PROEFSTATION VOOR TUINBOUW ONDER GLAS TE NAALDWIJK

The effect of season and artificial light on young cucumber plants

door

D. Klapwijk en S.A. Tooze

Naaldwijk , november 1982

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Introduction

The effect of season on the growth and development of cucumber and several other plant species grown under glass has already been studied (Klapwijk, 1979, Klapwijk, 1980 and Klapwijk and Tooze, 1982). The results indicated a growth period which increased linearly in the autumn to December 21st, decreased linearly in the spring and was constant in the summer. Through energy conservation practices made in many glasshouses the light levels are often reduced. This is especially detrimental in the winter months when the natural radiation levels are one-tenth that of the summer levels. Because the winter months are important for transplant production it is necessary to study the effect of supplementary lighting on young plants. The effect of different artificial lighting treatments on tomato has already been studied (Klapwijk, 1981). In this paper a similar system was used with young cucumber plants.

Materials and Methods

Cucumber seeds of the variety Uniflora-D, were sown in pots filled with peat at regular intervals from late August 1979 to March 1980. Upon emergence the pots were placed on tables containing a layer of nutrient solution to allow for uninterrupted growth. The plants were grown under artificial lighting and temperatures normal for commercial production. There were temperature differences of 2-3^{o}C created by the lamps.

Artificial lighting

High-pressure mercury lamps (400 W) were used above three rows of tables with two lamps at the end of each row.
The cucumber pots were spaced 37,5 cm apart on the tables, and there were 24 pots and therefore 24 different growing distances. The first pot stood directly under the lamps and the last pot was approximately 9 meters away. The lamps were suspended 75 cm above the plants. The lamps were not lit from 8.15 to 10.15 in the morning because of peak loading.
The light levels at each of the 24 growing distances were measured during the night and the average values are presented in table 1. The average daily radiation from September 1979 to March 1980 in j.cm^{2}.day^{-1} were 1, 143; 668; 323; 168; 266; 458; 752 respectively.

Data

The plants were grown from emergence to 20 g fresh. Samples were collected on a weekly basis. With each sample the fresh weight was measured and the total number of leaves initiated was determined through the aid of a stereomicroscope (20 x). The plant height was determined in the 2nd half of the experiment. The fresh weight was plotted against time on a logarithmic scale and the total number of leaves initiated was plotted against time on a linear scale. With the aid of the graphs the number of days required for the plant to develop from emergence to 20 g and from emergence to the 20th leaf were determined and plotted against the middle date of the corresponding growth period.

Results

Figure 1 is the growth periods to 20 g fresh weight for the mid-winter and spring. The autumn data is not presented because high light intensities in the early season resulted in a curve which, judging from previous data, is unrepresentative of the normal curve. Curve 1 in the figure is the averaged growth periods for the first four growing distances, curve 2 is the averaged values for the next four growing distances, and so forth.

Table 1. The light levels measured at night at the increasing growing distances from the lamps.

Growing distances	$W.m^2$	Growing distances	$W.m^2$
1	232	13	1.3
2	117	14	1.0
3	109	15	0.9
4	68	16	0.7
5	29	17	0.6
6	15	18	0.5
7	9.2	19	0.4
8	6.2	20	0.4
9	4.1	21	0.3
10	2.9	22	0.2
11	2.0	23	0.1
12	1.7	24	0.1

The y axis is the growth period in days and the x axis is the days of the year from December 21st (day 355) to April 5th (day 460). The growth periods to 20 g fresh weight were plotted against the middle date of the corresponding growth period.

From figure 1 it can be seen that the growth periods to 20 g decrease more or less linearly from mid-winter to spring with increasing radiation. The slopes of the curves change as the distance from the lamps change, resulting in the growth periods being more affected by season as the distance from the lamps increase.

The regression equations correlation coefficients and growth periods for beginning and ending dates are presented in table 2. It should be noted that the last four curves showed no differences in growing periods by April 5th.

Figure 2 shows the growth period to the initiation of the 20th leaf primordia for the 6 averaged growing distances.

The growth periods are plotted against the middle date of the corresponding growth period.

