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Night temperature and fruiting of glasshouse cucumber (*Cucumis sativus* L.)

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Summary

Of glasshouse cucumber, four plantings were grown at three night temperatures. Data observed on number of fruits harvested per stem, earliness and rate of production and fruit weight and length are presented and discussed in relation to planting date and night temperature.

More main stem fruit are obtained with later planting. Per axil this effect is still stronger. Night temperature only has a slight effect on number of fruits per stem; there is an optimum near 16 °C.

The rate of fruit production is almost insensitive to night temperature between 12 and 20 °C. With later planting the rate of production is somewhat higher. Production begins earlier with higher night temperature. Later planting results in a relatively early beginning of the production.

Growth of individual fruit is practically insensitive to night temperature. There is some reduction of 'hanging-time' into spring. Fruit weight at harvest was found to increase with season, but it was found not to be dependent on the treatments given. Also fruit length was not influenced by night temperature or planting date.

Introduction

Most of the heating energy for glasshouse crops is consumed during the night. Also in winter, cucumber, in the Netherlands, is grown under rather high night temperatures (16-20 °C). With rising energy prices it seemed worthwhile to study the relation between the cucumber production curve, temperature and planting date. An experiment was set up to investigate the effects of lower and of varying night temperatures relative to the usual ones in the Netherlands (van de Vooren et al., 1978). This experiment was carried out in the climate glasshouse of the Glasshouse Crops Research and Experiment Station at Naaldwijk (van de Vooren & Koppe, 1975).

In the present article some details on fruiting along the main stem of the three steady night temperature treatments are reviewed. Data on flowering and flower abortion of the same set of plants are presented elsewhere (de Lint & Heij, 1982).

Material and methods

Cucumber plants, cv. Farbio, a female flowering variety that develops parthenocarpic fruit, were planted in the climate house about 30 days after sowing. Four plantings were performed, with fortnightly intervals, on 13 and 27 December 1976, and on 10 and 24 January 1977. Plants were placed in rows.

Distance between rows was 1.6 m. On the row spacing between plants was 0.5 m. Night temperatures used were 12, 16 and 20 °C. These differences of night temperature were carried on until 1 April 1977. Day temperature was the same for all treatments, viz 21-27 °C (light-dependent). The switch from night to day was ½ hour before sunrise and from day to night it was at sunset. CO_2 concentrations were controlled during daytime at 0.1 %.

From all plants flower buds and lateral shoot buds were pruned up to the 10th axil. The main stem was stopped at the level of the supporting wire (2.2 m above border soil level). Shoot buds were taken out all the way along the main stem except for the two or three highest ones. This pruning procedure is generally adapted by glasshouse cucumber growers in the Netherlands. Flowering was registered three times a week. Fruits were initially harvested three times a week, but after three weeks only twice weekly. Fresh weight and length of fruits were determined for each individual fruit on the dates of harvest. Calculations are presented on production of fruit along the main stem. Data are obtained from five plants per plot and there were three plots per treatment.

Results[1]

Fruit number

The data on number of fruit produced from the main stem are presented in Tables 1 and 2. From Table 1 it is seen that the position of a plant in the row has a rather strong influence on the numbers of fruit produced on the main stem. The effect of the position in the row is gradual. Plant 1, on the outside of the crop, produces most, plant 9 least fruit. Between parallels the difference is quite large, but it is consistent. This block effect on the number of fruit per stem may be due to the fact that the present data only comprise three out of a total of eight night temperature treatments, which in total formed systematic threefold block pattern. These differences will be studied later for the total amount of data available. The effects of the experimental factors, night temperature and planting data, are presented in Table 2. Clearly, later planting results in more fruit per stem.

[1] Original data per plant, from which tables and graphs were derived, are available on request.

Table 1. Glasshouse cucumber, 1977. Fruit per plant from the main stem. Differences between parallels (1, 2, 3), and the influence of plant position on the row (1 → 9).

Parallel	Plant number					
	1	3	5	7	9	$\bar{m}$
1	20.8	18.3	16.3	15.0	15.2	17.1
2	13.9	14.4	13.9	13.7	12.8	13.7
3	17.0	16.2	14.7	14.7	13.5	15.2
$\bar{m}$	17.2	16.3	15.0	14.5	13.8	15.3

Table 2. Glasshouse cucumber, 1977. Fruit per plant from the main stem. Influence of night temperature and of planting date (I = 13-12-'76; II = 27-12-'76; III = 10-1-'77; IV = 24-1-'77).

