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The effect of season on the growth and development of young cucumbers

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Introduction

The increasing use of energy conservation methods in the glasshouse industry often means decreasing available light for plant growth. This makes it important to determine how seasonal light changes influence plant growth, particularly in the winter months when light is a limiting factor. The influence of season on tomato, lettuce, radish, grown under glass has already been studied (Klapwijk and De Lint, 1975; Klapwijk, 1979; Klapwijk, 1980). The studies showed a clear relationship between the level of radiation as effected by season and plant development. During the summer months the growth rate proved to be largely independent of radiation.
In this paper the growth rate of young cucumber plants as effected by seasonal changes in radiation was studied. Plants were sown on a year round basis, and the fresh weight, leaf primordia initiation rate and plant height were determined.

Methods

Cucumber seeds of the cultivar Uniflora-D were sown, in pots containing fertilized potting compost, at intervals from September 1979 to March 1982. Upon emergence the plants were placed in a glasshouse on tables containing a layer of nutrient solution which allowed for uninterrupted growth. The glasshouse temperatures were those used by commercial plant propagators in the Netherlands. Samples were collected on a weekly basis until the plants obtained a fresh weight of approximately 20 g. 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 in the later stages of growth was also measured.
The fresh weight was plotted against time on a logarithmic scale and the total numer 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. The use of the same dimension for the growth criteria i.e. days, allowed for later comparisons in growth. The growth periods from emergence to the 20th leaf and 20 g where used because these two criteria where determined to require the same number of days of growth during the summer months. The middle date of the growing period was used in place of the sowing date or ending date. With the sowing date the effect of season on the growing period is yet to come and with the end date the effect of season is already past. In earlier work conducted by Klapwijk (1979) it was shown that the use of the middle date of a growing period corresponded with a maximum growing time falling close to December 21st. The number of days required to reach the criteria measured was plotted against the middle date on a year round basis to determine how the season effected the growth pattern. The regression equations for these data were determined and are presented in this paper.

Results

The results of the fresh weight determinations are presented in figure 1. The number of days from emergence to a fresh weight of 20 g is plotted against the middle date of the growing period. The x axis of the graph is the days of the year beginning with August 28th which is day number 240. On the y axis is the number of days required for the plant to acquire fresh weight of 20 g.
Figure 1 shows a growth pattern which can be characterized by a linear increase in growth period from September 22nd to approximately the shortest day, December 21st.The growth period decreases linearly again in the spring. The regression equation for these two functions are as follows:
autumn $y = 0.357\ x - 80.9\ r = 0.940$
spring $y = 0.348\ x + 172.0\ r = 0.905$.

The beginning and ending points of the corresponding regression lines fell within clos range of the autumn and spring equinoxes (Sept. 22 and March 22) and these two dates were used as the cut-off points for the regression equations.
The growing period for a fresh weight of 20 g increased from 16.8 days on September 22nd to 47 days on December 24th, an increase of approximately one month. In the summer period (March 22nd to September 22nd) the growth pattern showed no change in rate of growth and averaged at 16.8 days.

Leaf initiation

The rate of leaf initiation is presented in figure 2. The y axis is the total number of days required for the plant to grow from emergence to the 20th leaf. The time required is plotted against the middle date as in figure 1.
Again, the growth pattern can be characterized by a linear increase from September 22nd to December 21st and a linear decrease to March 22nd. The regression equations for these two functions are as follows:
autumn $y = 0.300\ x + 65.6\ r = 0.910$
spring $y = 0.250\ x + 132.0\ r = 0.900$.

In the beginning of the autumn the plant required 16.4 days to initiate the 20th leaf and this growing period increased to 41 days Dec. 22nd. The growth pattern for the summer (March 22nd to September 22nd) was relatively constant at an average of 16.4 days and appeared uneffected by seasonal radiation changes.

