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Statens Væksthusforsøg, Virum (V. Aa. Hallig)

The seasonal variations in growth of *Codiaeum variegatum* under greenhouse conditions*)

Den årlige vækstvariation hos Codiaeum variegatum *dyrket i væksthus*

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Summary

The variation in the light intensity during the year caused a seasonal variability in the growth of *Codiaeum variegatum* Blume 'Geduldig'. An analysis of the effect of the increasing and decreasing daylength on the growth of the plants are also shown.

Plants were propagated every third week over a period of two years. The fastest growth took place when the plants were propagated in May and the slowest when propagated in September.

Key-words: Annual growth, light. *Codiaeum.*

Resumé

Lysintensitetens variation gennem året får væksten af *Codiaeum variegatum* Blume 'Geduldig' til at variere. Der er også vist en analyse af den tiltagende og aftagende daglængdes betydning for plantevæksten.

Planter blev formeret hver tredie uge igennem to år. Den hurtigste vækst fandt sted, når planterne blev formeret i maj og den langsomste, når de blev formeret i september.

Nøgleord: Årlig vækst, lys. *Codiaeum.*

Introduction

With the intension to achieve a better understanding of the annual growth this study was undertaken. At 3 weeks interval 24 top cuttings of *Codiaeum variegatum* Blume 'Geduldig' were propagated, with one cutting in each 10 cm pot filled with a peat-clay potting compost. The first propagation took place on 26th November 1968 and the last on 3rd June 1971. In all 26 sets of plants.

The propagation took place under a white plastic cover on solid benches at temperatures of 28–30°C with 100 plants per m². The top cuttings were as uniform as possible and had 6–7 large, mature leaves. When propagated the distance from the top of the pot to the top of the stem was 3 cm. When the rooting had taken place and after the plastic cover had been gradually removed the plants were placed on solid benches with 24 plants per m² until the terminal measurements.

Once a week the plants which had reached at least 15 cm in stem length were measured from the top of the pot to the top of the stem, and the number of leaves were counted.

The growth of the plants took place in a light modern greenhouse, where the temperature was maintained at 18–20°C in the winter, and 20–22°C in the summer as minimum temperatures. The plants were watered and fertilized as needed.

The experiment was carried out on the island of Fyn and the light intensity measured at Tåstrup, outside Copenhagen by a Kipp & Zonen solarimeter with sensitivity from 300 to 3000

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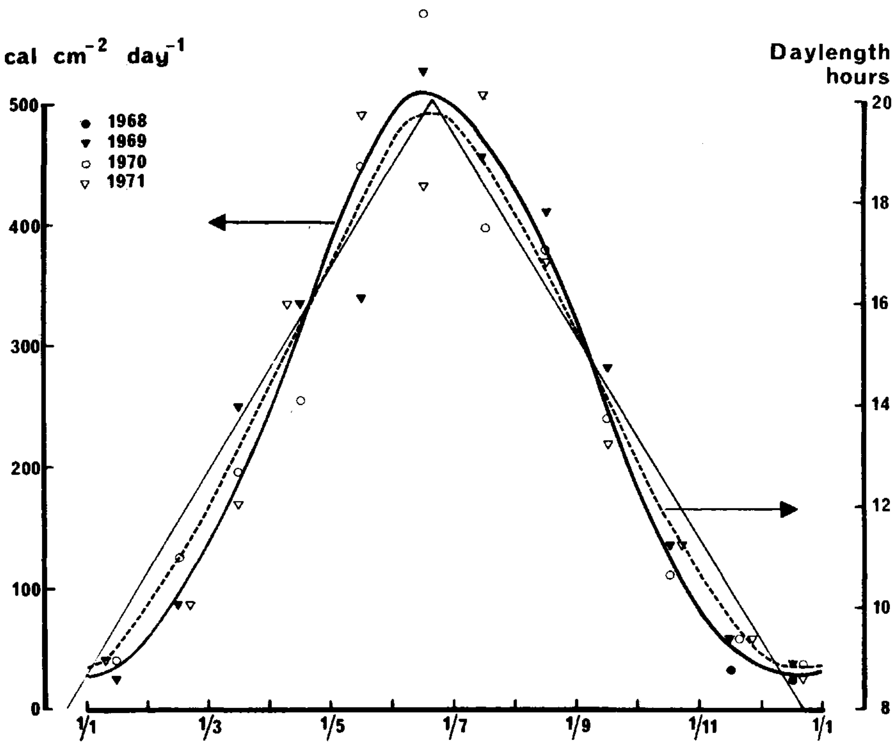

