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THE EFFECTS OF AIR POLLUTION ON THE MAIN PHYSIOLOGICAL PROCESSES OF THE GRAPEVINE GROWN IN THE VICINITY OF A POWER PLANT

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Abstract: The impact of air pollution can cause severe damages to the vineyards located near industrial areas. This study was conducted in order to assess the impact of air pollutants, respectively SO_2, NO_2 and O_3, emitted from a thermal power plant in Craiova municipality, Romania, on some physiological parameters of the grapevine (*V. vinifera* L., cv. *Merlot*), grown in the field, measured in different phenological stages from May to September, 2010. In this regard two vineyards were chosen, having different concentrations of pollutants: the urban site (Şimnic), located near the thermal power plant and the rural site (Banu Mărăcine), considered the vineyard which is not subject to pollution. The 8-h daily mean SO_2, NO_2 and O_3 concentrations registered higher values for the urban site that varied from 24.2 to 36.8 µg/m³ SO_2, 20.2 to 28.45 µg/m³ for NO_2 and from 68.1 to 105.4 µg/m³ in case of O_3 compared to the rural site that had lower values. The air pollution around the thermal power plant lead to a significant reduction of 98.8% in photosynthetic rate at veraison stage, 61.5% in transpiration at rippening and 75.4% in stomatal conductance at shoot growth. The study highlights that the emitted pollutants by the thermal power plant affect the environment and the adjacent agricultural crops, resulting that the grapevine is a sensitive plant to air pollution.

Key words: air pollution, power plant, grapevine, photosynthesis, transpiration, stomatal conductance

1. INTRODUCTION

The environment is constantly changing, a nowadays feature being that the environmental changes are occurring faster than the time of issuance and implementation of control and forecasting methods for environmental changes (Lupea et al., 2008). In this century of technology, a real problem for humanity is the pollution impact on the environment and particularly the air pollution through its impact on the biosphere, but also on water and soil (Gavrilescu, 2007).

The pollution is a consequence of human activities (Vinnikov & Grody, 2003), therefore the continued world population growth results in increased emission of gases from agriculture, combustion of fossil fuels, and industrial processes causing changes in the chemical composition of the atmosphere. It has been known for at least 250 years that air pollution can have damaging effects on plants, crop production beying highly dependent upon environmental conditions among which air quality can play a major role (Agrawal et al., 2006). For a quality crops it is important to know the interaction between plants and environmental factors like temperature, light, humitidy, CO_2 concentration in the air (Gruia et al., 2010).

Also the changes in the climatic conditions that occur on Earth, including global warming (Duchene & Schneider, 2005) and air pollution influence directly or indirectly the productivity of agricultural crops (Fuhrer, 2009). The distribution and atmospheric processes of pollution and its effects on environment are influenced by climate, geography, demography, and socio-economic profile of the region (Ilten & Selici, 2008). Global change will definitely introduce changes in agricultural ecosystems that will affect phenology (Gordo & Sanz, 2009), photosynthesis and plant productivity, but the effects on plants will be different for each region depending on the pre-existing climatic conditions and the adaptation potential of local cultivated species (Chartzoulakis & Psarras, 2005; Moriondo et al., 2009; Popescu et al., 2009). Agroecosystems may be strongly influenced by the projected increase in atmospheric CO_2 and associated climate change (Streck, 2005, Jones et al., 2005) revealing that the importance of understanding climate change impacts on agriculture is especially evident with viticulture.

To predict the climatic changes caused by the increased concentrations of the greenhouse gases and CO_2 in particular, a series of climate models have been used successfully (Stock et al., 2005). Among them, the one used by Jara-Rojas et al., (2009) includes a description of synergistic interactions among CO_2 concentration, atmospheric variables and plant factors.

Besides the CO_2, another air pollutant, from the greenhouse gases category, namely the tropospheric ozone, is injurious to plants. It was established for the first time in 1950 that this gas is phytotoxic to grapevine, in the south of California (Karnosky et al., 2007), its exposure to high concentrations have as result the suppression of photosynthesis, accelerated senescence, slow growth and low yields (Booker et al., 2009). All greenhouse gases like nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and ozone (O_3) have fundamental effects on CO_2 exchange by plants (Ali et al., 2008).