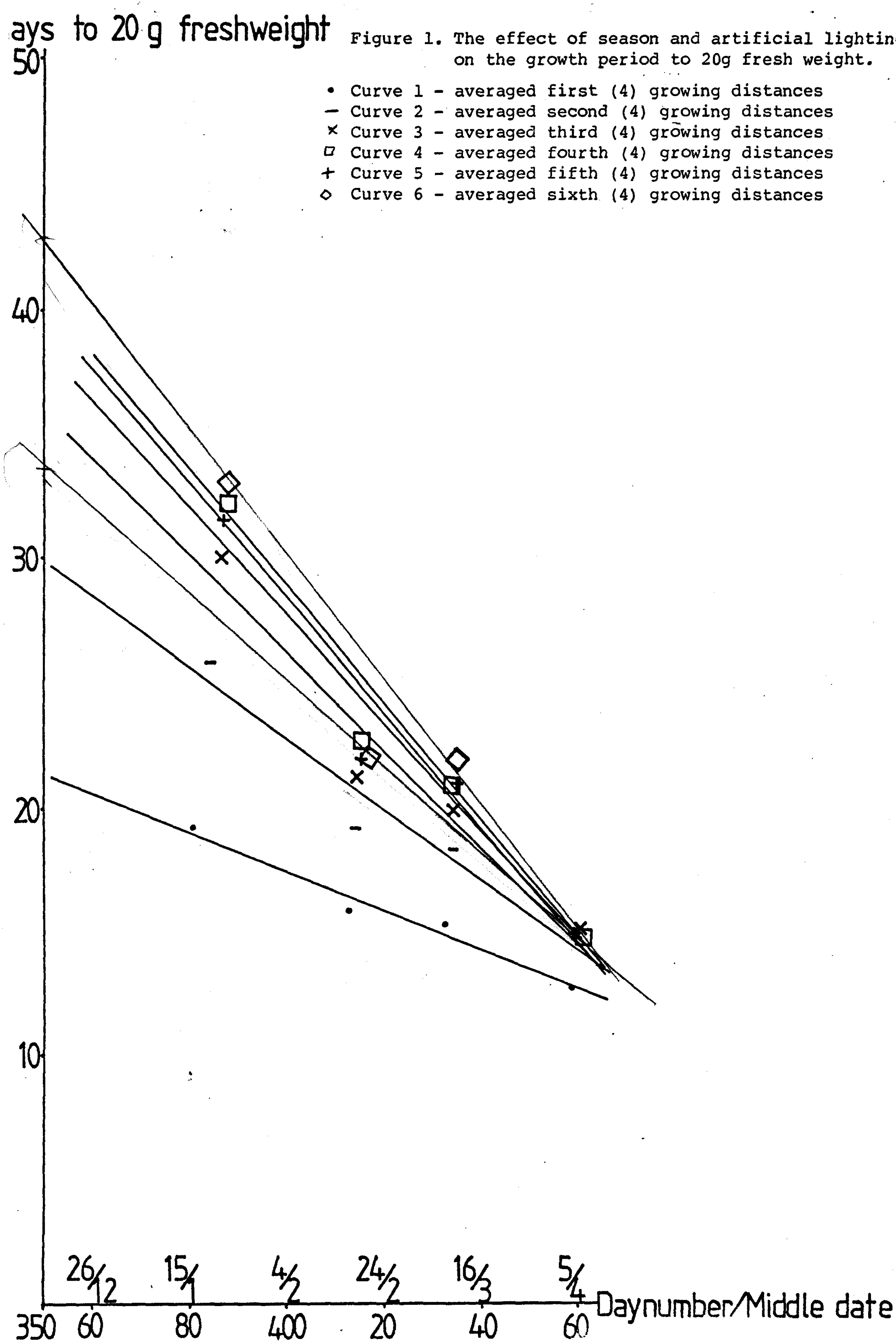


Figure 1. The effect of season and artificial lighting on the growth period to 20g fresh weight.

- • Curve 1 - averaged first (4) growing distances
- — Curve 2 - averaged second (4) growing distances
- × Curve 3 - averaged third (4) growing distances
- □ Curve 4 - averaged fourth (4) growing distances
- + Curve 5 - averaged fifth (4) growing distances
- ◇ Curve 6 - averaged sixth (4) growing distances

s to the 20th flower initiation

Figure 2. The effect of season and artificial lighting on the growth period to the 20th leaf initiation.