Fig. 1. The monthly daily mean of radiation and the daylength including twilight as a function of time during the year at 56° N.

nm. The recording took place every ten minutes and the sums are calculated per day. The monthly daily mean and the daylength including twilight at 56°N are shown in fig. 1.

Results

The stem length of the plants were measured as soon as the top leaves had matured after the plants had reached 15 cm, therefore the final size of the plants varied from one set of plants to another. The exact time when the plants had reached a stem length of 15 cm had been estimated by calculation and consequently the average daily growthrate in mm day^{-1}. In fig. 2 is shown the growth in relation to the time of propagation and in fig. 3 the relation to the middle date between propagation and 15 cm.

Both in fig. 1 and 3 a straight line is drawn between a low point on 22nd December to a high point on 22nd June. It can be seen in fig. 3 that there is a distinct deviation from the straight line by the actual growth rate. Therefore, the growth rate is analysed in relation to both the light intensity and the daylength.

The growth of *Codiaeum* is shown in fig. 4 in relation to light intensity. The data on and above the curve are from sets of plants which were propagated during the period from January to June (i.e. increasing light intensity), while the points beneath the curve are from sets of plant which were propagated during the period from July to December (i.e. decreasing light intensity).

When the plants are grown during a long period under natural daylength conditions the effect of daylength on growth can be expressed in different ways. In fig. 5 the growth is shown in relation to the daylength at the time of propagation. Every point is numbered and the

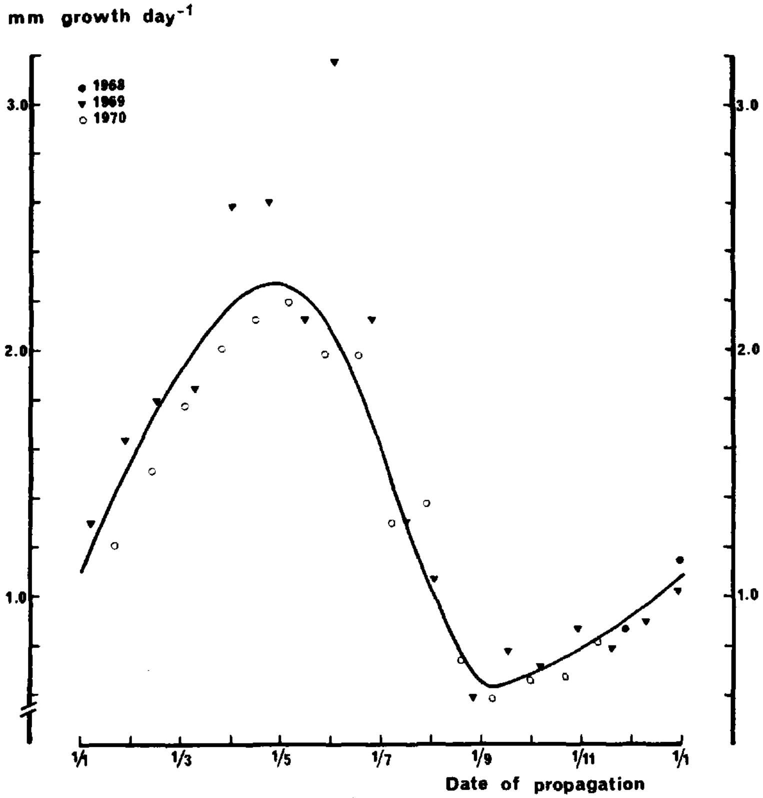

Fig. 2. The growth of the plants in relation to the time of propagation.

