft. x 20ft. was sown with oats, another portion of the field being sown the same day with the same variety. The control plot was about 150 yards distant, and had distinctly the advantage in point of soil and situation. The ground was rich pasture and had not been turned over for 30 years—whereas the experimental plot had grown root crops for four successive years, the last being Jerusalem Artichokes which are gross feeders. The crop on the electrified plot was an unusually luxuriant one, in some parts growing 27 stalks to one seed—the average height was 5ft. 10in., and was ready to cut eight days earlier than the control portion. Unfortunately there followed a very wet spell of weather which damaged the grain to a great extent, and made it impossible to weigh it satisfactorily; but from small samples obtained it was judged superior in quality to that from the unelectrified plot.

Another experiment was carried out in the summer of 1911 by the author in conjunction with Mr. Cameron on the farm of Lincluden Mains, Dumfries. The field was about 7 acres, half of which was electrified, the other used as the control. The land was practically level, having one or two slight undulations, the soil varied slightly, some portions being loamy and others gravelly, but as the inequalities were distributed over the whole field, care was taken in dividing the plots to include equal portions of each variety in both experimental and control areas.

The crop grown was potatoes of which four varieties were sown. The result was as follows :—

EXPERIMENTAL PLOT.

VARIETY.		TONS.	CWTS.	
Ringleader				
Seed Size		6	19	
Under $1\frac{1}{4}$ inches		1	2	
	Total	8	1	No disease

CONTROL.

VARIETY.		TONS.	CWTS.	
Ringleader				
Seed Size		4	13	
Under 1¼ inches		1	4	
	Total	5	17	No disease

Extra weight per acre from electrified plot 2 tons 4 cwts.

EXPERIMENTAL.

VARIETY.		TONS.	CWTS.	QRS.	LBS.	
Windsor Castle						
Seed Size		10	19	1	4	
Under 1¼ inches			15	0	24½	
	Total	11	14	2	19	No disease

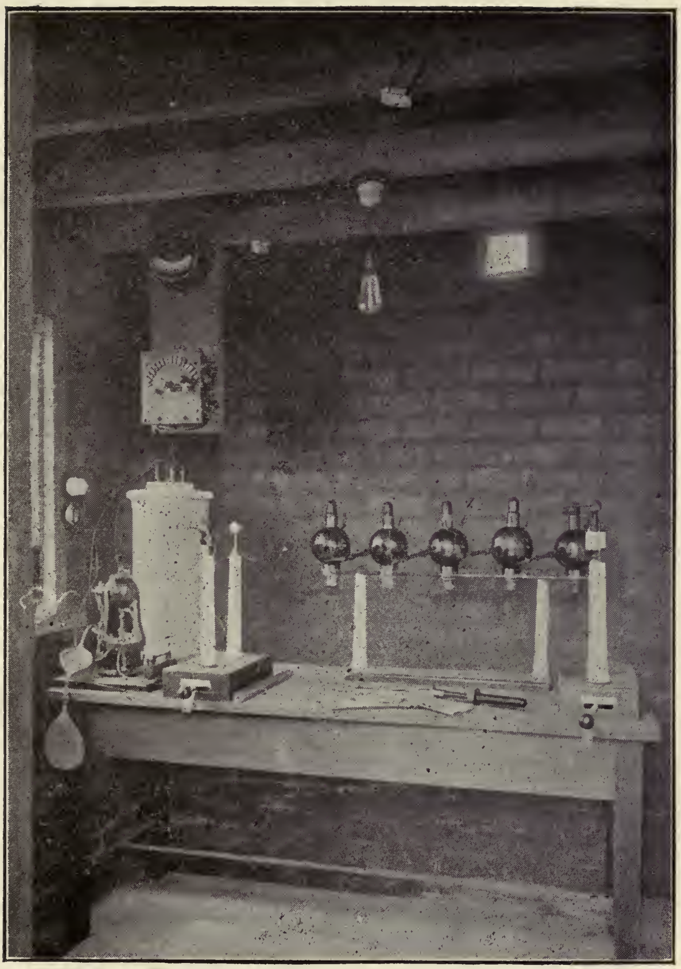
CONTROL.

VARIETY.		TONS.	CWTS.	QRS.	LBS.	
Windsor Castle						
Seed Size		8	18	0	19	
Under 1¼ inches			19	2	9	
	Total	9	17	3	0	No disease

Extra weight per acre from electrified plot 1 ton 16 cwt. 3 qrs. 19 lbs.

EXPERIMENTAL.

VARIETY.		TONS.	CWTS.	QRS.	LBS.	
Golden Wonder						
Seed Size		7	19	2	0	
Under 1¼ inches			15	0	24½	
	Total	8	14	2	24½	No disease



LODGE-NEWMAN ELECTRIC DISCHARGE APPARATUS.