Many air pollutants and greenhouse gases have common sources, contribute to radiative balance, interact in the atmosphere, and affect ecosystems (Bytnerowicz et al., 2007). The combustions of fossil fuels for electricity generation, industrial processes, transportation, and space heating are predominant source of primary pollutants in developed and industrialized countries (Ilten & Selici, 2008).

The industry is one of the major sources causing major changes in various environmental compartments (Arsene et al., 2006) and often cause large disruption to the adjacent crops, the main sources of pollution in the environment and of the atmosphere, in particular, beying the combustion of coal (bituminous and coal), ferrous, and nonferrous metallurgy, the chemical industry, as well as usage of lead-containing petrol, (Blum, 2007). Honour et al., (2009) study demonstrated clearly the potential for realistic levels of vehicle exhaust pollution to have direct adverse effects on urban vegetation like changes in growth and phenology, with a consistent trend for accelerated senescence and delayed flowering. The energy industry has a fairly large contribution to air pollution by the large and varied range of pollutants such as: SO_x, NO_x, CO, CO_2, CH_4, N_2O, NH_3, COV, PM and heavy metals. The harmful effect of sulfur and nitrogen oxides, of ozone and particulates on plants is manifested by the destruction of chlorophyll, by reducing photosynthesis and consequently by reducing yields and the life duration of affected plants (Cotigă, 2008).

The sensitivity of the grapevine to the action of the main air pollutants, namely the oxides of carbon, nitrogen and sulfur (Banu & Radovici, 2007), vary a lot in relation to variety, rootstock, grapevine age, stage of vegetation, the presence or absence of the grapes on the vine stock, and the vine-grower should permanently take into consideration the most important climatic factors such as: temperature, humidity and light (Yu et al., 2009).

Because at the basis of the main physiological processes of the grapevine is the gas exchange between the plant and the environment, different emissions as gas, dust, smoke after reaching the atmosphere act on the integrity of the plant, on the stomatal behavior, and the main regulator of this gas exchange has a crucial role in determining the potential damages caused by air pollution (Büker et al., 2007).

Thus, Schultz & Stoll (2010) reported the need to understand the physiological mechanism and the genetic background which underlie the interactions between plants and the environment and to pay special attention to researches in the field, which will be necessary for the development of sustainable concepts under changing conditions.

The viticulture is a multi-millenary traditional occupation, with deep roots in the culture and civilization of the Romanian people, Romania standing among the top 10 countries wine producers in the world in terms of cultivated surface with grapevine, grape production and wine.

The impact of air pollution can cause severe damages to the vineyards located near industrial areas, especially because the most Romanian thermal power plants were built at a time when their operation impact on the environment was undervalued, and the constraints related to the environmental protection were relatively few.

Therefore this study aims at determining, physiologically, the response of the grapevine cv. *Merlot*, grown in the field, to the action of an air pollutants complex which interacts with the main climatic factors. In this respect, two vineyards were chosen, located in two different areas of Craiova municipality, Romania, respectively the Şimnic Station of agricultural research and development - an area contaminated with pollutants discharged from the power plant CET II Craiova and Banu Mărăcine Viticultural Center - unpolluted area.

2. MATERIALS AND METHODS

2.1. The study area

The study was conducted in 2010 in Craiova City, Romania, at the Şimnic Station of agricultural research and development (44°19'16" N, 23°48'33" E), the data being recorded in May-September, during the active vegetation period of grapevine (*Vitis vinifera* L. cv. *Merlot*), in the vineyard owned by the research station which is under the impact of pollutant emissions from CET II Craiova power plant, branch of S.C.E. Craiova Energy Complex S.A. which produces electricity and heat. As reference values there was considered the vineyard belonging to the Banu Mărăcine Viticulture Center, located 12 km west far from the power plant, which is not subject to pollutant emissions (Figure 1).

