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Diurnal variation of physiological processes at peach species grown on sandy soils, under changing of climatic conditions

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Abstract Research conducted in the field of physiology concerned the influence of climatic conditions on trees metabolism. Due to the lack of rainfall in the area of sandy soils, the peach species have registered a very low amount of water on the leaf level, beeing obligatory the irrigation of trees grown on sandy soils.
The evaporated water through leaf transpiration at the varieties that registered high values at the rate of photosynthesis is efficiently used, compared to varieties that had a reduced assimilation and a greater transpiration. Lack of fruit per tree at peach species due to the frost in winter, reduced assimilation rate due to lack of consumers, the assimilates beeing used in vegetative growth. At peach varieties studied, the bound water ranged from 2.48 % at variety Anemona, and 3.45 % at Purpuriu variety. The Purpuriu variety is more resistant to drought because the water binds strongly at the cellular level and avoids losses through excessive transpiration. Vacuolar juice concentration varied between 16,0 % at Filip variety and 18.90 % at Purpuriu variety.

Key words

photosynthesis, active radiation, leaf transpiration, rootstock

The expected changes in climatic regime in Romania fits into the global context, but with specific particularities for geographic region in which it is located. Compared to Northwest Europe, for example, where the most pronounced warming is expected in winter, for Romania, is expected that warming would be more pronounced in summer (14).

Also negative temperatures and frost are harmful for a large part of annual plants, especially if these low temperatures occur during the growing season, they may affect the crops or even destroy them completely (8, 13).

Plant response at major climate changes is accurately reflected by the alteration of known phenological models and certified by the classical studies. Parameters wich had marked the phenological stages, from emergence of buds until the fall of leaves and conclusion vegetative cycle, associated with corresponding physiological data, generates authentic data to study the effect of climate change (1).

In terms of the phenology, the main reaction to these changes is considered to be the extension of the vegetation period, namely an earlier start of spring phenophases and an extention of autumn phenophases (9,10,12). As the temperature increases, increases the intensity of photosynthesis and optimum temperatures for the process of photosynthesis are between 25 ^{0}C and 37 ^{0}C. Temperature exceeding 37-40 ^{0}C determined rapid decreases of photosynthesis intensity (5).

At a certain light intensity, called compensation point, photosynthesis has the same value with respiration, which means that CO_2 produced in respiration is consumed in photosynthesis and O_2 and organic substances produced in photosynthesis are consumed in respiration (6).

Leaf transpiration intensity is directly related to atmospheric humidity. By reducing the saturation vapor of the air increases hydric deficit and respectively intensity of leaf transpiration. In air saturated with water vapor, leaf transpiration is very weak or is missing (7).

Previous research has shown that the impact of climate change on tree species is already being felt. For example, until the late 1990s, the flourishing of trees in Germany advanced by several days. The growing season in Europe was extended by 10 days in the last 10 years (3, 4, 2).

High temperatures have positive effects on plants, through growth of biomass accumulated (11).

Material and Method

The study was conducted at the Research-Development Center for Plants Crop on Sands Dăbuleni, at peach specie, on nine varieties.

Experience is polifactorial, two factors stand in randomized blocks in four repetitions. Numbers of trees per variant is 3 trees / variety / rootstock, and 54

trees in the experimental plot. Planting distance is 4/3 meters, crown shape is free flattened.

Studied factors:

- Factor A - The variety, with 9 variants:
  a 1 – Florin;
  a 2 – Purpuriu;
  a 3 – Creola;
  a 4 – Liana;
  a 5 – Anemona;
  a 6 – Monica;
  a 7 – Catherine;
  a 8 – 8NJc 105;
  a 9 – Filip.
- Factor B – The rootstock, with 2 variants:
  b 1 – adaptable;
  b 2 – Mc 5.

Obtained results

Table 1

Climatic conditions during March – September 2016, recorded at the weather station of the Research – Development Center for Plants Crop on Sands, Dăbuleni

Month/Decade	March	April	May	June	July	August	Septembe r	Average / Amount
I	9.4	16.0	13.7	20.2	24.3	26.1	22.7	18.9
II	6.3	16.0	16.4	24.0	24.1	22.3	21.5	18.7
III	9.1	13.1	20.3	26.6	25.8	22.1	17.0	19.1
Monthly average (^{0}C)	8.3	15.0	16.8	23.6	24.8	23.5	20.4	18.9
Maximum monthly (^{0}C)	23.5	31.4	32.9	37.3	38.0	38.0	34.1	-
Minimum monthly (^{0}C)	-3.1	0.8	5.5	11.0	11.4	11.0	5.1	-
Rainfall (mm)	113.2	60.2	104.4	53.2	31.6	1.0	37.6	401.2
The average monthly temperature, multiannual (^{0}C)	5.7	11.8	16.7	21.6	23.1	22.4	17.8	17.0
The amount of monthly precipitation, multiannual (mm)	36.50	47.05	61.40	69.56	53.51	37.88	48.00	353.9