At the left corner of table is seen the large induction coil connected to a mercury break, through which the direct current from the main source of electricity is taken. The five glass globes mounted on a glass stand are Sir Oliver Lodge's patent Valves, which only permit the electric charge to pass through them in one direction. Mounted on two porcelain tubes at either end of the "Valve" stand are the spark gaps, consisting of adjustable brass balls intended to take any overflow of current and also to indicate the available pressure.

CONTROL.

VARIETY.		TONS.	CWTS.	QRS.	LBS.	
Golden Wonder						
Seed Size		7	5	1	7	
Under 1¼ inches			17	1	5½	
	Total	8	2	2	12½	No Disease

Extra weight per acre from electrified plot 12 cwts. 0 qrs. 12 lbs.

EXPERIMENTAL.

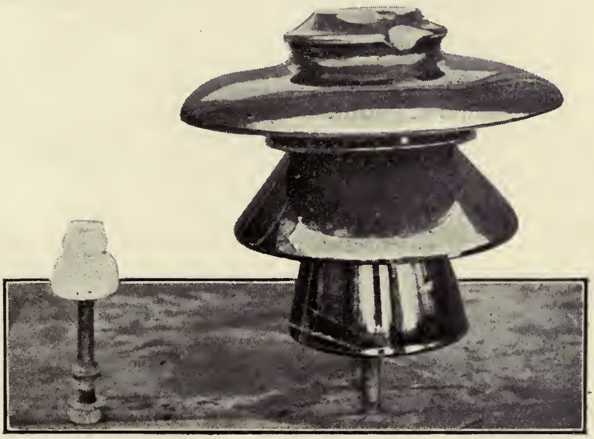
VARIETY.		TONS.	CWTS.	QRS.	LBS.
Great Scot					
Seed Size		11	1	1	15
Under 1¼ inches			10	2	6
Diseased			4	0	6½
	Total	11	15	3	27½

CONTROL.

VARIETY.		TONS.	CWTS.	QRS.	LBS.
Great Scot					
Seed Size		9	6	2	20
Under 1¼ inches			16	3	19½
Diseased			2	2	24
	Total	10	6	1	7½

Extra weight per acre from electrified plot 1 ton 9 cwts. 2 qrs. 20 lbs.

The foregoing tables show without doubt that the electrical discharge has a decidedly beneficial effect upon the growing of crops. It is also evident that some crops respond to the treatment better than others ; in all the experiments there has been a distinct advance in the percentage of wheat, in potatoes the returns vary considerably, with a few exceptions leguminous plants are adversely affected, but a curious point in connection with these plants is, that grown in rotation they have an opposite effect upon the soil to cereals. It may be that each variety of crop will require an electrical treatment of its own, some may respond to a stronger, some to a weaker discharge; the right amount of hours, according to climatic conditions will require to be known, and it will have to be seen if the plants only benefit at certain stages in their development. Only careful trials and minute scientific research will solve these questions and it remains for those who have time to devote to them, and who are not altogether dependent upon the products of their farms for a living to thoroughly investigate the subject and observe every detail connected with their experiments.



One of the large insulators used in the Electric Discharge Installation, shown in comparison with an ordinary telegraphic insulator.

CHAPTER IV

ATMOSPHERIC ELECTRICITY

WE are familiar with Nature's grand electrical displays in the form of lightning, and most of us have seen occasional displays of Aurora Borealis, or "Northern Lights," which are every day occurrences in polar regions. Lightning is simply a sudden electrical discharge between two clouds or between a cloud and the earth, while an Aurora is a gradual discharge of electricity through rarified air. It is generally believed that atmospheric electricity plays an important part in the formation of rain, hail and snow.

So early as 1783 it was suggested that atmospheric electricity was an important factor in the environment of a plant. Benjamin Franklin had drawn electricity from the clouds before that date, and lightning conductors had been introduced. And so it was suggested that atmospheric electricity might be collected and conveyed to growing plants. The Abbe Berthelon, in France, made such experiments at that time and reported that this "improved the appearance of the plants and increased their fertility." Similar experiments are still being carried on in France, some of the most interesting and recent being those conducted by a military officer—Lieutenant Basty. His system is to utilize the atmospheric electricity by means of a number of small portable lightning conductors placed in the middle of his crops. The metal points on these conductors become charged with the atmospheric electricity which by means of wires plunged into the ground is conducted to the roots of the plants. In a recent experiment Monsieur Basty planted out two plots with potatoes, sainfoin and hemp; the crops in one area were grown under normal conditions, the other area having the arrangement of lighting conductors. Taking 220 lbs. as his standard the results were as follows:—

Control Plot.		Experimental Plot.	
Potatoes	220 lbs.	Potatoes	373 lbs.
Sainfoin	220 lbs.	Sainfoin	552 lbs.
Hemp	220 lbs.	Hemp	775 lbs.

