RESEARCH ON THERMO HYDRIC STRESS EFFECT ON SOME EARLY POTATO PHYSIOLOGICAL PROCESSES

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Abstract

The main climatic factors that affect the metabolism of horticultural plants are high temperature, low precipitation (drought) and increased soil salinity, as a result of those. This research aimed to clarify key physiological changes in *Solanum tuberosum L.* plants exposed to thermo hydric stress compared to those grown under normal conditions. Potato plants grown on sandy soil in two active humidity interval (A.H.I.) 50% and 80% were analyzed. Water stress conditions (50% from AHI) reduced the average intensity of the photosynthesis process of the five varieties of potatoes with an average of 16%, compared with irrigated (80% AHI). Under water stress, the average intensity of respiration process of the five varieties was higher by 7.8% compared with the variants grown at soil moisture of 80% AHI. Water stress occurred in the case of the 50% AHI, caused inhibition of transpiration in all varieties. Thermo hydric stress had no net influence on leaf chlorophyll content. Tresor variety grown in water stress conditions (50% AHI) was characterized by the most intense metabolic activity, with the highest intensity of the processes of photosynthesis, respiration, transpiration and highest chlorophyll content in leaves.

Key words: *Solanum tuberosum L.*, thermo hydric stress, photosynthesis, respiration process, transpiration.

Plants are sensitive organisms, which interact with the environment and respond appropriately. They have adapted to specific environmental conditions that allow them to carry out their life processes under optimal conditions and can ensure the perpetuation of the species.

The main climatic factors that affect the metabolism of horticultural plants are high temperature, low precipitation (drought) and increased soil salinity, as a result of those. If the values of these factors are outside the limits of optimal temperature and humidity can become stressful and survival in these conditions varies with the specie and variety (resistant, tolerant or sensitive).

Under these conditions water loss from the cells determines hydro passive close of the stomata, wilting plants, decrease the intensity of photosynthesis, transpiration and respiration.

Simultaneously with passive reactions, some active reactions of acclimatization occur, which are achieved with the participation of genes and will enable plants to survive under accentuated stress.

The acclimatization is performed while the plants are exposed to moderate environmental stress.

This research aimed to clarify key physiological changes in *Solanum tuberosum L.* plants exposed to thermo hydric stress compared to those grown under normal conditions.

MATERIAL AND METHOD

The research was conducted with biological material taken from the Research Station for Plant Development on Sand Dăbuleni, Dolj County.

Following varieties of *Solanum tuberosum L.* were taken into research: "Astral", "Magic", "Robusta", "Sante" and "Tresor".

Potato plants grown on sandy soil in two active humidity interval (A.H.I.) 50% and 80% were analyzed.

The parameters studied were dynamically followed in three stages: budding, blooming and tuberization. Following variants were organized: V1 - Astral 50%, V2 - Astral 80% V3 - Magic 50%, V4 - Magic 80%, V5 - 50% Robusta, V6 - 80% Robusta V7 - Sante 50% V8 - Sante 80% V9 - Tresor 50% V10 - Tresor 80%.

Analyzes were conducted under field conditions for photosynthesis, respiration and transpiration and in laboratory conditions for pigments in leaves. The intensity of photosynthesis was determined by automatic analyzer LC Pro +, in

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the experience field, on young and mature leaves on different floors of the plant. The results were expressed as μmol CO_2 m^{-2} s^{-1}.

Leaf respiration intensity was determined by automatic analyzer LC Pro +, in the experience field, on young and mature leaves on different floors of the plant. The results were expressed as μmol CO_2 m^{-2} s^{-1}.

Leaf transpiration intensity was determined by automatic analyzer LC Pro +, in the experience field, on young and mature leaves on different floors of the plant. The results were expressed as μmol $H_2Om^{-2}sec^{-1}$.