The climatic conditions during March-September 2016 were characterized by average temperatures between 8.3 °C in March and 24.3 ^{0}C in July. During the entire period under review, the average monthly temperature was higher than the average monthly multiannual. The trend of increasing air temperature is significant. The monthly average during this period was 18.9 ^{0}C compared to multiannual average of 17 degrees C, with 1.9 ^{0}C higher.

Maximum temperature exceeded 30 ^{0}C from April (31.4 ^{0}C), while the highest temperature was recorded in July and August of 38 ^{0}C. The absolute minimum was registered in March (-3.1 ^{0}C), the temperature which affected flowering buds on peach species.

The rainfall during March-September totaled 401.2 mm, with 47.3 mm more than the multiannual sum and these were unevenly distributed, the largest amount being registered in March – April. Since the second decade of June, amid high temperatures, was installed drought, which was very intense, especially in July and August.

Research conducted in the field of physiology have targeted influence of climatic conditions on trees metabolism. For the determination of physiological indices, the observations were made with Lc pro+ device.

Fig. 1 Lc pro+ Portable photosynthesis system

In May determinations were made on the peach tree physiology, grown on sandy soils. Therefore was determined the influence of the weather conditions on the metabolism of trees that have been affected by frost during rest period, frost that destroyed fruit buds.

Were performed the folowing determinations:

- active radiation in photosynthesis;
- the rate of photosynthesis;
- leaf transpiration rate;
- air temperature.

At peach varieties, climatic conditions on sandy soils influenced the speed and rhythm of accumulation of assimilates in leaves. Photosynthetic active radiation oscillated between 967 – 1552 µmol/m^2/s at 9 am, between 1369-1738 µmol/m^2/s at 12 o'clock and between 1506 – 1815 µmol/m^2/s at 15 pm. Note that the varieties Anemone, Purpuriu and Filip, absorbed a large amount of radiation at foliar level.

Photosynthesis rate presented a diurnal variation under the influence of climatic conditions, agrotechnical factors, and the varieties studied. At 9 o'clock, photosynthesis rate values were between 6.32 µmol/m^2/s at Creola variety and 15.51 µmol/m^2/s at Florin variety, at 12 o'clock between 3.07 µmol/m^2/s at Filip variety and 12.72 µmol/m^2/s at NJC 105 variety, and at 15 o'clock between 3.98 µmol/m^2/s at Catherine variety and 16.83 µmol/m^2/s at Florin variety.

Daily average values of photosynthesis, fluctuated between 6.50 µmol/m^2/s at Liana variety and 14.20 µmol/m^2/s at Florin variety. Varieties Florin and NJC 105 recorded maximum values at the rate of photosynthesis compared with varieties Creola, Filip and Catherine, who have adapted more difficult at the conditions in the area.

Table 2

Diurnal variation of physiological processes at peach species on rootstock Mc 5

Variety	RAF µmol/m^2/s	Photosynthesis µmol CO_2/m^2/s	RAF µmol/m^2/s	Photosynthesis µmol CO_2/m^2/s	RAF µmol/m^2/s	Photosynthesis µmol CO_2/m^2/s	Daily average of photosynthesis µmol CO_2/m^2/s
	9 o'clock		**12 o'clock**		**15 o'clock**		
Florin	1178	15.51	1691	10.28	1666	16.83	14.20
Purpuriu	1095	6.91	1738	9.89	1812	6.80	7.86
Creola	1225	6.32	1477	6.84	1815	8.77	7.31
Liana	967	9.43	1583	4.63	1805	5.46	6.50
Anemona	1552	13.75	1511	6.22	1635	5.08	8.35
Monica	1220	12.83	1369	7.08	1622	6.08	8.66
Catherine	1212	11.55	1568	7.88	1506	3.98	7.80
NJC 105	1160	8.10	1405	12.72	1733	5.66	8.82
Filip	1065	12.53	1668	3.07	1815	8.25	7.95

