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PHYSIOLOGICAL PARAMETERS CHANGES IN HYACINTH BULBS DURING COLD STORAGE

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Abstract

Although the bulbs are produced in many countries, the Netherlands is the center of the world flower bulb industry. Bulbs are specialized underground organs that undergo a series of physiological and biochemical changes during the cold season. The main purpose of this paper was to to compare the correlations between physiological parameters and biochemical changes. The storage conditions for hyacinth bulbs were: T:1°C and RH: 90%, and the five cultivars of hyacinths chosen for analysis (Gipsy Queen, Jan Boss, Miss Saigon, Pink Pearl, White Pearl), these being analyzed at two different moments (before and after the storage period), and the analyzes performed were: respiration and transpiration rates, mass loss, glucose, fructose and soluble solids contents. From obtained results it was observed decreases of the mass loss between 6% (for Jan Boss and Pink Pearl cultivars) and 10% (for White Pearl cultivar), between the initial and the final moment of analyses. For respiration rate were observed increases between 4 times (for Jan Boss cv.) up to 6 times (for Pink Pearl cv), between the initial and final moments. The soluble solids content recorded an increase between 10% for Miss Saigon cv. up to 20% for Gipsy Queen cv., between the initial and final moments.

Key words*: hyacinth, mass loss, respiration rate, transpiration rate.*

INTRODUCTION

Although the bulbs are produced in many countries, the Netherlands is the center of the world flower bulb industry (De Hertogh, 1974). Bulbs are specialized underground organs that undergo a series of physiological and biochemical changes during the cold season (Khodorova, 2013).

The common hyacinth, *Hyacinthus orietalis,* belong to the *Hyacinthaceae* family (Addai, 2011), and is a perennial plant with high resistance to cold (Saniewski, 1977). The height at maturity reaches up to 25-30 cm, depending on the cultivar. It blooms very well both in the sun and in partial shade and lasts 2-3 weeks.

The factors that differentiate vegetative buds into flowering buds are temperature and storage time (Delian, 2013).

Low temperatures during storage cause the end of dormancy and the growth of flowering buds (Burzo, 2016). Hyacinth bulbs, like tulip bulbs, go through rest period during the summer (Burzo, 2016). The geophytes have stored reserves in their bulb (Addai, 2011), this is why the floricultural greenhouse industry use only large bulbs for forcing (De Hertogh, 1974).

Mitochondrial respiration increases when flower formation is induced (Kanneworf, 1994).

The correlation between the reserves of the bulb and the flower production, is important for the flower production industry and it depends on the bulb size (Addai, 2011).

Koksal (2010) suggests that knowledge about biochemical changes during bulb storage is largely related to onion bulbs, rather than ornamental ones.

The most important biochemical changes during storage period is the transformation of starch into sugars (Koksal, 2010).

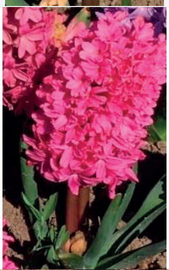
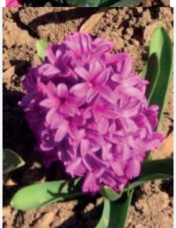
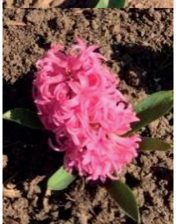
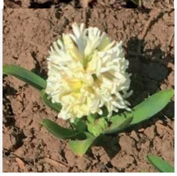
The main purpose of this paper was to to compare the correlations between physiological parameters and biochemical changes of five hyacinth cultivars, before and after the storage period, in cold room conditions.

MATERIALS AND METHODS

The hyacinth bulbs with about 75-85 g, in uniform size, for each cultivar, were stored in perforated paper bag.

The hyacinth cultivars studied were: 'Gipsy Queen' (orange flowers), 'Jan Boss' (red flowers), 'Miss Saigon' (blue-purple flowers), 'Pink Pearl' (intense pink color flowers), 'White Pearl' (white flowers) (Figure 1, Table 1).

Table 1. Features hyacinth cultivars studied

Cultivar	Flowering period	
Gipsy Queen	April – May	
Jan Boss	April – May	
Miss Saigon	April – May	
Pink Pearl	April – May	
White Pearl	March - April	

The bulbs were stored and monitored in cold room (Figure 2), under following conditions: T: 1°C and RH: 90%, for 160 days (Burzo, 2005; Burzo, 2017), in the Postharvest Technologies Laboratory of the Research Center for Studies of Food Quality and Agricultural Products, of the USAMV Bucharest.

Figure 1. Hyacinth cultivars used in this study, in experimental field

The main purpose of this study is to determine the correlations between physiological parameters like: respiration and transpiration rates and biochemical changes like: mass loss, total soluble solids (TSS), and the contents of glucose and fructose, after 160 days of cold storage.

Figure 2. Hyacinth bulbs after 160 days stored in cold storage

Respiration rate was determined with a static, closed system, in containers with hermetic closure with a volume of 1180 ml (Figure 3A, 3B). 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 (Enciu, 2020; Stan, 2020).