Assimilating pigments content in leaves was determined by extraction in 80% acetone and colorimetry at 663 nm, 646 nm and 470 nm wavelengths. One gram of plant material was weighed that was grounded in the presence of quartz sand. The tissue was washed several times with 100% acetone, filtered under vacuum and passed quantitatively into a 100 ml volumetric flask. The resulting acetone extract was dosed spectrophotometrically against a blank of acetone 80% in the three wavelengths specified. The results were calculated using formulas developed by Mackiney and values expressed in mg $100g^{-1}$ plant material

Chlorophyll a = (2,26 x DO_{663}) - (2,81 x DO_{646}) x 5
Chlorophyll b = (20,13 x DO_{646}) - (5,03 x DO_{663}) x 5
Carotenes and xanthophylls = (1000 x DO_{470}) - (3,27 x Cl.a - 1,04 x Cl.b).

RESULTS AND DISCUSSIONS

The intensity of photosynthesis

Research conducted so far have indicated that under thermo hydric stress, stomatal closure occurs, significantly lowering the activity of the enzyme ribulose-1 ,5-diphosphate carboxylase / oxygenase and electron transport between QA and QB conveyor plastochinones of photosystem II is inhibited (Havaux, 1999).

Measurements on the five potato varieties grown in two soil moisture conditions were carried out under measured conditions of temperature and light intensity (*table 1*).

Table 1

Conditions of temperature and light intensity in which the measurements have been made

Analyzed phase	Temperature °C	Light intensity μmoli/m^2/s
Budding	18.4 – 21.2	800 – 1300
Blooming	25.9 – 32.7	1202 – 1400
Tuberization	38.4 – 42.3	1129 - 1190

The data presented has shown that the measurements carried out during the leaves temperature rose from 18.4 to 21.2 ° C during the budding, at 25.9 to 32.7 ° C during the blooming and reached maximum values in tuberization period: from 38.4 to 42.3° C. Luminous intensity showed less variation, namely between 800 - 1300 μmoli/m^2/s during the bud, maximum values: 1202 to 1400 μmoli/m^2/s and intermediate values blooming period 1129-1190 μmoli/m^2/s during the tuberization (*tab.1*).

Table 2

The photosynthesis intensity of five potato varieties grown in two soil moisture conditions expressed in μmol CO_2 m^{-2} s^{-1}

Variety	Irrigation degree	Budding	Blooming	Tuberization	Average
Astral	50% AHI	17.01	14.64	4.25	11.97
	80%AHI	19.57	16.62	6.52	14.24
	Average	18.29	15.63	5.39	13.10
Magic	50%AHI	17.18	11.89	8.52	12.53
	80%AHI	11.59	8.92	15.47	11.99
	Average	14.39	10.41	12.00	12.26
Robusta	50% AHI	16.56	15.27	3.50	11.78
	80%AHI	11.06	14.40	8.55	11.34
	Average	13.81	14.84	6.03	11.56
Sante	50% AHI	19.05	8.16	3.94	10.38
	80%AHI	17.46	17.28	10.68	15.14
	Average	18.26	12.72	7.31	2.76
Tresor	50% AHI	12.88	15.98	12.16	13.67
	80%AHI	18.52	20.53	12.92	17.32
	Average	15.70	18.26	12.54	15.50
Average		16.09	14.37	8.65	13.04

From the average values for all variants it is showed that the intensity of photosynthesis peaked in young leaves in the bud stage (16.09 μmol CO_2 m^{-2} s^{-1}), although the light intensity presented in this period was minimum. The results correspond to those obtained by Sestak (1985), who found that during the growing season, the

intensity of this process decreases. However individual analysis of the five varieties showed that two varieties: Robusta and Tresor present the maximum photosynthetic intensity during blooming, when the highest light intensity was determined. (*tab. 2*).

The average intensity of the photosynthesis process varied depending on the variety.

The smallest value for this process where found at Robusta variety: 11.56 μmol CO_2 m^{-2} s^{-1} and the highest Astral: 13.10 μmol CO_2 m^{-2} s^{-1}.