Extension growth

In order to determine the rate of plant height increase, the length of the plant at 20 g was determined through the aid of a graph of plant length over time. This length was plotted against the middle date of the growth period as shown in figure 3. The plant length at 20 g fresh weight increases linearly from September 22nd to December to March 22nd. In September the plant length approximately 12,5 cm at 20 grams fresh weight and increased to 39.0 cm close to the shortest day. During the summer the average plant length was 12.5 cm. The regression equations for the linear functions are presented below:
autumn $y = 0.267\ x - 56.5\ r = 0.659$
spring $y = -\ 0.325\ x + 156.2\ r = 0.790$.

It should be noted that the correlation coefficients are low in comparison to those obtained for fresh weight and leaf initiation. This may have resulted from the limited number of observations available for length particularly in the winter months.

Discussion

Growth period and the effect of season

The relationship between the growth pattern and season can be described as a two-sided linear relationship with an intersection of the linear functions close to December 21st. In other words the maximum growing period coincides closely with the day of the lowest seasonal radiation. The conclusion can be drawn that the level of radiation during the autumn, winter and spring largely determines rate of growth.
During the summer months (March to September) the growth periods remained relatively constant indicating that the plant was light saturated and relatively independent of seasonal radiation changes. These results correspond closely with the results obtained by Klapwijk and De Lint for tomato, lettuce and radish.
In figure 4 is shown the comparison between the growth periods from emergence to a fresh weight of 20 g and the initiation of the 20th leaf as effected by season. As shown, in the summer the growth patterns for these criteria coincide, requiring approximately the same number of days to reach the desired growth stages. As the season progresses the slopes of the criteria begin to differ. For the fresh weight the growth period changes from 16.8 days in the summer to 47 days close to December 21st or a time ratio of 1:2.8. For leaf initiation the growth period changes from 16.4 days to 41 days, or a ratio of 1:2.5. Close to December 21st the plant requires approximately 6 extra days to reach a fresh weight of 20 g than to initiate the 20th leaf. In the middle of the winter the leaf is smaller than during the summer months requiring the plant more time to reach a fresh weight of 20 g.

Extension growth and season

The plant height at 20 g fresh weight increases linearly in the autumn and decreases linearly in the spring. The maximum plant height falls close to the shortest day of the year. On December 21st the plant height is 39.0 cm at 20 g and in the summer months 12.5, or a ratio of 1:3.1.

Conclusions

The effect of season on the growth and development of young cucumber plants is quite similar to that obtained by other glasshouse crops studied. The growth period can be characterized by a linear increase in the autumn and a similar decrease in the spring. The plant height at a fresh weight 20 g shows the same pattern. During the summer months (March-September) the growth period remains relatively constant indicating that it is independent of seasonal radiation changes during this period.
When using the middle date of the growing period the maximum growth period and plant height fall on or near December 21st. This indicates that solar radiation levels in the winter months largely determine the growth rate.