• Curve 1 - averaged first (4) growing distances
– Curve 2 - averaged second (4) growing distances
V Curve 3 - averaged third (4) growing distances
+ Curve 4 - averaged fourth (4) growing distances
O Curve 5 - averaged fifth (4) growing distances
Λ Curve 6 - averaged sixth (4) growing distances

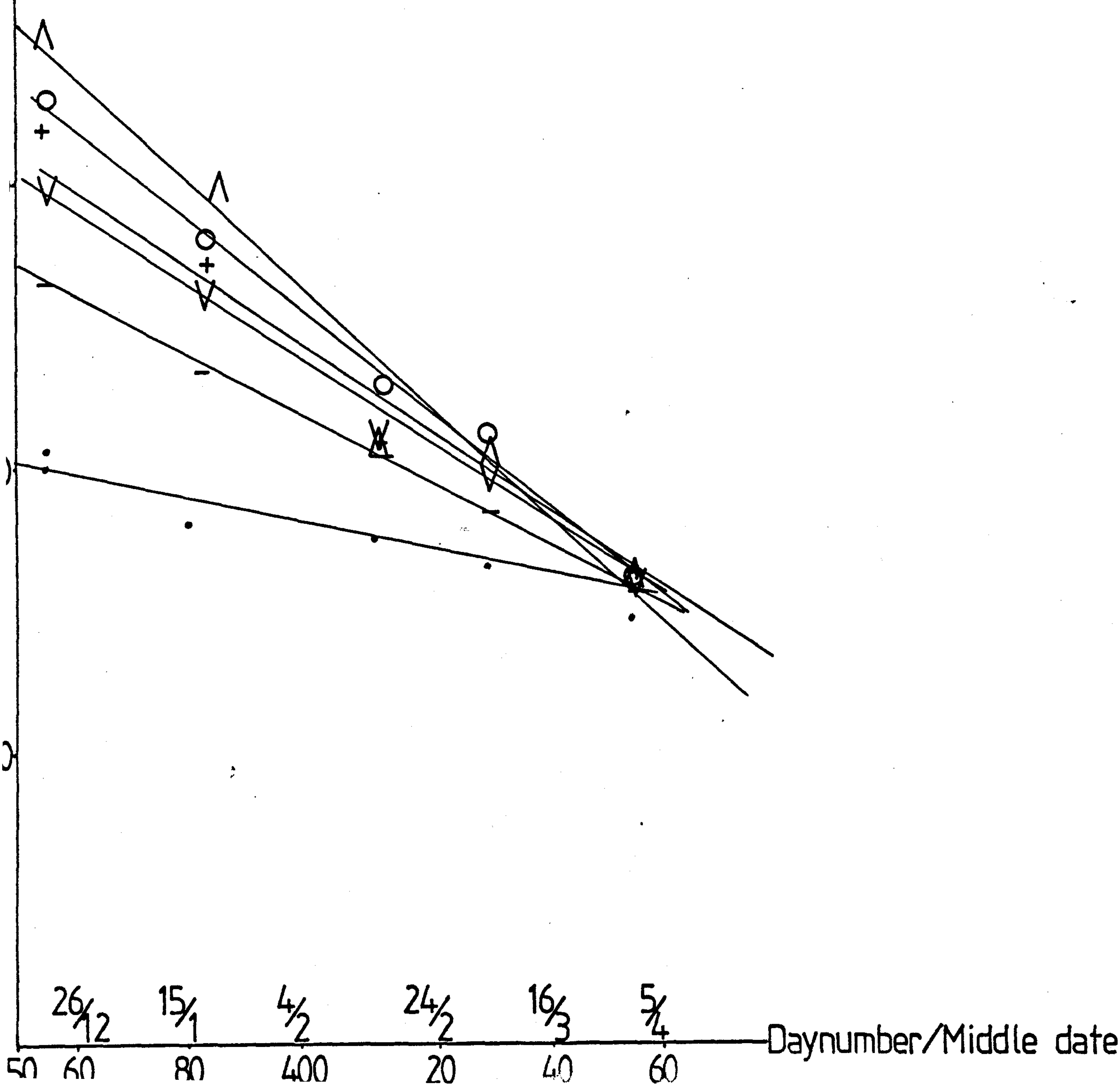


Table 2. The regression equations correlation coefficients and growth periods extrapolated for December 21st for the growth periods to 20g fresh weight plotted against the middle date. The 24 growing distances are averaged successively into 6 groups.

