PHOTOSYNTHESIS RATE, TRANSPIRATION AND STOMATAL CONDUCTANCE OF VEGETABLE SPECIES IN PROTECTED ORGANIC CROPS

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Abstract

This paper approached the variations of some ecophysiological parameters of the certain specie of vegetables under controlled systems such the greenhouses and solariums. The aim of this work is to appreciate the ecophysiological response through the processes of photosynthesis, transpiration and stomatal conductivity for water. It were studied the ecophysiological response of some varieties of tomato, eggplant and sweet pepper to a controlled condition in solarium. The analyses concerning processes of photosynthesis, transpiration were performed with LCi portable systems on field who analzyed with infrared on non damaging plant. The results were followed the comparative responses of the analyzed species cultivated in conventional and organic systems. The studies was performed in protected spaces (solariums)with mostly an organic fertilization before the analyzed crops setting.The photosynthesis, transpiration and stomatal conductance were higher after flowering phenophasis in organic and also in ecological systems, especially in the middle part of the plant (luxuriant tomato). It was also analzyed the assimilation of dry mass produced in photosynthesis per unity of lost water through transpiration process (WUE parameter). Stomatal conductivity of water was in generally correlated with transpiration process and is concerning the state of leaf dehydration. The dependency with the type of technology is linked to rate of decomposition of the nutrient from soil and to the entering into metabolism(photosynthesis and carbon assimilation); in this way the synthetic fertilizers are available quickly, while the organic nutrients are released slowly during vegetation duration.

Key words: photosynthesis, transpiration, LCi system, solarium.

Organic agriculture has emerged as an alternative to intensive crops of industrial type, the desire to maintain the ecological balance of the ecosystem and the interrelations between soil-plant-environment.

Organic culture is based on crop residues, animal manure and mechanical cultivation to maintain soil productivity and provide plant nutrients.

Culture organic vegetables in greenhouses and solariums in Romania have gained momentum after 1995, in research stations and agricultural production, and currently, it is accomplished in private farms. Nowadays, most organic production systems include use of modern equipment, improved cultivars and new technology as drip irrigation. In contrast, to classic agriculture, conventional one, organic farming relies on preventive rather corrective practices (Bilalis et al., 2009).

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MATERIAL AND METHOD

It was analyzed some varieties of different solanaceous plants from two kind of stations: classic(conventional) and organic. Station with classic technology system is greenhouse from Bârlad, but with organic crop are Fălticeni, Târgu Neamţ and Bacău stations. Tomato varieties are Baldwin, Buran and Precos from Bacău solarium, and respectivelly Cherry and Risoca from Bârlad greenhouse. Analyzed varieties of sweet pepper were following: Milica F1 from Bacău station and Baltasar from Bârlad greenhouse. Eggplant varieties were Black Pearl variety (Bacău solariums) and Aragon variety (Bârlad greenhouse).

The vegetables cultivated in these protected systems are selected hybrids. Solanaceous plants cultivated in Bârlad greenhouse have the conventional technology (chemical treatment and fertilizer), but varieties from Bacău are cultivated in ecological systems since 12 years ago. Crop plants cultivated in protected spaces have generally, indeterminate growth.

Photosynthesis, transpiration and stomatal conductance were determined with LCi analyzing portable system (ADC Bioscientific, U.K) at fifth leaf from the top of plant.

RESULTS AND DISCUSSIONS

In present paper we compared the plant adjustment in different crop condition, in protected space and also in the opened field.

In the first place we purposed to observe the variation of the photosynthesis, transpiration and stomatal conductance registered in some different fields and in the protected space in the organic farming.

Analysis of photosynthesis, transpiration and stomatal conductance performed at solanaceous varieties was made in comparison with type of technological systems. Photosynthesis(A) increased during plant vegetative growth. Thus, in plant with 4-5 alternate leaf, photosynthesis increased from basis, middle to top of plant (Winnona and Brilliant varieties, see *table 1*). In tomatoes cultivated in field vicinity, with 3 alternate leafs the photosynthesis is higher in basis and the top of the plant and decreased in the middle one. Greenhouse tomato varieties (Brilliant and Winnona) cultivated in the field in natural conditions has the same behaviour of photosynthesis which increased from basis to top when the middle cluster of leaves. In Bacău station, photosynthesis increased from basis, middle part to top plant. The tomato plant development arrived to the formation of 14^{th} and 15^{th} in Buran and 12^{th} and 13^{th} leaf in Baldwin varieties. Transpiration (E) increased in the same way as the photosynthesis did, from the basis to top in the field and in the protected spaces (*table 1*). The increasing in net assimilation rates has been explained to be due to increased intercellular CO_2 concentrations (*C*i). In our experiment with crop plant in protected spaces, we observed that concentration of intercellular CO_2 (Ci) is inversely related with photosynthesis rate. Thus, in cv. Winnona, Ci decreased from basis to top(308-231 μmol mol^{-1}) in the same way that photosynthesis rate increased (4.44-15.35 μmol m^{-2} s^{-1}). In organic tomato crop at Fălticeni station is observed the reducing of the concentration of internal CO_2 from leaf at once he is used in photosynthesis process which increased, no matter tomato cultivation conditions. In tomato varieties from Bacău, internal concentration of CO_2 increased in the middle part of plant which become more photosynthetic active and where assimilate transport increased. Stomatal conductance (Gs) for water is linked especially with transpiration, the increasing of the stomata pressure will lead to the great transpiration at leaf level. In our study we observed that transpiration increased from the early plant stage to the late one, from the basis until top of plant *(table 1)*.