Planting	Night temperature (°C)			
	20	16	12	$\bar{m}$
I	11.0	14.1	13.3	12.8
II	13.5	16.3	16.5	15.4
III	13.6	18.3	16.4	16.1
IV	14.8	18.1	18.3	17.0
$\bar{m}$	13.2	16.7	16.1	15.3

Night temperature has a considerable effect towards more fruit per stem for the first step down (from 20 to 16 °C). But, going from 16 °C night temperature down to 12 °C does not result in a further increase in fruit number. On the contrary, fruit number seems to show a small reduction.

Fruit production

The development of the production of fruit with time is given in Fig. 1 (a, b, c: night temperature; d, e, f, g: planting date). The higher the night temperature, the earlier production begins. However, the slope of the production curve does indicate hardly any temperature influence (Fig. 1; d, e, f, g).

With delayed planting date, the slopes of the production curve, expressed in number of fruits per stem per day, increase (Fig. 1; a, b, c). The moments of first production for the successive plantings differ in time less than the 14 days between plantings. Thus, later plantings produce sooner after planting. The speeding of later plantings is stronger with the lower night temperature, and it is stronger for the later plantings.

The intensity of production per day is rather irregular, when considering the original figures of harvests per plant. There might be some correlation with daily incident light, but this is weak. Also there could be some pattern of plant endogenous nature such that during the second week of harvest for each separate treatment production is lower than average and that this is so again 2½ to 3

