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Assessment of storage capacity of some red cabage varieties depending on the crop technology

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Abstract Cabbage presents a different storage capacity, depending on the variety and culture technology. The purpose of this paper is to establish the influence of technological links which are extremely important for the realisation of the red cabbage quality and its ability to maintain its attributes during long term storage. The experiments are based upon a number of factors, among which the influence of the cultivar, the plant density and the level of fertilisation upon quantitative losses and qualitative depreciations during storage under refrigerated conditions. The paper presents the results obtained in the period 2015-2017 on quality maintaining of the red cabbage after harvesting of three varieties: Azuro, Rebeca and Regilius, planted at density of 40,000; 45,000 and 50,000 plants/ha. The culture was fertilized with nitrogen in the following doses: 200; 300 and 400 kg active substance N/ha. Cabbage was kept in cold conditions (temperature = 0-2ºC, relative humidity = 85-90%) for a period of 90 days. After storage determinations were performed on the weight losses (expressed by evaporate-transpiration) and the losses by conditioning (resulted by removing browned leaves and of diseased ones). Researches show that the red cabbage from Regilius variety has a very good storage capacity, while the red cabbage from Rebeca variety is not suitable for a long-term storage. The losses increase proportionally to the dose of nitrogen applied to the crop. The fertilization with nitrogen in amounts up to 200 kg don't influence negatively the preservation capacity of the red cabbage, if it is storage a period of 90 days, while an abundant nutrition especially influences the qualitative depreciations during the storage. The ability to preserve the quality of the red cabbage during storage is also significantly influenced by the density of culture.

Key words

cultivar, plant density, level of fertilisation, quantitative and qualitative losses

Red cabbage *(Brassica oleracea* L. convar *capitata* (L.) Alef var. r*ubra* DC is practically the same species as white cabbage, being a variety of it. It was known and cultivated at once with the white cabbage at the end of the Stone Age [9]. Beyond appearance, between the red and white cabbage there are also other extremely important differences. For example, red cabbage contains up to 6-8 times more vitamin C than white cabbage (which has a higher vitamin C content than oranges), being a true concentrate of this vitamin. In addition, pigments giving red to this vegetable have a very important role as a medicine [14].

The therapeutic virtues of cabbage are known since antiquity. Its qualities are undeniable, therefore cabbage can be used successfully in the prevention and treatment of a very large number of diseases, being a real natural pharmacy. White cabbage is rich especially in pro-vitamin A, vitamins C and E, vitamin B1, vitamin B2, vitamin PP and in fibers, elements that provides cells health, giving it valuable therapeutic properties. Cabbage has few calories and a lot of substances with antioxidant effect, contains large amounts of magnesium, potassium, calcium, iron, copper, phosphorus, sulfur. These features and many others recommend the cabbage as a natural remedy against a large number of diseases [1,10]. It is an alkalizing, nutritional, energetic, remineralizing and tonic aliment, and it is preferable to be eaten raw, in order to keep intact its properties [12].

Storage capacity of the cabbage depends on the quality of raw material for storage, which is influenced by culture conditions and variety [3,4,13]. The variety imprints to the plants a certain chemical, histological and cytological structure [8,11] , detectable through different methods of analysis [6]. The chemical composition of cabbages, which determine the biochemical processes during storage and therefore storage capacity is strongly influenced by the fertilization regime. Based on this research results proved that the doses of organic and mineral fertilizer affect the chemical composition of fruit, with effect on storage capacity. As far as produce destined for long term storage are concerned, as it is the case for cabbage, respecting the technological links which influence the forming and maintaining of the quality and the storage capacity is of great importance because choosing the adequate type of cabbage for the storage spaces is of the essential importance when aiming to maintain the quality during storage [2,5,7]. In order to achieve this goal the crops destined for storage must be kept under observation beginning with the growing periods, meaning the moment when the crop is started .

The purpose of this paper is to evaluate the preserving storage capacity of red cabbage of the Azuro, Rebeca and Regilius varieties, depending on the plants density and doses of nitrogen fertilization during culture period. The final aim of our researches is to establish what is the most appropriate culture technology for the red cabbage destined to long term storage of and what are the varieties which have the best storage capacity.

Material and Methods

The experiments involved a number of factors and were carried out upon red cabbage cultivated in a vegetable farm near Bucharest, where the technological culture conditions and the obtaining of quality were verified. The storage of the produce and the verification of the maintaining of the quality were carried out at ICDIMPH-Horting Bucharest.

