ADAPTATION OF THE GLASSHOUSE CUCUMBER TO LOWER TEMPERATURES IN WINTER BY BREEDING

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Abstract

The Institute for Horticultural Plant Breeding (IVT) has in 1974 initiated a program to select slicing cucumbers that grow and produce well at lower temperatures in winter. The goal was set at 20°C day, and 15°C night from the time of planting, while soil heating kept the root temperature around 20°C. The resulting saving of fuel costs amounts to 30-40%, with cropping beginning at the usual time. Few out of hundreds of varieties from all over the world exhibited good growth in the selection environment. After four cycles of breeding and incorporation of Dutch slicer germplasm over 30 were developed with superior growth and fruit production, which were made available to the interested private breeding firms in The Netherlands in 1978. Early harvest of the best breeding lines at the low temperature equalled that of the control varieties at normal temperature. Most lines also gave promising yields in a 1979 trial with 12°C night temperature. Measurements of early growth at controlled fixed and alternating temperatures confirmed that outstanding lines grew faster than the control variety Farbiola. Changes in plant type may partly be responsible for the observed differences. Leaf area ratios (LAR) of the breeding lines were generally higher than those of the control variety at 20°C D/12°C N. Selection of fast growing plants at an early growth stage appeared to be possible.

Introduction

The glasshouse cucumber is the most thermophylic of the major indoor crops in Western Europe. Heating costs of a typical December/January started cultivation in The Netherlands amount to almost one third of the total production expenditures. Any reduction of the heating costs would ease the pressure on the rentability of this crop.

Recent research(Challa 1976;Van de Vooren,1980)has established that the cucumber tolerates a considerable drop in night temperature after fruit production has started. This lower night temperature of 16°C and in some experiments even 12°C for a few hours, can be introduced in the spring, when outside temperature is steadily increasing. The plants need most heat, however, in the coldest period of December till March. This is also the period with the shortest days and lowest light intensity, and therefore heating of the glasshouse is most expensive.

The Institute for Horticultural Plant Breeding (IVT) at Wageningen has therefore undertaken a program to breed cucumber lines that grow and produce well at lower temperatures in winter. Several aspects of the breeding program will be discussed, illustrated with some examples of experiments with the newly bred lines.

Materials and methods

Over 500 varieties from many countries of the IVT cucumber collection formed the basis of the breeding program. Seeds of the varieties were sown at the end of November, and seedlings grown at 20°C day temperature and 18°C night temperature. In the beginning of January, five plants of all varieties were planted in a glasshouse with temperature at 20°C day and 15°C night(about 15 hrs). Soil heating kept the soil temperature at 18-20° C. Five weeks after planting the fastest growing varieties were selected,selfed, and intercrossed in an incomplete diallel crossing scheme. Following seed production in the summer the selfed progenies and the F_2 of the crosses were tested the next winter season, at the same temperature regime. Also crosses were made with a vigorous Dutch slicing cucumber,Toska. Line selection, and recombination of outstanding individual plants was continued for three consecutive years,with 1400 till 3000 plants per selection cycle. The emphasis in the selection was extended during the program from solely fast vegetative growth, to a good plant type and female sex expression, early start of fruit production (high level of parthenocarpy and good growth of developing fruits) and reasonable fruit type without cold markings.

Growth and early production of 20 F_4 lines were compared with that of 5 control varieties at the selection temperature(20°C D/15°C N) and normal growing temperature (23°C D/20°C N). Therefore 20 plants of each entry were planted at random in each of two identical glasshouses, and growth and production until the 6th week of harvest were recorded per plant.

Growth analyses were performed on young plants of some of these lines and control varieties in an attempt to get some insight in the background of the observed differences in early vegetative growth.Four days old seedlings were planted in 12 cm pots and placed on benches or carts in temperature controlled glasshouses of the IVT-Phytotron. Periodically 6 plants were harvested of which plant lenght,number of leaves,leaf area and fresh and dry weight of leaves and stem were recorded.Physiological parameters were calculated on the basis of total above-ground dry weight and leaf area.

Results

The breeding program has resulted in the release of a set of over 30 fast growing and wellyielding lines to interested Dutch private breeding firms. This material is now being incorporated in their breeding efforts to create varieties with lesser energy demands.