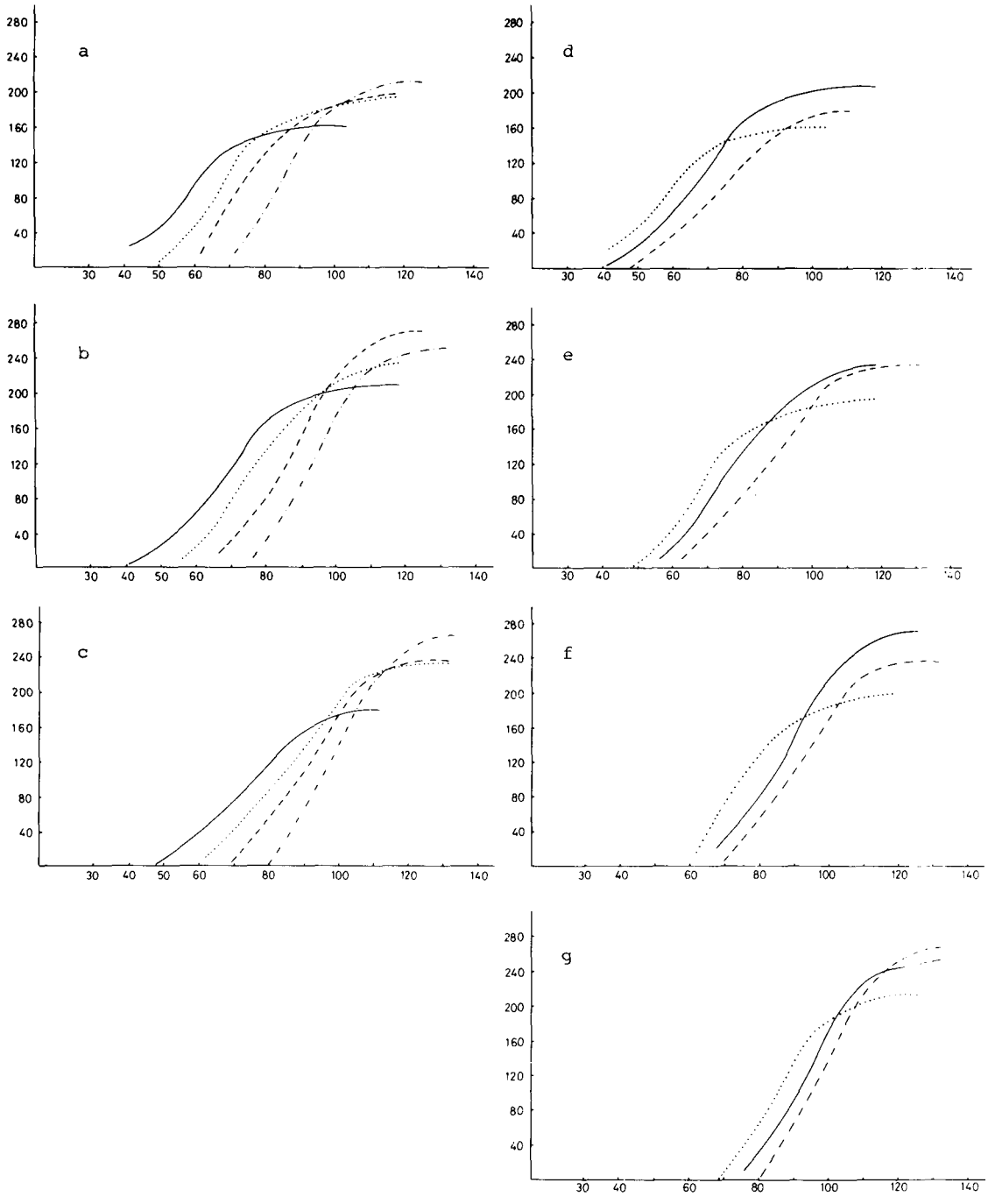


Fig. 1. Glasshouse cucumber 1977. Number of fruits harvested (ordinate) from the main stem of 15 plants versus date of harvesting (abscissa).
a, b and c: night temperature 20, 16 and 12 °C respectively. Planting dates: —— 13-12-1976; . . . 