Water stress conditions (50% of AHI) reduced the average intensity of the photosynthesis process of the five varieties of potatoes with an average of 16%, compared with irrigated (80% AHI). Thus, the average value of the intensity of the process, on the five varieties was 12.07 μmol CO_2 m^{-2} s^{-1} in 50% AHI conditions and 14.00 μmol CO_2 m^{-2} s^{-1} in 80% AHI variant. Among the varieties studied, the highest values of the intensity of photosynthesis, under thermo hydric stress, showed Magic with 12.53 μmol CO_2 m^{-2} s^{-1} and Tresor with 13,67μmol CO_2 m^{-2} s^{-1}.

Respiration intensity process

According to van Hoff's law, the process of breathing increases as the temperature increases. Under heat stress, over 40-45 ° C, the protein structure is affected, resulting in decreased intensity of breath process. The intensity of respiration of plants under water stress is less affected as compared with the intensity of photosynthesis.

Determining the intensity of respiration process was carried out with the LC pro + machine in the same temperature conditions as for the photosynthesis process. respiration intensity of the leaves had minimum value: 0.93 μmol CO_2 m^{-2} s^{-1} in the bud stage. In this step, the leaves are young, the intensity of respiration is maximized, but the lower temperature at which the analysis was carried out (18.4 to 21.2 ° C) determined the intensity of the process to be low (*tab.3*).

During blossoming, the leaves have not reached full maturity and the temperature rose from 25.9 to 32.7 ° C was achieved maximum intensity of this process: 2.24 μmol CO_2 m^{-2} s^{-1}. In tuberization phase was achieved highest leaf temperature: 38.4 to 42.3 ° C, but the advanced maturity of the leaves caused the breathing intensity to be less than the blossoming stage (1.62 μmol CO_2 m^{-2} s^{-1}).

Table 3

The leaves respiration intensity of five potato varieties grown in two soil moisture conditions expressed in μmol CO_2 m^{-2} s^{-1}

Variety	Irrigation degree	Budding	Blooming	Tuberization	Average
Astral	50% AHI	0.76	2.33	1.42	1.50
	80%AHI	0.50	2.36	1.00	1.29
	Average	0.63	2.34	1.21	1.40
Magic	50% AHI	0.45	1.76	1.53	1.25
	80%AHI	0.56	1.80	1.65	1.34
	Average	0.50	1.78	1.59	1.29
Robusta	50% AHI	0.63	1.10	2.11	1.28
	80%AHI	1.31	1.74	2.32	1.79
	Average	0.97	1.42	2.21	1.54
Sante	50% AHI	1.00	2.50	1.15	1.55
	80%AHI	0.72	1.94	1.18	1.28
	Average	0.86	2.22	1.16	1.42
Tresor	50% AHI	3.23	3.19	1.76	2.73
	80%AHI	0.15	3.73	2.15	2.01
	Average	1.69	3.46	1.95	2.37
Average		0.93	2.24	1.62	1.60

Leaves respiration intensity showed variations depending on the variety. The most intense average respiration was determined at the Tresor variety (2.37 μmol CO_2 m^{-2} s-1) and Sante variety 1.42 (μmol CO_2 m^{-2} s^{-1}) and lowest in variety Magic (1.29 μmol CO_2 m^{-2} s^{-1}).

Regarding the effect of water stress on the intensity of respiration process, it was found that in all five varieties, the average intensity of this process was higher by 7.8% compared with the variants grown in 80% AHI soil moisture. The highest values of the intensity of this process were determined at the Sante (1.55 μmol CO_2 m^{-2} s^{1}) and Tresor (2.73 μmol CO_2 m^{-2} s^{1}) varieties and the lower at the Magic variety (1.25 μmol CO_2 m^{-2} s^{1}).

Intensity of transpiration

The transpiration intensity is maximal in the case young leaves, but is related to the temperature and the relative humidity of the atmosphere. In case of thermo hydric stress, the intensity of this process increases in the early stages and then decreases due to hidropassive and hydroactive stomatal closure (Burzo and Dobrescu, 2012).

In field measured values are presented. (*tab. 4)*.

