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PHYSIOLOGICAL PARAMETERS CHANGES IN TULIP BULBS DURING COLD STORAGE

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Abstract

During the cold season, it is known that the tulip bulbs (Tulipa gesneriana L.), which are specialized underground organ, go through a series of physiological (respiration and transpiration) and biochemical changes (mass loss and total soluble solids). The main purpose of this study is to compare the physiological parameters changes during storage in cold room conditions of ten tulip cultivars (Allegretto, Margarita, Menton Exotic, Lion King, Sensual Touch, Jaap Groot, Marilyn, Indiana, Atlantis, Washington), before and after storage period. The samples were stored in conditions like: T: 1°C and RH: 90%, in the Research Center for Studies of Food Quality and Agricultural Products, of the USAMV Bucharest. From obtained results it was observed decreases with 10% of the mass loss between the initial and the final moment of analyses for Allegretto, Menton Exotic, Sensual Touch cultivars. For respiration rate were observed increases with 25% (for Lion King cv.) up to 6.6 times more (for Menton Exotic cv.) between the initial and final moments.

Key words*: Tulipa, respiration rate, transpiration rate, TSS, glucose*

INTRODUCTION

Over the years numerous studies have had as main directions the optimal conditions for storing different horticultural products. The main factors that differentiate the vegetative buds into flowering buds are the temperature and the duration of storage (Delian, 2013; Toma, 2009). It is known that the tulip bulbs (*Tulipa gesneriana* L.) go through their dormancy period in summer (Burzo, 2016). During their storage, the bulbs go through a series of physiological and biochemical changes, because the low temperatures cause the end of the dormant state and the growth of the flowering buds (Burzo, 2016).
According to Toma (2009) and Marasek-Ciolakowska et al. (2018) tulips can be classified according to shapes (dwarf and tall), depending on the flowering period (from mid-spring to mid-summer), and not least by the appearance of the flower (with single or double petals, with shape of lily or with fringed petals).
The bulbs are microblasts with spare materials in the fleshy leaves and are protected on the outside by cataphylls (dry leaves, thin). The stem itself is shaped like a disc, it has adventitious roots in the lower part, in the center 1-2 buds, from which develop fleshy leaves, called tunics, which have the role of storage. At the base of the fleshy leaves, the terminal and lateral buds form (Toma, 2009). In some cases the buds are tuberized and they turn into bulbs.
The main purpose of this study is to compare the changes in the physiological parameters of ten tulip cultivars, before and after the long term storage period, in cold room conditions.

MATERIALS AND METHODS

The variety groups of tulips studied are: Double late, Double fringed, Darwin, Lily flower, Fringed, Simple late and Triumph. The tulip bulbs, in uniform size for each cultivar, were stored in perforated paper bag. The tulips cultivars studied were: ‘Allegretto’, ‘Margarita’,

'Menton Exotic', 'Lion King', 'Sensual Touch', 'Jaap Groot', 'Marilyn', 'Indiana', 'Atlantis', and 'Washington' (Figure 1; Annex 1); and were stored and monitored in cold room, under following conditions: temperature (T): 1°C and relative humidity (RH): 90%, for 160 days (Burzo, 2005; Burzo, 2017), in Postharvest Technologies Laboratory of the Research Center for Studies of Food Quality and Agricultural Products - UASMV Bucharest.

The physiological parameters like: respiration and transpiration rates and the correlations with the biochemical changes like: mass loss, total soluble solids (TSS), and the concentration of glucose and fructose, were the main purpose of this study, so with T0 was noted the initial moment and with T1 the final moment, after 160 days.

Figure 1. Tulip cultivars bulbs used for physiological measurements

Respiration rate was determined with a static, closed system, in containers with hermetic closure with a volume of 280 ml (for smaller bulbs) and 1180 ml (for the bigger bulbs). With the Lambda T NDIR Monitor, ADC BioScientific LTd., the respiration rate was measured and the results were expressed in mg CO_2/kg/hour (Popa et al., 2019; Fonseca et al., 2002). By gravimetric analysis (Fante, 2014), the transpiration rate was measured and the results were expressed in g water/100 g f.w./hour.

By using the Memmert UN110 oven for drying, for 24 hours at 105°C, the water content of the samples was determined, method also used by Delian (2011). The content of total soluble solids, glucose and fructose were determined from 3 bulbs for each sample, with refractive device Kruss DR301-95 (% Brix), refractive device Milwaukee MA873 (%) for glucose and refractive device Milwaukee MA872 (%) fructose.