The experimental variants were the following:

a - cultivar
- a1 – Azuro
- a2 – Rebeca
- a3 - Regilius

b – plant density
- b1 – 40,000 plants/ha
- b2 – 45,000 plants/ha
- b3 – 50,000 plants/ha

c - fertilization level
- c1 – control (unfertilized)
- c2 – 200 kg active substance N/ha
- c3 – 300 kg active substance N/ha
- c4 – 400 kg active substance N/ha

The storage was effectuated in refrigeration conditions (temperature = 0-2ºC; air relative humidity = 85-90%) for a period of 90 days, thereupon the following determinations were effectuated:
- weight losses, resulted by evaporate-transpiration;
- losses by conditioning, resulted by removing browned leaves and of diseased ones;
- identification of pathogens that caused the rot of the cabbage;

The red cabbage was initially stored at temperatures of 1^{o}C, 5^{o}C and 10^{o}C. Given the fact that the best results were those obtained by the variants stored at 1^{o}C, they will be the only ones presented.

During storage the hydro-thermal factors in the storage room were verified on a daily basis in order to ensure the respecting of the optimal conditions for the maintaining of the quality. Also, appreciations were made concerning the red cabbage's capacity to maintain their quality during storage, as well as the possible occurrence and development of various specific diseases.

Upon removal from storage, the quantitative losses and qualitative alterations were determined by means of weighing the red cabbage heads.

Statistical elaboration of the experimental data was effectuated by analysis of variance, and the testing of significances of the differences between variants was done using the multiple comparison test – Duncan test.

Results

From the analysis of data presented in Table 1, it is observed that, after 90 days of refrigeration storage, weight losses are between 4.4% at cabbage variety Regilius and nearly double, of 8.2% at the red cabbage from Rebeca variety, with very significant differences between them.

Table 1

The influence of the cultivar upon the red cabbage's storage capacity

Losses (%)	Cultivar*		
	Azuro	Rebeca	Regilius
Quantitative losses	5.7 b	8.2 c	4.4 a
Qualitative depreciation	15.9 b	19.4 c	13.6 a
Total losses	21.6 b	27.6 c	18.0 a

*The cabbage was harvested from an unfertilized crop, with average density (45 thousand pl / ha).

Losses by conditioning (qualitative depreciation) increase from 13.6%, at variety Regilius, to 19.4% at variety Rebeca, with intermediary values (15.9%) for Azuro variety, differences being significant between the varieties.

Total losses are of between 17.0% (Regilius variety) and 27.6% (Rebeca variety), with very significant differences between the varieties.

This experience demonstrates that the red cabbage from Regilius variety has a very good storage capacity, while the red cabbage from Rebeca variety is not suitable for a long-term storage.

The influence of the plant density upon the level of losses: quantitative, qualitative and total (therefore upon the storage capacity) is presented in table 2.

Table 2

The influence of the plant density upon the red cabbage's storage capacity

Density (plants/ha)	Losses (%)	Cultivar	Average per cultivar		
		Azuro	Rebeca	Regilius	
b1-40,000	Quantitative losses	5.0	7.6	4.1	5.57
	Qualitative depreciation	15.1	18.0	13.2	15.43
	Total losses	20.1	25.6	17.3	21.00
b2-45,000	Quantitative losses	5.7	8.2	4.4	6.10
	Qualitative depreciation	15.9	19.4	13.6	16.30
	Total losses	21.6	27.6	18.0	22.40
b3-50,000	Quantitative losses	6.6	9.5	4.9	7.00
	Qualitative depreciation	17.3	22.2	14.7	18.07
	Total losses	23.9	31.7	19.6	25.07

The density of culture influences the values of the losses, average of quantitative and qualitative losses increasing with density. The smallest quantitative losses were recorded by the b1 variant (40,000 plants/ha), being of 5.57% for average per cultivar after 90 days. The highest quantitative losses (7.0%) were recorded by the b3 variant (50,000 plants/ha). The qualitative depreciations show larger differences between variants, being of 15.43% for density of 40,000 plants/ha, 16.30% for density of 45,000 plants/ha and 18.07 % for density of 50,000 plants/ha.

The cultivar Regilius registered the smallest total losses for all density experiments.

Data presented in Table 3, on the preservation of the red cabbage, show that between the first two graduations of fertilization with nitrogen that were studied, after 90 days of cold storage, there were no pronounced differences of the losses. It finds that weight losses recorded values very close to the variants, for all cultivars: from 5.7% (Azuro), 8.2% (Rebeca) and 4.4% (Regilius) in the case of c1fertilization variant (unfertilized) to 6.0% (Azuro), 8.9% (Rebeca) and 4.6% (Regilius) in the case of c2 variant, with the dose of fertilization of 200 kg active substance N/ha.