Table 4

Leaves transpiration intensity of the five varieties of potato, grown in two soil moisture conditions expressed in μmol $H_2Om^{-2}sec^{-1}$

Variety	Irrigation degree	Budding	Blooming	Tuberization	Average
Astral	50% AHI	1.49	1.59	3.17	2.08
	80%AHI	1.56	3.22	4.41	3.06
	Average	1.53	2.41	3.79	2.57
Magic	50% AHI	1.73	3.01	4.13	2.96
	80%AHI	1.60	2.64	5.96	3.40
	Average	1.67	2.83	5.05	3.18
Robusta	50% AHI	1.53	3.17	1.93	2.21
	80%AHI	1.80	3.05	4.03	2.96
	Average	1.67	3.11	2.98	2.59
Sante	50% AHI	1.38	2.13	2.31	1.94
	80%AHI	1.70	4.08	5.75	3.84
	Average	1.54	3.11	4.03	2.89
Tresor	50% AHI	1.76	4.10	6.07	3.98
	80%AHI	2.28	2.66	3.30	2.75
	Average	2.02	3.38	4.69	3.36
Average		1.69	2.97	4.10	2.92

It is noted that the transpiration intensity increased during the growing season, in correlation with the temperature values. Thus, during the buds when the temperature varied between 18.4 and 21.2 ° C, the intensity of transpiration had an average value of 1.69 μmol $H_2Om^{-2}sec^{-1}$. In flower temperature rose from 25.9 to 32.7 ° C and the intensity of transpiration increased to 2.97 μmol $H_2Om^{-2}sec^{-1}$ and in the phase of tuberization when the temperature varied between 38.4 and 42.3 ° C intensity of this process reached 4.10 $H_2Om^{-2}sec^{-}1$.

The highest values for the 3 stages were found in the Magic variety: 3.18 μmol $H_2Om^{-2}sec^{-1}$. The lowest values were found in the varieties Robusta and Astral (2.59 and 2.57 μmol $H_2Om^{-2}sec^{-1}$ respectively).

Soil moisture regime influenced the sweating process: water stress found for irrigation by 50% AHI plants, caused inhibition of this process in all varieties. The low intensity of the process of transpiration was found in cultivar Sante: 1.94 and highest in Tresor: μmol $H_2Om^{-2}sec^{-1}$.

Leaves total chlorophyll content

Chlorophyll content of leaf varies depending on the phenophase in which measurements are carried out and it is influenced by the thermo hydric stress which stimulates the degradation of this pigment (Sestak, 1985).

From the data obtained a fluctuation of the average chlorophyll content is observed: lowest in blooming and similar in buds and tuberization phases. This variation can be put down to the difference between the maturity degrees of the leaves harvested in the three stages of analysis.

Regarding the differences between varieties, there was a higher average content of chlorophyll in Magic and Sante varieties (146.16, respectively 146.26 mg / 100 g) and lower in Robusta variety (140.54 mg / 100 g)

Thermo hydric stress had no net influence on leaf chlorophyll content. Thus the average chlorophyll content of leaves of five varieties grown in two water supply conditions was almost identical: 143.20 and 143.81 mg / 100 g The highest content of chlorophyll of leaves of plants cultivated in 50% AHI conditions was determined at the Sante variety (145.17 mg / 100 g).

Table 5

Total chlorophyll content of leaves of five potato varieties grown in two soil moisture conditions mg/100 g vegetal material

Variety	Irrigation degree	Budding	Blooming	Tuberization	Average
Astral	50% AHI	149.58	145.70	136.62	143.97
	80%AHI	141.11	149.84	142.35	144.43
	Average	145.35	147.77	139.49	144.20
Magic	50% AHI	177.64	124.12	121.55	141.10
	80%AHI	140.50	130.63	182.38	151.17
	Average	159.07	127.38	151.97	146.14
Robusta	50% AHI	165.54	135.16	126.74	142.48
	80%AHI	136.82	124.11	154.84	138.59
	Average	151.18	129.64	140.79	140.54
Sante	50% AHI	127.53	155.00	152.98	145.17
	80%AHI	133.20	164.86	144.00	147.35
	Average	130.37	159.93	148.49	146.26
Tresor	50% AHI	149.21	162.66	118.06	143.31
	80%AHI	122.34	115.82	174.36	137.51
	Average	135.78	139.24	146.21	140.41
Total		144.35	140.79	145.39	143.51

