Arthur, J. C.

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# SUB-WATERING

AND

# DRY AIR IN GREENHOUSES.



BY

J. C. ARTHUR.

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The President: We will now be pleased to hear from Professor Arthur, who will read the paper he has prepared on Sub-watering and Dry Air in Greenhouses.

Professor Arthur: I had no idea when I consented to give a paper on Sub-watering, that we would have such a demonstration of the disadvantages of excessive surface watering as we have to-night. Neither had I any idea that I should be called upon to expend so much energy in getting here, and it is doubtful whether I have a reasonable amount of energy left to present a paper. In my paper that I presented a year ago I made the attempt, not to present a new thing, but to present what had been fairly well demonstrated and reasonably well published, but which had not been taken up simply because it had not been brought to the attention of those who should be most interested in it—the practical men—in a way that attracted their attention. So I attempted to do that one thing, and I am very much gratified indeed that the attempt should have succeeded so well that many have already made some effort in that direction, and some have made a very considerable attempt at demonstrating whether there is anything really good or not in the suggestion. The paper I have to present to-night is not very long, and it is in the way of a supplement to the first presentation.

## Sub-watering and Dry Air in Greenhouses.

BY J. C. ARTHUR, OF THE PURDUE EXPERIMENT STATION.

The time was when acceptable greenhouse culture called for a maximum growth without close inquiry into the question of healthy and normal development. The ideal of the gardener was a tropical jungle with steaming atmosphere, and a wealth of luscious foliage and flower.

The use of glass houses for winter production of vegetables and flowers delighting in cool weather, such as lettuce, radish, rose and carnation, brought with it some modification of the tropical ideal. But doubtless the most potent factor in changing the point of view has been the pressing necessity for protection against the many destructive parasitic diseases. When the rust, smut, rot or mildew carried off a crop, as it did much oftener and more completely than in the open air, an inquiry into the causes of the epidemic revealed advantages in methods that eliminated the conditions that favored the growth of the fungus as fully as could be done without interfering with the growth of the crop. Incidentally it was learned that the old time notions regarding greenhouse methods could be profitably modified, and a spirit of inquiry and willingness to change has been engendered, especially a desire to adapt the conditions to the fundamental needs of the crop grown, if such knowledge can be obtained.

In citing the chief factors in changing the ideals in greenhouse culture one must not forget the subtle but potent influence of the long-stemmed flower. To meet the demands of fashion for a large flower upon a strong leafy stem of considerable length, very fortunately a demand that rests upon a healthy taste, although one that is sometimes carried to extremes, the florist has been obliged to inquire into the conditions that especially promote a vigorous, yet substantial development. Besides producing a large flower upon a long stem, thorough business success requires that the petals be of a lasting texture and the stem firm and substantial, and that each plant shall produce a maximum number of such blooms continuously for the season. Only high bred plants, strengthened along every hereditary channel, kept under conditions for well-balanced and healthy development, can meet these exacting requirements.

A clear conception of the problem shows some radical defects in the old-time methods of rearing plants under glass. A year ago, in my paper before this Society under the caption, "Moisture, the Plant's Greatest Requirement," I presented reasons for believing that for the flowers and vegetables usually grown in commercial greenhouses, wrong ideas prevailed regarding the distribution and application of moisture. I pointed out that the plant would thrive best, especially the carnation, when the air was moderately dry, and the soil moist beneath and dry on the surface. To secure these conditions I advocated the abandonment of surface spraying and watering, and the substitution of uniform watering from beneath the soil.

My experience in presenting new methods to those who should presumably take the liveliest interest in them does not lead me to be sanguine of much support. I am often reminded of an attempt I once made to do a service to some elderly persons who had lived in a small town away from the direct lines of railway. Bananas were practically unknown in that region, and upon visiting them I carried some along at considerable inconvenience to myself. I expatiated upon the merits of the new fruit, but my friends would only take very small nibbles, and promptly came to the conclusion that they did not care for it, and said that I had better eat it myself, if I thought it was good. Some years afterward, when the town had grown and the shops were abundantly stocked with imported fruits, I paid a visit to the same old folks and found that bananas had become their special delight, and to live without them was a hardship.

So I had thought that sub-watering, especially in large and progressive establishments, might come about in time, and naturally have been greatly surprised and gratified to learn that on the contrary it has been taken up with promptness, both by large and small growers, and not at all in a gingerly manner, but on a scale that is likely to demonstrate its good and weak points with reasonable clearness.

The present paper is intended as a supplement to the former one, to strengthen some of the theoretical points and to amplify some of the practical details. In the first place I wish to call your attention to an able paper by Dr.

W. Wolley upon the influence of atmospheric moisture on the growth of plants, published a few months ago. The work was carried on at Munich in the experimental grounds of the Bavarian Agricultural College. Farm crops growing in the open field, including alfalfa, hairy vetch, barley, flax and potato, were used; and in order to control the amount of moisture in the air the experimental plants were covered with small houses, about three feet by six and five feet high, having glass on three sides. These houses were in groups of three, one having air like the outside air, one having it much moister and one much drier. The plants were enclosed and observations taken throughout the whole growing season, the houses being large enough to permit normal development. The extra moist air was secured by allowing water to drip upon blotting paper, and the extra dry air by using an absorbant like chloride of calcium. The work was well carried out and the results can evidently be accepted with confidence.

The well established conclusions may be summed up in a few sentences, the details not being especially important in this connection. It is particularly interesting to learn that the ash content is always greater in plants grown in dry air, and even the dry weight is usually more, which being interpreted, means that in the dry air more water passes up through the plant, bearing with it more food material derived from the soil, and that this induces an increased production of solid matter in the plant.

All parts of the plant become firmer in dry air, the woody fibers increase in strength, and the cuticle in thickness. This ensures a more substantial development, and in most cases brings about a heavier harvest. It is exactly in line with the aims of the florist, who wishes cut flowers that will ship well and that will stand up well in heated rooms.

A feature that is not so acceptable was the shortening of the stems and contraction of the leaves in the dry air, which was very marked in every trial. This is undoubtedly due, as the author has indicated, to the loss of water from the foliage being so great in the dry air that the roots were unable to take it up fast enough from the soil to maintain the internal pressure, which necessarily prevented the cells from duly expanding. That the difference in size of the organs was chiefly due to a deficiency of water supply is also evidenced by the failure of the potato tubers to properly increase and fill with starch in plants grown in dry air. Of course it remains an open question whether the roots would really take up sufficient water, if it were supplied to them abundantly to provide for the evaporation and still keep up the necessary internal pressure for maximum growth. This is a question that can only be answered by actual experiment, which so far is lacking.

From the Bavarian investigations we may safely infer that a moderately dry atmosphere promotes the substantial development of ordinary plants, increases the strength of stem and firmness of tissue, but that the full benefits can only be derived when there is an adequate supply of moisture for the roots. We may also believe from the knowledge we have derived from other sources, that plants in a dry atmosphere are less likely to take diseases.

However, we are chiefly interested at present in the plant's demand for water. What already has been said is enough to indicate that the plant should have as much water supplied to it as can be taken up by the roots. I believe no argument is needed to convince my hearers that for greenhouse crops sub-watering is immensely superior to any system of surface watering. Since the presentation of my paper before this Society a year ago, many articles have been published commendatory of the method, and a number of practical and theoretical points elucidated that were not touched upon in my necessarily brief paper.

