DIURNAL AND SEASONAL CHANGES IN THE TRANSPIRATION RATE OF APPLE TREES

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Abstract. The present work was undertaken to investigate relationships between diurnal and seasonal trends of environmental variables and transpiration of Idared, Golden Delicious and Jonathan Apple.

The seasonal course of transpiration was measured over a three years period (2003, 2004 and 2005); the diurnal course of transpiration was measured different days characterized by different light intensity, air humidity and air temperature.

For plants provided with the diurnal course has only maximum value, usually with one or two hours after 12 o'clock, on a sunny day. The diurnal course depends especially on the intensity of light on a days like one. On a cloudy day, the transpiration rate is lower. This happens because the clouds come between the light and the plants. Also, on such a day, the transpiration rate is lower due to the increasing air humidity.

In the spring, the transpiration rate has a significant increase, reaching the maximum value during summer. The maximum value can be registered in June and July when the light intensity is maximum, the days are longer and the soil has enough provisions of water.

Key words: *transpiration, diurnal course, seasonal course, apple trees.*

INTRODUCTION

Water use by plants is an important issue of study because water often limits the growth and establishment of plants in varying environments.

The transpiration process usually accounts for about 99% of the water used by plants whereas only 1% of water taken up by the plant is used in metabolic activities (Salisbury and Ross, 1992).

Transpiration is induced by evaporative demand resulting from net radiation absorbed by leaves and the drying power of the atmosphere, which in turn is related to wind speed and relative humidity (Monteith and Unsworth, 1990).

Stomata, through which CO_2 and water vapor diffuse into and out of the leaf, are involved in the regulation of both photosynthesis and transpiration (Jarvis and Morison, 1981).

The control of stomatal aperture involves state variables (e.g., leaf water potential and intercellular carbon dioxide concentration), interactions between processes (transpiration and photosynthetic rate), and is related to environmental conditions (Jones, 1992).

The present work was undertaken to investigate relationships between diurnal and seasonal trends of environmental variables and transpiration activities.

MATERIAL AND METHODS

Experiments were carried out at ICDP Maracineni (near Pitesti).

The rate of transpiration was estimated gravimetrically, of Idared, Golden Delicious and Jonathan apple. We also used: a thermometer for air temperature, a luxmeter for light intensity and a psychrometer for air humidity.

The seasonal course of transpiration was measured over a three years period (2003, 2004, 2005); the diurnal course of transpiration was measured different days (characterized by different light intensity, air humidity and air temperature).

One-way ANOVA was used to test the differences in the rate of transpiration among months or among hours (multiple comparisons: LSD test) (with SPSS 13,0 for Windows).

RESULTS AND DISCUSSION

Seasonal changes in the transpiration rate on Idared Apple are illustrated in Figure 1. In April the transpiration rate was 0,310 g $H_2O/dm^2/h$. the highest transpiration rate was found in July (1,258 g

$H_2O/dm^2/h$). the transpiration rate decreased in august to a value of 0,618 g $H_2O/dm^2/h$. statistical results of the seasonal changes in the transpiration rate on Idared Apple are shown in Table 1.

For Golden Delicious Apple the highest transpiration rate was found in June (1,227 g $H_2O/dm^2/h$) (Figure 2), with significant differences compared to the other months (at the 0,05 level) (Table 2).

Seasonal changes in the transpiration rate on Jonathan Apple can be seen in Figure 3. The maximum value was registered in July (1,322 g $H_2O/dm^2/h$). Statistical results are shown in Table 3.

Diurnal changes in the transpiration were determinated on the 24th of June 2005, 27th of July 2005 and 24th of August 2004.

On the 24th of June 2005 the maximum light intensity was 7525 lux, the relative humidity was around 90% and the maximum temperature was 21°C. It was a cloudy day and it rained in the afternoon.

