CAUSES FOR DIFFERENCES IN THE STORABILITY OF SUGAR BEET GENOTYPES

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Introduction and objectives

Storage of sugar beet roots before the delivery to the factory gains increasing importance as the campaigns are extended to more than 120 days also in Europe. During storage, a part of the stored sucrose is cleaved, which results in a reduction of the amount of sugar that can be processed. But more serious for processing is, that invert sugar accumulates in the root. That leads to a reduction in the alkalinity reserve and as a consequence, color is formed during evaporation decreasing white sugar quality and thereby increasing energy demand and costs.

Storage losses cannot be inhibited completely, as the root is still a living organism, but the extent of the losses can be influenced. The main factors affecting the losses are storage temperature and the length of the storage period, but unfortunately these factors cannot be controlled by the farmers. Harvest conditions, in particular the damage during harvest, can have a great impact on storage losses. But there is also some evidence, that sugar beet cultivars differ in their storage losses, which could then be taken into account to further reduce storage losses. The objective of the project was to quantify genotypic differences in storage losses, analyse possible causes for these differences and thus identify general relationships between genotypic properties and storage losses.

Material and Methods

18 genotypes were cultivated in completely randomized field trials at 4 locations in 2 years. Storage experiments were conducted under controlled conditions in climate containers at 8 and 20 °C constant temperature for 8 and 12 weeks. Each treatment had 6 replicates with 20 roots. The roots were sorted before storage, and all roots with rots or diseases were discarded. After storage, pathogen infestation was scored, and sugar content, invert sugar content and marc content were analyzed before and after storage.

Results and discussion

The genotype with the lowest losses lost 3 % of the initial amount of sugar, whereas the genotype with the highest losses showed 12 % sugar loss, so there were great differences between the genotypes at 8 °C. At 20 °C, the losses reached a higher level, but the differences between genotypes were similar. These distinct differences may be due to several possible causes. Genotypes might differ in their metabolic activity, in their enzyme activity, which results in the cleavage of sucrose and finally the respiration of sucrose, so that the sugar losses and the accumulation of invert sugar differs. There may also be a different susceptibility to damage during harvest operations. Injuries and damage lead to a wound healing process which requires the cleavage of sucrose. What is more, injuries can form entry points for pathogens, and pathogen infestation seems to be a serious reason for high sugar losses. Furthermore, genotypes may differ in the colonization of the tissue by pathogens resulting in sugar losses.

The sugar losses of the 18 genotypes varied from near zero to about 20 % of the initial amount of sugar, when the storage temperature was at 8 °C, and the losses increased to more than 80 % with a storage temperature of 20 °C. The invert sugar content after storage showed a highly significant relation to the sugar losses, so a high invert sugar accumulation was always related to high sugar losses with an r^2 of 0.98.

To find out what the influencing factors were for the lower r^2 at 8 °C, we looked a little bit deeper into the response of the genotypes at 8 °C storage temperature. There were genotypes with an average invert sugar content after storage of 10 mmol/kg, and others, which had 30 mmol/ kg invert sugar after storage. But there were also distinct differences with regard to the sites, where the plants have been grown. At a site where only a low level of invert sugar resulted after storage, there were no significant differences in the invert sugar content between the genotypes. However, at a site, at which a much higher level of invert sugar content occurred, genotypes with low invert sugar content on average also had low invert sugar content, but genotypes with a high invert sugar content showed an extremely high invert sugar accumulation after storage. So it is evident that the site, where the plants have been grown, has a major impact on the level of the storage losses. But it was also obvious that at sites where only low storage losses occur, genotypes do not much differ in their invert sugar accumulation and thus their sugar loss. But at sites, where high losses occur, the response of the genotypes will be extreme: genotypes with low losses still have low losses, but genotypes with high losses show an extreme response.

As the pathogen infestation could be a possible reason for a high invert sugar content, moulds and rots at the surface of the roots were scored. The pathogen infestation was higher at 20 °C than at 8 °C, as expected. There were also distinct differences between the genotypes. The invert sugar content of the roots was closely related to a visible infestation with moulds and rots after storage. Therefore, the infestation of moulds and rots on the root seems to be a major reason for storage losses of sugar beet. From these results it cannot be separated between the invert sugar produced by the microorganisms and the invert sugar coming from the metabolism of the sugar beet plant itself. But what has become clear is, that genotypes have a different susceptibly against the penetration and also the colonization of pathogens in the root tissue. Therefore, part of the genotype effect is certainly due to their susceptibility against storage pathogens.

A further question was, whether any reason for the genotypic differences in the susceptibility against pathogens can be identified. It has been demonstrated for maize, that the penetration of tissue by microorganisms can be reduced, when the epidermis and the tissue has a high stability. In sugar beet, all insoluble cell wall compounds in the root are summarized as marc. Hence, the marc content in the root could serve as an indicator for the stability of the cells and the tissue. In our experiments, a close negative correlation between the infestation of the root with moulds and rots after storage and the marc content of the roots before storage occurred. Hence, genotypes with a higher marc content before storage showed a lower infestation with pathogens after storage. It is probable due to a kind of unspecific resistance, like a mechanical barrier to the pathogen attack. Since the pathogen infestation was closely related with storage losses, our results give some evidence that genotypes with a higher marc content before storage have lower storage losses.

From these results it is assumed that the stability of the root tissue plays an important role for the storability of genotypes. Further research is needed to analyse the effect of the growing site on storage losses. Moreover, it has to be investigated in more detail whether the marc content, perhaps together with other parameters, can give some indication about the storability of sugar beet cultivars.