RESULTS REGARDING THE TOLERANCE TO THERMO-HYDRIC STRESS OF SOME POTATO LINES CULTIVATED ON THE SANDY SOILS FROM THE SOUTH OF OLTENIA

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ABSTRACT

In this paper are presented the results regarding the physiological reactions of the 11 potato lines studied, on vegetation phenophases, in order to determine their tolerance to the thermo-hydric stress characteristic of the sandy soils area in the south of Oltenia. During the vegetation period, determinations were made with the LC Pro SD portable device, which focused on active solar radiation in photosynthesis, photosynthesis rate, air temperature, leaf transpiration rate and correlations established between these physiological parameters, specific climatic conditions of 2020 and production of potatoes obtained under these conditions. Between the physiological processes of photosynthesis and foliar transpiration, registered at RDSPCS Dăbuleni, a positive, distinctly significant correlation was established. The lines with higher tolerance to thermo-hydric stress showed an intense assimilation, directly proportional to the intensity of foliar transpiration. Lines L 15-1876 / 7 and L 18-1828 / 6 were noted in this regard. At the opposite pole, the lowest physiological activity was recorded on the lines L 1901/11 and L 1901/6.

INTRODUCTION

The potato, in the south of the country, appeared as a novelty of the last decades, with the establishment of irrigation systems. Under irrigation conditions, it was found that the steppe area offers very good growing conditions for potatoes intended for extra-early, early and summer consumption.

The practice of potato cultivation worldwide proves that all potato varieties, by cultivating them year after year, progressively lose their initial production potential, depreciate qualitatively, degenerate (Aurelia Diaconu, 2019).

As a means of combating degeneration, Louis Augustine Parmantier (considered the father of the spread of potatoes in Europe) called for the continuous creation of new seed varieties and the removal of old, degenerate varieties from cultivation.

Potato production is influenced by a complex of biological, ecological and technological factors. The factor that most strongly limits production is the drought of May-September, at the time of intense formation and accumulation of tubers, which occurs very frequently in all areas of cultivation in the south of the Romania.

Climatic conditions have an influence on the growth and development of potato plants through the effect of temperature, precipitation, light, relative humidity of air and soil.

In potato cultivation, the heat required differs during the growing season. The starting of the fangs takes place at 6-7 °C, and the rising faster at 20-21 °C, the latter being also the optimal temperatures for raising the twigs. The optimum temperatures for tuber formation and growth are 16-18 °C, hence the need for potato planting, especially in lowland areas, to be done early, the plant benefiting from a longer period of favorable conditions for harvest accumulation.

High temperatures and drought influence all plant biosynthesis processes, but especially photosynthesis, the synthesis of reactive oxygen species and hormones. In the case of plants exposed to moderate stress, which acclimatizes, there is the synthesis of numerous proteins and enzymes that allow these plants to withstand the action of a more severe thermohydric stress.

The optimum temperature for the photosynthesis process in potato plants is about 20 °C after Ku et al. (1977) and 30 °C after Hodson and Bryant (2012).

Increasing the temperature determines the inhibition of the photosynthesis process and the stimulation of the respiration process, so that the intensity of the two processes can become equal, and the plants can no longer accumulate reserve substances (Burzo Ioan, 2014).

MATERIAL AND METHOD

During the vegetation period, determinations were made with the portable device LC Pro SD, which aimed at:

- active radiation in photosynthesis;
- rate of photosynthesis;
- air temperature;
- rate of foliar transpiration;
- stomatal conductance.

The experimental variants were represented by 11 potato lines, coming from the National Research-Development Institute for Potato and Sugar Beet Braşov, where it is in full improvement process:

V1 – L 18-1828/6
V2 – L 15-1677/2
V3 - L 15-1876/7
V4 – L 1895/1
V5 – L 1901/7
V6 – L 1901/11
V7 – L 1891/1
V8 – L 1890/13
V9 – L 1895/4
V10 – L 1901/6
V11 – L 19-0000/5

The increase in temperature is also accompanied by an increase in the intensity of solar radiation, which can exceed the degree of saturation of the photoreceptor antennas. Under these conditions, the activity of the oxygen-producing complex is affected and the photoreceptor activity of photosystem II decreases, which determines the inhibition of photosynthesis and the generation of the photoinhibition process (Rout and Das, 2013).

In 2020, within the ADER project 4.1.1. *Obtaining new potato varieties with superior ability to respond to abiotic and biotic stress by using genetic determinism of tolerance*, funded by the Ministry of Agriculture and Rural Development, at RDSPCS Dabuleni were monitored 11 potato lines, on vegetation phenophases, In order to determine their tolerance to the thermo-hydric stress characteristic of the sandy soils area in southern Oltenia.