In his report M. Basty notes that the potatoes grown on the experimental ground on which the conductors had been placed, were ready for lifting a week earlier than the control ones; were of stronger fabric and contained more starch.*

In France the erection of lightning conductors is being largely adopted for the protection of town and cultivated areas from the damage done by severe hailstorms. These conductors consist of gilded electrolytic copper mounted on a crown-shaped support which is connected with the earth and placed on a suitable column not less than 100 feet in height. A conductor of these dimensions is qualified to protect an area of about three miles right and left in direction of the wind, and by about three quarters of a mile each way at right angles. The electricity with which storm clouds are charged is attracted by the metal points on these conductors, and finding an easy path down the wires is conveyed to earth, thereby greatly minimizing, if not altogether dispersing, the hailstorms which in the middle and Southern districts of France are so prevalent, and which cause such havoc to vineyards.

Being reared in an electrified atmosphere not only is beneficial to plants, but to animals also, as recent experiments have shown. Professor Silas Wentworth, of Los Gatos, California, states that from the result of electric influence his lamb crop was more than doubled, and the yield of wool greatly increased. He divided a flock of 2,000 sheep into equal numbers, one half being placed on pasture over which was stretched a network of electrically charged wires, the other half being kept on ground entirely removed from the electrical influence; feeding and attention to each flock were identical. He reports that the wool on the ewes on the electrified area was finer and nearly twice as thick as that on the ewes kept on the control portion, and the production of lambs averaged a fraction over two lambs to each ewe, while the lamb average on the unelectrified area was a fraction under one lamb to each ewe, and the weight of wool considerably less.

It is no uncommon thing now on the Continent for chickens to be electrically hatched and reared, with the result that the physical standard of the young birds is considerably higher.

Herr G. Kesler, an enterprising German, has invented an incubator and foster mother, which has an ingenious yet simple arrangement of electric wires to constitute a heat radiator, which when the current is switched on keeps up an uniform temperature throughout the whole box. Once the degree of temperature is set requisite for incubating the eggs, it is automatically kept on the same level during the whole period of hatching, never varying more than one tenth of a degree, and when once set in action requires no further attention. Perfect ventilation is maintained, fresh air entering through the bottom of the incubator and be-

* Trans: "Journal Science et Commerce Industrie Mutualite" and "Le Progress Agricole."

One of the Mercury Vapour Lamps in Greenhouse.

The photograph does not show the second lamp which is at nearer end, suspended on flexible wire with weight attached, and can be lowered or heightened as required. Small Osram lamps may be noticed at intervals round the house which have been used to advantage for ripening strawberries.

coming heated to the necessary temperature by means of a special arrangement before reaching the main compartment.

As soon as the chickens are hatched they are passed into another compartment where they are kept for 20 hours without food, when they are removed to the brooder.

This brooder is divided into two compartments, both kept at equal temperature by means of an electric heat radiator, one for use at night, the other for occupation during the day. There is a special contrivance by means of which the temperature can be gradually lowered as the birds grow stronger, until finally the artificial heat can be dispensed with altogether. This hatching arrangement is, of course, merely dependent upon electricity as a source of heat, but one experimenter has gone a step farther.

Mr. T. Thorne Baker has recently completed an experiment of bringing up young fowls in an electrified atmosphere. The chickens were reared under exactly similar conditions, fed in the same manner, brought up by the same foster mother on the same plot of ground. Half the young birds were placed on a plot which was electrified by means of a high tension discharge apparatus, and from the commencement of their electrified treatment shewed a much more kindly and contented disposition than their un-electrified neighbours, and finally when the two lots were weighed shewed an average increase of 38.5 per cent. in weight.

CHAPTER V

ELECTRICITY AND MARKET GARDENING

ELECTRO-CULTURE is of even greater value to the market gardener than to the farmer. Unless the weather is exceptionally unseasonable the farmer can generally count on a certain amount of sunshine during the three or four months his crops are growing, but the market gardener has a rotation of produce extending throughout the whole year either in the open air or under glass.

Lack of sufficient sunshine in our country, especially in winter, is a want felt by all gardeners, and though "forcing" is adopted extensively the expense of production is great and the products are neither so good in flavour or quality as those grown under normal conditions; therefore any scheme for promoting the growth of plants in the absence of sunshine is a matter well worth the consideration of the horticulturalist.