Growing distance	Regression equations
1	y =- 0.080 x + 48.59
2	y =- 0.140 x + 79.03
3	y =- 0.196 x + 104.61
4	y =- 0.216 x + 113.93
5	y =- 0.229 x + 119.70
6	y =- 0.234 x + 122.42

Correlation coefficients	December 21st Growth periods *
r = 0.979	20.9
r = 0.972	29.0
r = 0.974	34.9
r = 0.973	37.3
r = 0.982	38.5
r = 0.961	39.3

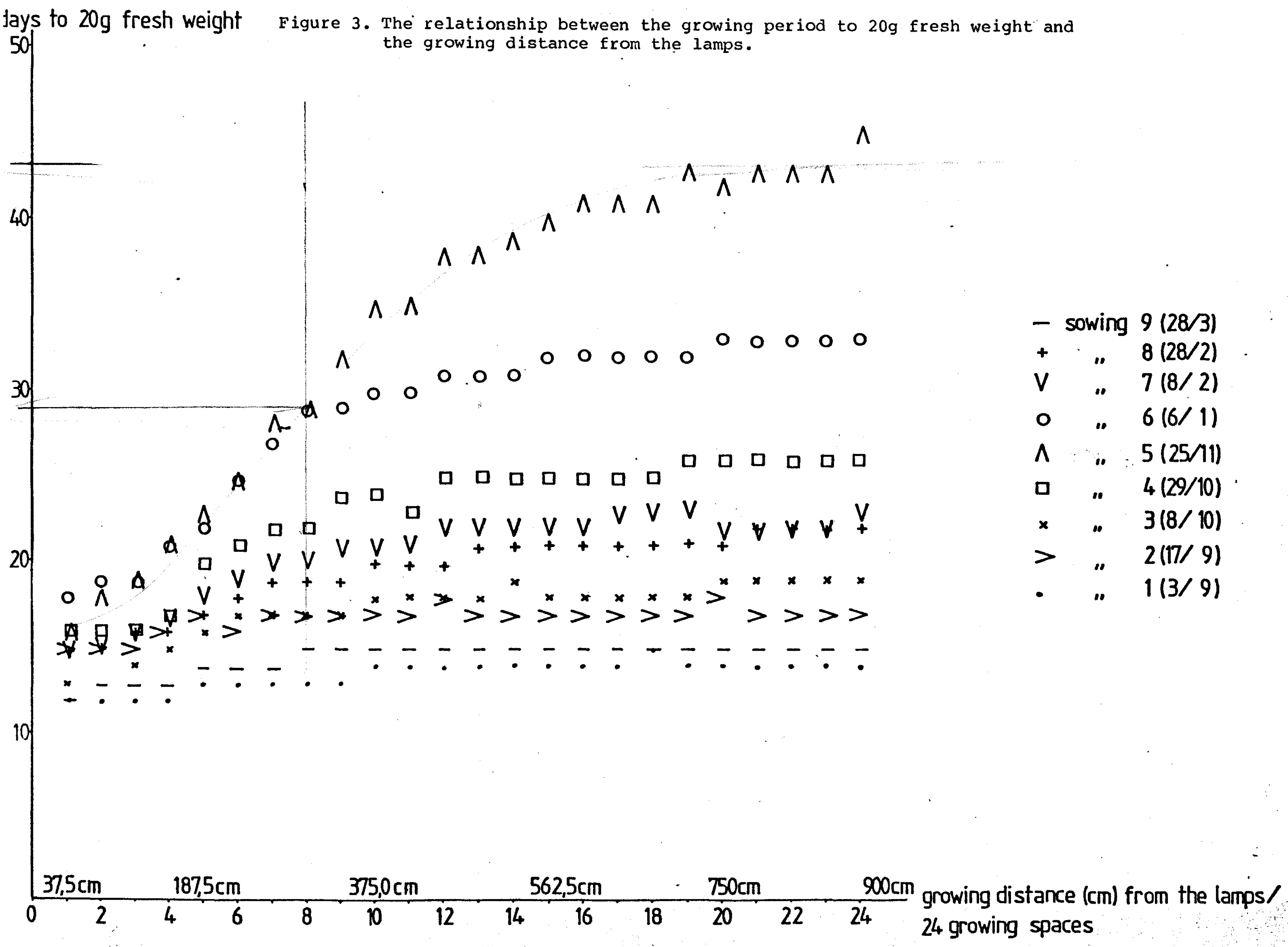
April 5th growth periods
12.8
14.8
15.0
15.0
15.0
15.0