Wue parameter gives the information about the assimilation of dry mass produced per unity of lost water through transpiration process. This parameter is important for giving us the information about the water management to agricultural productivity in protected space.

Wue increased from the basis until top of plant and becomes greater in ripening stage when the foliar apparatus is fully developed.

Table1

Variation of photosynthesis, transpiration and stomatal conductivity in some variety of tomato in flowering stage cultivated in different organic protected spaces

Station	Tomato variety	Parts of plants	Ci(μmol mol^{-1})	A (μmol m^{-2} s^{-1})	Gs (mmol m^{-2} s^{-1})	E (mmol m^{-2} s^{-1})	Wue (μml/mmol)
Fălticeni	Winnona	Basis	308	4.44	0.31	3.47	1.279
		Middle	265	9.53	0.36	3.9	2.44
		Top	231	15.35	0.4	4.35	3.528
	Brilliant	Basis	306	2.17	0.18	3.71	0.584
		Middle	181	16.58	0.14	3.3	5.024
		Top	253	11.87	0.48	6.15	1.930
	Tomato cultivated in the field	Basis	137	3.42	0.03	0.88	3.886
		Middle	308	2.34	0.22	4.01	0.583
		Top	171	5.75	0.06	1.81	3.176
	Greenhouse variety cultivated in the field	Basis	259	6.56	0.21	3.98	1.648
		Middle	252	9.78	0.31	4.79	2.041
		Top	47	14.44	0.09	2.58	5.596
Bacău	Baldwin	Basis	184	8.25	0.09	2.24	3.683
		Middle	214	14.81	0.26	4.03	3.675
		Top	196	17.05	0.28	4.42	3.857
	Buran	Basis	192	7.28	0.08	2.29	3.179
		Middle	210	9.53	0.08	2.80	3.40
		Top	159	13.16	0.14	3.09	4.25

Legend: Ci-Substomatal cavity CO_2 concentration, A-photosynthesis rate, E-transpiration rate, gs- stomatal conductance, Wue-water use efficiency

It were analyzed the variation of photosynthesis, transpiration and stomatic conductance in different eggplant varieties in organic crop comparatively with conventional one.

In eggplant from Bacău, Black Pearl variety, is observed the increasing of the internal concentration of CO_2(Ci) from basis to top plant, between 769-945 μmol mol^{-1} but not increasing of the rate of photosynthesis which is between

11.38-3.05 µmol m^{-2} mol^{-1} Meanwhile, the eggplant variety from Bârlad at internal concentration of CO_2 between 203-268 µmol mol^{-1}, the increasing of the photosynthesis is between 6.54-20.95 µmol m^{-2} mol^{-1}.

In both cases, the concentration of internal CO_2 is higher at the middle part of plant than others and photosynthesis is lower at this level, comparatively with basis and top parts. Transpiration increased from basis to top in Black Pearl variety (Bacău station) from 1.93-3.01 mmol m^{-2} s^{-1}. Transpiration is higher at basis and top of Aragon variety(Bârlad station) and decreased in middle part of plant. It seems that at middle level of Black Pearl intervened a mechanism of closure stomata and increasing of the concentration of the Ci which not led to the increasing of the photosynthesis in conditions of the increasing of the stomatal conductance (*table 2*). Closure stomata could take place in some condition of increased humidity, sun exposition, and plant variety. Increasing of the substomatic CO_2 (Ci) despite of no increasing of the photosynthesis and also increasing of the stomatal conductance and no significant increasing of transpiration led to a water use efficiency of 0.417-1.487. The comparison of the two station established that photosynthesis and other leaf exchange is slower in organic system than in classic one *(table 2*).