Using Excel, statistical analyses were performed, like: mean, standard deviation, ANOVA single factor, T Test and correlations (Pomohaci, 2017).

RESULTS AND DISCUSSIONS

For tulip bulbs, the respiration rate (Figure 2) during storage registered increases with 25% (for Lion King cv.) up to 6.6 times more (for Menton Exotic cv.) between the initial and final moments, Kanneworff W. (1994) suggesting that this behavior is an adaptation to low temperatures, being high energy users, due to number increased of mitochondria according to Khodorova (2013).

Koksal (2010) suggest that for long-term storage is not convenient due to high mass loss (Table 1).

All studied tulip cultivars registered a significant increase of respiration rate ($P<0.05$), between T0 and T1, with some particularities. Allegretto, Lion King, Marilyn and Indiana cvs. started the long term cold period storage with respiration rates up to 20 mg CO_2/kg/h, while the others registered, for the initial moment, lower values of this physiological indicator (Figure 2).

For Allegretto bulbs, between respiration rate (Figure 2) and TSS (Table 1) a very significant positive correlations $R^2 = 0.8521$, with linear regression equation $y = 0.286x + 2.9835$ and between transpiration rate (Figure 2) and water content (Table 1), a very strong significant negative correlations $R^2 = 0.9485$, with linear regression equation $y = - 84.572x + 60.43$. At respiration rate, for Margarita, significant differences ($P<0.05$) were registered, for the initial moment, with Jaap Groot cv., and for the final moment with Lion King, Jaap Groot, and Indiana cvs.

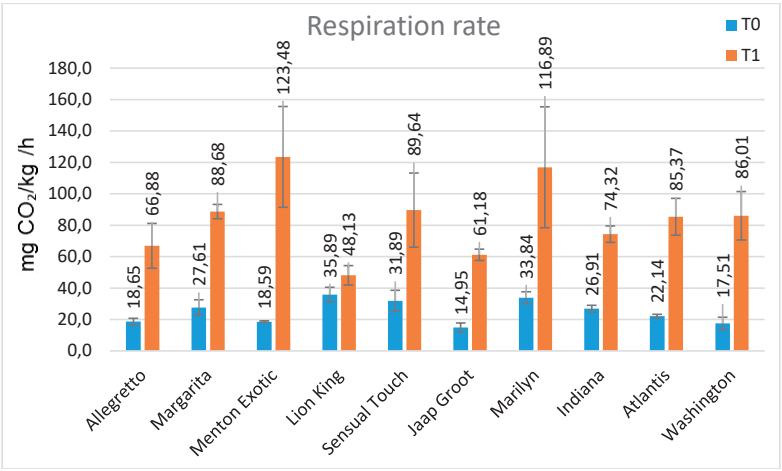

Figure 2. Respiration rate during storage in cold room

For Margarita bulbs, between respiration rate (Figure 2) and TSS (Table 1) a very strong significant positive correlations $R^2 = 0.9233$, with linear regression equation $y = 0.2399x + 2.426$ and between transpiration rate (Figure 2) and water content (Table 1), a negative correlations $R^2 = 0.6399$, with linear regression equation $y = - 48.885x + 53.061$.

At respiration rate, for Menton Exotic, significant differences ($P<0.05$) were registered, for the initial moment, with Lion King, Marilyn, Indiana, and Atlantis cvs.

For Menton Exotic bulbs, between respiration rate (Figure 2) and TSS (Table 1) a strong significant positive correlations $R^2 = 0.8178$, with linear regression equation $y = 0.0989x + 13.034$ and between transpiration rate (Figure 3) and water content (Table 1), a negative correlations $R^2 = 0.5334$, with linear regression equation $y = - 114.24x + 60.089$.

At respiration rate, for Lion King, significant differences ($P<0.05$) were registered, for the initial moment, with Jaap Groot, Atlantis, and Washington cvs., and for the final moment with Indiana, Atlantis, and Washington cvs.

For Lion King bulbs, between respiration rate (Figure 2) and TSS (Table 1) a positive correlations $R^2 = 0.5064$, with linear regression equation $y = 0.5372x – 4.5628$ and between transpiration rate (Figure 3) and water content (Table 1), a significant positive correlations $R^2 = 0.8321$, with linear regression equation $y = 100.66x + 55.588$.