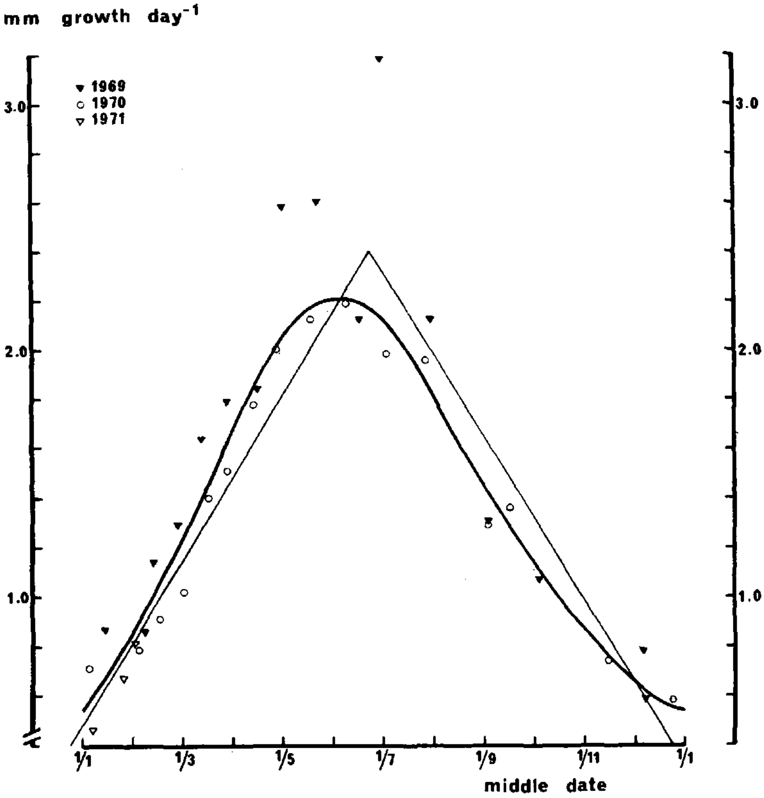

Fig. 3. The growth of the plants in relation to the middle date between propagation and when the plants were 15 cm in stem length.