In the winter of 1904 Mr. J. E. Newman fitted up an overhead discharge system at his gardens near Bitton, in the open, as well as in seven out of fifteen greenhouses, the other eight houses being kept as a control; cucumbers and tomatoes were planted in all.

The pots of Argentine Beans—the seeds of which were sown on the same day—the plant on the left was exposed to the radiation of the Mercury Vapour Lamp, that on the right was grown in greenhouse under ordinary conditions.

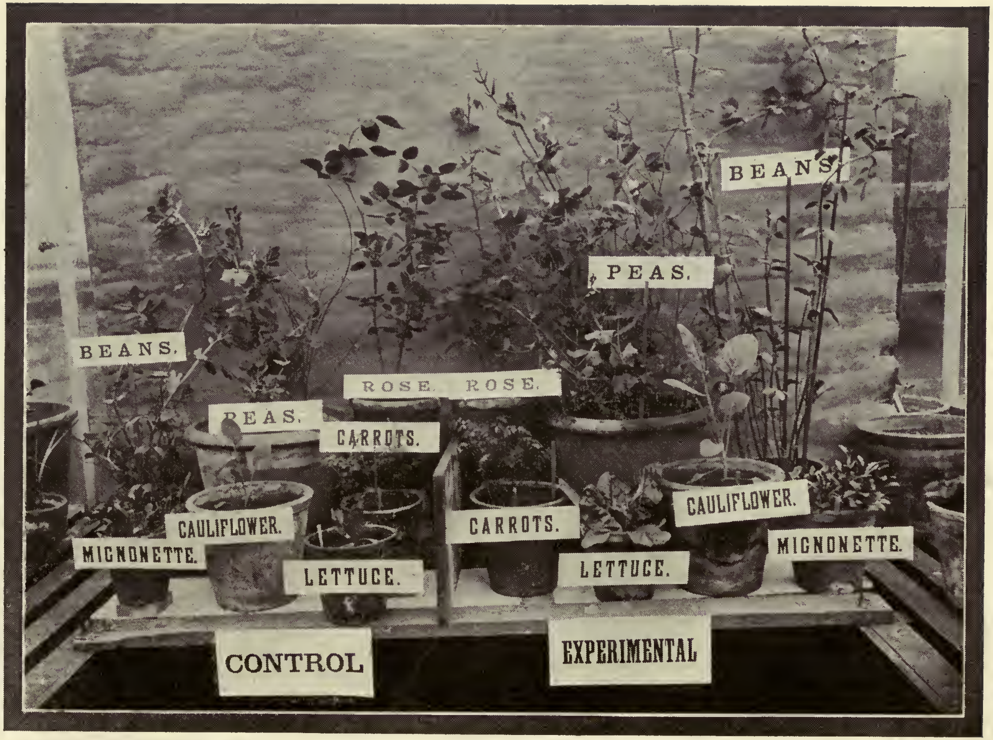
At the commencement of the experiment, the discharge was applied chiefly in the day time, after which it was principally on at night. The following table gives the results obtained from the electrified crops as compared with the unelectrified :—

Crop.		Percentage of increase over unelectrified crops.
Under Glass	Cucumbers.	17%
In the open.	Strawberries, 5 year old plants.	36%
	Strawberries, 1 year old plants.	80% and more runner.
	Broadbeans.	15% decrease but ready for picking 5 days earlier.
	Spring Cabbages	Ready for picking 10 days earlier.
	Celery	2%
	Tomatoes	No difference.

Spot disease was noticed upon the cucumbers in both the experimental and control houses, but those plants under the influence of the discharge were much less affected than the others. Professor Priestley, who kept in touch with the experiment, gave it as his opinion, in a paper written for the Journal of the Bristol Naturalists' Society, that " It seems probable that the ravages of the disease were largely inhibited by the electric discharge, for during one week, when the influence machine broke down, the disease progressed more rapidly under the wires and was again checked upon restarting the machine. The action of electric discharge may be due to one of two causes, either the resisting properties of the host have been increased or the attacking powers of the parasite diminished." A similar experiment was carried on the same year by Mr. Newman over a vegetable garden near Gloucester. In this trial the wires were fixed higher than at Bitton, and the plants experimented over were beets, carrots and turnips, with the following result :—

Crop.	Percentage of unelectrified crop.
Beets	33%
Carrots	50%

Turnips showed an increase, but the quantity could not be satisfactorily judged owing to the damage done by slugs to the crop.



The seeds of these plants were sown on the same day and grown under similar conditions in seperate houses. Those on the right side of picture with card "Experimental" were grown under the Mercury Vapour Lamp; those marked "Control" on the left were not exposed to the radiation of the lamp. The "Experimental" vegetables were ready for use fully a fortnight earlier than the "Control" ones.