At respiration rate, for Sensual Touch, significant differences ($P<0.05$) were registered, for the initial moment, with Jaap Groot cv. For Sensual Touch bulbs was determined between respiration rate (Figure 2) and TSS (Table 1) a positive correlations $R^2 = 0.7639$, with linear regression equation $y = 0.2111x + 7.0618$ and between transpiration rate (Figure 3) and water content (Table 1), a negative correlations $R^2 = 0.5135$, with linear regression equation $y = - 54.826x + 56.116$.

At respiration rate, for Jaap Groot, significant differences ($P<0.05$) were registered, for the initial moment, with Marilyn, Indiana, and Atlantis cvs. and for the final moment with Indiana cv.

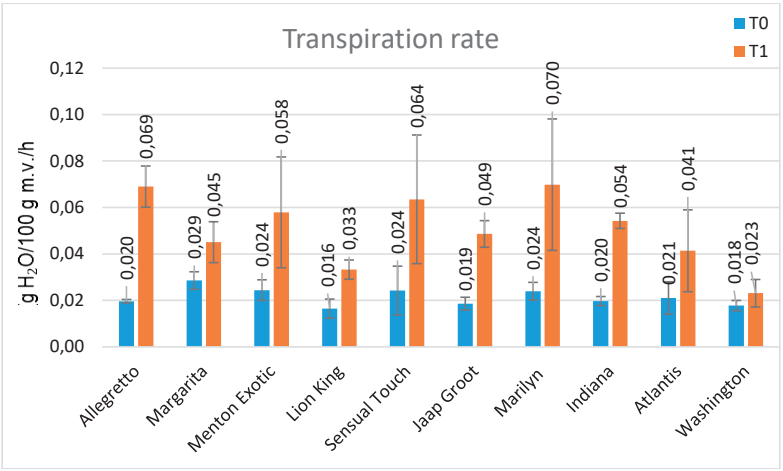

Figure 3. Transpiration rate during storage in cold room

For Jaap Groot bulbs, between transpiration rate (Figure 3) and water content (Table 1), a very significant positive correlations $R^2 = 0.9302$, with linear regression equation $y = 54.504x + 56.74$. At respiration rate, for Marilyn, significant differences ($P<0.05$) were registered, for the initial moment, with Atlantis and Washington cvs. For Marilyn bulbs, between respiration rate (Figure 2) and TSS (Table 1) a positive correlations $R^2 = 0.5868$, with linear regression equation $y = 0.0868x + 17.725$ and between transpiration rate (Figure 3) and water content (Table 1), a positive correlations $R^2 = 0.608$, with linear regression equation $y = 6.4281x + 50.022$.

At respiration rate, for Indiana, significant differences ($P<0.05$) were registered, for the initial moment, with Washington cv.

For Indiana bulbs, between respiration rate (Figure 2) and TSS (Table 1) was determined a positive correlations $R^2 = 0.6115$, with linear regression equation $y = 0.1334x + 16.908$ and between transpiration rate (Figure 3) and water content (Table 1), a very strong significant negative correlations $R^2 = 0.98$, with linear regression equation $y = -9.5894x + 51.342$.

Table 1. Variation of water content and TSS(%), glucose(%) and fructose(%) during storage in cold room

	Water content (%)		TSS (%)				Glucose (%)				Fructose (%)			
	T0	T1	T0		T1		T0		T1		T0		T1	
Samples			Average	Std	Average	Std	Average	Std	Average	Std	Average	Std	Average	Std
Allegretto	58.9	54.5	7.3	0.7	23.1	1.7	7.5	0.8	23.7	1.9	7.6	1.0	24.1	1.8
Margarita	51.9	50.6	8.9	0.1	23.9	2.8	8.6	0.5	24.7	2.2	9.7	1.1	23.9	1.5
Menton Exotic	59.0	51.8	14.1	1.9	26.1	0.9	14.1	2.1	27.0	0.7	14.0	1.7	27.6	0.5
Lion King	57.1	59.1	12.6	2.7	23.4	2.4	12.6	2.6	24.6	2.3	12.6	2.6	25.1	3.0
Sensual Touch	55.8	51.6	12.1	0.7	27.7	2.1	12.8	1.2	29.5	2.3	11.9	1.3	30.3	2.6
Jaap Groot	57.7	59.5	20.5	2.8	20.4	3.4	20.6	2.8	21.5	3.2	20.9	2.9	21.6	3.2
Marilyn	50.1	50.6	19.2	3.2	29.3	0.8	19.8	3.0	30.8	0.9	20.2	3.2	31.2	1.5
Indiana	51.2	50.8	20.4	2.7	26.9	2.9	21.2	2.3	27.8	3.1	21.2	2.5	30.4	1.3
Atlantis	54.2	55.5	15.9	1.8	23.3	0.8	16.1	1.8	24.3	0.8	15.9	1.4	25.0	0.7
Washington	53.5	53.4	15.6	1.3	23.6	1.2	15.9	1.4	25.0	1.5	15.4	1.7	25.5	1.8