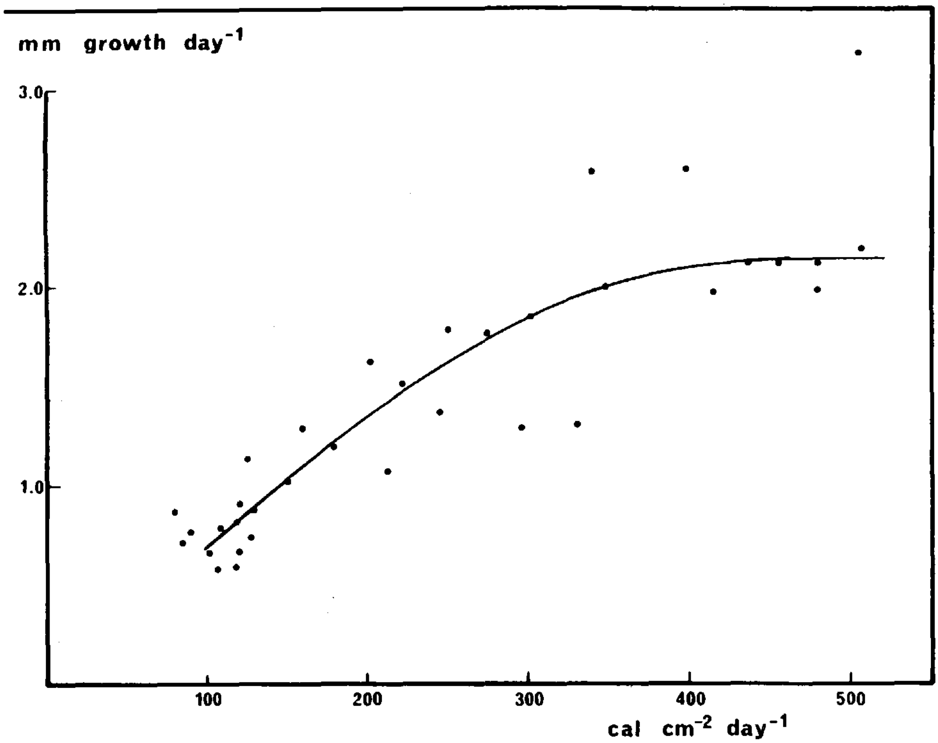

Fig. 4. The growth of the plants in relation to the daily mean radiation during the growing period.

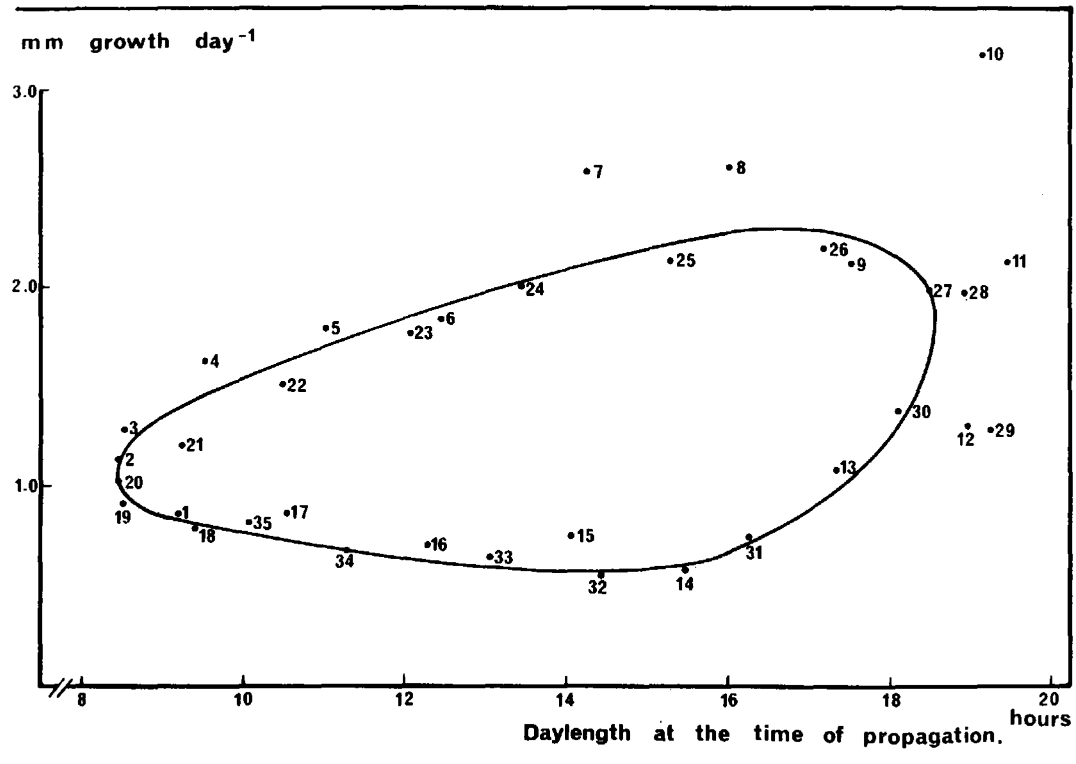

Fig. 5. The growth of the plants in relation to the daylength at the time of propagation. Number around the curve refer to set number.

curve is drawn starting from set of plant number 1 (daylength 9 hours and 18 minutes) going clockwise round and ending with the set of plant number 35. The upper part of the curve covering the plants propagated in the period from January to June (i.e. increasing daylength) and the lower part covering the plants propagated in the period from July to December (i.e. decreasing daylength).