Table 2

Variation of photosynthesis, transpiration and stomatal conductivity in some variety of eggplant in ripening stage cultivated in different organic protected spaces

Station	Eggplant variety	Parts of plants	Ci(µmol mol^{-1})	A (µmol m^{-2} s^{-1})	Gs (mmol m^{-2} s^{-1})	E (mmol m^{-2} s^{-1})	Wue(µml/m mol)
Bacău	Black Pearl	Basis	769	11.38	0.16	1.93	0.417
		Middle	945	3.03	0.53	2.74	1.487
		Top	929	5.95	0.37	3.01	0.866
Bârlad	Aragon	Basis	203	20.95	0.63	7.73	2.710
		Middle	268	6.54	0.32	4.8	1.362
		Top	206	20.15	0.67	7.54	2.672

Legend: Ci-Substomatal cavity CO_2 concentration, A-photosynthesis rate, E-transpiration rate, gs- stomatal conductance, Wue-water use efficiency.

Table 3

Variation of some photosynthetical parameters of tomato variety in ripening phenophase in relation with type of technology system(classic and organic)

Station	Specie	Qleaf(µmol m^{-2} s^{-1}	Ci(µmol mol^{-1})	A (µmol m^{-2} s^{-1})	E (mmol m^{-2} s^{-1})	gs (mmol m^{-2} s^{-1})	Wue(µml/m mol)
Fălticeni(organic)	Margarita	581	316.812	7.27	6.606	1.435	1.10
Bacău(organic)	Precos	794	266.181	11.105	3.205	0.242	3.464
	Cristal	529	297.09	12.98	6.68	0.614	1.941
Tg. Neamţ (organic)	Greenhouse variety	700	266.05	15.75	4.73	1.26	3.42
Bârlad(classic)	Risoca	200	289.75	5.593	1.391	0.33	4.018
	Cherry	100	290.533	2.829	0.869	0.059	3.254

Legend: Ci-Substomatal cavity CO_2 concentration, A-photosynthesis rate, E-transpiration rate, gs- stomatal conductance, Wue-water use efficiency

From the table above, tomato varieties from conventional system (Bârlad) registered a photosynthesis rate between 3 (Cherry)-5.5µmol m^{-2} mol^{-1}(Risoca) at a respiration between 0.8-1.3. Tomato varieties from the organic culture had a higher photosynthesis (7-15 µmol m^{-2} mol^{-1}) and also and increased respiration (3-6 mmol m^{-2} mol^{-1}). At a lower photosynthetical active radiation (Q leaf) of 100-200 µmol m^{-2} s^{-1}, the value of the concentration of the CO_2 substomatic in varieties of Bârlad is close to the Bacău varieties, but with a small respiration and stomatal conductance.

This "strategy" conducted to water use efficiency between 3.2-4 in varieties of Bârlad, comparatively with 1.10-3.4, in varieties of Bacău. The major function of stomata is to maximize the rate at which CO2 can diffuse into the leaf for photosynthesis while minimizing the simultaneous loss of water vapour, an optimization that requires continuous regulation. Many factors are known to influence stomata and their response to the environment is often highly predictable (Ball et al., 1987). Increasing of the active radiation at leaf level increase the rate of photosynthesis and highly the gs(five times more).

A great value of wue parameter not means the increased assimilation of plant. At ripening stage, a higher value (after 4) means a higher water consumer. In protected space, all vegetables are water consumer and depending on that. Applied fertilizer and chemical treatment led to a higher need of water.

Some authors established a correlation between internal concentration of CO_2 (Ci) and photosynthesis (A) (David et al, 1990). In protected spaces we are observed a relation between transpiration rate (E) and stomatal conductance (gs), which implied a humidity factor. Mechanism of opening-closure stomata played a very central role in carbon assimilation and water elimination. A decreasing of substomatic CO_2 with increasing photosynthesis rate as well as increasing the stomatal conductance and transpiration rate is observed in early stage (flowering), especially at the top of plant where metabolism is accelerated (*table 1*). At ripening stage, at basis and top of eggplant in the opening stomata are observed the increased activity of assimilating of substomatic CO_2 relieved through a higher photosynthesis rate (*table 2*). During vegetation stage some adjustments occurred depending of variety, sun exposure, humidity, agricultural practice etc. In other works we observed that technological system had the influence on carbohydrate accumulation and photorespiration adjustment (Acatrinei , 2009).

CONCLUSIONS

Protected spaces assured the controlled conditions for plant growth. During vegetation are observed some adjustments in those systems with a smaller human intervention, as organic or ecologic one where plant respond to the environmental changes. In all protected space are observed that increasing photosynthesis rate is in followed by the decreasing CO_2 concentration from the substomatic cell, as well is consumed in assimilation process. Stomatic conductance increased once with increasing transpiration rate. Stomatal conductivity of water was generally correlated with transpiration process and is concerning the state of leaf dehydration. The dependency with the type of technology is linked to rate of decomposition of the nutrient from soil and to the entering into metabolism.

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