In the summer of 1909 Mr. Newman erected the discharge wires over eight acres of strawberry plants, which gave a return of rather over 4½ tons to the acre.

The Highfield Nurseries Co., Essex, have this year installed a new type of machine for electrifying the atmosphere of glasshouses invented by Mr. Clark, of Bishopston, Nr. Bristol. The dimensions of the house in which the trial is to take place are 200ft. by 24ft. and it is fitted with about 1,000ft. of overhead wire. The inventor states that his apparatus with complete outfit would not cost more than £36, and the cost of working it to generate the discharge for a house of the above size would not be more than 3s. a week. The results of this experiment will be watched for with great interest.

CHAPTER VI

FORCING BY ELECTRIC LIGHT

If the use of electric light under glass would make up for a deficiency of sunshine the market gardener would have an invaluable agent in the rearing of winter stuff and numerous experiments point to the possibility of this being the case.

With a view to finding out if electric light had a similar effect on plant growth as solar radiation, Sir William Siemens, an electrical engineer of great fame, commenced in the winter of 1880-1881 some very interesting experiments at his home in Tunbridge Wells, Kent, which were only terminated by his untimely death due to an accident.

He installed in a greenhouse of 2,318 cubic feet capacity a powerful electric arc lamp; in this house were planted peas, French beans, wheat, barley, oats, cauliflowers, as well as strawberries, raspberries, peaches, vines and tomatoes. During the whole of the experiment a temperature of 60 Fahrenheit was maintained. The effect of the lamp was found at the commencement of the experiment to be anything but satisfactory. On the presumption that the naked light from the arc was too strong, he devised a means of softening the rays by introducing a jet of steam through small tubes which produced a cloudy effect between the plants and the light. This had a decidedly beneficial effect, but still the plants did not respond in the way that had been anticipated. He next arranged a clear glass lantern round the light to act as a screen after which satisfactory results soon manifested themselves as the following testifies:—

Peas.	Sown end of Oct.	Ready for Picking Feb. 16.
Raspberry Canes	Planted Dec. 16th	Fruit ripe on March 1st
Strawberries	Planted middle of Dec.	Produced ripe fruit of excellent quality and flavour on Feb. 14th.
Vines	Broke Dec. 26th	Grapes of unusually fine flavour picked off them on March 16th.

On a former occasion Siemens made an interesting experiment on strawberry plants. Having proved to his own satisfaction that electric light had practically the same effect as sunlight in the production of chlorophyl, he considered that it was quite reasonable to suppose that it might also act like the sun in ripening fruit and producing sugar. To test this he placed several pots of strawberry plants in two groups, one of which was exposed to daylight only, the other to solar light during the day and electric light at night. Both sets of plants were kept at a temperature of from 65 to 70 Farenheit under glass.

The plants, at the commencement of the experiment were some in bloom, others had the fruit just beginning to set. At the end of a week the fruit on the plants exposed to the electric light had swelled considerably more than the control ones, and some of the fruit showed signs of ripening. For two nights the lamp was not on, but when resumed, progress was very remarkable, in four days the fruit was ripe and of a rich colour, while the plants exposed to daylight only were scarcely coloured at all. He also found that with melons reared under the electric light, the fruit set better, ripening was accelerated and the flavour distinctly improved.

Barley and oats germinated under the lamp, made rapid growth, but did not come to maturity; the same variety of seeds, however, were sown in the open in January, in a plot over which the arc light was installed; they germinated slowly at first, owing to frost and snow on the ground, but as soon as the weather became milder developed very quickly and bore ripe grain by the end of June. Siemens observed, during a night of hoar frost, "that though the temperature on the ground did not differ materially within the range of the electric light and beyond it, the radiant effect of the light entirely prevented frost within its range," he therefore suggested that the application of electric light in front of fruit walls, in orchards and kitchen gardens, would be a useful means of saving fruit buds at the time of setting. Of course the question is, would the cost of doing so repay the fruit grower? In some districts where electric mains from large towns extend out to the suburbs and the Board of Trade price per unit of current does not exceed twopence or threepence, it might quite well be done with profit. Lamps would not be in use in the greenhouses at the time when late spring frosts are experienced, so might easily be temporarily erected outside and incalculable loss be saved in crops of peach plums and other stone fruits.

In these experiments of Sir William Siemens the light was kept on all night, thus extending daylight into twenty-four hours, which is contrary to the accepted opinion that plants require a period of rest for their normal development. In order to test whether continuous light had had any injurious effect on their reproductive powers he sowed some of the peas matured under the arc light which germinated in a few days, and showed every promise of vigorous growth.

