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DIURNAL CHANGES IN LEAF PHOTOSYNTHESIS AND RELATIVE WATER CONTENT OF GRAPEVINE

Monica Popescu*, Gheorghe Cristian Popescu**

*University of Pitesti, Faculty of Sciences, Department of Natural Sciences, Pitesti, Romania
E-mail: monica_26_10_10@yahoo.com
** University of Pitesti, Faculty of Sciences,
Department of Applied Sciences and Environment Engineering, Pitesti, Romania
E-mail: christian_popescu2000@yahoo.com

Abstract
Variation in light intensity, air temperature and relative air humidity leads to diurnal variations of photosynthetic rate and leaf relative water content. In order to determine the diurnal changes in net photosynthetic rate of vine plants and influence of the main environmental factors, gas exchange in the vine leaves were measure using a portable plant CO_2 analysis package. The results show that diurnal changes in photosynthetic rate could be interpreted as single-peak curve, with a maximum at noon (10.794 µmol CO_2 m^{-2} s^{-1}). Leaf relative water content has maximum value in the morning; the values may slightly decrease during the day (day of June, with normal temperature, no rain, no water restriction in soil).

Keywords: net photosynthetic rate, relative water content, diurnal change, environmental factors, vine plants.

1. INTRODUCTION

Variation in light intensity, air temperature and relative air humidity leads to diurnal variations of photosynthetic rate and leaf relative water content. The overall rate of vine photosynthesis is maximally effective at about one-third of full sunlight intensity. The effect of temperature on photosynthesis varies slightly throughout the growing season (Jackson, 2014). Moisture conditions significantly influence the rate of photosynthesis. Like any other plant, water plays an essential role in the life of the vine. Tissues and organs of vines present a significant water content, which depends on many internal factors (age, phonological phase, etc) and external (temperature, soil moisture, air wettability, etc). Water deficit determine the synthesis of hydrogen peroxide and nitric oxide (Patakas et al., 2010). Tomas et al. (2012) consider that water-use efficiency by the leaves alone is not adequate to assess whole plant water-use efficiency.

2. MATERIALS AND METHODS

The studies were conducted to plant vines from plantation to National Research and Development Institute for Biotechnology in Horticulture Stefanesti-Arges. Laboratory measurements were performed in the laboratories of the University of Pitesti.

At different times of the day we determinate the rate of photosynthesis and relative water content, correlated with light intensity, relative air humidity and air temperature.

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Net photosynthetic rate was measured in attached leaves maintained in an assimilation chamber, with portable plant CO_2 analysis package.
Relative water content in leaf was determined according to the method of Barrs and Weatherley (1962).
A statistical analysis was performed using SPSS16.0 software. Means were compared using Duncan's multiple range tests at 5% level. In order to determine the correlation between physiological parameters and main environmental factors, we calculate the coefficient of determination (R square) and we established trend lines.

3. RESULTS AND DISCUSSIONS

Diurnal variation of rate of photosynthesis is determined by a complex of factors, the weather having a decisive role. The course of net assimilation in a June day for the vines is shown in figure 1. Determinations were performed during the day, at 8, 11, 14 and 17. At 8:00 net photosynthetic rate was 5.032 µmol CO_2 m^{-2} s^{-1}; at 14:00 we determined 10.794 µmol CO_2 m^{-2} s^{-1}. Daily variation takes the form of a unimodal curve, with the maximum value registered at noon (14:00 h).