So, for Idared Apple, at 9 o'clock the transpiration rate was 0,55 g $H_2O/dm^2/h$, at 13 o'clock – 0,53 g $H_2O/dm^2/h$ and at 17 o'clock – 0,34 g $H_2O/dm^2/h$. For Golden Delicious Apple, at 9 o'clock the transpiration rate was 0,44 g $H_2O/dm^2/h$, at 13 o'clock – 0,45 g $H_2O/dm^2/h$ and at 17 o'clock – 0,34 g $H_2O/dm^2/h$. For Jonathan Apple, at 9 o'clock the transpiration rate was 0,29 g $H_2O/dm^2/h$, at 13 o'clock – 0,44 g $H_2O/dm^2/h$ and at 17 o'clock – 0,32 g $H_2O/dm^2/h$. Given these conditions, the transpiration rate wasn't higher than 0,7 g $H_2O/dm^2/h$ (Figure 4). Using these data, we made the variance analysis of the transpiration rates. The results are in Table 4.

On the 27th of July 2005 the light intensity was maxim, the relative humidity was around 50% in the afternoon and the maximum temperature was 33°C. It was a sunny day.

So, for Idared Apple, at 9 o'clock the transpiration rate was 1,25 g $H_2O/dm^2/h$, at 13 o'clock – 2,12 g $H_2O/dm^2/h$ and at 17 o'clock – 1,05 g $H_2O/dm^2/h$. For Golden Delicious Apple, at 9 o'clock the transpiration rate was 0,784 g $H_2O/dm^2/h$, at 13 o'clock – 5,406 g $H_2O/dm^2/h$ and at 17 o'clock – 2,474 g $H_2O/dm^2/h$. For Jonathan Apple, at 9 o'clock the transpiration rate was 1,095 g $H_2O/dm^2/h$, at 13 o'clock – 3,572 g $H_2O/dm^2/h$ and at 17 o'clock – 2,831 g $H_2O/dm^2/h$. Given these conditions, the maximum transpiration rate was around 6 g $H_2O/dm^2/h$ (Figure 5). Using these data, we made the variance analysis of the transpiration rates. The results are in Table 5.

On the 24th of August 2004 the maximum light intensity was 60000 lux, the relative humidity was around 60% in the afternoon and the maximum temperature was 25°C.

So, for Idared Apple, at 9 o'clock the transpiration rate was 0,50 g $H_2O/dm^2/h$, at 13 o'clock – 0,87 g $H_2O/dm^2/h$ and at 17 o'clock – 0,81 g $H_2O/dm^2/h$. For Golden Delicious Apple, at 9 o'clock the transpiration rate was 0,42 g $H_2O/dm^2/h$, at 13 o'clock – 0,81 g $H_2O/dm^2/h$ and at 17 o'clock – 0,77 g $H_2O/dm^2/h$. For Jonathan Apple, at 9 o'clock the transpiration rate was 0,63 g $H_2O/dm^2/h$, at 13 o'clock – 1,09 g $H_2O/dm^2/h$ and at 17 o'clock – 0,85 g $H_2O/dm^2/h$. Given these conditions, the maximum transpiration rate was around 1,4 g $H_2O/dm^2/h$ (Figure 6). Using these data, we made the variance analysis of the transpiration rates. The results are in Table 6.

CONCLUSIONS

For plants provided with the diurnal course has only maximum value, usually with one or two hours after 12 o'clock, on a sunny day. The diurnal course depends especially on the intensity of light on a days like one. On a cloudy day, the transpiration rate is lower. This happens because the clouds come between the light and the plants. Also, on such a day, the transpiration rate is lower due to the increasing air humidity.

In the spring, the transpiration rate has a significant increase, reaching the maximum value during summer. The maximum value can be registered in June and July when the light intensity is maximum, the days are longer and the soil has enough provisions of water.