Tomato Plants grown during the months of November and December. The plants grown under the influence of the Mercury Vapour Lamp averaged a growth of three quarters of an inch a week more than those in the Control house. The temperature of both greenhouses was kept the same.

The next experiment in this country of any note, was one by Mr. B. H. Thwaite, undertaken in the year 1907 at the Royal Botanic Gardens, London. Mr. Thwaite had an arc lamp mounted upon an automatic carrier, installed in one of the greenhouses, which constantly, but almost imperceptibly, moved backwards and forwards along the roof of the whole house. The more powerful rays of the lamp were cut off by a specially contrived water screen, and the light was turned on every day at sunset and kept alight from four to five hours.

Another greenhouse was kept as a control house, and in both houses chrysanthemums, geraniums and tomatoes were planted. By the end of the first month considerable difference was observed between those plants grown under the light and those away from it, the former grew much more rapidly, and were in those few weeks almost twice the height of the control ones. The foliage was of a much deeper green, showing an increase of chlorophyl, which is one of the most important factors in plant composition, upon which they greatly depend for the manufacture of their most important foods. The tomatoes showed a lanky appearance, although they had ample foliage—possibly the light had been too powerful for the size of the house in which they were grown. Unfortunately this experiment was not completed owing to Mr. Thwaite's illness and subsequent death.

Mr. L. H. Bailey, of Cornell University, U.S.A., made a series of most interesting experiments in plant culture by the aid of electric arc light. As the result of his experiments he gave his opinion as follows :—" That the general effect of the electric light was to hasten maturity, and the nearer the plants were to the light the greater the acceleration, which was particularly marked in the case of crops like endive, spinach, cress and lettuces "—but if too near the light he noticed a tendency to run to seed. Lettuces within three feet of the light were killed outright—if grown at a suitable distance from the lamp he considered the effect of the radiation made the plants more vigorous, though not so vigorous as those grown in sunlight; but for lettuce growing he was of opinion the electric light would be a source of profit. He also considered that flowers benefited by it.

One of the market gardeners in Boston has used electric light for many years in the raising of lettuces, and considers it to have an advantageous effect, and to be a source of profit. Amongst other experiments in America those of Mr. F. W. Rane, of West Virginia Experimental College, are of interest. He made use of the ordinary incandescent electric light such as is used for lighting houses. He considered as a result of his experiments :—

1. That the incandescent light has a marked effect on greenhouse plants.

2. That the light is beneficial to plants grown for foliage; lettuces matured earlier, stood more erect and weighed more.

3. Flowering plants blossomed sooner and remained longer in bloom.

The writer found that in the case of ripening strawberries after the fruit was swelled the incandescent light had good results. Plants placed about 18 inches below the small lamps ripened several days earlier than those beyond their influence ; the fruit was sweeter and of a much deeper colour.

In the year 1844 Dr. Draper, of the University, New York, made some exceedingly interesting experiments to determine the individual effect of the different coloured rays from the solar spectrum upon plant growth. By means of a specially arranged prism he separated the seven different colours, red, orange, yellow, green, blue, indigo and violet, and arranged a box with seven different compartments in which seeds had been germinated in the dark, so that each compartment should have a separate colour falling on it. Before long he noticed that those small plants exposed to the yellow and adjacent rays turned green, but those exposed to the extreme red and extreme violet underwent no change. Sir William Siemens repeated this experiment with the arc lamp, the different rays from which he caused to fall by means of a special arrangement on mustard and cress grown in the dark. The results he obtained confirmed Dr. Draper's theory.

The arc lamp is very rich in red and violet rays, and in both Sir William Siemens and Mr. Thwaite's experiments the naked light had an injurious effect on the plants ; by screening off some of the red and violet rays a great acceleration of growth was found as compared with ordinary daylight. For these and other reasons the mercury vapour lamp has many advantages over the arc lamp for cultural purposes. It requires practically no attention ; there are apparently no harmful rays from it, for though rich in violet rays, results show that the glass tube and four or five feet of atmosphere must cut off any injurious portion, and the amount that reaches the plant has only a beneficial effect. In the arc lamp the carbons require to be renewed about every eight hours, and cost 1s. to renew, whereas the mercury lasts for 2,000 hours, which means two winter seasons, before it is exhausted, when the tube can be renewed at the cost of about 21s. The initial cost of the lamp of the automatic type is about the same as the arc lamp and the consumption of current is considerably less.

A considerable economy is effected in coals for heating. A single row of flow and return 5-inch piping is sufficient to keep up a maximum temperature of 55 which seems to meet the requirements of certain plants better than forcing heat of 65 to 75. They have not the attenuated and delicate appearance so often seen in plants raised in heat—and the saving of both labour and space is an item of no small importance to the market gardener which he would gain in being able to plant his seedlings in the open air without any hardening off process being necessary.