The transpiration rate was measured through gravimetric analysis (Figure 3 C) (Fante, 2014; Enciu, 2020; Stan, 2020) and the results were expressed in g water/100 g f.w./hour.

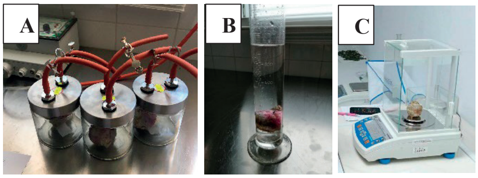


Figure 3. Physiological parameters determination

The water and dry matter contents were determined using the Memmert UN110 oven, for 24 hours at 105°C (Figure 4), method also used by Delian (2011) and Popa et al. (2019).

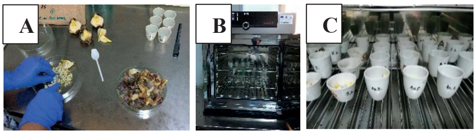


Figure 4. Determination of dry matter content by oven

The contents of total soluble solids, glucose and fructose were determined from 3 bulbs for each sample (Figure 5): with refractive device Kruss DR301-95 (% Brix) for total soluble solids, with refractive device Milwaukee MA873 (%) for glucose and with refractive device Milwaukee MA872 (%) for fructose.

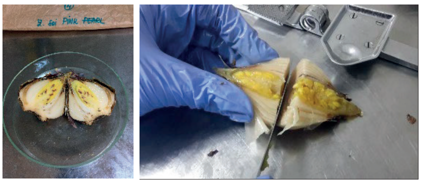


Figure 5. Determination of total soluble solids, glucose and fructose of hyacinth cultivars

Statistical analyses were performed using Excel, like: mean, standard deviation, ANOVA single factor, T Test and correlations (Pomohaci, 2017) and also applying Tukey HSD and Bonferroni and Holm (https://astatsa.com/OneWay_Anova_with_TukeyHSD/_get_data/).

RESULTS AND DISCUSSIONS

For hyacinth bulbs, the respiration rate (Figure 6) registered increases between 4 times (for 'Jan Boss' cv.) up to 6 times (for 'Pink Pearl' cv), between the initial and final moments. Kanneworff W. (1994) suggest 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 2).

At respiration rate, for all cultivars, significant differences ($P<0.05$) were registered, for the initial moment, using ANOVA single factor.

For 'Gipsy Queen' bulbs, between respiration rate (Figure 6) and TSS (Table 2) was registered a significant positive correlations $R^2 = 0.7924$, with linear regression equation $y = 0.0459x + 20.23$ and between transpiration rate (Figure 7) and water content (Table 2), was registered a strong significant negative correlations $R^2 = 0.828$, with linear regression equation $y = - 287.43x + 73.575$.

Respiration rate showed significant differences ($P<0.05$) for initial moment, between 'Gipsy Queen' cv. and 'White Pearl' cv., and between 'Miss Saigon' and 'White Pearl' cv., applying Tukey HSD and between 'Gipsy Queen' cv. and 'White Pearl' cv., applying Bonferroni and Holm (https://astatsa.com/OneWay_Anova_with_TukeyHSD/_get_data/). No significant differences appeared for respiration rate between cultivars., for the final moment.

For 'Jan Boss' bulbs, between respiration rate (Figure 6) and TSS (Table 2) was registered a positive correlation $R^2 = 0.3994$, with linear regression equation $y = 0.0432x + 20.946$ and between transpiration rate (Figure 7) and water content (Table 1) was registered a very significant negative correlations $R^2 = 0.9419$, with linear regression equation $y = - 224.98x + 72.504$.

For'Miss Saigon' bulbs, between respiration rate (Figure 6) and TSS (Table 2) was registered a positive correlations $R^2 = 0.3706$, with linear regression equation $y = 0.0222x + 22.723$ and between transpiration rate (Figure 7) and water content (Table 2) was registered a very significant negative correlations $R^2 = 0.9745$, with linear regression equation $y = -239.52x + 73.763$.

For 'Pink Pearl' bulbs, between transpiration rate (Figure 7) and water content (Table 2) was registered a semnificant negative correlations $R^2 = 0.8231$, with linear regression equation $y = -101.79x + 66.729$.

For 'White Pearl' bulbs, between transpiration rate (Figure 7) and water content (Table 2) was registered a negative correlations $R^2 = 0.5543$, with linear regression equation $y = -73.878x + 67.173$.

The transpiration rate for hyacinth bulbs, (Figure 7) during storage registered increases with 2 times (for 'Gipsy Queen' and 'Jan Boss' cvs.) up to 3 times more (for 'White Pearl'cv.) between the initial and final moments. From obtained results it was observed decreases of the mass loss between 6% (for 'Jan Boss' and 'Pink Pearl' cultivars) and 10% (for 'White Pearl' cultivar), between the initial and the final moment of analyses.

For transpiration rate, no significant differences ($P<0.05$) were registered, between all five cultivars, for each moment, applying Tukey HSD and Bonferroni and Holm (https://astatsa.com/OneWay_Anova_with_TukeyHSD/_get_data/).

