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Relationship of Seasonal Changes in Carbohydrates and Cold Hardiness in Buds of Two Rose Hip Genotypes

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Abstract

Two rose hip types thorny '25-mrk-14' (*Rosa canina* L.) and thornless '25-mrk-15' (*Rosa dumalis* Bechst.) selected from previous studies were used in this investigation. Samples of one year old twigs were collected and exposed to the artificial freezing test at –30 °C for 0, 8, 16 and 24 hours from November through March.

Throughout the experiments, several biochemical analyses on the buds of the rose hip genotypes, including total sugar, reducing sugar, sucrose and starch were performed monthly. Results indicated that there was a significant difference between the species of rose hips for resistance to cold, according to hours of treatment and month of samples taken. The '25-mrk-15' was less resistant than the '25-mrk-14' in terms of cold hardiness. Freezing tolerance in both rose hip genotypes is higher in January and February than November and December. The sugar ingredients of rose hip types increased from November to February, but decreased in March.

Zusammenfassung

Zusammenhang zwischen jahreszeitlichem Kohlenhydratgehalt und Winterhärte der Knospen von zwei Hagebutten-Wildarten. Die in dieser Untersuchung verwendeten hagebuttenbildenden Rosenarten, die mit Dornen behaftete '25-mrk-14' (*Rosa canina* L.; Hunds-Rose) und die dornlose '25-mrk-15' (*Rosa dumalis* Bechst.; Graugrüne Rose), stammten aus Selektionen früherer Versuche. Von November bis März wurden von einjährigen Zweigen Proben genommen und 0, 8, 16 oder 24 Stunden unter kontrollierten Bedingungen einer Kältebehandlung bei –30 °C unterzogen.

Während der gesamten Versuchsdauer wurden an den Rosenknospen monatlich biochemische Analysen, wie Bestimmungen des Gehalts an Gesamtzucker, reduzierendem Zucker, Saccharose und Stärke durchgeführt. Die Ergebnisse zeigten einen signifikanten Unterschied im Merkmal Kälteresistenz zwischen den Hagebuttenarten, der Dauer der Kältebehandlung und dem Monat der Probennahme. '25-mrk-15' war weniger kälteresistent als '25-mrk-14'. Bei beiden Arten ist die Kälteresistenz im Januar und Februar größer als im November und Dezember. Die Zuckerinhaltstoffe nehmen in den beiden Rosenarten von November bis Februar zu und fallen im März ab.

Introduction

The genus *Rosa* includes over 100 species, distributed throughout temperate and subtropical regions of the world (NILSSON 1972). Rose hips have high carbohydrate, vitamin C, vitamin A, K, niacin, essential oils, iron, phosphorus, potassium, calcium and fruit acid contents (JACOBI 1994; GULERYUZ and ERCISLI 1996).

One of the most important seasonal factors limiting production of fruit is damage to flowers and buds caused by winter minimum temperatures. Cold hardy varieties are selected for the critical low temperate regions (RENZI and GAOCHAO 1997). Cold hardiness is genetically controlled in fruit trees and resistance is influenced by internal factors such as carbohydrate, lipid, protein etc. (PALONEN and BUSZARD 1997). Several internal changes occur during acclimation of tissues to cold and some of these changes, alone or together appear to account for cold resistance (BURAK and ERIS 1992). In most fruit trees, sugars are known to lower freezing point and increase the intracellular osmotic potential. This would reduce the amount of dehydration during extra cellular freezing (BURAK 1989; PALONEN 1999).

There are many reports of the relationship between cold hardiness and seasonal carbohydrate changes in fruit trees but very few studied in rose hip, and almost none have compared thorny and thornless genotypes. The present study deals with the cold hardiness of thorny and thornless selected rose hip genotypes and the physiological relationship between freezing tolerance and some internal factors.

Material and Methods

One–year-old shoots of thorny '25-mrk-14' (*Rosa canina*) and thornless '25-mrk-15' (*Rosa dumalis*) rose hip genotypes were used as plant material based upon studies of ERCISLI et al. (1996). The genotypes were at the same place and age and treated in similar cultural practices.

Starting from the mid November, in every month one-year-old shoots at the length of 20 cm were sampled

and exposed to artificial freezing tests at –30 °C for 0, 8, 16 and 24 hours during the winters of 1996–97 and 1997–98 experimental years. The temperature controlled freezer was dropped to –30 °C, by decreasing 5 °C every hour.

After having the completed temperature exposure periods, the cuttings were taken from the freezer and placed into refrigerator for one hour. They were then transferred to greenhouse at 20 ± 2 °C and 80 ± 5 % humidity and placed in a perlite medium.

The bud survival observations were made over 8 weeks. At the end of this period, the buds that failed open were cut and primordial browning was considered to be dead (ERIS 1982).