CHAPTER VII

THE MERCURY VAPOUR LAMP

In the winter of 1910 to Spring, 1911, I experimented with the mercury vapour lamp, which was, I believe, the first time that it had been applied to electro-cultural experiments in this country. This lamp consists of a long glass tube about an inch in diameter, with a bulb at the end containing a small quantity of mercury. When the electric current is switched on the lamp tilts, sending the mercury along the tube till it makes contact with the wire conveying the electric current at the other end. It then automatically returns to its former position, part of the mercury becoming vapourised as it runs back which gives a curious bluish yellow light as long as the electric current is kept on.

The house in which the experiment was tried was about 20ft. x 10ft., a smaller house being kept as a control house. The first trial was to see the effect of this lamp upon the germination of seeds, some British and some foreign ones being planted on December 7th in 6in. pots, and one of each variety placed in both houses. Under the influence of the light germination commenced much more quickly in the experimental than in the control house, as the following table will show :—

Experimental.		Control.	
Variety.	Days.	Variety.	Days.
French Beans	13	French Beans	21
Carrots	11	Carrots	26
Cauliflowers	6	Cauliflowers	26
Lettuce	6	Lettuce	12
Maple Peas	6	Maple Peas	16
Oats	7	Oats	12
Barley	7	Barley	12
Wheat	8	Wheat	16

The temperature of the two houses was kept as nearly as possible the same, also the temperature of the soil, the readings of the thermometer were taken each morning at 9 a.m. The control

The author's experimental house with Mercury Vapour Lamp.

house had the slight advantage of getting any sun there was, whereas the experimental house in winter was almost completely shaded from it, therefore on days when there was bright sunshine the temperature in the former house rose slightly higher than that of the latter; the average temperature of the two houses was for the first three months of the year :—

EXPERIMENTAL.	MAX.	MIN.	CONTROL.	MAX.	MIN.
January	50	46	January	59	48
February	60	44	February	67	55
March	73	47	March	78	50

Except on the days with brilliant sun the average day temperature was from 50 to 63 in both houses. The lamp was put on about sunset and kept alight for about five hours.

Lettuces, carrots and cauliflowers responded to the treatment in a remarkable manner—while the lettuces in the control house never came to maturity and the carrots were fully three weeks later.

Some of the cauliflowers, when showing their centre leaves, were planted out of doors in raised beds surrounded by 6in. boards; for the first three nights glass lights were put over them, the next two a mat was laid lightly on a few stakes above them, after which they were left unprotected, and though there were nine degrees of frost two nights later they were not in the slightest degree checked, and produced finely shaped heads fully a week earlier than those of the same age, raised in heat and grown afterwards under normal conditions.

Strawberries responded remarkably well to the treatment. There was a profusion of bloom and the fruit set well, the plants bore fully 25 per cent. more fruit than the control plants, and were 10 days in advance of them, but unfortunately the plants in both houses became affected by white mildew just as they were colouring, which rendered the crop unfit for picking.

One or two pots of vegetable peas were sown in December, of which the following table gives the result :—

EXPERIMENTAL HOUSE.	CONTROL HOUSE.
Peas "Filbasket"	Peas "Filbasket"
Sown December 7th	Sown November 25th
Germinated December 13th	Germinated December 27th
Ready for picking May 4th	Ready for picking May 7th.

In the experimental house, plants from 12 seeds produced 54 well-filled pods ; in the control house, five seeds produced 19 pods. The former were of excellent flavour, almost equal to peas grown outside, while the control ones had less flavour, and the pods not so well filled.

Some sweet peas were sown for out-door culture on April 4th. They germinated in six days, and on April 18th were planted in the open, being 8½in. high ; they grew robustly and bloomed well. Professor Priestley kindly made a structural examination of some of the plants sent to him, and gave it as his opinion that there was " greater depth in colour and sturdiness of growth in the treated plants, the leaf cells showed a markedly greater accummulation of granules containing green colouring matter (the chlorophasts) and their stems showed the presence of a large quantity of fibre at a time when the control plants showed practically none."

I am repeating the experiment chiefly over tomatoes, and the results are very encouraging—in germination, sturdiness of growth and depth of green. The response is what would have been expected from last year's trials with vegetables—plants which were from 7½ to 8 inches high when put in the experimental house measured over three feet within a few weeks, with a profusion of foliage and a good show of buds, which at the time of writing are not yet in blossom, those in the control house not having made anything like the same growth. Seedlings sown on October 20th, and germinated under the lamp are now plants from 14 to 17 inches high, and of a very healthy appearance, whereas the control seedlings have made no growth for five weeks, and are only from 5 to 7 inches high.