Here again, the effect of season on the growth curves can be described by a linear decrease in growth periods with increasing radiation. The slopes of the curves increase as the growing distance from the lamps increase. The change in growth periods is approximately 4 days for curve 1 as compared to 16 days for curve 6. By April the growth periods for these two curves differ by less than 2 days. The difference in the slopes of curves 1 and 2 is greater than that of the other curves. The increase in temperature for the plants grown close to the lamp was the probable cause. The regression equations, correlation coefficients and growth periods for the beginning and ending dates are presented in table 3.

In figure 3 is shown the growth periods to 20 g fresh weight plotted for the different sowing dates from September to March. The (y) axis is the total number of days required for the plant to acquire a fresh weight of 20 g. The (x) axis is the 24 growing distances from the lamps to the table extensions.

The figure shows that the growth periods increase as the distance from the lamps increases for each sowing date.

Figure 3. The relationship between the growing period to 20g fresh weight and the growing distance from the lamps.



As the sowing dates advance in the autumn the growth periods increase and the difference in the growing period for the growing distances increases also.
In the spring the reverse is true.
In the winter the growing distances directly under the lamps had growth periods of approximately 16 days. This increased in a more or less linear manner to 38 days at a spacing of 450 cm from the lamps after which it increased more gradually to 45 days at a 9 meter distance.

Figure 4 shows the growth periods to the initiation of the 20th leaf primordia plotted against the growing distances for the different sowing dates. Here again, it can be seen that the growing periods increase as the distance from the lamp increases,but the results are less consistent than those obtained with fresh weight. The change in growth periods is not as great as that experienced with the growth periods to 20 g fresh weight. This is due to the fact that the leaf size decreases with decreasing radiation requiring the plant more time to acquire a fresh weight of 20 g.

Figure 5 shows the plant length at 20 g fresh weight. The data were extrapolated from the growth curves.
The plant height at 20g increases to adistance of 450 cm from the lamps, after which the height remains constant. In the winter the length is approximately 11 cm directly under the lamp, this increases linearly to 35 cm height at 400 cm growing distance after which the lamps appear to have little affect on height. This was also true for the March sowings where the natural radiation was enough to prevent excessive length increase.

Table 3. The regression equations, correlation coefficients and growth periods extrapolated for December 21st for the growth periods to the 20th leaf and plotted against the middle date. The 24 growing distances are averaged into 6 groups.

Averaged Growing distances	Regression equations	Correlation coefficients	* Dec. 21st growth periods	Growth periods for April 5th
1	y = - 0.040x + 34.13	0.950	19.4	14.7
2	y = - 0.100x + 62.39	0.999	26.4	15.7
3	y = - 0.127x + 74.79	0.991	29.4	16.0
4	y = - 0.134x + 78.06	0.972	30.4	16.2
5	y = - 0.152x + 86.38	0.996	32.5	16.2
6	y = - 0.180x + 98.08	0.960	34.3	16.0

Figure 4. The relationship between the growth period to 20th leaf initiation and the growing distance from the lamps.