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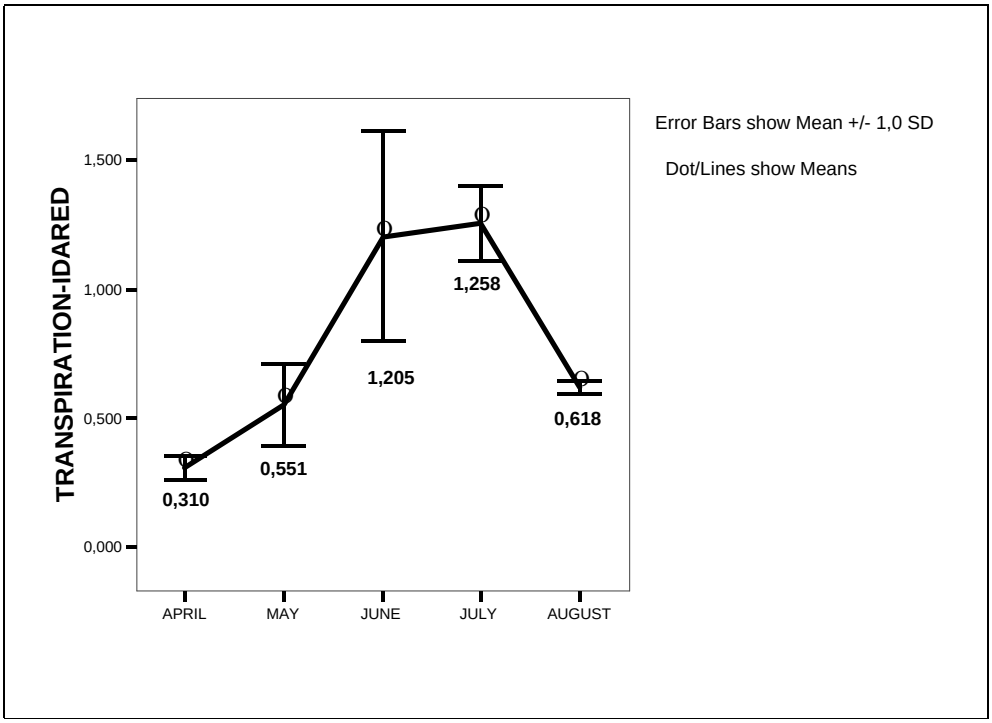

Fig. 1. Seasonal changes in the transpiration rate on Idared Apple

Table 1. Statistical results of the seasonal changes in the transpiration rate on Idared Apple

Multiple Comparisons

Dependent Variable: TRANSPIRATION-IDARED

LSD

		Mean Difference	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
APRIL	MAY	-,240600*	,000	-,35758	-,12362
	JUNE	-,895400*	,000	-1,01238	-,77842
	JULY	-,947800*	,000	-1,06478	-,83082
	AUGUST	-,308000*	,000	-,42498	-,19102
MAY	APRIL	,240600*	,000	,12362	,35758
	JUNE	-,654800*	,000	-,77178	-,53782
	JULY	-,707200*	,000	-,82418	-,59022
	AUGUST	-,067400	,256	-,18438	,04958
JUNE	APRIL	,895400*	,000	,77842	1,01238
	MAY	,654800*	,000	,53782	,77178
	JULY	-,052400	,377	-,16938	,06458
	AUGUST	,587400*	,000	,47042	,70438
JULY	APRIL	,947800*	,000	,83082	1,06478
	MAY	,707200*	,000	,59022	,82418
	JUNE	,052400	,377	-,06458	,16938
	AUGUST	,639800*	,000	,52282	,75678
AUGUST	APRIL	,308000*	,000	,19102	,42498
	MAY	,067400	,256	-,04958	,18438
	JUNE	-,587400*	,000	-,70438	-,47042
	JULY	-,639800*	,000	-,75678	-,52282

*. The mean difference is significant at the .05 level.