In fig. 6 the growth rate is shown in relation to the mean daylength for each set of plant. The mean daylength is calculated for each set of plants by summarizing each daylength in the period from propagation to time of reaching 15 cm in stem length and dividing that with the number of days in the same period. As in fig. 4 the points on and above the curve represent sets of plants which have been propagated in the period from January to June and the points beneath the curve represent sets of plants propagated in the period from July to December.

The relationship between the mean daylength and the measured radiation is shown in fig. 7. The mean daylength used in this figure is the same as used in figure 6 and the cal cm^{-2} day^{-1} is the same as used in figure 4. The points are scattered around the drawn line and are not related to the time of the year.

Discussion

The growth rate varied during the year. From approximately 0,6 mm day^{-1} when the plants were propagated around 1st September or with the middle growing period in December and January, to approximately 2,3 mm day^{-1} when propagation took place around 1st May or with the middle growing period in May and June. This is a variation over the season by a factor of four, while *Cooper* (1966) found a factor in net assimilation rate in tomato of nine, and *Bunt* (1972) found a factor in dry matter production in carnation of ten.

The measurement of growth in this experiment is distinct from the two other experiments, where the dry matter production was measured over a period of $6^1/_2$ day (tomato) and 27 days (carnations).

The growth of *Codiaeum* was measured from propagation until the plants had reached a certain size (i.e. 15 cm in stem length), which gave growing periods from 53 days to 211 days.

As can be seen in figure 1 the actual radiation varied during the year from about 30 to 500 cal cm^{-2} day^{-1}. However, when measured as the average over the growing period for each set of plants it varied from 100 to 500 cal cm^{-2} day^{-1} (fig. 4), and growth was approximately proportional with light intensity from 100 to 400 cal cm^{-2} day^{-1} but levels off above that point.

The different methods of measuring the growth of plants can be the reason for different results. Because the plant growth took place over so long periods, some errors can occur as plants do not grow after a straight line. On the other hand, when measuring the growth of plants over the actual growing period, data are obtained which shows the actual growth of plants under conditions in horticultural greenhouses.

In both *Hedera canariensis* (*Christensen*, 1973) and *Kalanchoë blossfeldiana* (*Christensen*, 1974) it has been found that the slowest growth occurs when the plants are propagated approximately 1st September which is in accordance with *Codiaeum*. However, the fastest growth for *Hedera* and *Kalanchoë* takes place when propagated approximately 1st March, but in *Codiaeum* it is when propagation takes place approximately 1st May.

The three main factors which have a year round rythm and effect the plant growth are light intensity, daylength and temperature.

The temperature was not measured continuously in this investigation and has, therefore, not been used in the analyse. In glasshouses a relative constant air temperature can be maintained, but when the light intensity is high both the air – and mainly the leaf temperatures increase. The value of measured air temperature is, therefore, limited because the