Table 2 - continuation

Variety	Temperature °C	Leaf transpiration mmol $H_2O/m^2/s$	Temperature °C	Leaf transpiration mmol $H_2O/m^2/s$	Temperature °C	Leaf transpiration mmol $H_2O/m^2/s$	Daily average of leaf transpiration mmol $H_2O/m^2/s$
	Ora 9		**Ora 12**		**Ora 15**		
Florin	25.7	1.90	30.2	1.49	29.8	3.44	2.27
Purpuriu	25.8	0.84	28.5	1.27	31.1	1.43	1.18
Creola	26.1	1.33	29.5	0.80	31.7	2.03	1.38
Liana	26.3	1.76	30.8	0.81	32.0	2.18	1.58
Anemona	26.6	1.45	31.3	1.14	32.3	1.33	1.30
Monica	27.0	1.55	31.4	0.98	32.8	1.14	1.22
Catherine	27.3	1.94	31.7	1.57	33.2	1.05	1.52
NJC 105	27.2	2.19	31.6	3.45	33.2	1.71	2.45
Filip	27.5	1.84	31.6	0.83	33.6	1.31	1.32

Leaf transpiration rate presents a diurnal variation, being influenced by air temperature, atmospheric humidity and soil moisture. At 9 o'clock, values of leaf transpiration rate ranged from 0.84 mmol $H_2O/m^2/s$ at Purpuriu variety and 2.19 mmol $H_2O/m^2/s$ at NJC105 variety, at 12 o'clock between 0.80 mmol $H_2O/m^2/s$ at Creola variety and 3.45 mmol $H_2O/m^2/s$ at NJC 105 variety, and at 15 o'clock between 1.05 mmol $H_2O/m^2/s$ at Catherine variety and 3.44 mmol $H_2O/m^2/s$ at Florin variety.

NJC and Florin varieties have presented higher values of leaf transpiration rate, but accumulating through maximum photosynthesis, recorded in this stage of vegetation, results that the water was harnessed effectively for vegetative growth.

Fig. 2. Drying peach leaves in an drying oven at 105 ^{0}C

Fig. 3. Drying oven with thermoregulation

Table 3

The variation of physiological indices in leafes at peach species

Variety	Total water	Free water	Bound water	Dry substance	Concentration of vacuolar juice %
Florin	67.2	64.06	3.14	32.8	18.0
Purpuriu	70.69	67.24	3.45	29.31	18.9
Creola	70.67	68.00	2.67	29.33	18.2
Liana	69.85	66.66	3.19	30.15	17.4
Anemona	70.38	67.90	2.48	29.62	17.3
Monica	70.84	68.05	2.79	29.16	16.3
Catherine	71.02	68.11	2.91	28.98	16.7
NJC 105	69.74	67.10	2.64	30.26	16.8
Filip	72.31	69.23	3.08	27.69	16.6

In the phase of intense growth of trees were carried out determinations at the following physiological indices: the total water, dry substance, free water, bound water and concentration of vacuolar juice.

At the peach species, the total water recorded values between 67.20 % at Florin variety and 72.31 % at Filip variety. Dry substance recorded values between 27.69 % (Filip variety) and 32.8 % (Florin variety). Free water recorded values between 66,6 % at Liana variety and 69.23 % at Filip variety. It notes that Philip variety presents a higher foliar hydration, than Liana variety.

Bound water was between 2.48 % at Anemone variety and 3.45 % at Purpuriu variety. The purple variety is more resistant to drought because it strongly bounds the water at the cellular level and avoids losses through excessive transpiration.

Vacuolar juice concentration varied between 16,0 % at Filip variety and 18.90 % at Purpuriu variety. Varieties which increase their concentration of vacuolar juice are more tolerant and resistant to drought.

Due to the lack of rainfall in sandy soils area, the fruit trees recorded very low amount of water on the leaf level, being obligatory the irrigation of trees grown on sandy soils.

Conclusions

1. At peach species, bound water was between 2.48 % at Anemone variety and 3.45 % at Purpuriu variety. The Purpuriu variety is more resistant to drought because it strongly bounds the water at the cellular level and avoids losses trough excessive transpiration.
2. Vacuolar juice concentration varied between 16,0 % at Filip variety and 18.90 % at Purpuriu variety. Varieties which increase their concentration of vacuolar juice are more tolerant and resistant to drought.
3. The rate of photosynthesis at peach species presented a diurnal variation under the influence of climatic conditions, agrotechnical factors (rootstock), phases of vegetation and varieties studied.
4. Leaf transpiration rate presents a diurnal variation, being influenced by air temperature, atmospheric humidity, soil humidity, species and varieties studied.

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