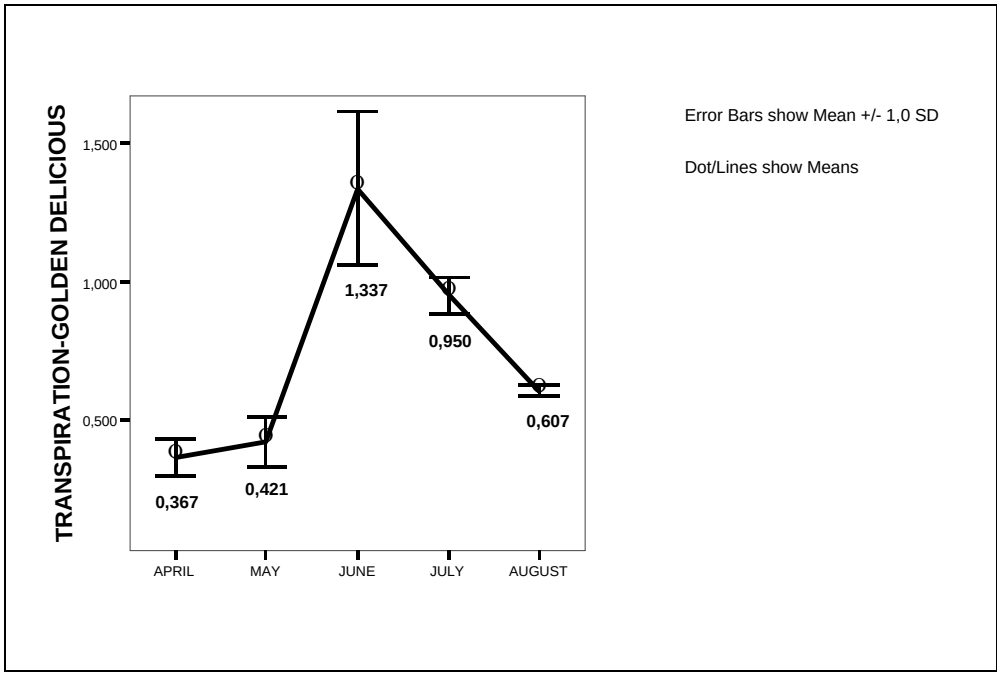

Fig. 2. Seasonal changes in the transpiration rate on Golden Delicious Apple

Table 2. Statistical results of the seasonal changes in the transpiration rate on Golden Delicious Apple

Multiple Comparisons

Dependent Variable: TRANSPIRATION-GOLDEN DELICIOUS

LSD

		Mean Difference	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
APRIL	MAY	-,053800	,167	-,13049	,02289
	JUNE	-,969800*	,000	-1,04649	-,89311
	JULY	-,583000*	,000	-,65969	-,50631
	AUGUST	-,240000*	,000	-,31669	-,16331
MAY	APRIL	,053800	,167	-,02289	,13049
	JUNE	-,916000*	,000	-,99269	-,83931
	JULY	-,529200*	,000	-,60589	-,45251
	AUGUST	-,186200*	,000	-,26289	-,10951
JUNE	APRIL	,969800*	,000	,89311	1,04649
	MAY	,916000*	,000	,83931	,99269
	JULY	,386800*	,000	,31011	,46349
	AUGUST	,729800*	,000	,65311	,80649
JULY	APRIL	,583000*	,000	,50631	,65969
	MAY	,529200*	,000	,45251	,60589
	JUNE	-,386800*	,000	-,46349	-,31011
	AUGUST	,343000*	,000	,26631	,41969
AUGUST	APRIL	,240000*	,000	,16331	,31669
	MAY	,186200*	,000	,10951	,26289
	JUNE	-,729800*	,000	-,80649	-,65311
	JULY	-,343000*	,000	-,41969	-,26631

*. The mean difference is significant at the .05 level.