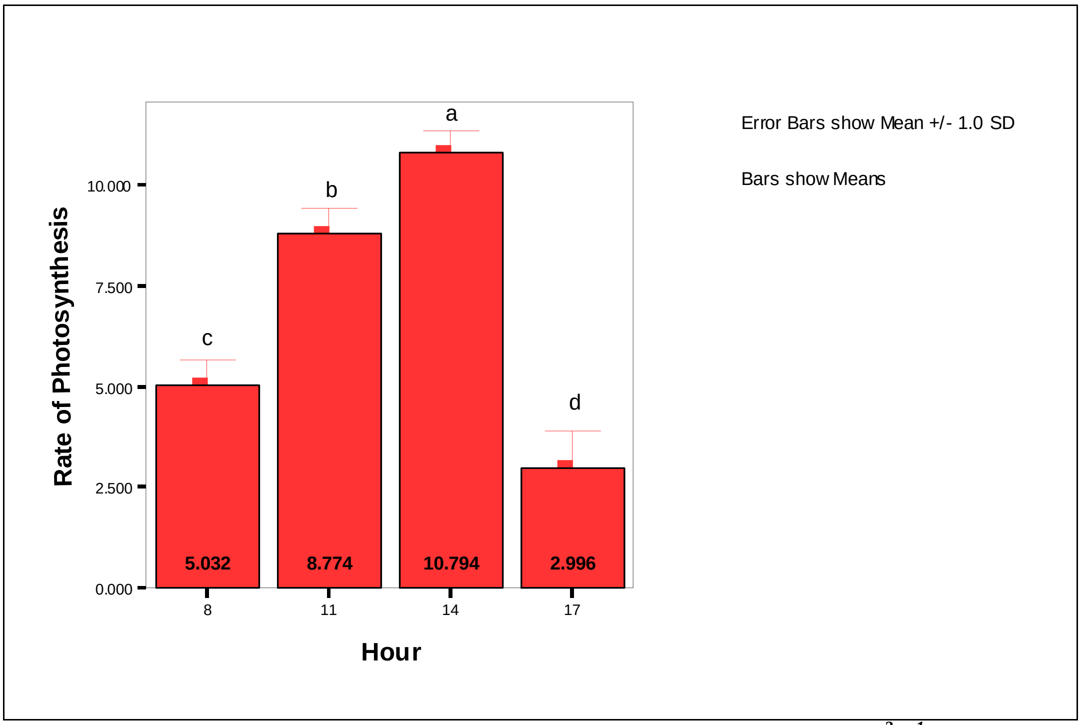

Figure 1. Diurnal changes of net photosynthetic rate (µmol CO_2 m^{-2} s^{-1})
(bars with the different letters are significantly different at the 5% level, according to Duncan's multiple range test)

The values obtained confirm the scientific data that shows that, in the phase of vegetative growth, maximum value of photosynthetic rate is reached at 13:00, and at some leaves even later (Georgescu et al., 1991).
The course of assimilation throughout the warmer day for vines is shown by Downton et al. (1987). They made measurements in a day with air temperature increased linearly from 20°C at 09:00 h to 31°C at 14:00 h and then remained constant. Assimilation decreased from about 11 µmol CO_2 $m^{-2}s^{-1}$ during early morning to 5 to 6 µmol CO_2 m^{-2} s^{-1} during the afternoon.
Figure 2 shows the correlation between the intensity of photosynthesis and light intensity. Given the primary role in the formation of products of photosynthesis, light is considered the main

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environmental factor influencing photosynthesis (Georgescu et al., 1991). There is an increasing photosynthesis values with increasing light intensity in the range of 50,000 – 120,000 lux.