Carotene and xanthophyll leaves content

The average value of the carotene and xanthophyll pigments leaves content of plants from the experimental variants was minimum in the process of budding (25.91 mg / 100 g) in blooming rose to 32.92 mg / 100 g and made the maximum value

Differences between the average content of xanthophylls and carotene pigments from leaves of five cultivars ranged in very near limits: 31.49 mg / 100 g Tresor variety and 32.74 mg / 100 g Astral variety.

Table 6

Carotenes and xanthophylls content from leaves of five potato varieties grown in two soil moisture conditions mg/ 100 g leaves

Variety	Irrigation degree	Budding	Blooming	Tuberization	Average
Astral	50% AHI	27.62	33.58	41.83	34.34
	80%AHI	25.66	34.20	33.54	31.13
	Average	26.64	33.89	37.69	32.74
Magic	50% AHI	30.52	28.13	32.56	30.40
	80%AHI	24.80	33.42	40.79	33.00
	Average	27.66	30.78	36.68	31.70
Robusta	50% AHI	30.85	31.11	37.38	33.11
	80%AHI	26.70	33.81	33.70	31.40
	Average	28.78	32.46	35.54	32.26
Sante	50% AHI	23.26	35.35	39.76	32.79
	80%AHI	21.84	38.39	34.38	31.54
	Average	22.55	36.87	37.07	32.16
Tresor	50% AHI	25.63	35.46	26.31	29.13
	80%AHI	22.22	25.72	36.24	28.06
	Average	23.93	30.59	31.28	28.60
Average		25.91	32.92	35.65	31.49

The average content of carotenes and xanthophylls pigments from leaves of five varieties grown in the two moisture regimes showed significant differences: 21.95 mg / 100 g for the variants grown under 50% AHI and 31.03 mg / 100 g in the case of the grown under 80% AHI respectively.

Water stress conditions (50% from AHI) reduced the average intensity of the photosynthesis process of the five varieties of potatoes with an average of 16%, compared with irrigated (80% AHI). Thus, the average value of the intensity of this process, for the five varieties was 12.07 μmol CO_2 m^{-2} s^{-1} in conditions of 50% AHI and 14.00 μmol CO_2 m^{-2} s^{-1} in 80% AHI variant. Among the varieties studied, the highest values of the photosynthesis intensity, under thermo hydric

CONCLUSIONS

stress, was found for Magic with 12.53 μmol CO_2 m^{-2} s^{-1} and Tresor 13.67 μmol CO_2 m^{-2} s^{-1}.

Under water stress, the average intensity of respiration process of the five varieties was higher by 7.8% compared with the variants grown at soil moisture of 80% AHI. The highest values of the intensity of this process have been determined for the Sante variety (1.55 μmol CO_2 m^{-2} s^{-1}) and Tresor (2.73 μmol CO_2 m^{-2} s^{-1}) and lowest in variety Magic (1.25 μmol CO_2 m^{-2} s^{-1}).

Water stress occurred in the case of the 50% AHI, caused inhibition of transpiration in all varieties. The lowest intensity of this process was found to Sante variety: 1.94 μmol $H_2Om^{-2}sec^{-1}$ and highest in Tresor: 3.98 μmol $H_2Om^{-2}sec^{-1}$.

Thermo hydric stress had no net influence on leaf chlorophyll content. Thus, the average chlorophyll content from leaves of five varieties grown in two water supply conditions was almost identical: 143.20 and 143.81 mg/100 g The highest content of chlorophyll from leaves of plants cultivated in 50% AHI conditions was determined for the variety Sante (145.17 mg/100 g).

Tresor variety grown in water stress conditions (50% AHI) was characterized by the most intense metabolic activity, with the highest intensity of the processes of photosynthesis, respiration, transpiration and highest chlorophyll content in leaves.

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