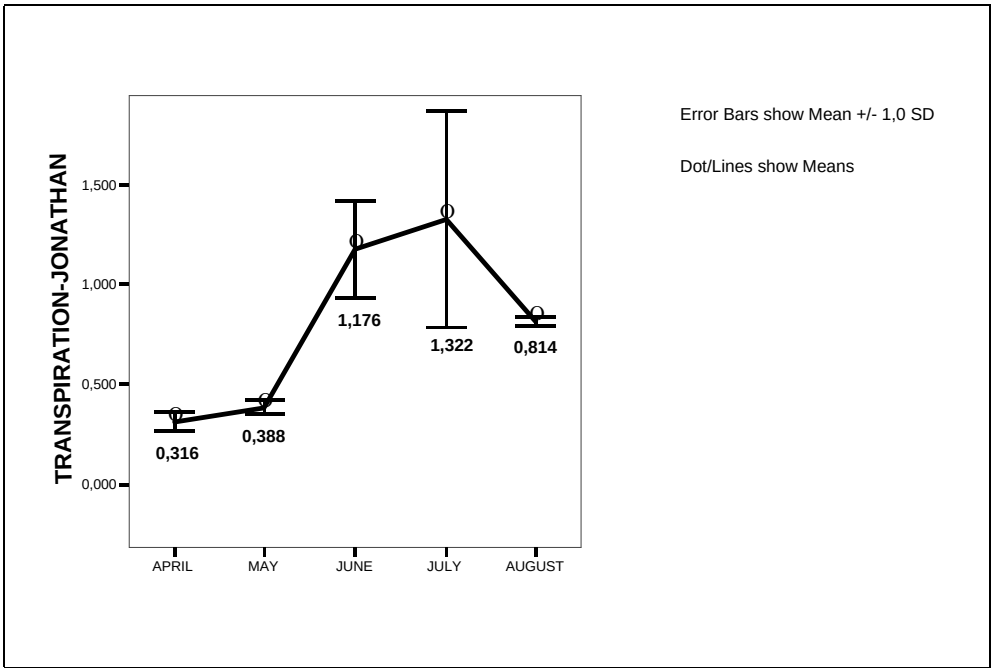

Fig. 3. Seasonal changes in the transpiration rate on Jonathan Apple

Table 3. Statistical results of the seasonal changes in the transpiration rate on Jonathan Apple

Multiple Comparisons

Dependent Variable: TRANSPIRATION-JONATHAN

LSD

		Mean Difference	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
APRIL	MAY	-,072480	,339	-,22200	,07704
	JUNE	-,860400*	,000	-1,00992	-,71088
	JULY	-1,006000*	,000	-1,15552	-,85648
	AUGUST	-,498400*	,000	-,64792	-,34888
MAY	APRIL	,072480	,339	-,07704	,22200
	JUNE	-,787920*	,000	-,93744	-,63840
	JULY	-,933520*	,000	-1,08304	-,78400
	AUGUST	-,425920*	,000	-,57544	-,27640
JUNE	APRIL	,860400*	,000	,71088	1,00992
	MAY	,787920*	,000	,63840	,93744
	JULY	-,145600	,056	-,29512	,00392
	AUGUST	,362000*	,000	,21248	,51152
JULY	APRIL	1,006000*	,000	,85648	1,15552
	MAY	,933520*	,000	,78400	1,08304
	JUNE	,145600	,056	-,00392	,29512
	AUGUST	,507600*	,000	,35808	,65712
AUGUST	APRIL	,498400*	,000	,34888	,64792
	MAY	,425920*	,000	,27640	,57544
	JUNE	-,362000*	,000	-,51152	-,21248
	JULY	-,507600*	,000	-,65712	-,35808

*. The mean difference is significant at the .05 level.