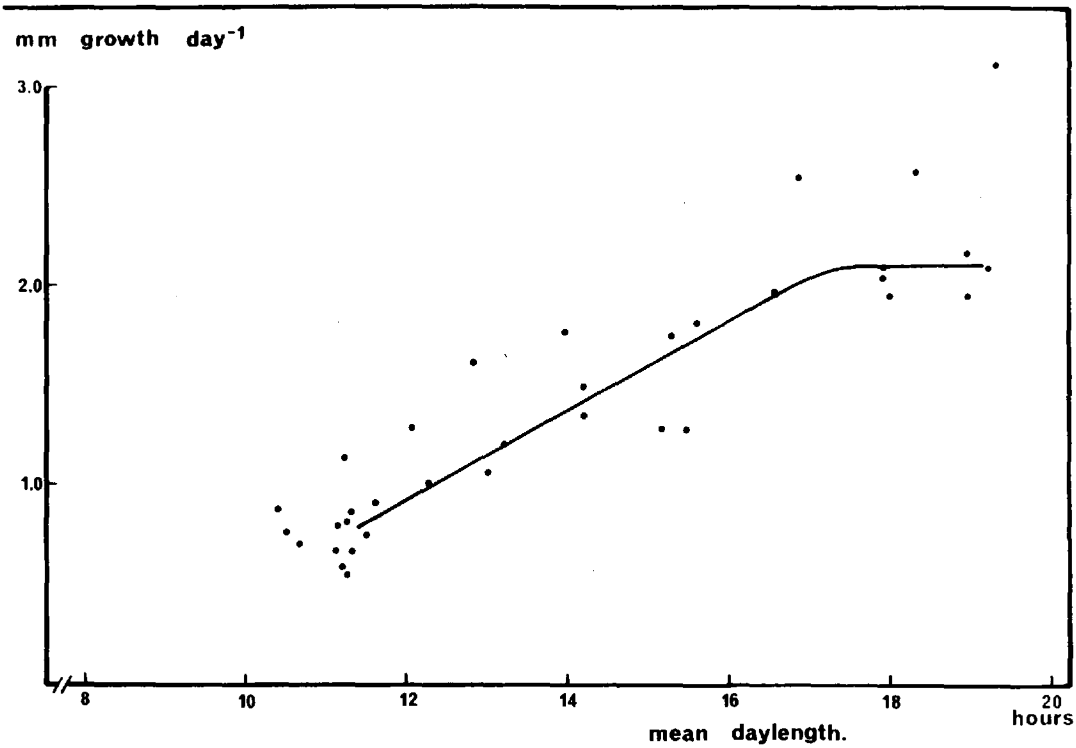

Fig. 6. The growth of the plants in relation to the mean daylength during the growing period.