The mean plant length of 20 selected F_4-lines and 5 control varieties at 30 days from planting averaged 110 cm at 20° C D/15°C N, and almost 200 cm at 23°C D/20°C N. There was a good correlation between vegetative growth at the low and the high temperature. Mean fruit yield during the first 6 weeks of harvest of the lines and varieties is presented in Fig. 1 and Fig 2. For both the number and total weight of the fruits the control varieties are situated in the lower right hand corner of the graphs, because they produced well at the normal temperature, but were outyielded by many lines at the lower temperature regime. These differences were found to be significant by analysis of variance. Most lines produced more fruits and higher total weight at the high than at the low temperature, with only three high yieldingones(5,9,18) excepted. It should be pointed out, however, that many of the lines tested in this experiment were not yet fully female flowering, especially at the higher temperatures. This hampers the production of early fruits on the main stem. Also the level of parthenocarpy in several lines was not as high yet as in the varieties. Several of the lines were still segregating quite widely and individual plants were selected, that out-yielded the best variety by more than 100%.

The yields of three outstanding F_4 lines and three control varieties are summarized in Table 1. It is evident that these lines yielded as much at the low temperature as the varieties at the normal temperature. This advantage derives partly from an earlier start at the production.

Table 2 gives an example of the results of growth analyses. Plant length and dry weight of the above-ground parts of four breeding lines at 30 days from sowing are expressed as percentages of the actual values for variety Farbiola. Only two relevant temperatures have been included in the table, along with the average over all 8 temperatures used. All lines were taller than Farbiola,two lines even 50% at the selection temperature. In general the lines had higher dry weight than the control, but the differences were smaller than for length. Line b had hardly accumulated more dry matter than Farbiola at any temperature, but line c had gained an excess of almost 25%.

Some physiological parameters calculated according to Challa and Brouwer (1978) from the above data indicated, that the success of the breeding lines may mainly be due to a higherleaf area ratio (LAR), especially at the lower temperatures. This can also be concluded from a recent growth comparison of one breeding line and Farbiola, the derived growth parameters of which have been entered in Table 3. Breeding line 52-3 had a higher average relative growth rate than the control variety, both for the total dry weight ($R.G.R._W$) and the leaf area ($R.G.R._L$). It is significant, that the relative preponderance of the line was highest at the regime with the very low night-temperature. Differences in the average netto assimilation rate (NAR) were small. The line possessed a much higher leaf area ratio (LAR) at the 23°C D/10°C N regime. The increase of LAR at 20°C over the latter regime is smaller for the breeding line, so its plant stature is relatively stable as opposed to that of Farbiola. A very strong reaction of LAR to temperature was also found for Farbio by Challa and Brouwer (1978).

Discussion

When comparing production of lines with that of varieties, one should bear in mind, that the first are still segregating and heterogeneous, while the latter are F_1-hybrids with (some) heterotic vigour, earliness and uniformity. Monoecious segregants in the lines will depress the mean yield. The potential of the breeding lines may still be increased by selecting more highly female and parthenocarpic individuals. The quality of the fruits was reasonable and the length generally sufficient, but more breeding will be necessary to comply with the high Dutch standards.

Every line is the selfed offspring of a selected individual plant of the previous generation, therefore the spread of the mean yields of the lines in Fig. 1 en 2 indicates that the character under selection is not easily transferred from one generation to the next - its heritability seems to be low. This aspect needs further study.

In a trial at 12°C night temperature instead of 15°C, a number of the advanced lines proved still capable of good growth and production.

This temperature regime would result in a 50% reduction of fuel costs, in comparison with 30-40% saving for the 15 °C night temperature regime.

The attractive characteristics of the developed lines are two fold: firstly they grow fast at relatively low temperatures during the potted plant stage and directly following transplanting. This could be associated with a high leaf area ratio (LAR), but more research is needed for a conclusion. Secondly, they start fruit production early, whereas fruitlets of control varieties don't develop, but remain on the plant without being thrown off. The differences cannot be ascribed to levels of parthenocarpy, since all control varieties used are highly parthenocarpic. The lines may have a better balance between vegetative growth and fruit growth, or their fruits act as more effective sinks at low temperature.

The high LAR associated with fast vegetative growth at low temperature appears to offer possibilities for early selection of plants before they are transplanted in the glasshouse. The efficiency of the selection can be improved. This would be especially helpful, since the large space-requirement of the cucumber poses severe limitations on the size of the population available for selection. Preliminary studies on preselection have not yielded unequivocal results, but moderate negative mass selection nevertheless appears appropriate.

Literature

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Challa, H., and Brouwer, P., 1978. Effecten van temperatuur op de groei van jonge komkommerplanten. Verslag nr.16, CABO, Wageningen. pp.28.

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Table 1 : Fruit number and weight of three outstanding F_4-lines and three control varieties at two temperatures. Planting date January 18 ; harvest March 10 - April 20.

Variety/Line	Fruit number		Total weight (kg)	
	20 D/ 15 N	23 D/ 20 N	20 D/ 15 N	23 D/ 20 N
2	7,0	8,7	2,08	2,08
5	8,0	6,6	2,41	2,28
18	7,4	6,3	2,26	2,27
Farbiola	2,0	7,0	0,66	2,13
Corona	2,5	8,1	0,82	2,50
Toska	4,5	7,5	1,33	2,15

Table 2 : Plantlength (cm) and dry weight (mg) of four breeding lines as a percentage of the values for variety Farbiola at 30 days from sowing.

Temperature	20/14		23/23		Average*	
	Length	Dry w.	Length	Dry w.	Length	Dry w.
Farbiola	22,8	182	86,0	551	64,5	353
Line a	116**	118	131	116	120	120
b	116	104	101	92	116	111
c	155	124	138	129	124	115
d	149	104	159	130	143	124

* Average values of all 8 temperatures : 26/26, 26/20, 23/23, 23/17, 20/20, 20/17, 20/14, 17/17.

** Percentage of value above.

Table 3 : Growth parameters of an advanced breeding line and variety Farbiola at 28 days from sowing at two temperature regimes (20 D/ 20 N and 23 D/ 10 N, daylength 9 hrs.).

Parameter		A. Farbiola	B. Line 52-3	B/A.100%
$\overline{RGR}_W$	20/20	0,115	0,130	113
	23/10	0,079	0,095	121
$\overline{RGR}_L$	20/20	0,122	0,147	121
	23/10	0,093	0,119	128
$\overline{NAR}$	20/20	0,023	0,025	109
	23/10	0,027	0,025	93
$\overline{LAR}$	20/20	4,92	5,29	108
	23/10	2,88	3,81	133

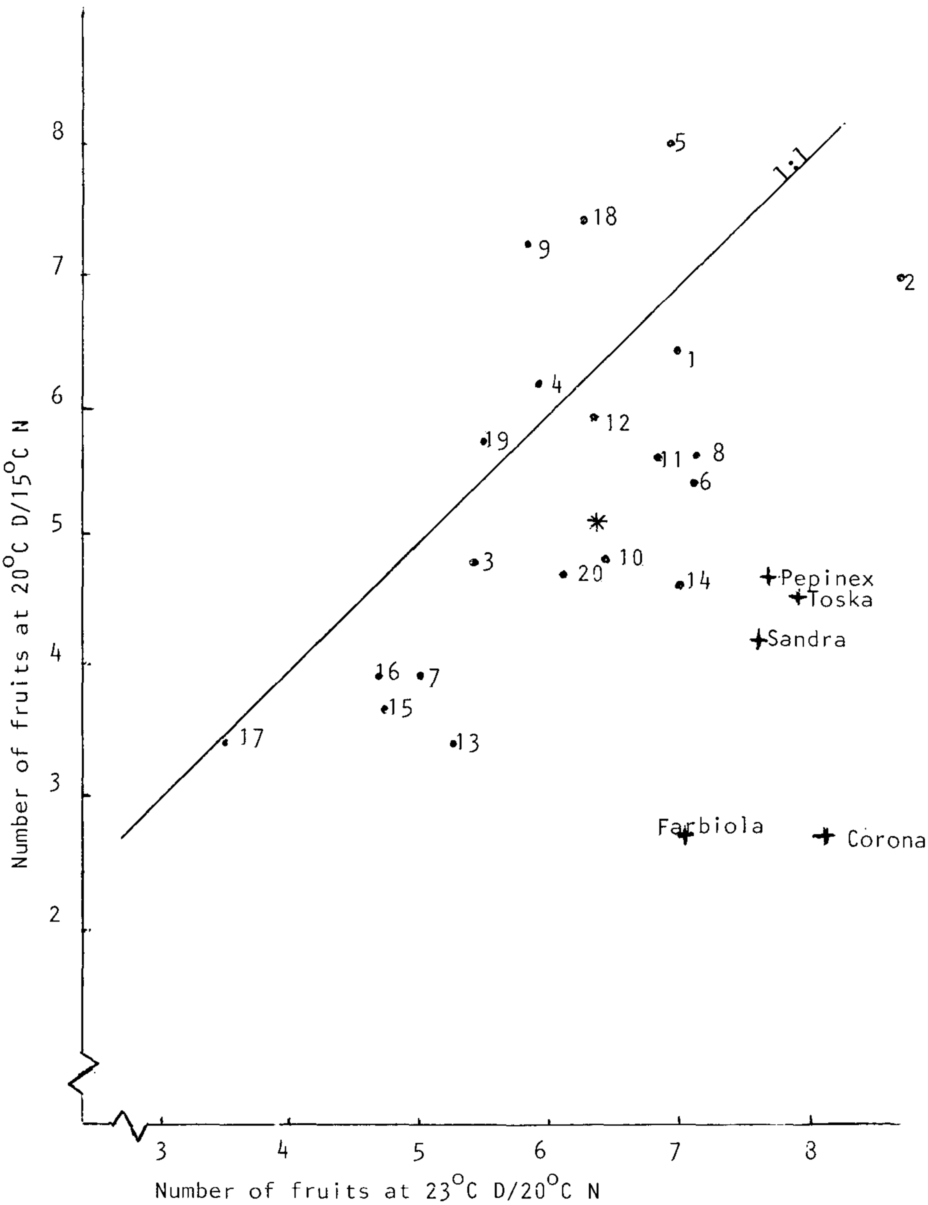

Fig 1. Number of fruits produced by 20 breeding lines and 5 varieties during the first six weeks of harvest at two temperatures.
*: grand mean.