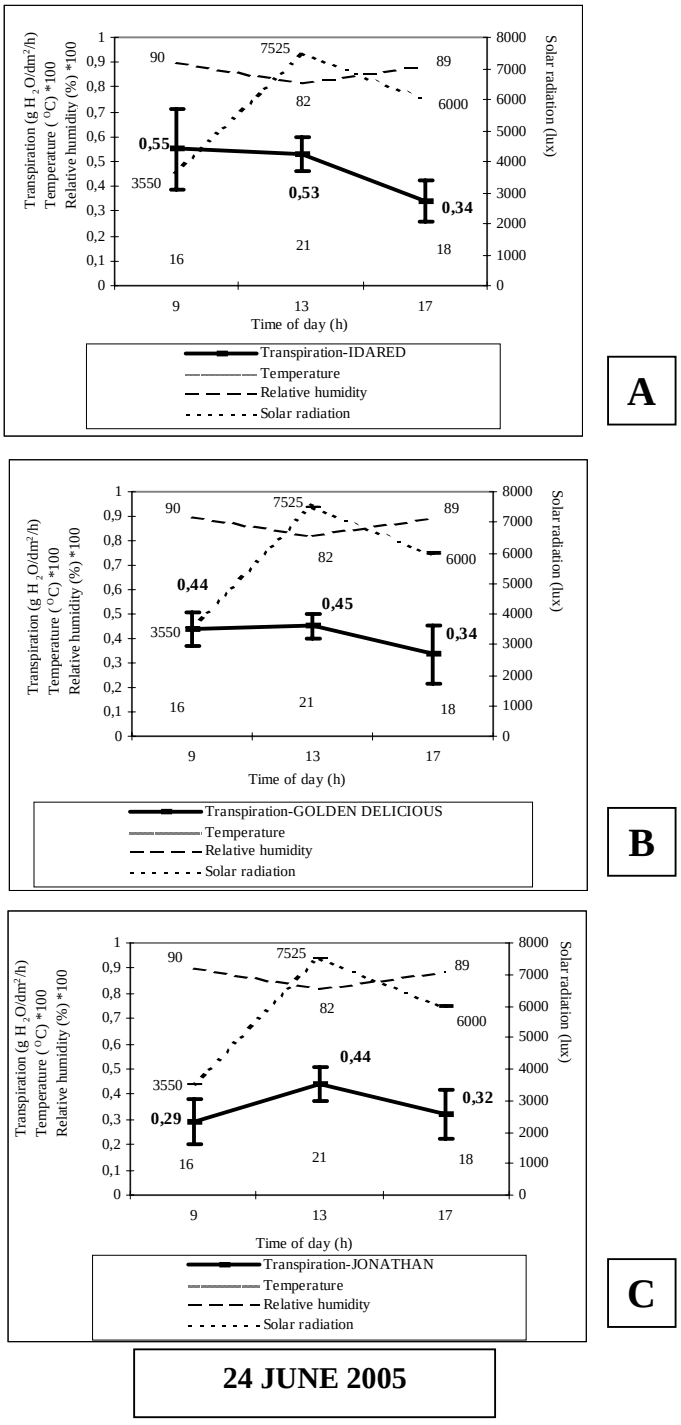

Fig. 4. Diurnal changes in the transpiration rate on apple trees
(A – Idared; B – Golden Delicious; C – Jonathan) (24 June 2005) (Error bars show mean +/-1.0 SD)

Table 4. Statistical results of the diurnal changes in the transpiration rate on apple trees (24 June 2005)

Multiple Comparisons

LSD

Dependent Variable	TIME OF DAY (H)	TIME OF DAY (H)	Mean Difference	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
TRANSPIRATION-IDARED	9	13	,022800	,524	-,04840	,09400
		17	,210200*	,000	,13900	,28140
	13	9	-,022800	,524	-,09400	,04840
		17	,187400*	,000	,11620	,25860
	17	9	-,210200*	,000	-,28140	-,13900
		13	-,187400*	,000	-,25860	-,11620
TRANSPIRATION-GOLDEN DELICOUS	9	13	-,010950	,689	-,06538	,04348
		17	,104200*	,000	,04977	,15863
	13	9	,010950	,689	-,04348	,06538
		17	,115150*	,000	,06072	,16958
	17	9	-,104200*	,000	-,15863	-,04977
		13	-,115150*	,000	-,16958	-,06072
TRANSPIRATION-JONATHAN	9	13	-,151400*	,000	-,20546	-,09734
		17	-,031000	,256	-,08506	,02306
	13	9	,151400*	,000	,09734	,20546
		17	,120400*	,000	,06634	,17446
	17	9	,031000	,256	-,02306	,08506
		13	-,120400*	,000	-,17446	-,06634

*. The mean difference is significant at the .05 level.

