RECENT TRENDS IN HORTICULTURAL RESEARCH

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So rapidly do the different areas of plant science change and enlarge that I may be pardoned if I first attempt to express a viewpoint of what horticulture is, and thus account, in part, for the diversity of its activities in modern research.

It is indeed not easy to delineate horticulture, to hit on a definition that adequately expresses the modern concept of the word. One attempts to trace its boundaries only to discover overlappings in other fields, controversial spheres of influence. Yet there is a popular notion of horticulture which brings people to flower shows, to cherry blossom festivals, to the market place. That practical horticulture and research are inexorably bound together is a fact that cannot be ignored. So if I refer to practical matters it is not that I am trying to find a place to hide but because of a patent fact.

It must be obvious to anyone that horticulture has to do with certain kinds of plants or crops which have through long custom been associated with it. Furthermore horticulture represents a special type of viewpoint. This latter is rather intangible but none the less true. In the beginning horticulture referred to a garden, that is, to an intensive type of plant growing in contrast to the culture of field crops. This meant fruits, flowers, vegetables, and ornamental plants. It represented a certain refinement of agriculture which came with leisure or was associated with the home itself. As plantings were expanded for commercial purposes the old idea of interest in the individual plant was retained. Whether apple, potato, or rose farming is still horticulture might be debated by some. But certainly horticulture has emerged from a garden into a vast enterprise and includes such features as nursery practice, the growing of vegetable and flower seeds by the thousands of acres, the processing of canned and frozen foods, the manufacture of spray materials and fertilizers, as well as the growing of fruits, flowers, vegetables, and ornamental plants.

Finally, it must be pointed out that horticulture is both an art and a science. It was an art long before there was any science or any agricultural colleges, and the art will continue whether there is a science or not. It is practiced by the untaught and by those of the greatest learning and culture. That is, horticulture, the art, does not belong to horticultural departments, neither is it destroyed no matter into whose hands it may find itself for a time. It retains its distinctive features, no matter into what university melting pot it may be thrown.

Having expressed this as a background I will attempt to point out some trends in horticultural research. The cases have been selected at random and quite arbitrarily.

THE PLANT'S ENVIRONMENT

If we consider ecology as that branch of biology which deals with the mutual relations between organisms and their environment, then horticulture makes the widest use of it. Ordinarily we do not call the studies by this name, and perhaps a new term will be introduced which will refer more particularly to applied or artificial relationships. Some reference must, therefore, be made to the manipulation of environmental factors, particularly those that are within the hands of the operator. As Livingston says: In all our experiments the environment lurks behind the scenes, as it were, ever ready to baffle our efforts and always calling for very watchful alertness on our part.[1]

The grower of crops must deal with the environment below and above ground. As he changes the environment by cultural practices, whether it be tillage, irrigation, pruning, or spraying, he to some degree affects the plant behavior. Let us look briefly at some of the work along this line.

Temperature.—It is only in the greenhouse and in the refrigerated storage that much can be done about temperature. True, orchard heating is practiced in some sections, mulching is used in part to prevent great fluctuations in soil temperature, but in the main, the horticulturist must select varieties and cultural practices that give the least trouble. Temperature is, however, receiving considerable study and most marked effects are obtained. That temperature has an influence on growth, anatomy, and the metabolism of the plant is manifest.

An interesting and illuminating case of the effect of temperature upon the vegetative and reproductive phases of development is that reported for cabbage. Premature seeding or "bolting" of cabbage is of common occurrence. The cause was usually assigned to poor seed although it was known that early sowing of seed predisposed the crop to this trouble.

Work conducted under the direction of Thompson[2] at Cornell showed that "mature plants taken up in the fall before they were subjected to low temperature did not seed when grown subsequently in a warm greenhouse (60° to 70° F.), while those grown in a cool greenhouse (50° to 60° F.) produced flowers and seed. The plants grown continuously in the warm house produced three heads in succession during the first year. One of the plants was kept in the warm house for two years after it was brought in from the field in October, 1925, and this plant produced six heads. After the sixth head developed and the plant was about three years old it was moved to a cool house and within a few months it flowered. The plants used represented a pure-line strain so that all of them had the same genetic constitution."