Table 3

The influence of the nutrition regime upon the red cabbage's storage capacity

Fertilization level (kg a.s. N/ha)	Losses (%)	Cultivar			Total
		Azuro	Rebeca	Regilius	
c1- unfertilized	Quantitative losses	5.7	8.2	4.4	6.1
	Qualitative depreciation	15.9	19.4	13.6	16.3
	Total losses	21.6	27.6	18.0	22.4
c2- N 200	Quantitative losses	6.0	8.9	4.6	6.5
	Qualitative depreciation	16.8	21.2	14.3	17.43
	Total losses	22.8	30.1	18.9	23.93
c3- N 300	Quantitative losses	8.1	10.2	5.8	8.03
	Qualitative depreciation	18.0	22.4	16.1	18.83
	Total losses	26.1	32.6	21.9	26.87
c4-N 400	Quantitative losses	9.8	11.4	7.0	9.40
	Qualitative depreciation	19.3	23.6	17.6	20.17
	Total losses	29.1	35.0	24.6	29.57

During storage period have not reported disease attacks for this fertilisation level (200kg a.s. N/ha) and the conditioning consisted only in the removing of 1-2 browned leaves, which made that the qualitative depreciation to be compared to variant c1-unfertilized (between 14.3% in the case of Regilius variety and 21.2% in the case of Rebeca variety).

Based on these results it can be considered that the fertilization with nitrogen in amounts up to 200 kg don't influence negatively the preservation capacity of the red cabbage, if it is storage a period of 90 days.

Analyzing the data presented in Table 3, it also finds that the losses increase proportionally to the dose of nitrogen applied to the crop.

The weight losses increase from 6.1% (the average of the cultivars) in the case of control, up to 9.40% in the case of variant c4, fertilized with 400 kg active substance N/ha.

The data reveals the fact that an abundant nutrition (c4 variant) especially influences the qualitative depreciations during the storage, the value being of 20.17% in comparison to the c1 variant (16.3%).

During storage (in the second part of storage period) there appeared various diseases and the conditioning losses resulted largely by removing rotting leaves.

Among the pathogens that caused the rot of outer leaves can mention: *Botrytis cinerea, Sclerotinia sclerotiorum, Alternaria brassicae* and bacteria of the genus *Pseudomonas*. The attack was emphasized at the cabbage of c3 and c4 variants. In addition, at c4 variant were found brownings of the inner leaves oh the heads..

Total losses ranged from 22.4% (the average of the cultivars) at the control variant to 29.57% at variant c4, differences between these variants being very significant.

It observe that there are large differences between varieties regarding the storage capacity. Thus, total losses are, from the same fertilization level (c4 variant) of 24.6% in the case of Regilius variety and of 35.0% in the case of Rebeca variety.

From the data presented up to now, it results that the effect of nitrogen fertilization on the storage capacity of the red cabbage is negative only at high doses (over 200 kg a.s. N/ha). Until this dose there have not been reported the negative effect, for which we can consider as limit to which we can apply nitrogen fertilizer without affecting the storage capacity of the cabbage is 200 kg a.s. N/ha.

Conclusions

The agro-technical crop conditions influence the technical quality characteristics as well as the storage capacity to the red cabbage. The red cabbage destined for long term storage must benefit from the application of specific agro-technical measures which ensure a better storage capacity.

The cultivar is a limitative factor for the storage capacity to the red cabbage. There are differences between varieties regarding storage capacity and their response to applied storage technology. The cultivar Regilius has better storage capacity compared with those of the Azuro and Rebeca varieties, due the greater resistance to deposit diseases and therefore, the lower percentage of quality losses during storage.

The plant density influenced the values of the quantitative and qualitative losses. The smallest losses during long term storage were recorded by the red cabbage in the variant with 40,000 plants/ha.

The abundant nutrition level negatively influences the values of the depreciations during storage, which are higher in comparison to a more reduced nutrition level. The influence of nitrogen fertilization on maintaining of the quality of white cabbage during the preservation period is negative only at high doses (over 200 kg active substance N/ha). In case of dosages of 300 and 400 kg active substance N/ha losses were recorded of up to over 30% after 90 days of preservation. Therefore, in the case of cabbage destined to preservation it is not recommended the use of fertilizers in dosages greater than 200 kg active substance N/ha.

As far as specialised red cabbage crops concerned, whose production is destined for storage, the cultivation of specialised cultivars is recommended to be carried out in moderate densities and with a moderate nutrition level.

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