The experimental design was completely randomized blocks with three replications of five cuttings containing at least 60 buds each treatment. Means were separated according to DMRT test. Correlation analyses between cold hardiness data and data regarding the carbohydrate also performed. The contents of total sugar, reducing sugar and sucrose of buds were analyzed monthly. Total sugar and starch analyses were carried out by KAPLANKIRAN (1984) with the modified anthrone method. The reducing sugar was determined by KAPLANKIRAN (1984) through a modified dinitrophenol method and sucrose which was calculated by (Total sugar % – Reducing sugar %) x 0.95 formula.

Results

Bud Survival

The levels of cold hardiness of rose hip buds varied with sampling time and treatments (Tables 1 and 2). The control cuttings of both genotypes had 100.0 % survival in both experimental years. However, the other exposure periods gave different survival rate (Tables 1 and 2).

In 1996–97 experimental periods, the survival was higher in 8-hour treatment and followed by 16 and 24-hour cold treatments for both rose hip genotypes. The 24-hour cold exposure resulted in 0.0 % survival in both rose hip genotypes in November and December. However, in the other months a few survived of those genotypes. The degree of freeze tolerance was lower in November for both genotypes. By January the freeze tolerance began to increase and the highest freeze tolerance for both genotypes obtained from February (71.6 % for thorny and 68.3 % for thornless genotypes, respectively). After the February, the levels of freeze tolerance decreased (Table 1).

Table 1. The effect of –30 °C cold exposure on the percentage bud viability of rose hip genotypes in different months during 1996–1997.

Genotypes	Months	Bud viability (%) Cold exposure periods (hour)				
		0	8	16	24	Mean
Rosa canina '25-mrk-14' (thorny)	November	100.0 NS	33.4 c	18.4 c	0.0 c	38.2 e
	December	100.0	49.8 b	25.3 bc	0.0 c	44.0 d
	January	100.0	86.3 a	61.6 a	29.6 ab	69.5 ab
	February	100.0	89.7 a	64.2 a	32.4 a	71.6 a
	March	100.0	79.4 a	33.0 b	21.6 b	58.5 c
	Mean	100.0 a	67.7 b	40.5 c	16.7 d	
Rosa dumalis '25-mrk-15' (thornless)	November	100.0 NS	28.6 cd	16.6 d	0.0 c	36.1 c
	December	100.0	35.4 c	14.2 d	0.0 c	37.4 c
	January	100.0	80.7 ab	56.8 b	27.6 a	66.3 a
	February	100.0	85.4 a	60.3 a	28.5 a	68.3 a
	March	100.0	72.3 b	29.5 c	16.7 b	54.6 b
	Mean	100.0 a	60.5 b	35.5 c	14.6 d	

*Mean separation within column and genotype by DMRT, 5 % level.

Table 2. The effect of –30 °C cold exposure on the percentage bud viability of rose hip genotypes in different months during 1997–1998.

Genotypes	Months	Bud viability (%) Cold exposure periods (hour)				
		0	8	16	24	Mean
Rosa canina '25-mrk-14' (thorny)	November	100.0 NS	26.7 c	7.4 c	0.0 d	33.5 d
	December	100.0	23.2 c	6.8 c	0.0 d	32.5 d
	January	100.0	88.4 a	57.2 a	35.5 a	70.2 a
	February	100.0	85.8 a	58.4 a	28.6 b	68.4 ab
	March	100.0	67.3 b	48.7 b	18.3 c	58.5 c
	Mean	100.0a	58.3b	35.7c	16.5d	
Rosa dumalis '25-mrk-15' (thornless)	November	100.0 NS	30.4 c	9.2 d	0.0 c	34.9 c
	December	100.0	36.8 c	4.4 e	0.0 c	35.3 c
	January	100.0	74.3 ab	45.6 b	24.2 a	60.9 a
	February	100.0	80.3 a	50.3 a	23.1 a	56.9 ab
	March	100.0	66.3 b	37.4 c	7.7 b	52.7 b
	Mean	100.0 a	55.8 b	27.4 c	9.6 d	

*Mean separation within column and genotype by DMRT, 5 % level.

Table 3. The relationships between cold hardiness and carbohydrate contents in thorny *Rosa canina* ('25-mrk-14') and *Rosa dumalis* thornless ('25-mrk-15') rose hip buds

Criteria	Years	Total Sugar	Starch	Reducing Sugar	Sucrose
		Rosa canina '25-mrk-14' (thorny)			
Cold Hardiness	1996–97	0.897*	–0.927**	–0.773	0.913**
	1997–98	0.823*	–0.888*	–0.661	0.897**
		Rosa dumalis '25-mrk-15' (thornless)			
Cold Hardiness	1996–97	0.711*	–0.775	–0.773	0.797*
	1997–98	0.727*	–0.863*	–0.661	0.811*

In November and December months, 24 hour cold application caused completely lethal injury to both rose hip genotypes. By January the cold tolerance began to increase and the highest cold tolerance obtained from this month (70.2 % for thorny and 60.9 % for thornless genotype, respectively). After the January, the cold resistance level decreased (Table 2). It appears that the thorny genotype was hardier than thornless.