The opposite of this situation obtains with lettuce, high temperatures favoring premature seeding.

In none of these cases has length of day been a factor.

With greenhouse plants grown for their flowers, equally interesting results have been secured. For instance, stocks, which also belong to

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[1]Livingston, Burton E., 1934. Environments. Sci. 80: 569–576.

[2]Thompson, H. C., 1939. Vegetable Crops. McGraw-Hill Co.

the Criciferae, respond very similarly to cabbage, but since it is the flowers that are wanted the early "bolting" is desirable, and subjecting the seedling plants to low temperature may now be practiced.

Bulbous plants also are treated to force early flowering. Daffodils and bulbous iris subjected to 50° F. before forcing will bloom about four weeks early. If tulips are first preheated at a low temperature of 75° to 80° F. and then subjected to a low temperature they can be advanced considerably in time of bloom. This work has been done in Holland, England, and America. Darwin tulips can be secured in this manner in November instead of February as had been customary.

Lilies do not initiate flower primordia in the bulb stage as do other bulbs; hence it is possible to subject the young plants when a few inches high to a temperature of 50° for about two weeks. Such treatment will increase the number of buds per stock.

If gladiolus corms are placed in a temperature of 75° to 80° for a month before forcing, that is, preheated, they will flower about a month early.

Equally striking anatomical differences may be noted at different temperatures.

Water.—Water is such a commonplace that one would not expect to pay attention to it unless there was a great surplus or deficiency. Yet a successful greenhouseman will tell you that one of the most difficult operations to teach to a beginner is that of watering the plants. The desired amount varies with the kind of crop, the weather, the season of the year, the stage of development of the plants, and the nature of the soil. Many a crop is ruined by the misuse of water.

We have always thought of water as "water," but there are those who say that now we must unlearn that. Quoting Professor Salisbury: "Much of the water we drink is not simple water, but double water composed of two H_2O groups linked together as dihydrol. What constitutes water in the state of ice is not known, but when ice melts the water which is released is neither simple H_2O nor the double brew, but is composed of three molecules linked together as trihydrol. Whether these variations on the simple watery theme have any significance in horticulture cannot yet be stated with certainty. It is true that when plants are watered with what is simple water, as, for example, water from condensed steam, they do not, so it is said, grow so well as when they are watered with melted ice water. . . . It is often claimed by gardeners, and probably the claim is sound, that heavy falls of snow have a beneficial effect on the subsequent growth of plants."[3] And so the simplest elements of the environment are in for re-examination in the light of their effect on plants.

An interesting case of research in regulating water supply is provided in studies with tomatoes. Limited watering which allows the soil to be alternately wet and dry results in a large percentage of the crop (more than 75%) being affected with blossom-end rot, whereas similar plants which are kept well supplied at all times show practically none of this trouble. In fact, this simple treatment has practically eliminated it from greenhouses.

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[3]The plant and its water supply. 1938. Gard. Chron., March 19.

Light.—Following the classic work of Garner and Allard on the effect of length of day on plants, the horticulturist has made some practical use of this finding, notably with greenhouse crops. The chrysanthemum, being a short-day plant, was particularly amenable to treatment. Laurie and his associates[4] used black cloth to cover the beds in the greenhouse from 5:00 P. M. until 7:00 A. M. each day for a period of 30 to 35 days beginning July 15. This treatment has advanced the crop a month or more. On the other hand using electric lights to lengthen the day delayed flowering so that the mum season is now six instead of the usual three months.

Similarly, asters may be brought into bloom earlier by shortening the daylight period.

Just as shortening the day has induced early flowering of certain plants, so lengthening the day has had equally beneficial effects with certain other commercially grown flowering plants. The additional light should be applied from 5:00 to 10:00 P. M. or from 2:00 A. M. to 7:00 A. M. during fall and winter. Particularly responsive are *Lilium longiflorum*, annual chrysanthemum, *cineraris*, *Gypsophila*, and stocks.

Atmosphere.—It is not easy to regulate the atmosphere about plants and perhaps as conspicuous an example of efforts in this direction as might be cited is the use of modified atmospheres for the storage of fruit, or gas storage, as it is called in England. Trials have been made for years on the effect of artificial atmospheres in the storage and transit of fruits. As early as 1821 Berard was presented with a medal by the French Academy of Science for his paper on the storage of fruit in atmospheres devoid of oxygen, but it is only within the past few years that interest in the subject has developed from a commercial standpoint.

Smock[5] has described this type of storage and the results procured by it. He points out that respiration is diminished in intensity not only by lowering the temperature but also by reducing the amount of oxygen or allowing CO_2 to accumulate. Yellow Newtown apples held in CO_2 concentration of 10 per cent at a temperature of 45° F. were as green and firm as those held in air temperatures of 32° and 36°. Northwestern Greening apples after 30 weeks in 5 per cent CO_2 and 2.5 per cent oxygen (normal is 21 per cent O_2) at 40° F. were still as green as when first stored. Comparable fruit stored in normal air at 40° for the same period was completely broken down and worthless. Similar fruit stored at 36° was wholly unmarketable after 30 weeks because of softening, yellowing, and 100 per cent brown core. Excellent results were secured with McIntosh and other kinds of fruit.

I need scarcely call your attention to this work as pointing to a new method of commercial fruit transportation and storage.

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[4]Poesch, G. H., and Laurie, Alex. 1935. The use of artificial light and reduction of the daylight period for flowering plants in the greenhouse. Ohio Agr. Exp. Sta. Bull. 559.

[5]Smock, R. M. 1938. The possibilities of gas storage in the United States. Refrig. Eng. Dec.

The Soil.—So extensive is the work with soils that I can only touch on a few trends.

Probably the most conspicuous to those of us who have been associated with horticulture for a good many years is that of soilless culture or hydroponics, as it has come to be known in some quarters. The very thought of growing crop plants to maturity without soil, without organic matter, is rank heresy. If I had not been in the midst of this work for the past few years I too would smile. How extensive it will become cannot be said, but the fact is that better quality flowers are being grown in a medium of gravel, cinders, or a similar inert material than in soil. In some cases the yields are also higher. For instance, 35 rose flowers are being produced per plant in gravel culture and 20 is the usual number in soil. Sweet peas average about 50 per cent more in gravel. Carnations produce no more cut flowers in gravel, but the blooms bring a premium on the market because of their quality. The same may be said of snapdragons, calendulas, stocks, lilies, daffodils, iris, and many annuals.

Among the vegetables, tomatoes are having a wider trial than others and there is some reason to suppose that they may be grown profitably without soil.

Among the advantages of this system of culture are better aeration, uniform moisture conditions, better control of soil-borne diseases, a better balanced condition of the nutrients, and control of the reaction of the medium.

Quoting an English reaction to soilless culture we see what is a somewhat facetious quip. "Of course, it is only right and proper in a commercial age to prove all things and hold fast to that which is cheap! Of course, it is very attractive for anyone with a love of the picturesque in prophecy to foretall the time when the soil of North America—and elsewhere—having slipped away in the sea or blown away into the air, the teeming millions of that and other continents will be sustained by the produce of the Great Lakes. The charm of Lake Superior and all the rest of them covered with crops! Waving fields of maize and wheat and all kinds of vegetables, all growing in and out of the water! We, for our part, however, would rather exercise our imagination in picturing how happier and healthier we should all be if research could discover how to make the earth more fertile."[6]

Turning more directly to the soil itself there are several factors that are being studied with profit and which have a much wider application, although not so spectacular as soilless culture.