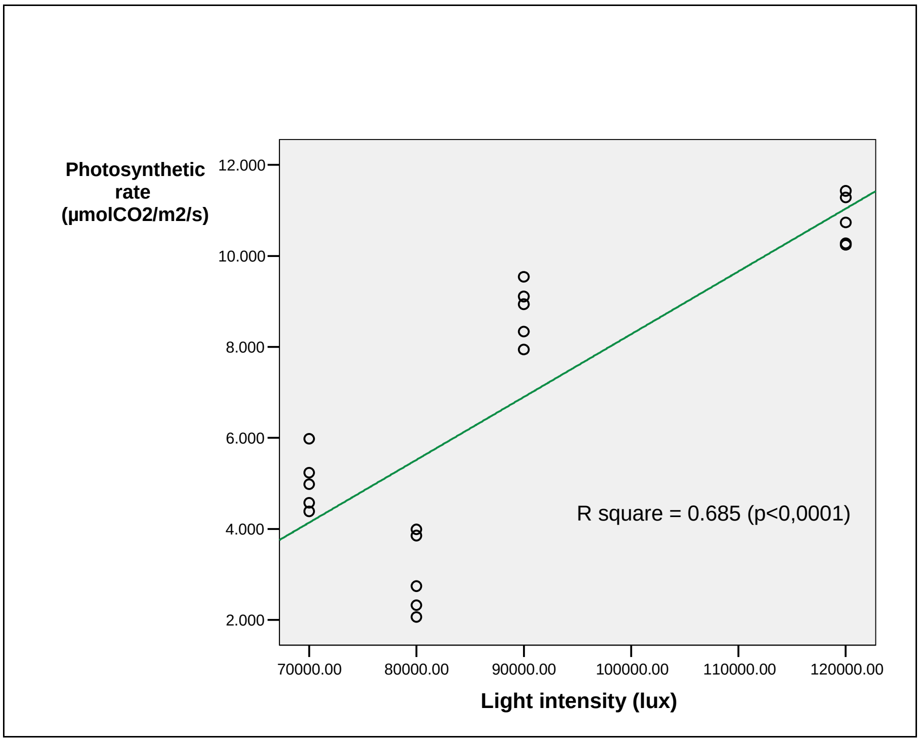

Figure 2. Correlation between photosynthetic rate and light intensity in grapevine leaves

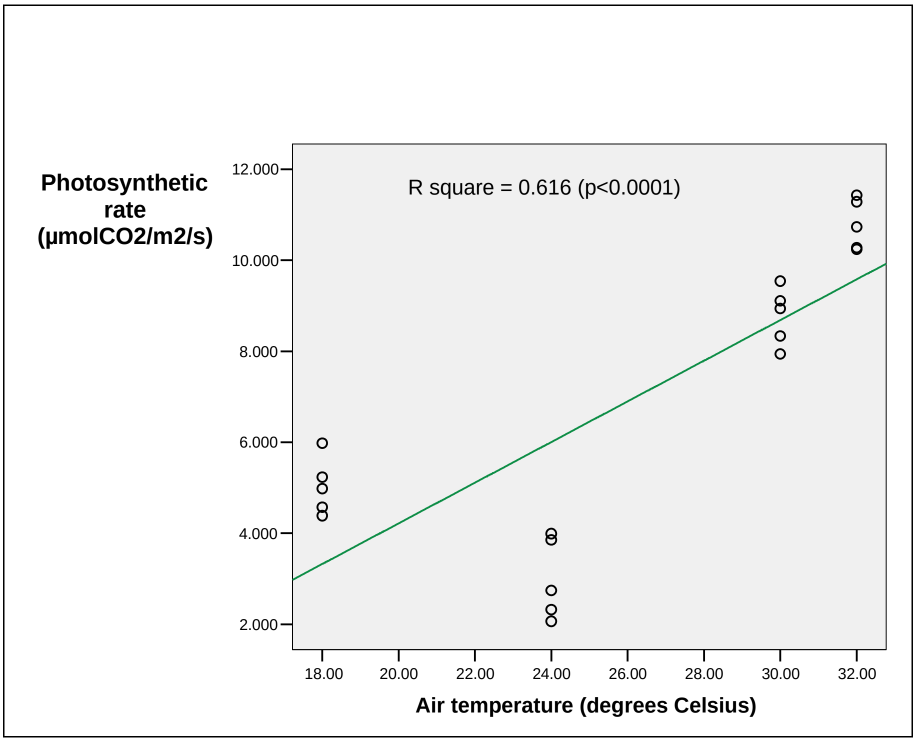

Figure 3. Correlation between photosynthetic rate and air temperature in grapevine leaves

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Calculation of Pearson correlation coefficient and its significance shows that between photosynthesis and light intensity (in the range of 50,000 – 120,000 lux) there is a significant positive correlation (Table 1). The intensity of photosynthesis is optimal for lighting conditions of 50,000 to 60,000 lux, and can reach 60,000 to 90,000 lux in drought conditions (Kriedemann, 1977). Photosynthesis occurs at low light intensities, increasing sharply to a light intensity of 18,000 lux, then increases slowly, reaching its peak at 35,000 lux (Georgescu et al., 1991).

In figure 3 is shown the correlation between photosynthetic rate and air temperature. There is an increasing intensity of photosynthesis with air temperature, for values of temperature between 18°C and 32°C. Between the two parameters we calculated a correlation coefficient r = 0.785 ($p<0.01$) (table 1).