Seasonal changes of carbohydrates

In first experimental year, the total sugar and sucrose content of buds of both rose hip genotypes as lower in November, but increased from December to January, however, decreased in February. The second year was similar in total and sucrose percentage and was lower in November in both rose hip types. The total sugar content increased from December to February then decreased in March (Fig. 1). The fluctuations in total soluble sugar content are parallel to the hardiness increase of the genotypes. However, starch content, contrary to sugars, as high in November, lower in January and February, but again high in March (Fig. 1).

Cold hardiness and carbohydrate content relationships

The total sugar and sucrose contents of both rose hip genotypes increased during winter months and started to decrease at the beginning of spring in both years and genotypes. The correlation between the total sugars, sucrose content and cold hardiness was positively significant (Table 3). However, the correlation between starch, reducing sugar and cold hardiness was negative in both years and genotypes (Table 3).

Discussion

Although rose hip species grow best in East Anatolia Region of Turkey, they are sometimes damaged by winter freezes. This study showed that the resistance to cold varies among two thorny and thornless rose hip genotypes. Thorny genotype ('25-mrk-14') was more resistant cold compared to thornless genotype ('25-mrk-15'). It was shown that, the hardiness degree of fruit trees strongly depend on species and cultivars (ANDRZEJEWSKA and RADAJEWSKA 1998; PALONEN 1999). The cold tolerance of rose hip buds increased throughout winter months and decreased in early spring months. Previous studies showed that there was an increase in the freezing tolerance during winter months (PALONEN 1999; PALONEN et al. 2000; BITE and DRUDZE 2000).

Generally, there has been a decrease in the cold hardiness of buds with the increasing length of temperature exposure at the beginning and at the end of dormancy period. Our results were in an agreement with the study done by ERIS (1982).

In our study, in general total sugar content increased from December and continued to increase during winter months, but decreased in March. BURAK (1989), obtained similar results from peach cultivars. However, contrary to that of sugars, we found that there was negative relationship between starch content of buds were higher in November and March, but lower in the January and February.

Our results support the idea that starch content has negative relationship on freezing tolerance of fruit trees (PALONEN 1999). The decline of starch content during winter months due to conversion of the starch to low-moleculer weight carbohydrates (DOWLER and KING 1966) is related to hardiness in rose hips.

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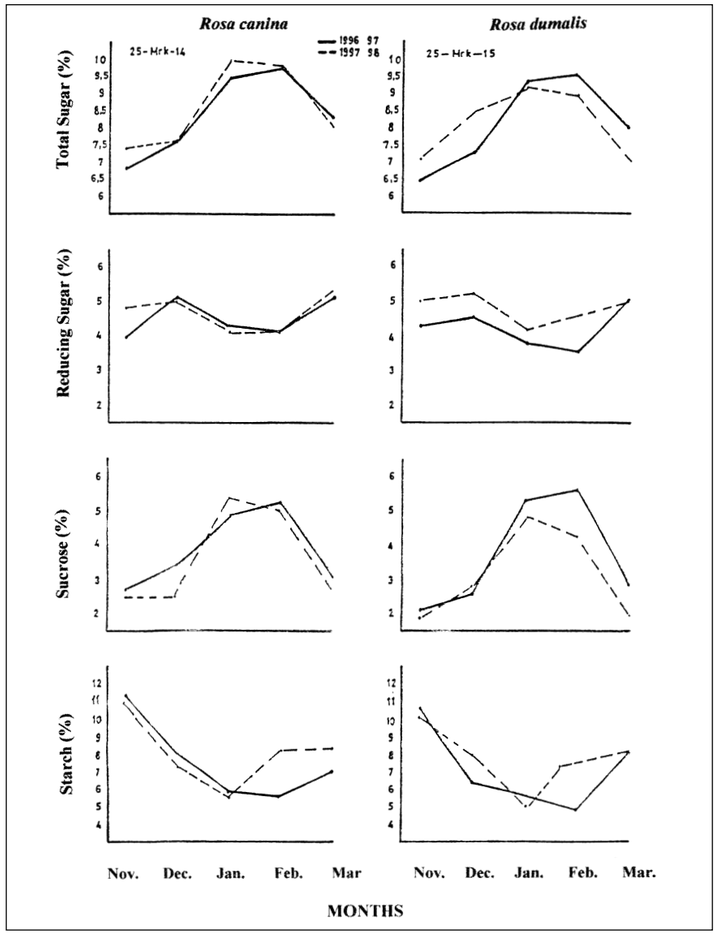


Fig. 1. The seasonal changes of carbohydrats of rose bud hips

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