DYNAMIC BALANCE OF SOLAR RADIATION MEASURED AT TOMATO LEAFS IN FIELD AND GREENHOUSE

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Abstract. The aim of the research was to investigate the way in which the intensity of solar radiation, at different hours of the day, influences the tomato plants grown in greenhouse and field conditions. The experiments underlying the research were located in the area of Cluj-Napoca. The assimilation of the radiation by the tomato plants has an important role for farmers growing tomatoes in greenhouses in geographic regions above 45 degrees north and south latitude.

Keywords: *Lycopersicon esculentum Mill.*, solar radiation, light intensity, leaf position, greenhouse

INTRODUCTION

Tomatoes (*Lycopersicon esculentum* Mill.), from the Solanaceae family, are usually annual plants, although in their origin areas they act as perennials. Under greenhouse conditions, they can grow for many years (Popescu V, et al 2003).

The intensity of solar radiation increases from 5 am to 12 pm and then decreases until 19 pm. In nature, however, daytime photosynthesis exhibits multiple deviations from the solar radiation curve. In the second half of the day, the intensity of photosynthesis is lower than in the first half of the day, due to the accumulation of a part of the organic substances in the chloroplast, as a result of the photosynthesis process (Criveanu and Micle, 2002).

During the long summer days, with temperatures ranging from 17^0C to 30^0C, the intensity of photosynthesis can be based on bimaximal curves, with a peak in the morning and a second one in the afternoon (Criveanu and Micle, 2002). At noon, the intensity of photosynthesis can decrease to the point of compensation, sometimes even below, as the CO2 is eliminated. Therefore, the diurnal course of photosynthesis can follow both bimaximal and unimaxial curves, this being determined by the variation of external factors during the day or season. As the days become shorter, during the vegetation period, the curve of the photosynthesis intensity moves from the type with two maxims to the unimaxial type.

Solar radiation changes from a spectral point of view due to the height of the Sun over the horizon, so the highest share is the visible radiation (46%) and the infrared (50%), the ultraviolet radiation occupying 4%. At 0.50 the infrared radiation (72%) prevails and the ultraviolet radiation is absent. The angle of incidence has an important role in modifying the intensity of solar radiation on the terrestrial surface (Povara, 2006). Solar radiation falling perpendicularly warms a much larger surface than the oblique solar radiation and the value of the incidence angle depends on the height of the Sun above the horizon, which depends on the location's latitude and the moment of the day (Criveanu and Micle, 2002).

The world production of tomatoes in 2016 was 177 million tonnes, 32% of it was done in China, followed by the European Union, United States, Turkey and India. Global tomato exports were valued at 85 billion US dollars in the year 2016 (FAO).

MATERIAL AND METHOD

The polyfactorial experience was performed in three repetitions, in the area of Cluj-Napoca, with the following factors:

Factor A with 5 graduations:

9. TSRI - Total Solar Radiation Intensity
10. ISRLA - Intensity of the Solar Radiation on the Leaf Area
11. ISRLPL - Intensity of the Solar Radiation on the Lower Part of the Leaf
12. ISRTL - Intensity of Solar Radiation at the Tip of the Leaf
13. ISRLP - Intensity of Solar Radiation at Leaf Petiole

Factor B with 3 graduations:

1. hour 8 am
2. hour 12 pm
3. hour 4 pm

Factor C with 2 graduations:

- field
- greenhouse

Control - the average of experience

The processing of statistical data was performed by variance analysis, interpretation of the differences from the control, by limiting difference (DL) for significance thresholds of p = 5%, 1% and 0.1%.

RESULTS AND DISCUSSION

Influence of radiation in the experiment performed in the field (factor C)

The experiment performed on the interaction between hour x foliar area has found that the intensity of radiation has positive influence on the factor B (hour). In order to facilitate comparison and provide a clear overview, the data is presented in the form of synthetic tables for each of the mentioned indicators. Following the analysis of the results of the experiments, lower values were recorded in field conditions at 8 am, statistically assured as significant negative. Significantly positive differences were recorded in the field at 12 pm and 4 pm.