The physiology determinations were performed in two phases of vegetation, in three repetitions, and for the interpretation of the obtained data mathematical functions and analysis of variance were used.

RESULTS AND DISCUSSIONS

The climatic conditions from March to June 2020 are presented in Table 1.

The average monthly temperature was between 7.9 °C in March and 20.9 °C in June, with a four-month average of 15.4 °C, 1.2 °C higher than the multiannual average of 14, 2 °C. These data confirm that the average air temperature is constantly rising.

However, winter came late in March in three episodes, with temperatures of -5.5 °C, with precipitation in the form of snow and rain. The low temperatures of minus 2 °C continued in the first decade of April, these episodes of very cold weather delaying the start of the fangs and the emergence of all the potato lines studied.

Table 1

Air temperature (°C) and precipitation (mm) during March-June 17, 2020, recorded at the weather station of RDSPCS Dăbuleni

Month /Decade	March	April	May	June (1-17)	Average / Sum
I	7.9	9.5	21.9	20.5	
II	8.8	14.5	21.6	21.3	
III	7.0	14.8	15.8	-	
Medium temperature (°C)	7.9	12.9	19.8	20.9	15.4 +1.2
Maximum temperature (°C)	24.7	29	30	32.2	32.2
Minimum temperature (°C)	-5.5	-2	8	6.7	-5.5
Precipitations (mm)	62.77	11.6	59.2	45.2	178.77 -41.44
Multiannual medium temperature (°C)	6.0	11.9	17.1	21.6	14.2
Precipitations, multiannual total (mm)	39.48	47.14	62.86	70.73	220.21

The precipitation recorded in these months were 178.77 mm, with -41.44 mm below the multiannual amount for the four months. After the late winter episodes, recorded in march, the temperatures started to increase constantly, reaching maximums of over 29-30 °C. Against the background of high temperatures, correlated with the deficit of precipitations, the phenomenon of drought was installed, being necessary the irrigation of the potato culture.

Many experts have looked at the effects of heat stress on horticultural plants. Thus, the limit temperature at which photosystem II from potato plants was irreversibly depreciated is 38 °C (Havaux, 1999). But the plants that were exposed to the temperature of 40 °C did not suffer obvious depreciations in the activity of photosystem II, if they were acclimatized at temperatures between 30 and 35 °C.

The intensity of the photosynthesis process of the potato lines cultivated on the sandy soils from Dăbuleni is presented, in diurnal variation, in tables 2 and 3.

Table 2 shows the research results obtained in the floral bud phenophase-beginning of flowering.

At 9 o'clock the air temperature was between 21-22 °C, and the active radiation in photosynthesis showed values between 500 and 741 μmol / m^2 / s. Under these conditions, the rate of photosynthesis varied between 10.90 μmol CO_2 / m^2 / s at line L 1901/11 and 18.03 μmol CO_2 / m^2 / s at line L15-1876/7, the latter differing significantly from of control (average of the values recorded on all lines).

At noon, with the increase of temperature (23-25.1 °C) and light intensity, the photosynthetic activity of the plants intensified, especially the lines L 1891/1 and L 1890/13, with values of photosynthesis included between 21.85-22.71 μmol CO_2 / m^2 / s. The lowest values were recorded, this time as well, at line L 1901/11.

At 3 pm, the temperature rose to 31.6 °C, and the solar radiation was between 1100 and 1385 μmol / m^2 / s. Under these conditions, the average value of photosynthesis decreased slightly compared to the values recorded at noon, differing very significantly 5 of the 11 lines studied (Table 2).

Table 3 shows the diurnal variation of photosynthesis in the flowering phenophase. Compared to the results

obtained in May, in the floral bud phenophase, the rate of photosynthesis showed much lower values, with a tendency of continuous decrease during the day.

Table 2

Rate of potato photosynthesis in the floral bud phenophase

Experimental variants	Photosynthesis (µmol $CO_2/m^2/s$) - 15.05.2020								
	9^{00} o'clock			12^{00} o'clock			15^{00} o'clock		
	Average	Diff.	Signif.	Average	Diff.	Signif.	Average	Diff.	Signif.
L 18-1828/6	17.68	+2.61		18.80	+0.02		21.12	+4.22	***
L 15-1677/2	15.54	+0.47		18.51	-0.27		16.10	-0.80	
L 15-1876/7	18.03	+2.96	*	20.46	+1.68	*	20.71	+3.81	***
L 1895/1	16.43	+1.36		20.44	+1.66	*	17.20	+0.30	
L 1901/7	14.17	-0.90		16.67	-2.11	0	17.69	+0.79	
L 1901/11	10.90	-4.17	00	15.83	-2.95	00	13.86	-3.04	000
L 1891/1	14.29	-0.78		21.85	+3.07	***	18.56	+1.66	**
L 1890/13	14.53	-0.54		22.71	+3.93	***	18.99	+2.09	***
L 1895/4	13.25	-1.82		16.83	-1.95	0	12.51	-4.39	000
L 1901/6	16.95	+1.88		17.10	-1.68	0	9.90	-7.00	000
L 19-0000/5	14.05	-1.02		17.34	-1.44		19.26	+2.36	***
Control (variants average)	**15.07**	**-**		**18.78**	**-**		**16.90**	**-**	
DL 5%	2.72			1.65			1.02		
DL 1%	3.69			2.24			1.39		
DL 0.1%	5.01			3.04			1.89		