From what has been published, and from my rather extended correspondence, I am more fully than ever convinced that the use of tile for supplying water, and make-shifts in place of a thoroughly watertight bench bottom, which are generally selected on account of cheapness, are likely to bring disappointment. The most satisfactory lining, probably in the order named, is zinc, galvanized iron, or cement, which should extend three or four inches up the sides of the bench, or to the top, if the expense does not seem too great. The bottom is then covered with four inches of porous bricks, set so close together that soil will not drop between them; and ample space is provided for water and air to circulate freely by removing about a half inch of the lower edges of the bricks before setting. The bed is then filled with soil in the usual manner.

Water is run into the bottom of the bench through an inch tube set at intervals of five to ten feet along the front edge, or an even better way probably is the plan I recently saw in use in Mr. Fred. Dorner's houses, of using a flue about two by six inches instead of the tube. Mr. Dorner's plan permits water to run in a little easier from the hose, and does away with any necessity for a gauge, as the bottom of the bench can be readily seen through the flues, and the presence or absence of standing water noted.

Overflows should be provided at the back of the bench, so that only a certain depth of water can be added, even by the most careless workman. These can be placed at two inches above the bottom, which experience shows to be about right.

These items cover the essential features of what is believed to be at present the most perfect system of subwatering. So far as the application in commercial houses has come to my knowledge, there seems to be misapprehension of the full philosophy of the system. The soil should at all times be well supplied with air, which largely comes from beneath, and therefore should not be kept too wet. Unless benches are made far deeper than usual, water standing in the bottom of the bench any large part of the time cannot fail to keep the soil too wet, besides depriving it of the circulation of air that should take place through the brick. It must be remembered that the bricks continue to supply water to the soil above long after it has entirely disappeared from the bottom of the bench. The usual depth of soil is scarcely enough for this system, even with the most judicious attention. It would be better to have five or six inches of soil above the bricks, and then an inch of the surface soil can always be kept dry to act as a mulch and protection against fungi.

After a bench is first filled, water should be applied cautiously and time enough given for the slow process of diffusion. It will take from one to three days for the moisture to appear at the surface after water is run into the bottom. Water enough for the operation can be supplied in two or three applications; what more is added tends to puddle the soil and injure it. Patience is needed for the first watering, for it cannot be hurried, but can easily be overdone.

In all subsequent watering it must be borne in mind that it takes a long time for the water that is put in the bottom to reach the upper layers of soil; and that no water is lost. At first when the plants are small, it will probably be sufficient to water once in one or two weeks. By a watering is meant to run water into the bench until it runs out at the overflow. In three or four hours it will all have been taken up by the bricks, and will be given up slowly to the soil. As the crop grows, watering must be more frequent, but will rarely need to be oftener than once in one to three days. If the surface of the bench does not keep dry, too much water is certainly being applied. The amount to be used must be a matter of experience, and requires careful judgment. The tendency at first is to over water. The process is so different from the usual surface method of watering that some time and close observation are required in order to fully master it, and obtain the greatest advantage from it.

It will be a convenience in construction and give greater control over the watering, if the benches are divided into lengths of 25 or 30 feet by partitions. These sections can be at different levels, which will also provide for the slope in long houses.

Experiments carried on since my last paper make it certain that the extra feeding of the plants can be done by applying the liquid fertilizer through the bottom, of course taking care that no solid material is allowed to pass in to clog up the spaces beneath the bricks. This does away with all surface applications.

If now the house be piped for water by running a line along the front of each bench, with an opening for each section of bench, the whole house can be watered at once with the opening and closing of a single stopcock. The saving of labor which this change implies must go some ways toward meeting the additional first cost of construction.

Of course a house that is already piped in the ordinary way, with hose attachments provided, could not be changed profitably, but if a house is being built for this purpose, the hose can be entirely done away with, and a line of pipe run along the front of each bench, and the whole watering done by turning a single stop-cock, or stop-cocks can be added for each one of the different sections, and then you have the house under more perfect control.

There seems to be but little remaining that calls for the services of the Experiment Station. If it is found that the Stations have done a signal service to commercial horticulture, as it now appears, they ask nothing in return but commendation, and a support that will increase their usefulness.