Table 1

Influence of the intensity of solar radiation (IRS) on the factor A (leaf position) in field conditions

Factor A	IRS / SRI (luxi)	%	Difference	Significance
	1536.31	100	0	Mt.
TSRI	2261.67	147.2	725.36	***
ISRLA	1977.22	128.7	440.91	***
ISRLPL	503.89	32.8	-1032.42	0
ISRTL	1362	88.7	-174.31	0
ISRLP	1576.78	102.6	40.47	-

DL/LSD p=5% 163.73
DL/LSD p=1% 238.15
DL/LSD p=0,1% 357.22

Influence of radiation in the experiment performed in the greenhouse (factor C)

The experiment performed in the greenhouse shows that in the case of the interaction hour x foliar area, the intensity of radiation that was recorded at 12 pm and 4 pm has positive influence on factor B (hour). The analysis of the results of the experiments show lower values in the greenhouse conditions at 8 am.

Table 2

Influence of the intensity of solar radiation (IRS) on the factor B (hour) in field conditions

Factor B	**S / SRI (luxi)**	**%**	**Difference**	**Significance**
	1536,31	100	0	Mt.
Hour 8 am	189,33	12,3	-1346,98	0
Hour 12 pm	1273,67	174,0	1137,36	***
Hour 4pm	1745,93	112,6	209,62	***

DL/LSD p=5% 113,67
DL/LSD p=1% 154,47
DL/LSD p=0,1% 209,40

Table 3

Influence of the intensity of solar radiation (IRS) on the factor A (leaf position) in greenhouse conditions

Factor A	IRS / SRI **(luxi)**	**%**	**Difference**	**Significance**
	1273,38	100	0	Mt.
TSRI	2276,89	178,8	1003,51	***
ISRLA	1684,44	132,3	411,07	***
ISRLPL	351,78	27,6	-921,60	0
ISRTL	740,56	58,2	-532,82	0
ISRPF	1313,22	103,1	39,64	*

DL/LSD p=5% 33,66
DL/LSD p=1% 43,96
DL/LSD p=0,1% 73,43

Table 4

Influence of the intensity of solar radiation (IRS) on the factor B (hour) in greenhouse conditions

Factor B	**S / SRI (luxi)**	**%**	**Difference**	**Significance**
	1273,38	100	0	Mt.
Hour 8 am	408,53	32,1	-864,84	0
Hour 12 pm	1828,73	143,6	555,36	***
Hour 4 pm	1582,87	124,3	309,49	***

DL/LSD p=5% 23,08
DL/LSD p=1% 31,37
DL/LSD p=0,1% 42,52

CONCLUSIONS

Following the analysis of the results of the experiments, in both field and greenhouse conditions lower values were recorded at 8 am, and positive values at 12 pm and 4 pm.

Solar radiation dynamics measured on tomato leaves show that the light radiation increases progressively from the early hours of the morning to a peak at midday. Thus the intensity of photosynthesis increases rapidly as the intensity of light and temperature rise.

The maximum value of solar radiation is at noon (the height of the sun is 90^0), when the radiation is perpendicular to the surface of the soil.

This study is important for farmers growing tomatoes in greenhouses in geographic regions above 45 degrees north and south latitude. Because it is a link between the angle and the orientation of the sun towards the plant, farmers geographically positioned between the two poles and the 45-degree parallel will have a lower yield on the tomato production. Thus, yields can be increased by introducing solar diffusion screens into the greenhouse. Such a screen will increase production, directly proportional to the amount of light transmitted and will be reflected by the financial gain. Other solutions could be matte polycarbonate panels, the orientation of artificial light sources in the direction of the plant and vertical farming, and designing the shape of the greenhouse that allows the directing of solar radiation.

REFERENCES

1) Criveanu H., Svetlana Micle, 2002, Cercetări privind distribuția și captarea energiei luminoase la tomate și influența asupra biologiei și calității fructelor. University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture (PhD Thesis).
2) Criveanu H., Svetlana Micle, 2002, The Behaviour of Leaf Optical Properties in Dependence to Content in Chlorophyll and Water, Buletinul USAMV, Cluj-Napoca, nr.57, Seria Horticultura
3) FAO – Food and Agriculture Organization of the United Nations, http://www.fao.org
4) Popescu V, Angela Popescu, 2003, Cultura legumelor în câmp şi în solarii, Editura M.A.S.T., Bucureşti, p. 127-140.
5) Povara R., (2006). Mathematical Model for the Study of the Solar Radiation through Canopy, Bullletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture.