Growth and mebrane lipid composition in cucumber

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SUMMARY and CONCLUSIONS

In the framework of research, directed to diminish energy consumption of thermophilic crops as cucumber, tomato and sweet pepper, an investigation was started comparing two low temperature tolerant cucumber genotypes, originating from a breeding program of the Centre of Plant Breeding and Reproduction Research (CPRO-DLO), Wageningen, with a low temperature sensitive cucumber cv. Farbio.
The aim of the investigation was to get more insight into the physiological background of a better functioning of cucumber plants under a suboptimal temperature regime (20/12°C day/night instead of 25/20°C day/night) and low light conditions. Young cucumber plants were used with the goal of creating a selection criterion for young plants, in order to be able to shorten the selection procedure of genotypes with better growth capacity at suboptimal conditions.
A growth study on hydroculture, showed significant differences for Farbio and line 79345 between the temperature regimes in total weight, relative growth rate, leaf area ratio, specific leaf area, leaf weight ratio, shoot/root ratio, stemlength and percentage of dry weight. No significant differences in net assimilation rate were observed. Related to the temperature regime, significant differences in morphology and distribution of dry matter over stem, roots and leaves between Farbio and the low energy lines were also present. Genotype x temperature interactions occurred for leaf area ratio and stem length. In general the low energy lines showed increased growth, as compared with Farbio (Chapter 2).
The observation that the leaf area ratio correlated with growth differences between the lines and Farbio, combined with a different morphology of the plants, led to the investigation whether non destructively determined leaf parameters could be used for selection of genotypes with different growth performance. Differences in leaf shape, leaf area and the development of the leaves were examined by measuring leaf length and width during growth at optimal and suboptimal temperature and low light conditions. Differences in leaf shape were observed for the first leaves of the genotypes, but they did not correlate with differences in plant growth. Leaf area was calculated by taking leaf length x width and by using the experimentally derived equation of Robbins and Pharr (1986): leaf area = 11.306 + 0.109 x length + 1.1381 x length^2. Both methods were tested. The calculated leaf area deviated from the measured area. As a consequence, in both methods, a genotype dependent

correction factor was needed. These results imply that selection on leaf area by non destructive leaf area measurements of cucumber genotypes is only possible when correction factors have been previously determined for each genotype.
A malfunctioning of plants under low temperature conditions is usually related to a disturbance of membrane functioning. Therefore, the lipid composition of the genotypes was examined under exactly the same conditions as for growth. Total lipid, phospholipid and fatty acid composition of leaves and roots were determined . Hardly any genotypic differences were observed at either temperature regime. At low temperature the degree of unsaturation of esterified fatty acids was increased. The hypothesis of Murata stating that the percentage of high melting point fatty acids in phosphatidyl glycerol would determine chilling sensitivity was also investigated. No correlation between fatty acid composition of phosphatidyl glycerol and genotypic differences in growth were observed. At low temperature the lines reacted by a lower level of the amount of phosphatidyl glycerol without a change in the proportion of saturated phosphatidyl glycerol fatty acids. The control variety reacted by lowering of the proportion of saturated phosphatidyl glycerol fatty acids at a stable phosphatidyl glycerol content. In general, no valid selection criterion based on lipid composition was found.
In an earlier experiment on other lines of the same breeding program, which were grown in soil, differences in lipid composition were found. In our experiments, plants were grown on hydroculture. Since literature pointed to the possibility that lipid changes, ascribed to low temperature adaptation, might be primarily the result of drought, we tested this hypothesis. Both drought and low temperature resulted in reduced growth, especially in Farbio, the genotype which was least tolerant to low temperature. Drought resulted in an increase in total lipid and phospholipid per g fresh weight. Total lipid of the lines was less influenced by drought than that of cv. Farbio, which was in accordance with the better growth performance of the lines under suboptimal temperature regime (Chapter 2 and Chapter 5). The fatty acid composition was changed by drought and low temperature, resulting in an increase in the degree of unsaturation. The observed increase in phospholipids on a fresh weight basis was in accordance with earlier results of Horvath, so it was concluded that those lipid changes, ascribed to the effect of low temperature, might have been influenced by drought stress. Screening plants grown in soil at low temperatures probably includes

selection for drought resistance.

The lack of differences in lipid composition between the cucumber genotypes at suboptimal temperature might also be due to the fact that they were genetically too identical. Related pumpkin species (Cucurbita ficifolia and two Sicyos angulatus genotypes), normally used as a rootstock for cucumber, which had different growth characteristics at suboptimal temperature, were investigated and compared with the cucumber genotypes. Growth of the pumpkins decreased at low temperature but the Sicyos angulatus genotypes were more tolerant to low root temperature than Cucurbita ficifolia. Low root temperatures only affected root lipid composition. An increased phospholipid and a markedly lower sterol and sterol ester level resulted in a strongly decreased sterol/phospholipid ratio at 12°C. Comparison with the cucumber genotypes for this ratio (Table 4, Chapter 6) showed a negative correlation with low temperature tolerance, as measured by growth. However, within a single temperature regime, no correlation between growth and sterol/phospholipid ratio was observed neither for cucumbers nor for the rootstock genotypes. This suggested that a lower phospholipid/sterol ratio was primarily an indication for low temperature tolerance but that it could not be used as selection criterion for adaptation of plants to suboptimal temperature conditions.

In conclusion, no direct morphological and physiological selection criteria for improved growth capacity at suboptimal temperature and light conditions were found. It became clear that adaptation to low temperature and low light, and perhaps also drought, is a complex process in which many aspects of physiology are involved. Related genotypes tended to find a homeostasis by different means and directed their reactions to the best possible fit to the environment. The question whether the genotypes of the breeding program of the CPRO-DLO were selected for the best genotype or the most flexible phenotype still remains obscure. Membrane lipid composition within a single temperature regime, optimal or suboptimal, never showed large differences between the control Farbio and the lines, however, upon low temperature exposure growth of the lines showed to be less influenced by temperature changes than growth of Farbio, which might indicate a larger capacity for phenotypical flexibility in the lines.