Perhaps no phase of the soil factors has been so blandly discussed as the role of organic matter. I would not want to jostle this eternal verity from its throne in agricultural science, but it seems to me that some of our early teachings were pretty much fairy tales in the light of recent findings. That organic matter is built up as a bank account by the return to the soil of large quantities of manure or cover crops to be drawn on by the tree at some future time, has not stood the test of investigation. Referring to orchard soils in particular, it has been

[6]Growing plants without soil. **1938.** The Gard. Chron., Dec. 3.

found that the growing of green crops which were turned into the soil has resulted in a net loss of total organic matter as compared to land which was left in sod or where the trees were mulched. At the Ohio Station we find, after 25 years, that the tilled land has 1.8 per cent organic matter as compared to 3 to 5 per cent under sod and mulch. Tillage of orchards on rolling land has been a fallacy which has resulted in untold loss of soil and ruination of its physical characteristics which many years of intelligent husbandry will not restore.

Another result of recent studies has been the value of porosity or the movement of air and water through soil. The importance of this matter had been recognized for a long time, but not until the comprehensive work of Oskamp and other horticulturists at Cornell and elsewhere, had its real importance in the life and productiveness of an orchard been measured. The value of aeration in a soil has moved from its sacred place in the laboratory to a most vital position in agricultural practice. The curse of a compact soil, whether natural or brought about by injudicious culture, even in the name of a soil-building program, cannot be overestimated. I am here tempted to quote the familiar lines of Pope:

Where grows? Where grows it not? If vain our toil
We ought to blame the culture, not the soil.

We should not have expected Pope to know that the physical characteristics of a soil are of more importance than the system of culture for orchard purposes, but some who recently quote his lines with approval should know better.

With this we shall reluctantly leave an absorbing phase of horticultural work which is essentially ecology, and look briefly at some other areas of present day research.

PHYSIOLOGY

The importance of physiology in the minds of horticulturists can be measured by the number who take their basic training in this field and immediately engage in investigations in which this science provides most of the tools. To even catalogue these researches would be as impossible as undesirable in this connection. It seems even more difficult to determine just what does and what does not belong in this category.

Perhaps the investigation which stimulated more thinking and additional work than any other was that of Kraus and Kraybill on the relationship of nitrogen complexes and carbohydrates on the flowering of plants. In this the plantsman found a way of thinking about plants, something he could take hold of and manipulate to his purposes.

The discovery of deficiencies of so-called rare elements, such as boron, manganese, magnesium, copper, and zinc has opened a renewed interest in nutritional studies and some important progress has already been made.

Notable in the physiological studies is the development of apparatus for the study of carbon assimilation by leaves in the field and under controlled conditions, by Heinicke and his associates. This type of apparatus affords a means of conveniently determining the photosynthetic activity of leaves which have been sprayed with various materials and of leaves which are being attacked by insects and diseases, for determining the respiration rate of plants and their products at varying temperatures and with different amounts of light. Horticultural practice has already been influenced by these findings.

From the standpoint of an orchardist, the problem of securing higher color on fruits is of serious moment, especially since the use of nitrogen as a fertilizer tends to prevent the development of sufficient red color for highest market value. Chemical and experimental evidence shows clearly that a high foliage-fruit ratio favors high color provided the synthesis of nitrogen and carbohydrates into amino and protein complexes does not deplete carbohydrates. That is a ratio of 20 leaves per apple gives a lower sugar accumulation and a poorer development of color than 75 leaves. Expressed in orchard terms, the thinning of fruit results in higher color than occurs when a tree bears an excessive crop. These matters are within the hands of the orchardist but the situation is still not satisfactory. Very recently Dustman and Duncan have published results of spraying trees with soluble thiocyanates. The foliage is subjected to spray burn and to a chlorotic condition arising from the effect of the chemical on the green coloring matter of the plant, but in the fruit, the amount of red color occurring normally tends to be increased and the ground color tends to be reduced or replaced by varying shades of yellow and yellow green.[7]

Gardner, Marth, and Batjer[8] have demonstrated the value of certain plant growth substances (hormones) as capable of preventing abscission of various plant organs, including leaves, flowers, and fruits. This discovery has been put to practical use in delaying the preharvest drop of apples by spraying with dilute solutions of naphthaleneacetic acid. The commercial effect of increasing color of fruit as a result is yet to be worked out, but appears promising.