In the summer, optimal CO_2 fixation tends to occur at between 25 and 30°C (Stoev and Slavtcheva, 1982). Photosynthesis is more sensitive to temperature below 15°C than to temperatures above the optimum (Jackson, 2014). Scientific literature indicates that photosynthetic efficiency is week at 10-15°C. High temperature (20-25°C) lead to rapid increase in photosynthetic efficiency, and at 30-35°C begins to decrease. Excessive temperatures (>40°C) reduces photosynthesis almost totally due to thermal instability of enzymes and leaf tissue dehydration (Georgescu et al., 1991; Dejeu, 2006).

In the figure 4 is shown correlation between the intensity of photosynthesis and relative air humidity. Measurements were performed for the values of relative air humidity between 40% and 55%, for which there was a slight increase in photosynthesis. Between the two parameters was not established a significant correlation (table 1).

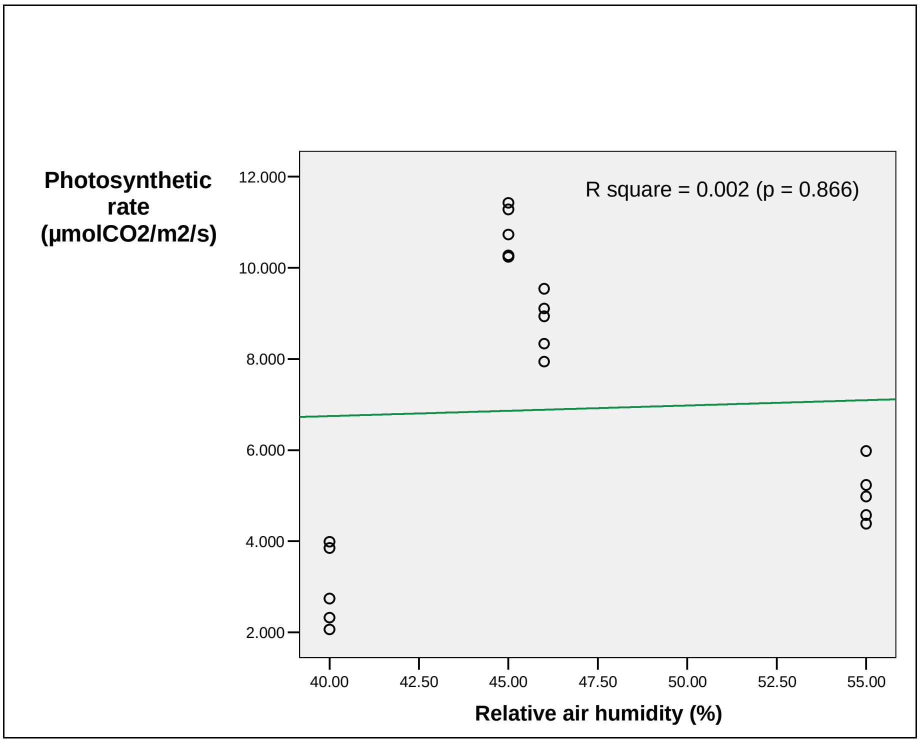

Figure 4. Correlation between photosynthetic rate and relative air humidity in grapevine leaves

Tissues and organs of vines presents a significant water content, which depends on many factors. Meristematic tissues contains 80-95% of water, growing shoots 90-95%, depending on the phenophases; two year branches 40-55%, leaves 70-85%, buds 50-55%, grapes 70-80% in the core, 60-80% in the skins, 15-50% in seeds and 55-80% in bunches. It follows that the vines, having

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developed vegetative apparatus are consuming water (Oprean, 1975). Figure 5 shows the results for relative water content throughout the day. At 8:00, the value recorded was 86.02%. During the day there was a slight decrease to 17:00 (79.37%).

Figure 5. Diurnal changes of relative water content (%)
(bars with the different letters are significantly different at the 5% level, according to Duncan's multiple range test)