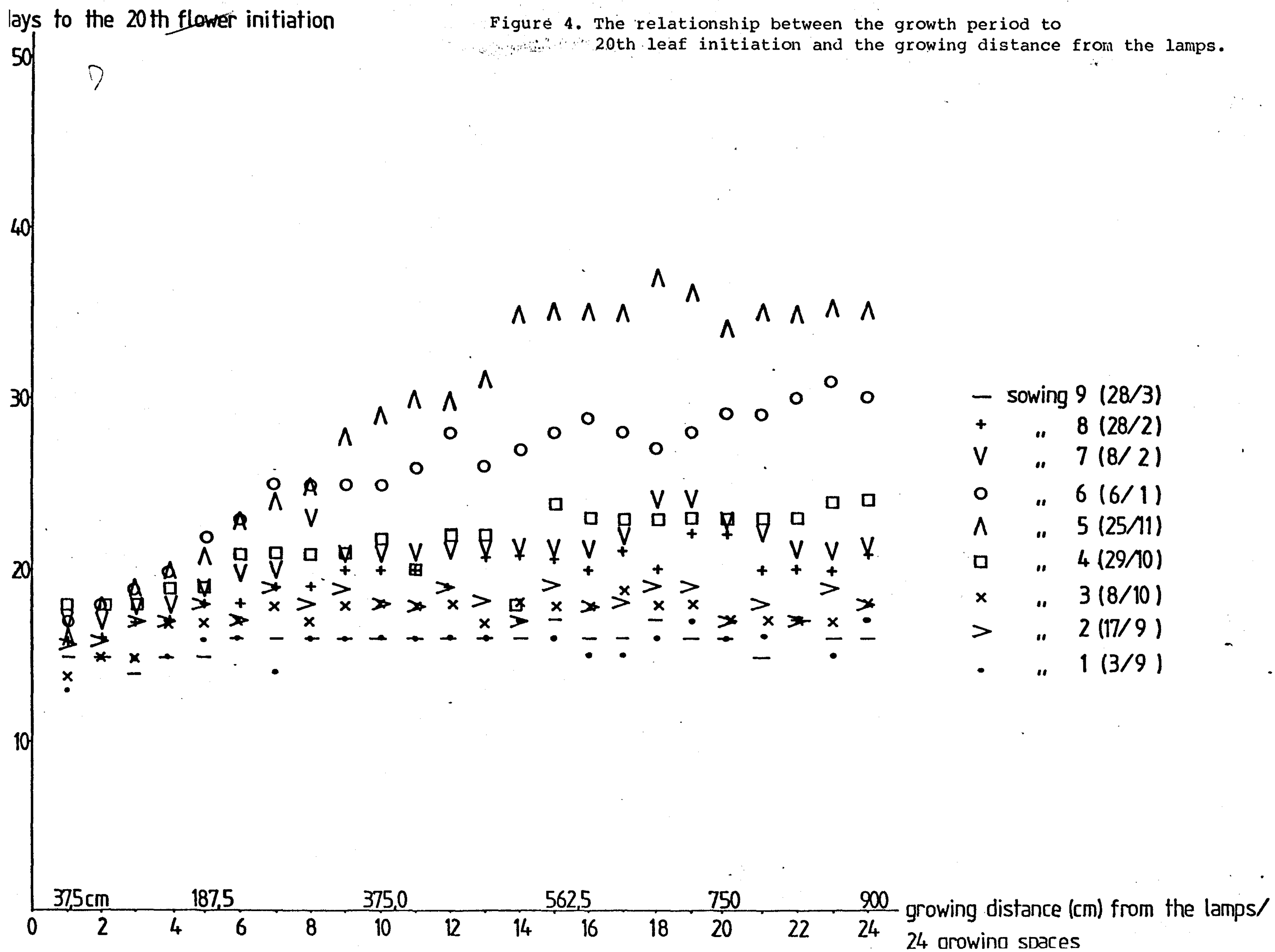
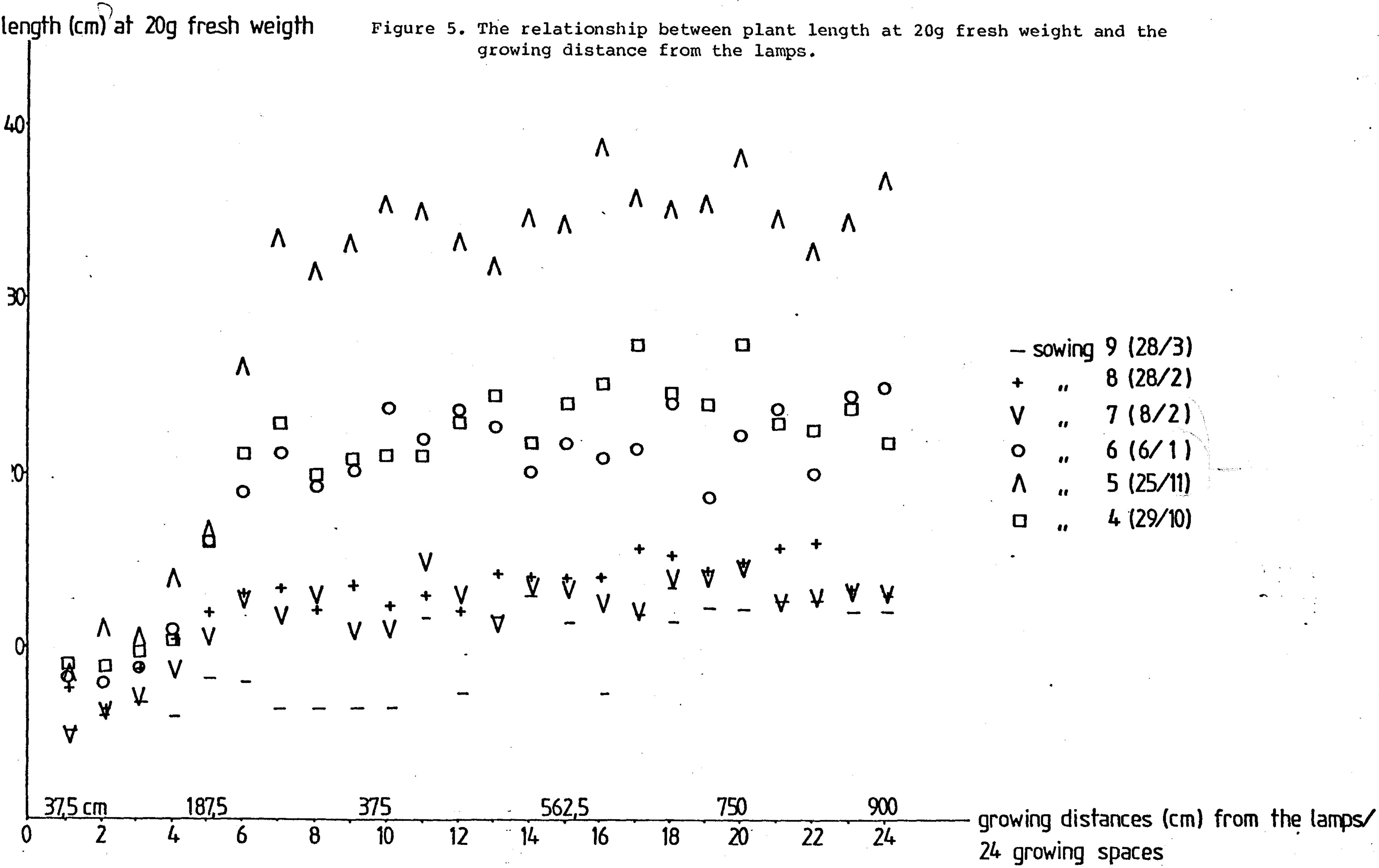