Table 3

Rate of potato photosynthesis in the flowering phenophase

Experimental variants	Photosynthesis (µmol $CO_2/m^2/s$) - 04.06.2020								
	9^{00} o'clock			12^{00} o'clock			15^{00} o'clock		
	Average	Diff.	Signif.	Average	Diff.	Signif.	Average	Diff.	Signif.
L 18-1828/6	19.97	+7.65	***	12.06	+3.32	***	6.62	+2.08	***
L 15-1677/2	9.96	-2.36		8.49	-0.25		6.26	+1.72	***
L 15-1876/7	20.24	+7.92	***	21.28	+12.54	***	4.83	+0.29	
L 1895/1	13.29	+0.97		7.29	-1.45		5.18	+0.64	
L 1901/7	8.17	-4.15	0	8.02	-0.72		2.83	-1.71	000
L 1901/11	5.20	-7.12	000	2.13	-6.61	000	4.46	-0.08	
L 1891/1	16.08	+3.76	*	18.25	+9.51	***	2.07	-2.47	000
L 1890/13	14.15	+1.83		3.93	-4.81	000	8.99	+4.45	***
L 1895/4	7.15	-5.17	00	2.20	-6.54	000	1.30	-3.24	000
L 1901/6	8.16	-4.16	0	3.23	-5.51	000	2.76	-1.78	000
L 19-0000/5	13.11	+0.79		9.21	+0.47		4.70	+0.16	
Control (variants average)	**12.32**	**-**		**8,74**	**-**		**4,54**	**-**	
DL 5%	3.76			1.63			0.69		
DL 1%	5.11			2.22			0.94		
DL 0.1%	6.93			3.00			1.27		

Table 4

Climatic conditions in the flowering phenophase (04.06.2020)

The moment of determinations (hour)	Temperature (°C)	Active radiation in photosynthesis (µmol/m^2/s)
9^{00}	30.1-32.2	1700-1756
12^{00}	32.4-34	1814-2012
15^{00}	34.5-36.1	1100-1790

This is due to the climatic conditions recorded in early June, which, from a physiological point of view, became unfavorable for the potato, the temperature and light intensity exceeding the optimal values for this species (Table 4).

With an increased tolerance to thermal stress, the lines L 18-1828 / 6 and L 15-1876 / 7 were noticed, at the opposite pole being the lines L 1901/11, L 1895/4 and L 1901/6.

The decrease in the photosynthesis process in potato plants was due, first of all, to the closure of the stomata, the prolongation of the thermal stress subsequently influencing the efficiency of the photosystem II.

The transpiration process is dependent on both the temperature level and the water content of the soil and the plant. The moderate rise in temperature stimulated the process of plant perspiration and cell dehydration. Thus, the increase of the temperature up to 25 °C, in the presence of open stomata, determined the decrease of the resistance of the tissues to the transport of water vapor and the achievement of the maximum intensity of this process (table 5).

Temperatures higher than 30 °C determined the dehydration of the stomata and their hydropassive closure, which resulted in the increase of the resistance of the tissues and the decrease of the diffusion rate of water vapor through them (table 5).

Lack of water during the formation of tubers prevents the tuberization process resulting in fewer tubers, with different ages, which leads to uneven boiling resistance and decreased yield. Drought during the period of simultaneous growth of shrubs and tubers greatly reduces production, this being the critical period for water of the plant. The potato has a fragile system of regulating water consumption and no longer economically uses water that occurs after relatively short-term deficiencies, the thermohydric stress disrupting the entire physiological activity of plants.

Between the physiological processes of photosynthesis and foliar perspiration, registered at RDSPCS Dabuleni in 2020, a positive, distinctly significant correlation was established (figure 1). The lines with higher tolerance to environmental factors specific to the area with sandy soils in southern Oltenia showed an intense assimilation, directly proportional to the intensity of foliar perspiration. Lines L 15-1876 / 7 and L 18-1828 / 6 were noted in this regard. At the opposite pole, the lowest physiological activity was recorded on the lines L 1901/11 and L 1901/6.