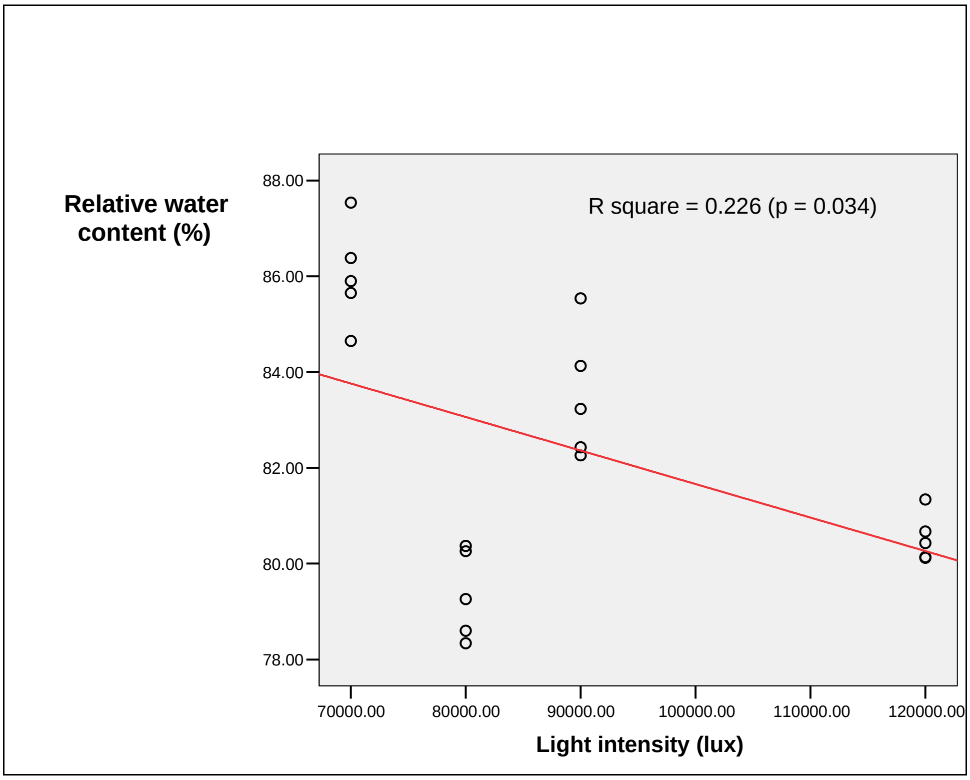

Figure 6. Correlation between relative water content and light intensity in grapevine leaves

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Figure 6 presents the correlation between the relative water content from the leaves of vines and light intensity. Pearson correlation coefficient (table 1) shows that between the two parameters is a significant negative correlation ($p<0.05$).

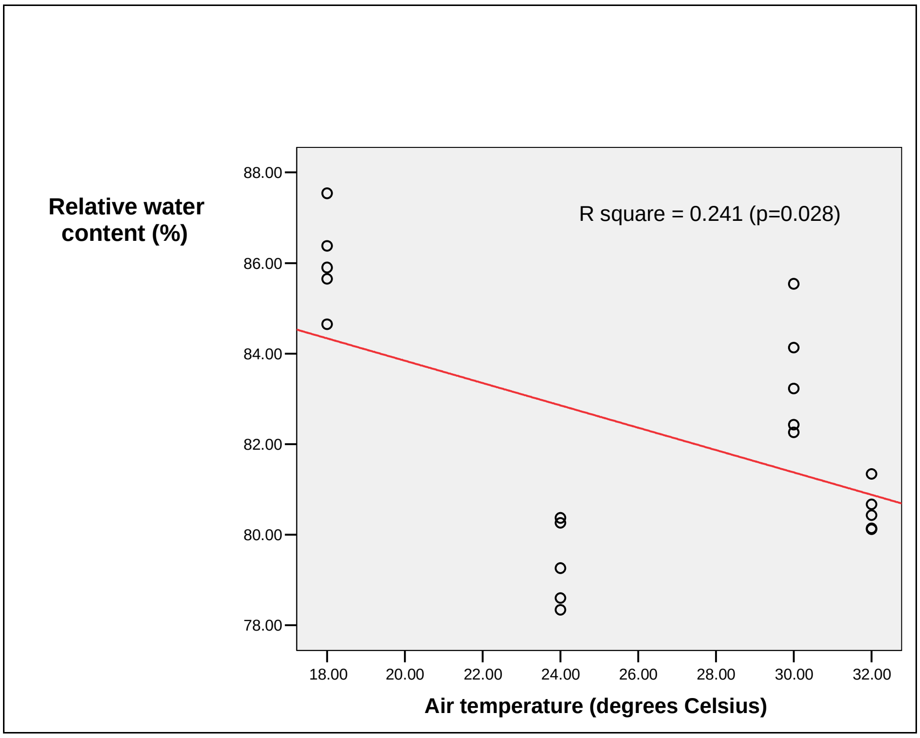

Figure 7. Correlation between relative water content and air temperature in grapevine leaves