Figure 5. The relationship between plant length at 20g fresh weight and the growing distance from the lamps.



Discussion

It is already known that season greatly influences the development of young plants grown under glass. This research was carried out over one season which may not give a complete picture of how season would effect the results. It was felt unnecessary to repeat the work over another season, however, because the results obtained were similar to those obtained with tomato grown under artificial lighting and with cucumber grown under natural lighting.
The effect of season combined with artificial lighting resulted in a linear increase in growth periods in the autumn and a linear decrease in the spring. There were not enough observations available to determine whether December 21st would be the intersecting point for these two curves, but drawing from previous data it is assumed that this would be so. For this reason the Dec. 21st values were extrapolated from the existing data and were presented in table 2 and 3. The artificial lighting effected the growth periods, resulting in curves with less slope than that obtained with cucumber grown under natural light. This can be seen well in figures 1 and 2. It must be taken into consideration that the localized temperature increases from the lamps also had an effect on the growth curves. And probably an effect on the plant height at 20 g fresh weight.

The fresh weight and leaf initiation growth periods were similar in the early autumn and late spring, but as the winter advanced the 20 g fresh weight growth period fell behind that of the leaf initiation. This is an indication that the leaf size was reduced as the days grew shorter. This effect was slight for the plants grown within the first few meters of the lamps. The growth periods for the criteria measured showed increases to approximately 7.5 m distance where the light levels at night were measured at 0.4 $W.m^{-2}$.
It would seem unlikely that these low light levels would increase production of carbohydrates through photosynthesis, but rather that the artificial light would be used for formative growth of the leaves which in turn would be capable of absorbing more natural light.

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