For Atlantis bulbs, between respiration rate (Figure 2) and TSS (Table 1) a strong significant positive correlations $R^2 = 0.8424$, with linear regression equation $y = 0.1113x + 13.629$ and between transpiration rate (Figure 3) and water content (Table 1) was a positive correlations $R^2 = 0.4079$, with linear regression equation $y = 27.33x + 54.005$.

For Washington bulbs, between respiration rate (Figure 2) and TSS (Table 1) a strong significant positive correlations $R^2 = 0.8456$, with linear regression equation $y = 0.1061x +$

14.11 and between transpiration rate (Figure 3) and water content (Table 1), a negative correlations $R^2 = 0.2991$, with linear regression equation $y = -4.5106x + 53.501$.

The transpiration rate for tulip bulbs, (Figure 3) during long term cold storage registered great variation between cultivars, most of them due their genetics characteristics, correlated with their humidity. According to Atanasova (2020) the bulbs quality could influence the profitability ratio due to their flowering capacity and price costs.

The transpiration rate registered low variations during long term cold storage for Atlantis and Washington cvs., and significant differences ($P<0.05$) were registered for Allegretto, Jaap Groot or Indiana cvs.

The tulip bulbs water content varied according to the cultivar. The most important water loss was registered at Menton exotic bulbs, probably with the transpiration rate increase, despite the high relative humidity (RH 90%) storage conditions. Significant differences ($P<0.05$) were registered between Jaap Groot and Washington transpiration rates at final moment, as well as between Indiana and Washington cv.

The Allegreto bulbs metabolism registered in that experimental conditions, a high, increased, intensified metabolism, while the physiological processes took place at the lowest intensities at variety Lion King.

According to Burzo (2005) and Koksal (2010), exposure of the bulbs to low temperatures determine increased glucose, fructose and sugar levels that could increase the respiratory quotient and respiratory rate, too. For Allegreto and Margarita the glucose, fructose and TSS concentrations increased greatly during long term cold storage (Table 1), beeing correlated with increased respiration rates (3-4 times in 160 storage days).

CONCLUSIONS

Allegretto, Margarita, Menton Exotic, Atlantis and Washigton cultivars presented significant positive correlations between respiration rate and TSS content during storage period. Allegretto and Indiana presented significant negative correlations between transpiration rate and water content. Lion King and Jaap Groot presented significant positive correlations between transpiration rate and water content.

However, future research is needed for a better understanding of the influence of temperature on physiological and biochemical processes in tulip bulbs during long term cold storage.

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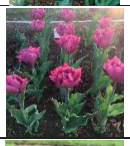
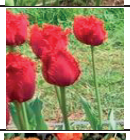
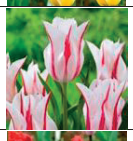
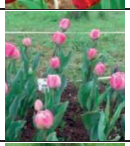
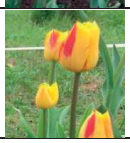
Annex 1. Characteristics of studied tulips cultivars

Variety	Group	Description	
Double late	Allegretto	the height of the flowers reaches up to 35 cm with red flowers in the lower part and yellow in the upper part	
	Margarita	the height of the flowers reaches up to 30 cm with a cyclamen flower, fragrant	
	Menton Exotic	the height of the flowers reaches up to 45-50 cm with a pink flower	
Double fringed	Lion King	the size of the flowers reaches up to 30-35 cm with a red flower beaten with a serrated edge	
	Sensual Touch	the height of the flowers reaches up to 40 cm with orange blossom beaten with a serrated edge	
Darwin	Jaap Groot	talia reaches up to 50-60 cm with yellow flower with flames and white margin, with medium flowering	
Lily flower	Marilyn	the height of the flowers reaches up to 50 cm with a white flower with red flames	
Fringed	Indiana	the height of the flowers reaches up to 50 cm, a red flower with a serrated edge	
Simple of late	Atlantis	the height of the flowers reaches up to 40 cm, the flower is purple with a yellow-white edge	
Triumph	Washington	the height of the flowers reaches up to 60-70 cm with a yellow flower with red flames, with medium flowering	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