Acknowledgement

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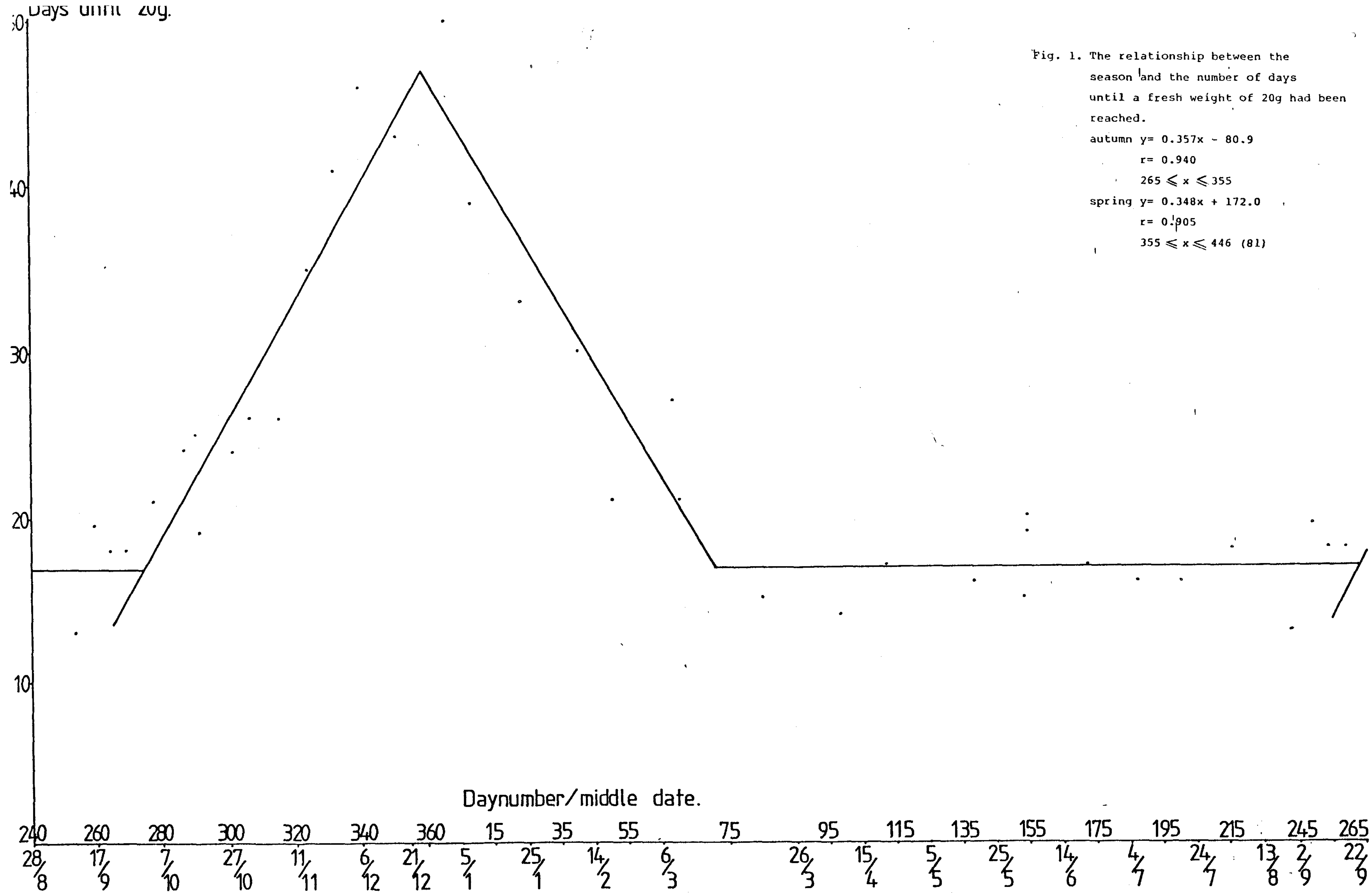

Fig. 1. The relationship between the season and the number of days until a fresh weight of 20g had been reached.

autumn $y = 0.357x - 80.9$

$r = 0.940$

$265 \leqslant x \leqslant 355$

spring $y = 0.348x + 172.0$

$r = 0.905$

$355 \leqslant x \leqslant 446$ (81)

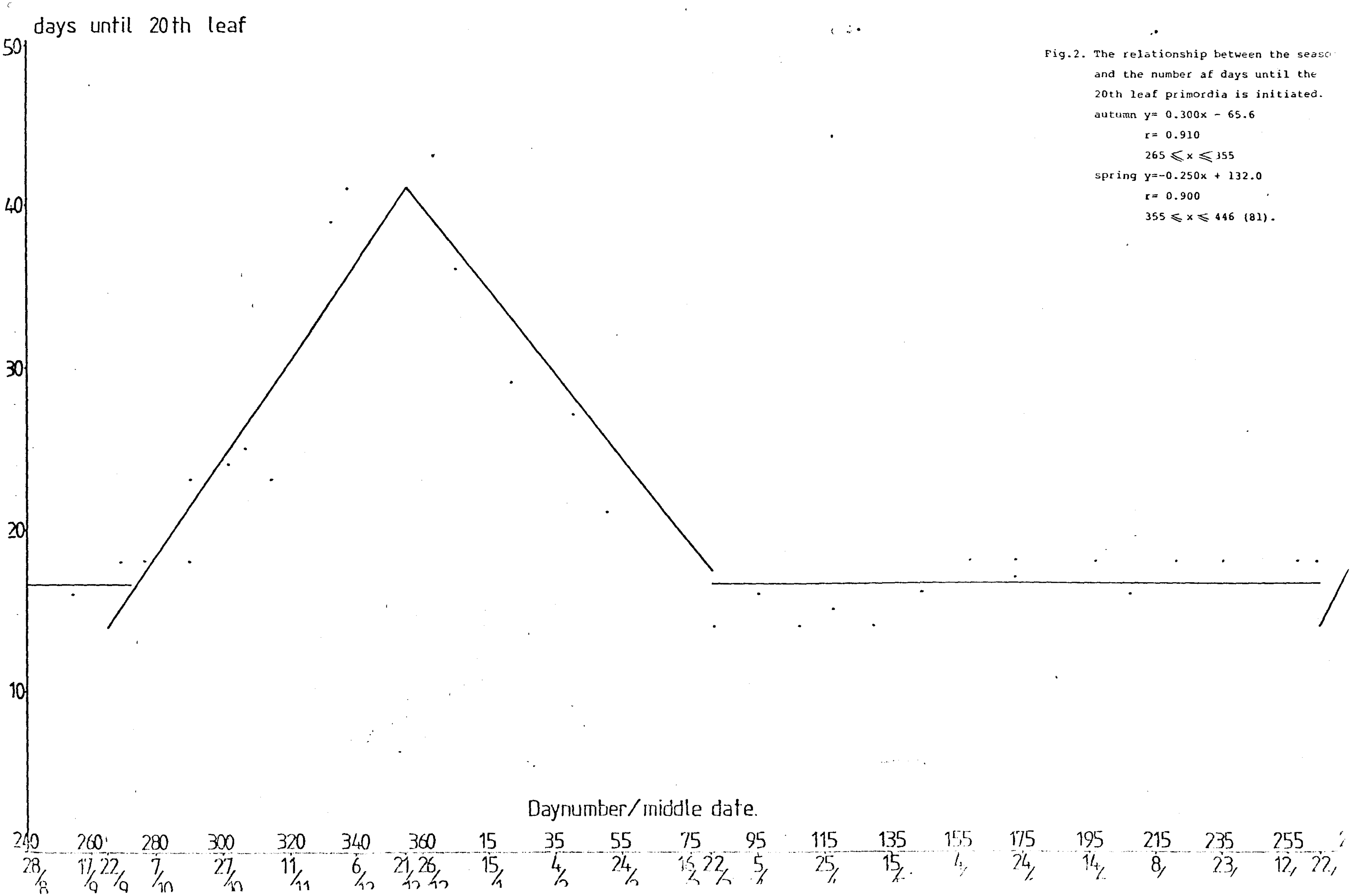

Fig.2. The relationship between the seaso[n] and the number af days until the 20th leaf primordia is initiated.

autumn $y = 0.300x - 65.6$

$r = 0.910$

$265 \leqslant x \leqslant 355$

spring $y = -0.250x + 132.0$

$r = 0.900$

$355 \leqslant x \leqslant 446$ (81).

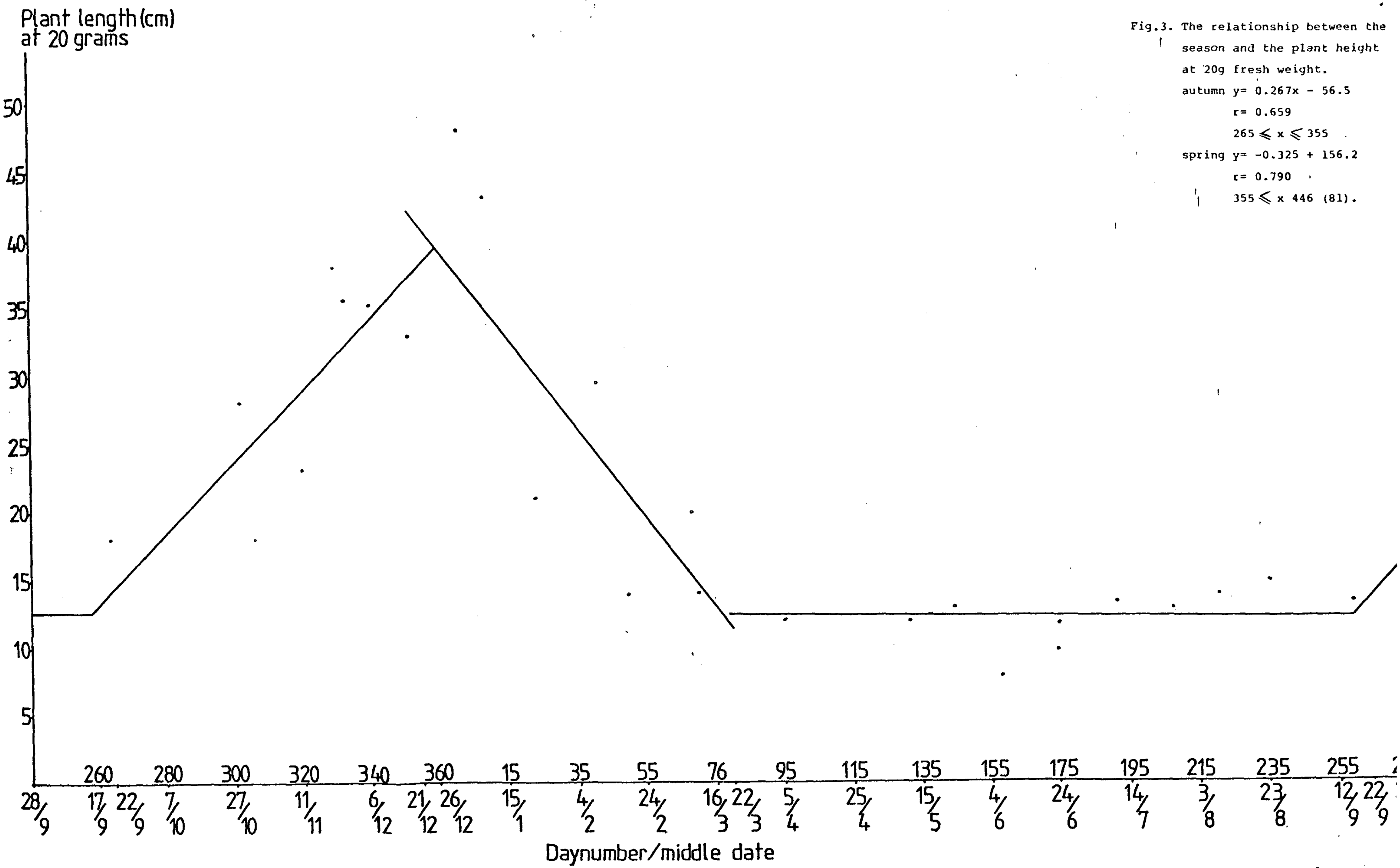

Fig.3. The relationship between the season and the plant height at 20g fresh weight.

autumn $y = 0.267x - 56.5$

$r = 0.659$

$265 \leqslant x \leqslant 355$

spring $y = -0.325 + 156.2$

$r = 0.790$

$355 \leqslant x \; 446$ (81).