27-12-1976; – – – 10-1-1977; – . – . – 24-1-1977.
d, e, f and g: planting date 13-12-1976, 27-12-1976, 10-1-1977 and 24-1-1977 respectively. Night temperature: . . . 20 °C; —— 16 °C; – – – 12 °C.

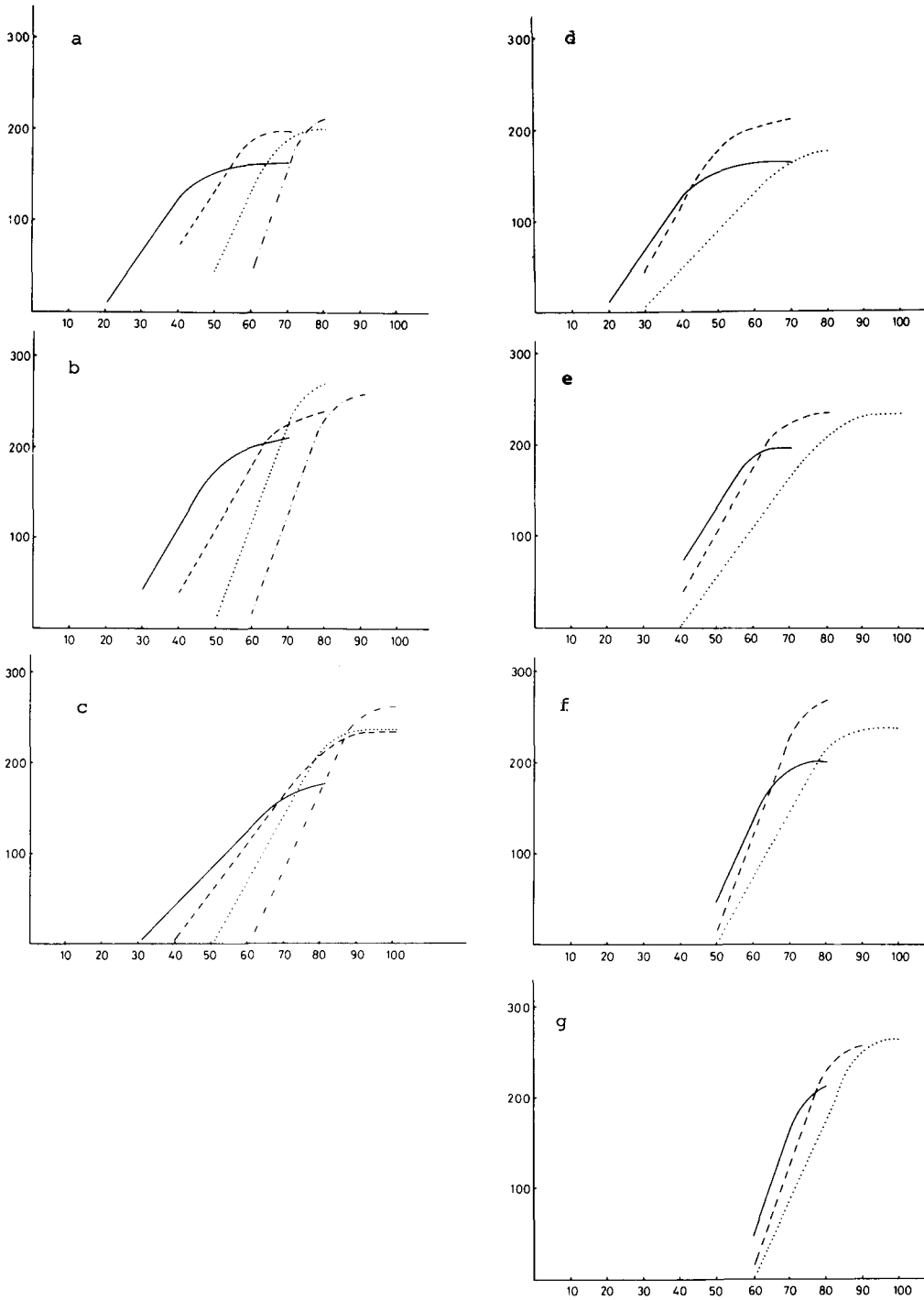
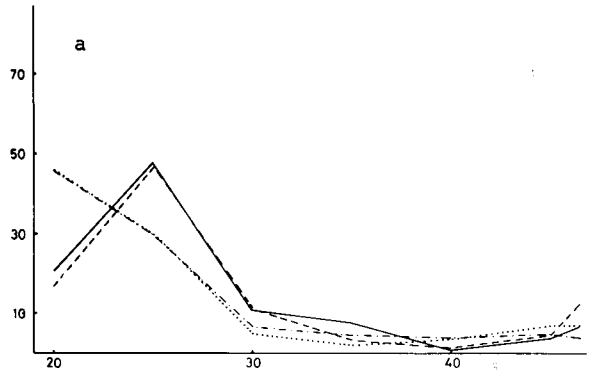