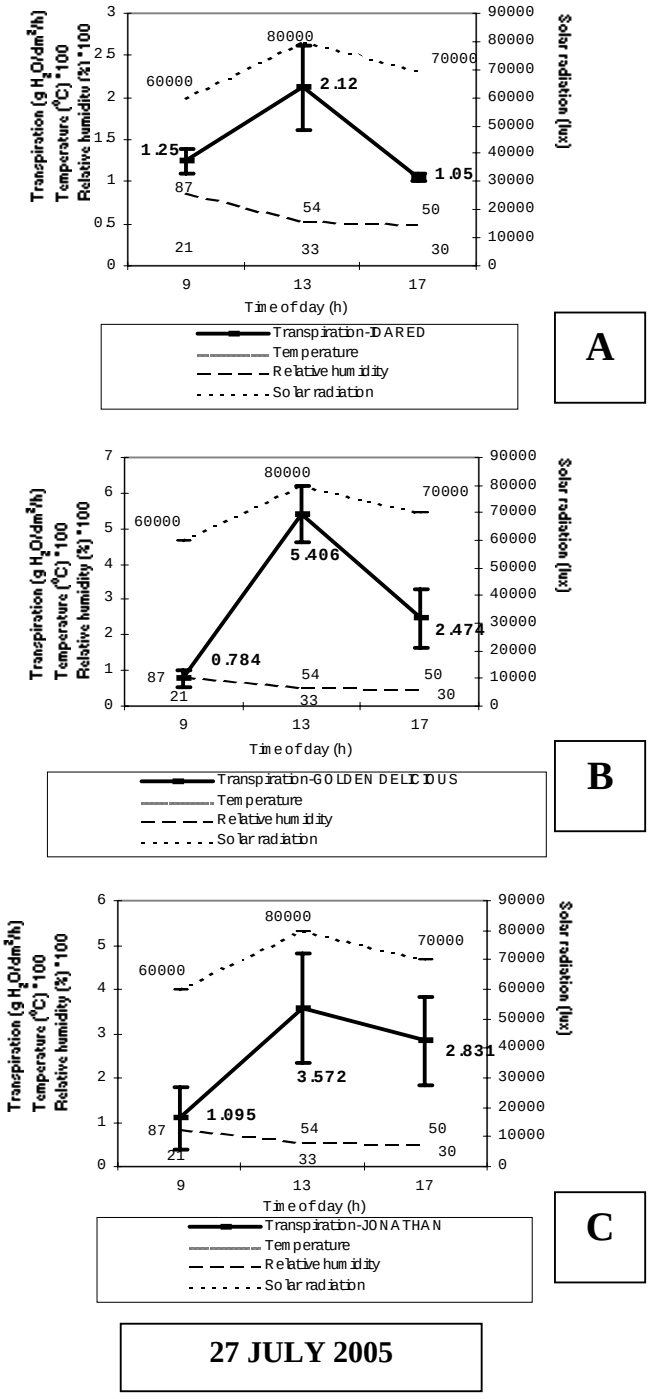

Fig. 5. Diurnal changes in the transpiration rate on apple trees
(A – Idared; B – Golden Delicious; C – Jonathan) (25 July 2005) (Error bars show mean +/-1.0 SD)

Table 5. Statistical results of the diurnal changes in the transpiration rate on apple trees (25 July 2005)

Multiple Comparisons

LSD

Dependent Variable	TIME OF DAY (H)	TIME OF DAY (H)	Mean Difference	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
TRANSPIRATION-IDARED	9	13	-,868800*	,000	-1,09106	-,64654
		17	,205600	,069	-,01666	,42786
	13	9	,868800*	,000	,64654	1,09106
		17	1,074400*	,000	,85214	1,29666
	17	9	-,205600	,069	-,42786	,01666
		13	-1,074400*	,000	-1,29666	-,85214
TRANSPIRATION-GOLDEN DELICOUS	9	13	-4,621600*	,000	-5,12244	-4,12076
		17	-1,689400*	,000	-2,19024	-1,18856
	13	9	4,621600*	,000	4,12076	5,12244
		17	2,932200*	,000	2,43136	3,43304
	17	9	1,689400*	,000	1,18856	2,19024
		13	-2,932200*	,000	-3,43304	-2,43136
TRANSPIRATION-JONATHAN	9	13	-2,477800*	,000	-3,21483	-1,74077
		17	-1,736400*	,000	-2,47343	-,99937
	13	9	2,477800*	,000	1,74077	3,21483
		17	,741400*	,049	,00437	1,47843
	17	9	1,736400*	,000	,99937	2,47343
		13	-,741400*	,049	-1,47843	-,00437

*. The mean difference is significant at the .05 level.