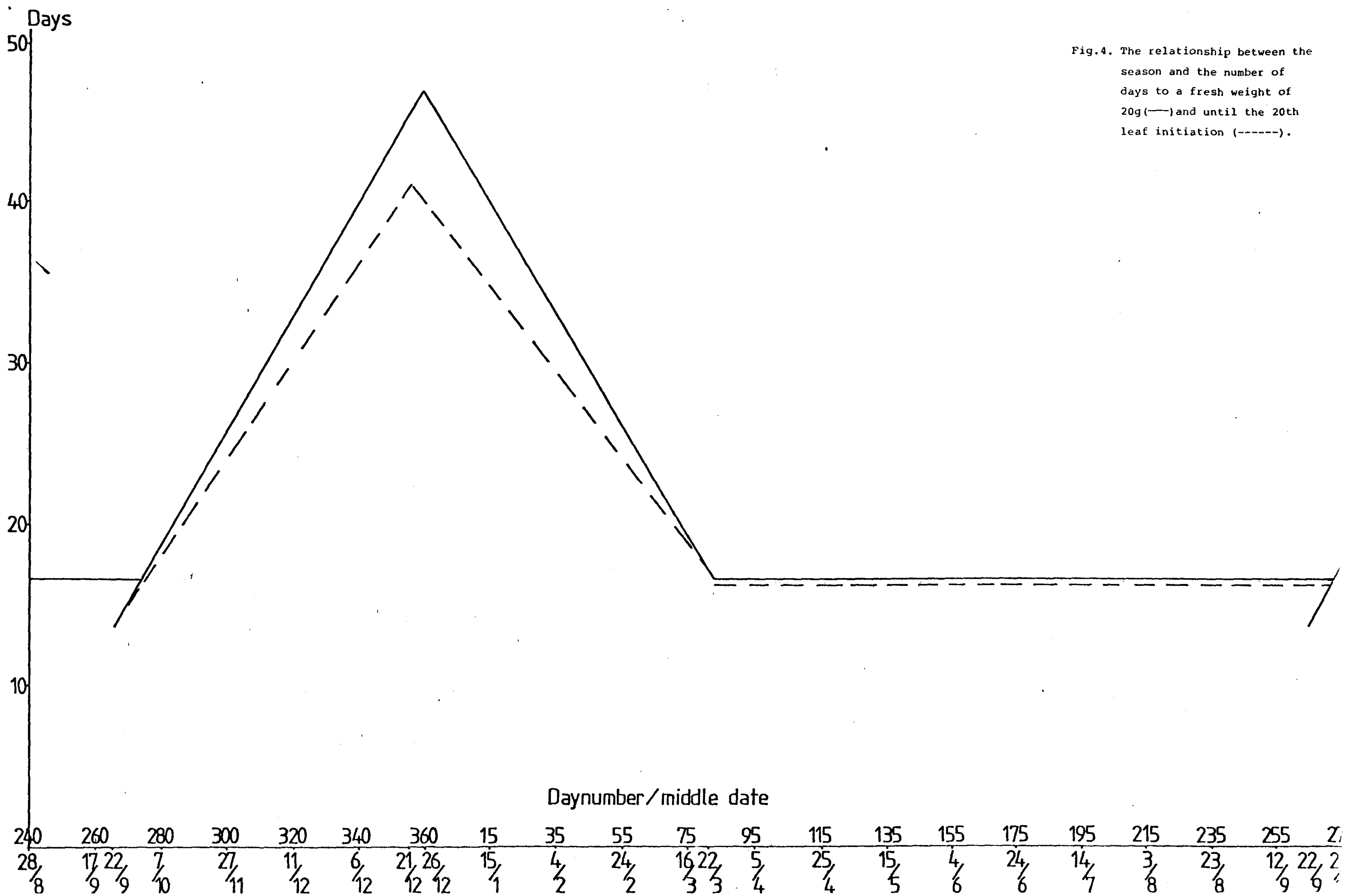

Fig.4. The relationship between the season and the number of days to a fresh weight of 20g (——) and until the 20th leaf initiation (------).