Other work with hormones and vitamins is in the limelight at the moment. The discoveries and the techniques used in the discoveries represent an epochal advance in the knowledge of plants and the forces that direct plant behavior. As might be expected, there are some exaggerations of what may be expected from these discoveries; on the other hand, some of the possibilities arising from these findings would be difficult to overstate. I refer particularly to the use of naphthaleneacetic acid in the production of seedless fruits of tomato, cucumber, and other fruits, not so much because the fruits are seedless, as because of the possibilities of getting a crop of fruit once the flowers are formed even though the pollen is not viable, as often happens in the greenhouse. I refer also to the use of acetylene and ethylene in controlling flower formation as demonstrated, for instance, with the pineapple in Hawaii and Australia where the entire harvesting period has been regulated.

The use of growth promoting substances in the rooting of cuttings

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[7]Dustman, R. B., and Duncan, I. J. 1940. Effects of certain thiocyanate sprays on foliage and fruit in apples. Plant Phys. 15: 343–348.

[8]By correspondence.

seems to be over rated from a commercial standpoint, as does the use of Vitamin B_1 for plant growth.

ULTIMATE OBJECTIVE IS QUALITY

With our typical stress on bigness and quantity, it is not strange that agricultural experiment stations have largely neglected quality except so far as there are dollar signs on it. A healthy, sturdy race of animals and men has not received first consideration. True, we have known that man and animal were dependent upon the products of the soil, have even recognized in a general way that "man was three parts water and one part concentrated grass," but to study the exact composition of these products from the standpoint of proper nutrition, not much was done, at least for man.

QUACKERY

I dislike to conclude with any remarks on quackery, but something akin to this is constantly in the picture and might as well be admitted. The fertile field for lurid colors, get-rich-quick schemes, for magic, wizardry, and the supernatural is probably a result of the large number of amateurs who engage in some sort of plant growing. The doctor, lawyer, and Indian Chief, alike, fall for the fabulous tales of an expert salesman; and, I regret to say, often the experienced greenhouse man, orchardist, and gardener are rivalled perhaps only by the golf greens-keeper as suckers.

Just recently I received a gallon can of Reico, which when sprayed on apple trees "will change the biennial bearing habit!" Other proprietary products now on the market, some with merit, others of doubtful value, are: transplantone, auxilin, vita-flor, hormodin, root-tone, bloomlife, fruitone, and, of course, vitamin B_1. We must admit that if science comes, the commercial adventurer will not be far behind.

With all this, experiment stations and colleges still have ample work to do if the real merit of new products is to be determined and the innocent public protected.

The Great Naturalists Explore South America

It is unusual to run across a book on natural history written for the layman, which is both entertaining and authentic. The Great Naturalists Explore South America is a volume which conforms to the above standards. It consists of two parts. Part I gives an historical account of the naturalists who have traveled in South America. These include Humboldt, Boupland, Waterton, Darwin, Schomburgk, Edwards, Wallace, Bates, Spruce, Hudson, Pritchard, Beebe and Ditmars.

Part two consists of thirty chapters, devoted to descriptions of various animals peculiar to South America. There are forty excellent photographs of many of the animals discussed. Samples of interesting chapters are those dealing with the Vampire Bat, the Jaguar, Hummingbirds, Giant Boas, Electric Eels and Insects as Food. A five-page bibliography is included. We highly recommend this book, not only to the general reader, but also as a stimulating reference for Zoology students.—*D. C. Rife.*

The Great Naturalists Explore South America, by Paul Russel Cutright. 340 pp. New York, The MacMillan Co., 1940. $3.50.