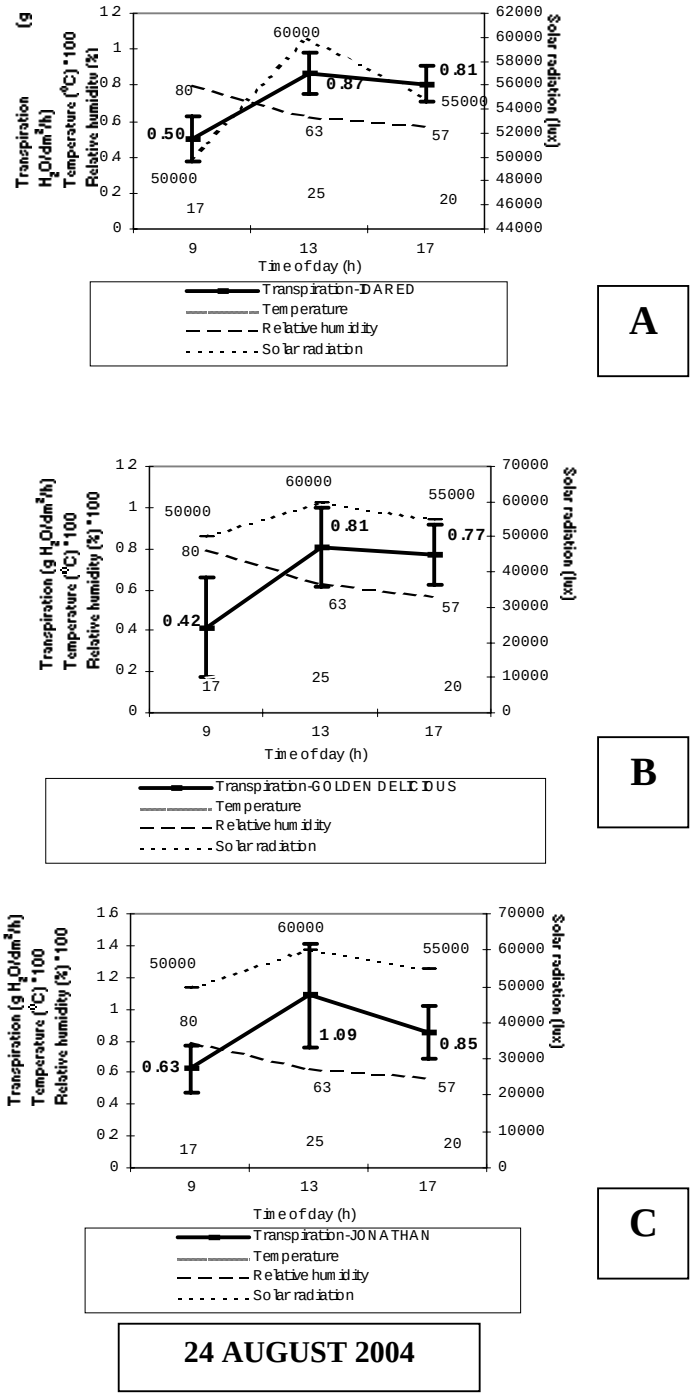

Fig. 6. Diurnal changes in the transpiration rate on apple trees
(A – Idared; B – Golden Delicious; C – Jonathan) (24 August 2004) (Error bars show mean +/-1.0 SD)

Table 6. Statistical results of the diurnal changes in the transpiration rate on apple trees (24 August 2004)

Multiple Comparisons

LSD

Dependent Variable	TIME OF DAY (H)	TIME OF DAY (H)	Mean Difference	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
TRANSPIRATION-IDARED	9	13	-,365800*	,000	-,43861	-,29299
		17	-,301400*	,000	-,37421	-,22859
	13	9	,365800*	,000	,29299	,43861
		17	,064400	,082	-,00841	,13721
	17	9	,301400*	,000	,22859	,37421
		13	-,064400	,082	-,13721	,00841
TRANSPIRATION-GOLDEN DELICOUS	9	13	-,391590*	,000	-,48143	-,30175
		17	-,351490*	,000	-,44133	-,26165
	13	9	,391590*	,000	,30175	,48143
		17	,040100	,375	-,04974	,12994
	17	9	,351490*	,000	,26165	,44133
		13	-,040100	,375	-,12994	,04974
TRANSPIRATION-JONATHAN	9	13	-,460940*	,000	-,60541	-,31647
		17	-,227840*	,003	-,37231	-,08337
	13	9	,460940*	,000	,31647	,60541
		17	,233100*	,002	,08863	,37757
	17	9	,227840*	,003	,08337	,37231
		13	-,233100*	,002	-,37757	-,08863

*. The mean difference is significant at the .05 level.