Fig. 2. Glasshouse cucumber 1977. Number of successful flowers (producing marketable fruit) on the main stems of 15 plants (ordinate) versus date of flowering (abscissa) (days numbered with 1-1-1977 = 1).

a, b and c: night temperature 20, 16 and 12 °C respectively. Planting date: ——— 13-12-1976; – – – 27-12-1976; . . . 10-1-1977; – . – . – 24-1-1977.

d, e, f and g: planting date 13-12-1976, 27-12-1976, 10-1-1977 and 24-1-1977 respectively. Night temperature: ——— 20 °C; – – – 16 °C; . . . 12 °C.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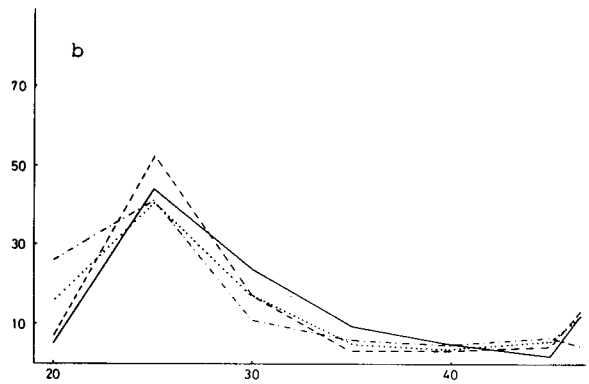
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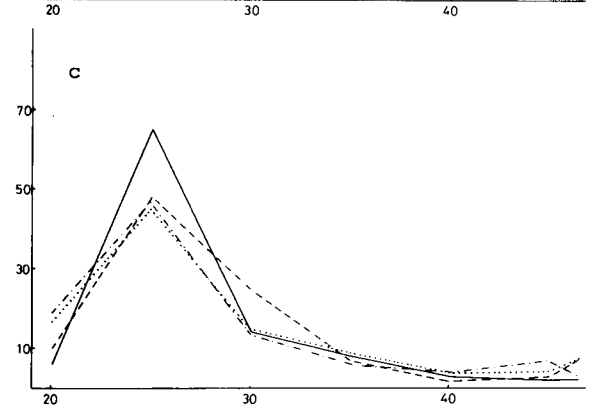
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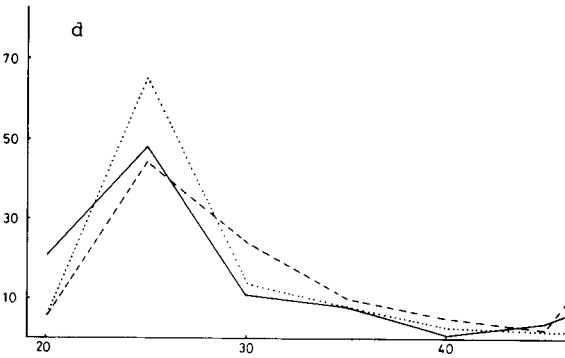
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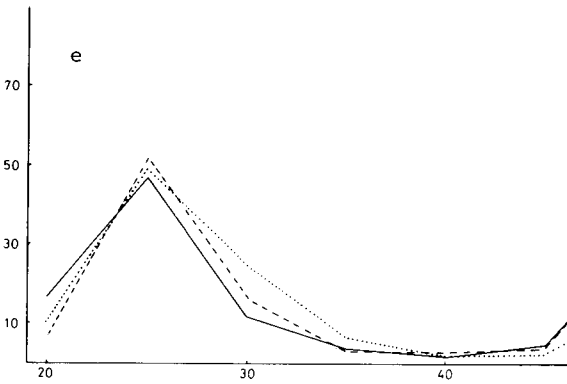
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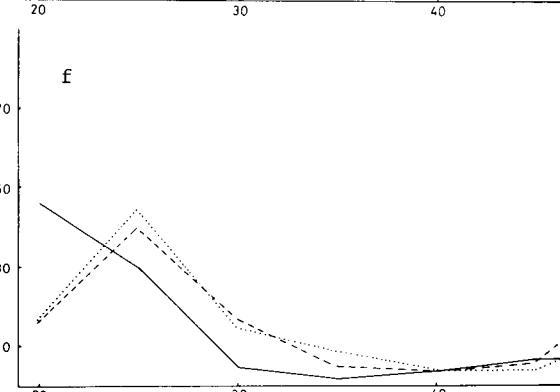
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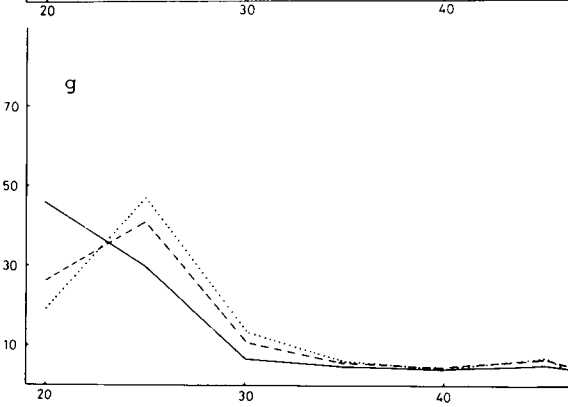
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Table 3. Glasshouse cucumber, 1977. Percentual distribution of hanging-time of fruit from flowering till harvest.
A. Effect of night temperature: 1 = 20 °C; 2 = 16 °C; 3 = 12 °C.
B. Effect of planting date: I = 12-12-1976; II = 27-12-1976; III = 10-1-1977; IV = 24-1-1977.

	Days between flowering and harvest								
	20	25	30	(<35)	35	40	45	45	(>40)
A. Night temperature									
1	33	39	9	(81)	5	3	5	8	(13)
2	13	44	17	(74)	6	4	5	11	(16)
3	13	51	17	(81)	8	3	4	5	(9)
B. Planting									
I	10	52	16	(78)	9	3	3	7	(10)
II	11	49	18	(78)	5	2	4	11	(15)
III	26	38	12	(76)	5	4	6	9	(15)
IV	30	39	11	(80)	6	4	6	4	(10)

weeks later. But also this is not too evident. In the cumulative presentation these details of production rate variations have been neglected (Fig. 1).

In Fig. 2 flowering of only those flowers that produced a fruit are presented against time. A comparison between the graphs in Fig. 1 and Fig. 2 shows clearly that these two characteristics for the various treatments indicate that differences between treatments for flowering are greatly reflected in differences for dates of harvest. In general, but especially for the later plantings the harvesting period is longer than that for flowering. This is also reflected in the maximum numbers of weekly values for flowering and fruit production.

Days from flowering till harvest for each fruit have been calculated and are presented in Fig. 3 as curves for 'hanging-time' of fruits. Clearly, most fruits were harvested between 20 and 25 days after flowering for all treatments. Moreover, curves show two types of fruit development:
a) a group that is ready to be harvested within 40 days, and
b) another group that comes off much delayed.

The percentage of the fruit harvested within 20 days from flowering is slightly higher for later plantings and also with higher night temperature. However, the percentage harvested within a month is insensitive to either factor (Table 3). Fruit that take more than 40 days are found most with the medium night temperature (Table 3A).

Fig. 3. Glasshouse cucumber 1977. Distribution of fruit hanging-times for a harvesting period of five days as a percentage of total numbers harvested per stem (ordinate) versus hanging-time in days (abscissa).
a, b and c: night temperature 20, 16 and 12 °C respectively. Planting date: —— 13-12-1976; – – – 27-12-1976; . . . 10-1-1977; – . – . – 24-1-1977.
d, e, f and g: planting date 13-12-1976, 27-12-1976, 10-1-1977 and 24-1-1977 respectively. Night temperature: —— 20 °C; – – – 16 °C; . . . 12 °C.

Table 4. Glasshouse cucumber, 1977. Fruit fresh weight (median/harvest, g/fruit). Approximated influence of harvest period (Day 1 = 1-1-1977).

Harvest day	Fruit fresh weight (g/fruit)
50	280
60	320
70	360
80	420
90	380

Table 5. Glasshouse cucumber, 1977. Fruit fresh weight (median/harvest, g/fruit).
A (top): effect of night temperature.
B (middle): effect of planting date (I = 13-12-1976; II = 27-12-1976; III = 10-1-1977; IV = 24-1-1977).
C (bottom): effect of interval between harvests (3 or 4 days).

Harvest day	Night temperature (°C)		
	20	16	12
73	362	375	422
76	402	399	413
80	411	406	442
83	377	358	387
87	312	373	422
$\bar{m}$	377	375	422

Harvest day	Planting date			
	I	II	III	IV
73	414	365	369	340
76	411	406	396	392
80	420	417	421	395
83	380	376	360	362
87	349	380	377	387
$\bar{m}$	411	380	377	387

Harvest day	Harvest interval	
	3 days	4 days
73		375
76	406	
80		419
83	374	
87		379
90	375	
$\bar{m}$	375	379

Fruit size

All fruits were weighed and measured for their lenght. The median values for each harvest have been calculated for the seperate treatments. Over all treatments there was a shift towards more heavy harvesting of the fruits into the season. A rather rough indication of this effect is presented in Table 4.

In the period of about 'mid-harvest' of stem fruits over all treatments, the effects of treatments were determined. These data are presented in Table 5. The data are taken from the medians of the harvest dates 76 through 87. It is seen that the 12 °C night treatment delivered slightly heavier fruit. Also earlier planting gave slightly heavier fruit. Almost no effect of the median fruit weights

Table 6. Glasshouse cucumber, 1977. Fruit lenght at harvest (median/harvest, cm/fruit). Approximated influence of harvest period (day number 1 = 1-1-1977).

Harvest day	Fruit length (cm/fruit)
50	27
60	28
70	29
80	31
90	29

Table 7. Glasshouse cucumber, 1977. Fruit length at harvest (median/harvest, cm/plant).
A (top): effect of night temperature.
B (bottom): effect of planting date (I = 13-12-1976; II = 27-12-1976; III = 10-1-1977; IV = 24-1-1977).