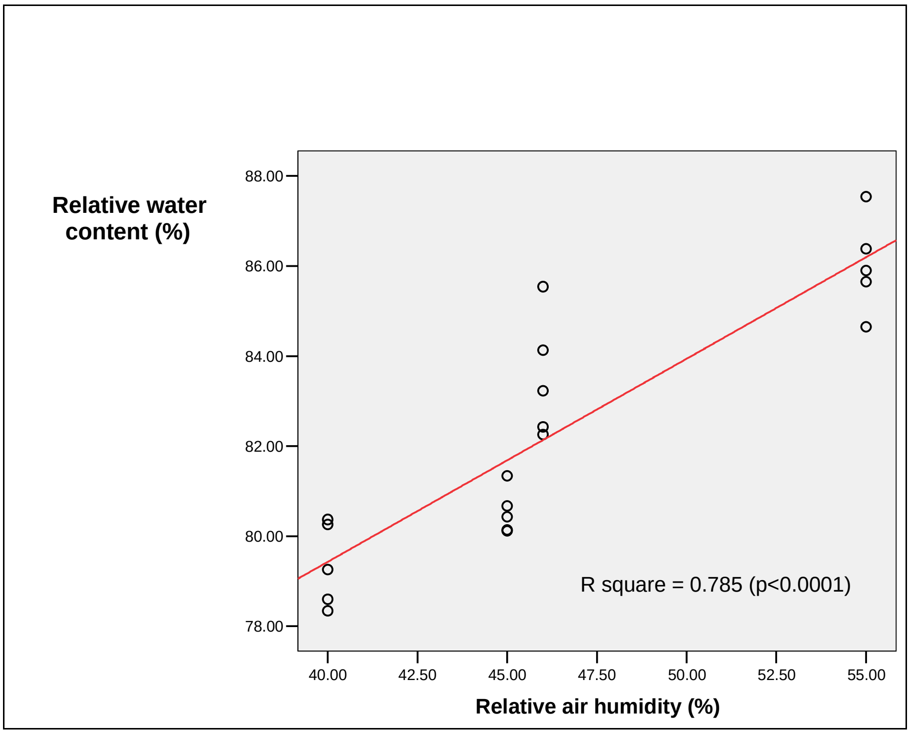

Figure 8. Correlation between relative water content and relative air humidity in grapevine leaves

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One of the factor influencing the development and severity of water deficit is ambient temperature. Isohydric vine cultivars adjust rapidly by closing their stomata, and through other metabolic modifications, to retain water under deficit conditions (Jackson, 2014).

Figure 7 shows the correlation between the relative water content from the leaves and air temperature. With the increase in air temperature between 18^oC and 32^oC occurs a significant decrease in relative water content (R square = 0.241, $p=0.028$; $r = - 0.491$; $p<0.05$)

In the figure 8 is observed an increase in relative water content values of vine leaves with increasing relative air humidity. Statistical interpretation of the results shows the correlation is significant at $p<0.01$ ($r = 0.886$) (Table 1).

Table 1. Correlation coefficients between physiological parameters and the main environmental factors

		Light intensity	Air temperature	Relative air humidity
Rate of Photosynthesis	Pearson Correlation	.828**	.785**	.040
	Sig. (2-tailed)	.000	.000	.866
	N	20	20	20
Relative water content	Pearson Correlation	-.476*	-.491*	.886**
	Sig. (2-tailed)	.034	.028	.000
	N	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4. CONCLUSIONS

The variation of photosynthetic rate is dependent on environmental conditions and is expressing their interaction (light intensity, air temperature, relative air humidity). Net photosynthesis intensity increases significantly with increasing light intensity (50,000 – 120,000 lux) and air temperature (18-32^oC).

Leaf relative water content have maximum in the morning; the values may slightly decrease during the day (day of June, with normal temperature, no rain, no water restriction in soil).

With the increase in light intensity between 70,000 and 120,000 lux occurs significant decrease in relative water content of leaves. The increase in air temperature between 18 and 32^oC produce a significant decrease in relative water content of vine leaves.

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