Between the initial moment and the final moment significant differences ($P<0.05$) were registered, for transpiration rate, for 'Gipsy Queen', 'Jan Boss', 'Miss Saigon', and 'Pink Pearl' cvs., applying Tukey HSD and Bonferroni and Holm0(https://astatsa.com/OneWay_Anova_with_TukeyHSD/_get_data/).

For transpiration rate, no significant differences ($P<0.05$) were registered, between the initial moment and the final moment, for 'White Pearl' cultivar, applying Tukey HSD and Bonferroniand Holm (https://astatsa.com/OneWay_Anova_with_TukeyHSD/_get_data/).

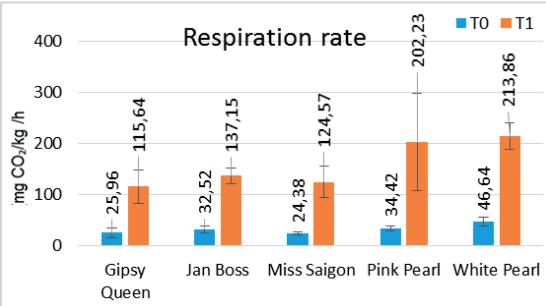


Figure 6. Respiration rate during storage in cold room

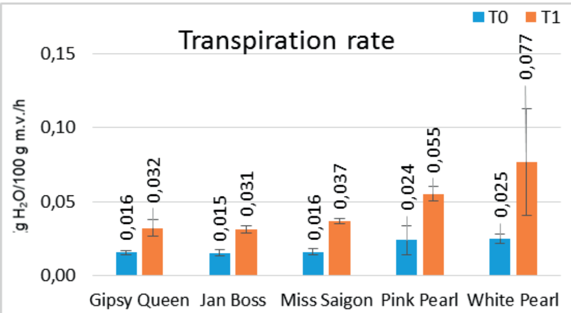


Figure 7. Transpiration rate during storage in cold room

Table 2. Variation of water content (%), 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
Gipsy Queen	69,6	63,9	20,9	0,4	26,0	0,2	22,0	0,4	27,5	0,4	22,1	0,3	27,7	1,2
Jan Boss	69,2	65,3	22,3	4,0	26,9	1,5	23,4	4,9	28,0	1,2	24,1	4,2	28,3	0,7
Miss Saigon	70,0	64,9	23,1	1,6	25,7	1,5	24,2	2,2	26,5	1,2	23,4	2,5	26,4	1,3
Pink Pearl	64,6	60,8	29,0	1,6	26,7	1,6	29,8	1,6	28,9	1,9	29,7	1,4	29,4	2,2
White Pearl	66,9	60,0	21,9	3,7	25,2	4,2	23,0	3,9	26,9	4,1	23,0	3,5	27,6	4,5

The soluble solids content for hyacinth bulbs, (Table 2) during storage registered increases between 10% (for Miss Saigon cv.) and 20% (for Gipsy Queen cv.) between the initial and final moment. Only for Pink Pearl cv., from the obtained results it was observed a decrease of the soluble solids content with 8.5% between the initial and final moment.

The glucose content for hyacinth bulbs (Table 2) during storage registered increases between 9.5% (for Miss Saigon cv.) and 20% (for Gipsy Queen cv.) between the initial and final moment. Also fructose content registered increases between 11% (for Miss Saigon cv.) and 20% (for Gipsy Queen cv.), between the initial and final moment.

Only for Pink Pearl cv., from the obtained results it was observed decreases of the glucose content with 3% and fructose content with 1%, between the initial and final moment, mostly due to the respiration rate increase.

Between all cultivars, the contents of total soluble solids, glucose and fructose registered significant differences ($P<0.05$) for the initial moment, using ANOVA single factor.

After storage, for all cultivars, the contents of total soluble solids, glucose and fructose registered no significant differences ($P>0.05$) using ANOVA single factor.

No significant differences ($P>0.05$) were registered between the initial moment and the final moment, for soluble solids content (White Pearl cv.), for glucose content (Pink Pearl and White Pearl cvs.) and for fructose content (Pink Pearl cv.), applying T Test.

According to the results obtained in this study, shown in Table 2, similar to Burzo (2005), it is concluded that exposure of bulbs to low temperatures leads to increased glucose, fructose and sugar levels (Koksal, 2010).

CONCLUSIONS

'Gipsy Queen', 'Jan Boss' and 'Miss Saigon' cultivars presented positive correlations between respiration rate and TSS content during storage period.

'Gipsy Queen', 'Jan Boss', 'Miss Saigon' and 'Pink Pearl' presented significant negative correlations between transpiration rate and water content.

The 'Pink Pearl' cultivar showed a different behavior compared to the others, the values registering decreases in soluble solids content by 8.5%, glucose content by 3% and fructose content by 1%, while the rest of the cultivars registered increases in values, between the initial and final moment. 'Pink Pearl' and 'White Pearl' bulbs started the vegetation period during their storage in the cold room, according to the physiological processes results.

However, it requires further research for the changes appeared on the physiological and biochemical processes, to highlight the influence of temperature on bulbs.

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