Harvest day	Night temperature (°C)		
	20	16	12
73	30	29	31
76	31	31	33
80	31	30	32
83	30	29	31
87	28	30	32
$\bar{m}$	30	30	32

Harvest day	Planting date			
	I	II	III	IV
73	32	30	31	30
76	32	32	31	31
80	31	31	31	31
83	30	30	30	30
87	29	29	30	30
$\bar{m}$	31	30	31	30

Table 8. Glasshouse cucumber, 1977. Fruit per node (average per main stem), nodes per main stem and fruit per main stem.
A (top): effect of night temperature.
B (middle): effect of planting date (I = 13-12-1976; II = 27-12-1976; III = 10-1-1977; IV = 24-1-1977).
C (bottom): effect of plant position on the row (position 1 = on the outside of the crop).

	Night temperature (°C)		
	20	16	12
nodes	12.2	13.1	17.1
fruit	13.2	16.7	16.1
fruit/node	1.08	1.27	0.94

	Planting date			
	I	II	III	IV
nodes	15.3	15.1	13.9	12.3
fruit	12.8	15.4	16.1	17.0
fruit/node	0.84	1.02	1.16	1.38

	Plant position				
	1	3	5	7	9
nodes	14.7	14.6	14.3	13.8	13.3
fruit	17.2	16.3	15.0	14.5	13.8
fruit/node	1.17	1.12	1.05	1.05	1.04

was seen after 3 or 4 days harvest intervals.

Fruit length, in the same way as weight, increased with season as can be seen from Table 6. Planting time had no influence whatsoever on fruit length. Night temperature had a very slight effect in that from 12 °C night treatments somewhat longer fruits were harvested (Table 7).

Discussion and conclusions

The number of fruit harvested from the main stems is higher for later plantings. The effect is on average some 0.7 fruit per plant per week of later planting. In combination with the observation (de Lint & Heij, 1982a) that later planting reduces the number of nodes per stem with about 0.5 nodes per week, it must be concluded that the average number of fruit per axil is higher for later plantings. It is calculated to be 0.8 fruit per node for the first planting and 1.4 fruit for the last planting six weeks later (Table 8B). The effect of night temperature on the number of fruit per stem, showing an optimum at 16 °C, results in an even more pronounced optimum at the same temperature for the fruiting intensity per node (Table 8A). The effect of the position of a plant on the row on fruit number per plant is in the same direction as on the number of nodes. Nevertheless, plants on the outside of the crop do have a slightly higher fruit production per

node than the plants further in the crop (Table 8C). The beginning of fruit production is clearly favoured by higher night temperatures (Fig. 1). For later plantings the production begins relatively early, since the time between plantings was 14 days and the beginning of harvests started with 10-day intervals, except for the interval between the first two, where it was 13 days. In fact, as these two factors are counteracting each other, and as they are coupled in the experiment, it must be concluded, that the night temperature effect is even stronger than actually shown by the data.

The rate of fruit production is almost insensitive to night temperature. It seems a rather unexpected observation that the number of fruit harvested per day is practically equally high with 12 °C nights as with 20 °C nights. It is the more so surprising, in combination with the observation that the rate of flowering is rather strongly reduced by low night temperatures (de Lint & Heij, 1982). These data can be discussed in connection with obsercations on flower abortion of the same experiment (de Lint & Heij, 1982b).

When one realizes that the experiment was taken under gradually improving conditions, especially with respect to light, the suggestion could be put forward that the delayed production of fruit on plants at low night temperature could have relatively favoured the rate of harvest of the slow groups, so that a low-temperature retardation of production could have been neutralized. However, from Fig. 2 it must be concluded that the increase of the rates into spring are far too small to be put forward as an explanation for the low sensitivity to night temperature. The 'hanging-time' of the fruit, from flowering till harvest, also is only very weakly sensitive to night temperature. Thus, fruit growth rates are practically the same over the range of night temperatures from 12 to 20 °C.

Also the effect of later planting is limited (Fig. 3). Indeed, fruit from later plantings can be picked slightly faster in that some 20 % fruit do not hang between 20 and 25 days, but are ready within 20 days. However, the percentage harvested within one month is identical for all night temperatures and planting dates.

The fact that fruit from all treatments are harvested at essentially the same median weight after the same 'hanging-times' indicates that fruit growth rates practically are insensitieve to both night temperatures and light conditions. This conclusion is the more so justified as fruit harvest weight tends to be even slightly heavier with earlier planting and with lower night temperature (Table 5). Fruit length does not seem to be influenced specifically by either experimental factor. There is only some relation observed to weight in that heavier fruit are also longer (Table 6).

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