Tablel 5

Rate of potato transpiration in 2020

Experimental variants	TRANSPIRATION (mmol $H_2O/m^2/s$)					
	15.05.2020			04.06.2020		
	9^{00} o'clock	12^{00} o'clock	15^{00} o'clock	9^{00} o'clock	12^{00} o'clock	15^{00} o'clock
L 18-1828/6	1.67	2.46	2.89	4.13	3.25	2.38
L 15-1677/2	1.49	2.27	2.51	3.04	2.54	2.93
L 15-1876/7	1.88	2.18	3.76	5.01	6.09	2.10
L 1895/1	1.81	2.52	3.54	3.59	2.34	2.33
L 1901/7	1.55	1.71	3.71	1.88	2.73	1.35
L 1901/11	1.37	1.89	3.12	1.51	0.78	2.02
L 1891/1	1.60	2.17	4.33	3.82	4.74	1.02
L 1890/13	1.55	2.66	4.19	4.59	1.04	3.63
L 1895/4	1.47	2.22	2.69	1.71	0.54	0.73
L 1901/6	1.72	2.23	2.23	2.10	0.99	1.21
L 19-0000/5	1.45	1.89	3.87	3.26	2.97	1.45
Control (variants average)	**1.60**	**2.20**	**3.35**	**3.15**	**2.55**	**1.92**

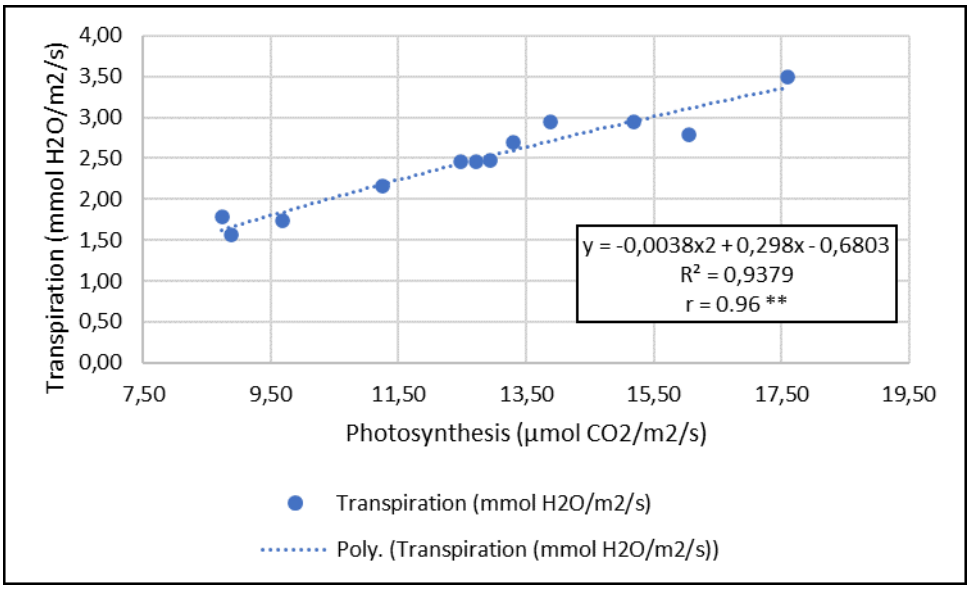

Figure 1. Correlation between photosynthesis and leaf potato transpiration-2020

CONCLUSIONS

Climatic conditions have an influence on the growth and development of potato plants through the effect of temperature, precipitation, light, relative humidity of air and soil.

Temperatures higher than 30 °C determined the dehydration of the stomata and their hydropassive closure, which resulted in the increase of the resistance of the tissues and the decrease of the diffusion rate of water vapor through them.

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At the opposite pole, the lowest physiological activity was recorded on the lines L 1901/11 and L 1901/6.

BIBLIOGRAPHY

1. **Burzo, I.,** 2014 – *Modificările climatice și efectele asupra plantelor horticole,* Editura Sitech, Craiova.
2. **Diaconu, Aurelia, and colab.**, 2019 – *6 decenii de cercetări privind cultura plantelor pe nisipuri*, p. 265, SITECH, Craiova
3. **Havaux, M.**, 1999 – *Characterisation of termal damage to the photosynthetic electron transport system in potato leaves*, Plant Science, vol. 94, no. 1-2, 19-33.
4. **Hodson, M.J., Bryant, J.A.**, 2012 – *Functional Biology of Plants,* Wiley – Blackwell, Oxford.
5. **Ku, S.B., Edwards, G.E., Tanner, C.B.**, 1977 – *Efects of light, carbon dioxide and temperature on photosynthesis, oxigen inhibition of photosynthesis and transpiration in Solanum tuberosum,* Plant Physiol. 59, 868-872.
6. **Rout, G.R., Das, A.B.,** 2013 – *Molecular Stress,* Physioligy of Plants, Springer, India.