THE INFLUENCE OF DAY-LENGTH ON THE HEALTH OF PLANTS

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Light as a factor of plant growth is usually spoken of as if it were the simplest thing on earth, for the complex action of solar radiation is not often realized. Most biologists consider a deficiency of light to cause a lack of carbohydrates, as a result of insufficient photosynthesis. During the last decades, however, it has become more and more clear that the duration of the daily light period is decisive for the behaviour of many plant species (photoperiodism). Not only is the formation of flowers often regulated by this factor, but also growth itself. In short days the lengthening of stems and petioles may be retarded; too short days therefore may cause a definite type of stunting. In the course of my investigations on the use of artificial light in plant growth, I have found some instances in which a deficiency of light was not related to photosynthesis. In these instances it was possible to prove that the unhealthy condition of the plants was due to an abnormal photoperiod.

About 1930, at the Horticultural Laboratory of Wageningen, many efforts were made to force *strawberries* early in winter (November). We worked with the best forcing-variety: Deutsch Evern. Soil-mixture, temperature and other conditions received the best possible care. Artificial light was given at night. In spite of these efforts the attempt proved a failure. A few flowers on short stems appeared and developed only small fruits; but the worst feature was a yellow discoloration of the older leaves, which died off, accompanied by *Botrytis* attack. We had to pick the leaves, so that the plants became smaller and smaller.

The same symptoms were observed in a Dutch-light house belonging to the Laboratory, the plants being in such a state that the Phytopathological Service was called into help. No cure for the trouble was found at the time, however. Many years later, from a study of the literature on photoperiodism, I came to the conclusion that, on account of the length of day at this time of the year, nightly illumination of the plants should start at least one month earlier – i.e. at the end of September.

The result of this treatment was amazing; the plants continued their summer type of growth, they developed new leaves with well-extended petioles and leaf-blades; the older leaves remained alive and healthy. The flower stems acquired a good length and many flowers were produced. The intensity of artificial light given was so low that photosynthesis could not have played a part in the result; yet the disease was entirely prevented. The weak incandescent light given during the night hours could have acted only as an artificial lengthening of the short days of autumn. It prevented the strawberry plants from entering their winter rest period and they maintained their summer growth capacity. On the other hand, the non-irradiated plants, kept in the greenhouse at approximately 15 °C, declined steadily; their growth was checked; later, VAN DEN MUYZENBERG (1942) called this a "state of inertness". If they survived the winter, it appeared impossible to stimulate such plants to new growth in the spring. Only winter cold is able to wake them from their state of rest. This is the reason why in

practice the forcing of strawberries is not started before the 1st of January. If started in November with exactly the same plant material, the forcing produces only a sickly-looking crop. The symptoms might be mistaken for those of root-rot, whereas the real cause is too short a daylength accompanied by a temperature higher than out of doors.

At Aalsmeer I had to deal with difficulties in the cultivation of mother-plants of *winter-flowering Begonias*, particularly the species which bear large flowers. These originate from crosses of tuberous begonia with stem begonia. They offer the advantage of initiating many flowers in the short autumn days, but they have the disadvantage that their partly tuberous nature gives them a propensity to die off in winter without forming proper tubers.

For a long time this gave the Aalsmeer-growers a lot of trouble. It proved very difficult to keep the mother-plants alive during winter; many of them died and the remaining ones lacked very much in appearance; it was summer before they had regained some vigour, so that the first cutting could barely be obtained in June, which was much too late. That is why cultivation first became really possible when it was noticed that the plants grew better if illuminated during the night hours with ordinary incandescent lamps. Afterwards I was able to prove that here again the length of day was the decisive factor. The short days of the autumn have a twofold influence. In September, for example, with an astronomical day-length of 12 hours, the plants produce leafy shoots forming a lot of flowers. This is still quite normal. Later in winter – for example with a day of 8 hours – the winter state of rest begins to predominate to such an extent that one might suppose the plants to have become the victims of a disease, the leaves turning yellow and falling off. The only development achieved is that of flowers; leaf-shoots are lacking, and growth comes finally to a complete standstill, the stump of the clipped stalk sometimes ending with a tuber. Occasionally some small tuberous thickenings of the stalk are also found below soil level. There are no more young leaves coming on; the old foliage has become dark green in consequence of the standstill of growth, with the leaf-blades often bulging. All this could be entirely prevented by means of incandescent lamplight of an extremely low intensity, which can be obtained by installing an average of only 8 Watts per square meter. The primary cause of the diseased condition of the plants has thus nothing to do with an affection by parasites. It seems likely that the plants are suffering from a deficiency of growth-promoting substances, or of what produces the same effect: a surplus of growth-inhibiting substance.

Thus we have landed on the field of hormone-pathology of which we have but yet a vague conception. Many symptoms of diseases, also in other fields of phytopathology, often bring to mind hormonal actions. I am mentioning only the outward similarity of symptoms of some virusdiseases with those occurring when growth hormones are being used as weedkillers.

Returning to the subject of light: already at the beginning of my research work at Wageningen, I noticed that a fairly strong irradiation with incandescent lamps prevented the damping-off of seedlings of *Sinapis chinensis* L. affected by *Rhizoctonia*. The effect was less marked under Neonlight. At the time, I supposed that the desiccating action of the incandescent lamp irradiation (infrared) contributed to the effect by drying up the surface of the soil, thus robbing the fungi of their chance of infection. This seemed to explain also why

Neonlight was less effective, for it contains considerably less infrared rays than the incandescent lamplight. On the other hand we must admit that the light of incandescent lamps was not so suitable for the purpose, as it caused an excessive lengthening of the stems of the seedlings. A long, spindly seedling is generally considered to be more susceptible to damping-off than a sturdy thick-set one. So the theory did not quite fit here. I then thought that the seedlings under light might sooner outgrow the sensitive stage, as plants develop more quickly under artificial light when care is taken to give them sufficient to ensure that carbon dioxide assimilation becomes important. In this respect, however, the same success should be obtained when using Neonlight or other discharge lamps.

Meanwhile, in recent years, I have been able to establish at Utrecht, an effect of artificial light on damping-off in seedlings and the like, which is in no way connected with drying or with carbohydrate formation, but which is already noticeable with very weak irradiation by incandescent lamps. A long-day effect must therefore be presumed here also. As the cost of the very weak irradiation practised in nurseries producing begonia mother-plants is very low, many florists began trying incandescent lamps near other plants. This was not because of any theoretical considerations, but because growers tend to try anything they think may give a chance of improvement. It was soon found that treated seed begonias appeared less susceptible to damping off.

Many plantspecies however, do not react well to night-irradiation by means of incandescent lamps. Thus the stems of *Gloxinia* seedlings became too elongated, which proved a disadvantage all through their cultivation, as the mature plants became rickety. It was noticed, however, that with irradiated plants damping-off occurred less often in the first phases of development.

Because of the high price of coal, growers wish to burn as little fuel as possible, but *Gloxinia* seedlings require sufficient heat. In the winter of 1950/'51 we cultivated Gloxinia of the species „Kaiser Wilhelm" at a greenhouse temperature which was intentionally kept too low. It was found that a very weak illumination by means of incandescent lamps avoided the stagnation of growth caused by too low a temperature and prevented damping-off. The only thing we did was to lengthen the day artificially, thus promoting growth of the stalks and expansion of the leaves. If this could be explained e.g. by an increase in the production of the growth promoting substance, the quantity of this to be found in the plant could determine the possibility of infection by soilfungi. The turgescency of the tissue-cells may play a part in it.

The examples given show how strongly day-length may effect the state of health of some photoperiodically sensitive plants.

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