CONCLUSION

The foregoing experiments all show that the application of electricity, whether in the form of a silent discharge from overhead wires, or luminous by means of lamps, has a decidedly beneficial effect upon plant growth. In the illuminating experiments it has been the object of each experiment to imitate as closely as possible the rays emanating from the sun that have the most favourable affect upon vegetation.

CHAPTER VIII

HOW DOES ELECTRICITY AFFECT THE GROWTH OF PLANTS ?

It will be of interest to consider some of the theories which have been deduced as to the actual effect of the electrical discharge upon vegetation.

Nitrogen.

Electricity is believed to have a nitrifying effect upon the soil, and every farmer knows the value of this ingredient in raising crops. Analysis have been made of soil taken from under the electric discharge wires in which more nitrogen was found than in soil taken from the unelectrified area. Nitrogen composes about four fifths of the atmosphere, but in its free state is not made use of by plants as food, except in the case of leguminous plants whose power of obtaining nitrogen from the air is connected with the formation of nodules, the bacteria of which penetrates the roots and fixes the nitrogen, thus storing it up in the plants for them to feed upon. To show the importance of electricity in connection with the nitrification of the soil, rain brings down about 10.7 pounds of nitrogen per acre a year, and a greater proportion is precipitated by thunder rain than by rain when the atmosphere is less electrically charged—the lightning discharge causes a combination of the oxygen and nitrogen in the air, the product of which is brought down by the rain to earth, thereby adding small quantities of nitrates to its store for the nourishment of plants and which, though by no means sufficient to maintain the supply required by them, is a considerable supplement to artificial methods of enriching the soil—if, therefore, we can increase this supply of nitrogen to the soil from natural and manurial sources by aid of the application of electricity, that in itself would be a considerable gain.

Assimilation.

Another suggestion is that the electric current in the earth assists in making certain plant foods contained in it more soluble, and therefore more easy of assimilation. To take an everyday analogy we might compare the action of the current to one of "peptonising." The sun has a powerful action on the soil in

One of the earliest suggestions of electro culture.

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decomposing its constituents, and Sir Oliver Lodge admits that though the electric discharge cannot take the place of sunshine, in a minor way it is quite possible it assists growth, especially on dull days. Lack of sufficient sun in our climate is one of the great reasons that our crops are less luxuriant than in those countries where, from the time of seed sowing to the harvesting of crops, a day without sunshine is rarely recorded. We have a few days, in exceptional seasons perhaps a few weeks in succession, of cloudless sky and brilliant sunshine, during which period vegetation makes vigorous progress; then come days when the sky is dull and grey and plant life seems practically at a standstill. Is it not a natural inference to make, that the electric discharge, though by no means having the powerful influence of sunshine, accelerates growth where otherwise it would be making very imperceptible progress?

Moisture.

The small interstices between the particles of the soil have the capacity of sucking up the moisture from lower levels by what is known as capillary attraction. If we take a small "capillary" glass tube bent in the form of a horse shoe, pour some water into it till it about half fills the tube, the water will be observed to stand at the same level on either side. By placing an electrically-charged wire (negative) above one arm of the tube the water will creep up the side of the glass under the charged wire; from this fact we might quite reasonably imagine that a current of negative electricity going through the soil might substantially assist these tiny passages in the ground in their work of drawing up moisture from a lower level. A good instance was seen to confirm this theory in a trial carried on at Lincluden House during the remarkably dry season of 1911. The leaves on the potato plants in the electrified area were observed to be much less affected by radiation from the sun during the day, than those in the non-electrified area. But great judgment would be required in the application of the discharge during a long spell of dry weather, as the crop, though benefiting at the start, might deteriorate considerably owing to the moisture becoming exhausted.

Flow of Sap.

Weak electric currents are passing through the plants and discharging into the atmosphere by means of the leaves. By directly testing living plants a feeble current has been detected when sap is flowing vigorously, so that it would be quite reasonable to suppose that by augmenting these small currents we should have an increase in flow of sap and consequently greater stimulation of the plant. The formation of both starch and sugar have been found to increase under the influence of the discharge, and germination is accelerated.

To fully understand the physiological effect of the discharge is of the very greatest importance. Professor Priestley, of Leeds University, has been for some time engaged in making investigations when time permitted him to do so. His researches entail an immense amount of work and must necessarily extend over a period of years, for besides analytical work in the laboratory, the crops have to be carefully watched, and every condition of the soil they grow in taken into consideration. Therefore it is obvious that some years must elapse before we can expect to have placed before us, as the result of his important researches, a practical treatise which will guide us in how to apply the electric discharge with the greatest advantage to our different crops.

W. J. McKenzie, The Devonshire Press, Torquay.