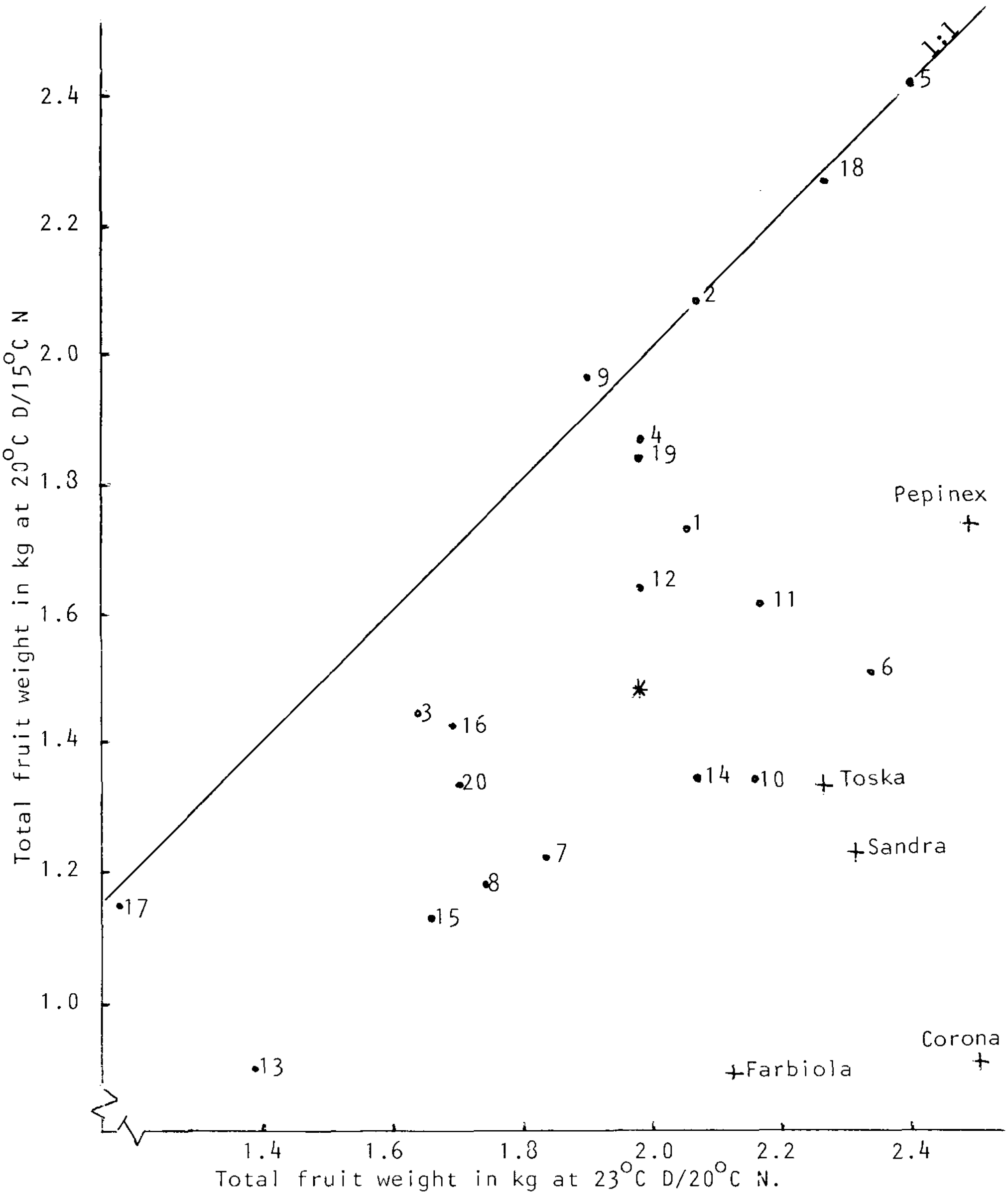

Fig 2. Total weight of fruits produced by 20 breeding lines and 5 varieties during the first six weeks of harvest at two temperatures.
*: grand mean.