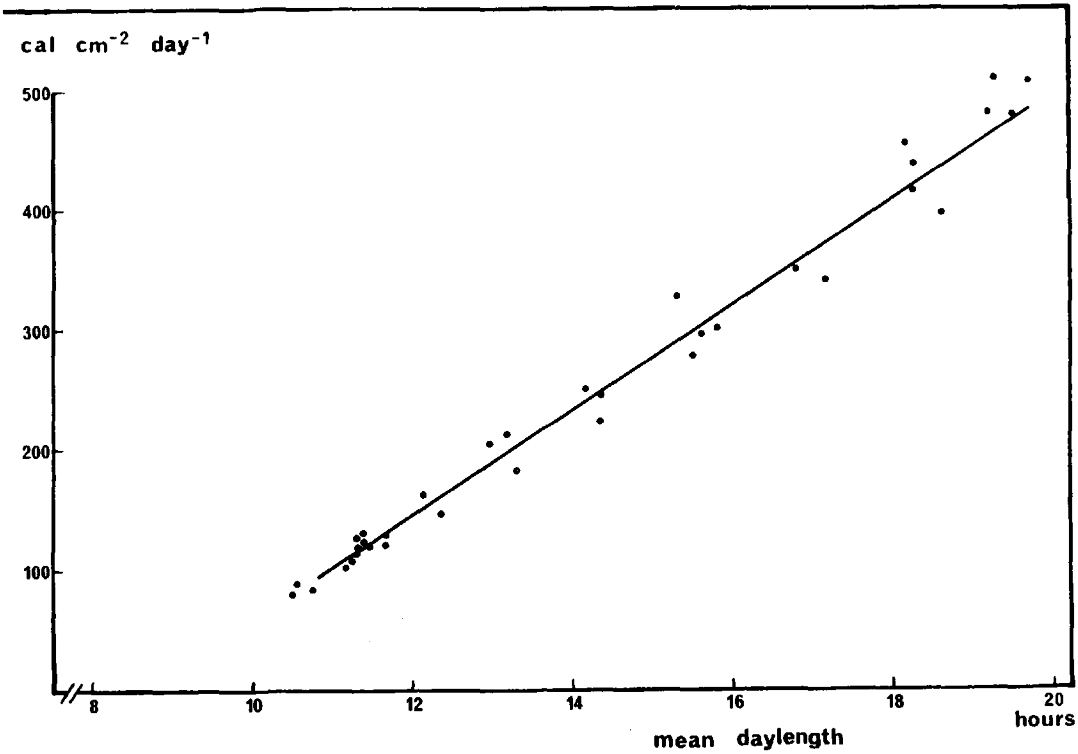

Fig 7. The daily mean radiation in relation to the mean daylength during the growing period.

leaf temperature is decisive for the plant reactions. On the other hand *Bierhuizen* (1963) has shown that in glasshouses the heat sum in the autumn is much higher than in the spring for the same total radiation, which is due to a phase lag of temperature behind radiation.

Plotting the yield of various vegetables against the heat sum *Bierhuizen* found two different lines which can be distinguished, the one for spring having a steeper slope than that for autumn. The difference between seasons nearly disappears when using total radiation, and he concludes that the effect of radiation is many times larger than that of the heat sum. Both the phase lag of temperature behind radiation, and that the radiation has a greater effect on plant growth than temperature, has also been shown for carnation by *Bunt* (1972).

Although the daylength and the mean daily radiation are symmetrical around the longest day (fig. 1), the growth is not symmetrical as can be seen in fig. 3. An analysis of the radiation and the daylength on the growth is shown in fig. 4–6. In fig. 4 and 6 the points below the curves are from plants grown in the autumn. In various vegetables Bierhuizen (1963) did not find this lower production (dry weight and fresh weight) when relating his data to radiation, while Bunt (1972) showed an advanced growth for carnations. In the present experiment the growth is lower in the autumn than in the spring which could be due to *Codiaeum* having a low optimum temperature for growth. However, no results are known which show the optimum temperature for the growth of *Codiaeum*. From practical experience it is known to be a plant with high temperature requirement for maximum growth, certainly higher than for carnation. It is, therefore, not likely that it is the temperature which causes the lower growth in the autumn than in the spring.

Two other explanations can be suggested. Plants propagated one in the spring and another in the autumn under the same light intensity conditions, having the same leaf area index, will both grow to a certain higher leaf area index. The plants in the spring will receive higher radiation than the plants in the autumn compared with the initial radiation, and therefore make better use of the incoming light. Because the plant density is high in these experiments, competition occurs, which also can advance the above mentioned tendency.

Another explanation can be that the plants respond to the daylength. In fig. 6 it can be seen that the plants respond to increasing daylength up to 17 hours. The different response from plants propagated in the spring and in the autumn can be due to the increasing and decreasing daylength. But because the light intensity and the daylength follow the same year round pattern it is difficult to separate the response of the two factors on plant growth.

Acknowledgement

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Literature

Bierhuizen, J. F., 1963. Growth and water use of vegetables in a greenhouse. In: The water relations in plants 246–256. Blackwell, Oxford.

Bunt, A. C., 1972. Effect of season on the carnation (*Dianthys caryophyllus* L.). I. Growth rate. J. hort. Sci. 47: 467–477.

Christensen, O. Voigt, 1973. Produktionstidens årlige variation hos *Hedera canariensis* Willd. 'Gloire de Marengo' (Seasonal variation in the production time of *Hedera canariensis* Willd. 'Gloire de Marengo'). Tidsskrift for Planteavl 77: 224–231.

Christensen, O. Voigt, 1974. Produktionstidens årlige variation hos *Kalanchoë blossfeldiana* (Seasonal variation in the production time of *Kalanchoë blossfeldiana)*. Tidsskrift for Planteavl 79: 357-377.

Cooper, A. J., 1966. Seasonal changes in net assimilation and leaf growth of young tomato plants. Acta Hort. 4: 76–78.

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