The climate of both areas is temperate continental and is characterized by mild winters and dry summers, specific to plain areas, with annual average temperature of 10.7° C, for July and August the average temperature reaching 22,2^{o}C, respectively 21.7^{o}C and the annual average rainfall being of 569.9 mm, the most rainy months being June and May, with monthly average of 70.2 mm and respectively 63.4 mm (Sandu et al., 2008).

The soil from Şimnic vineyard (the urban site) and Banu Mărăcine Viticultural Center (the rural site), is a preluvosoil type, having the depth of approx. 20 cm for Ao horizon, with a density of 1.28 g/cm^3, the pH being moderately acid with a range of variations from 5.7 to 6.9, and low humus content.

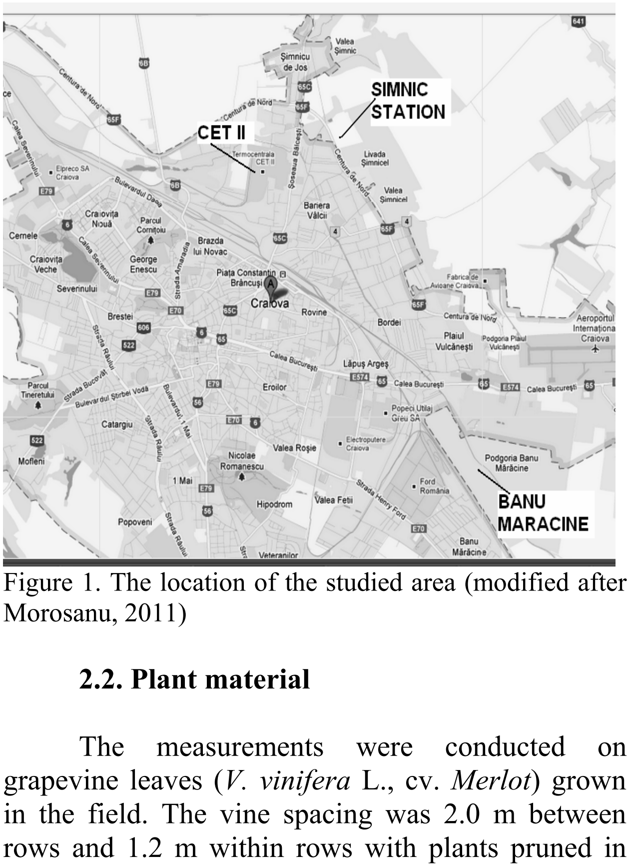


Figure 1. The location of the studied area (modified after Morosanu, 2011)

2.2. Plant material

The measurements were conducted on grapevine leaves (*V. vinifera* L., cv. *Merlot*) grown in the field. The vine spacing was 2.0 m between rows and 1.2 m within rows with plants pruned in Guyot system, a mixed pruning system, the bud load being of 24 buds/m^2. We specify that throughout this study, only works of pruning and soil maintenance were executed in the two vineyards, without use of herbicides and insecticides, thus practicing an organic viticulture. Soil moisture was kept at a level that did not induce any water stress.

2.3. Environmental measurements

Among the climatic factors that influence the grapevine (Lisek, 2008) and determine the opening of stomata, causing the polluting gases to enter into the plant body, the most important are: temperature, relative humidity, rainfall and sunshine. The climatic data are similar for both vineyards and were obtained from the Meteorological Station in Craiova municipality (Table 1).

Air quality monitoring was performed 8 h between 10.00 and 17.00, 4 days for each specific phenological stage, for SO_2, NO_2 and O_3, using a portable gas detector Oldham (Model MX 21 – Plus Multigas, France), placed at canopy level.

2.4. Gas exchange measurements

The assessment of the effects of air pollutants on the studied physiological processes was achieved by tracking some physiological indicators in the daily dynamic, namely: net rate of photosynthesis, stomatal conductance and transpiration. Leaf gas exchange measurements were made on fully expanded leaves, along 4 days (in the same days when the air pollutants monitoring was made), in each phenophases: blooming (from 2 to 2 days), shoot growth (once a week), véraison (once a week) and ripening (once for 3 days), every 2 hours, between 10 a.m to 5 p. m, on sunny days with a portable photosynthesis system ADC BioScientific Ltd., model LCpro, UK (Jara-Rojas et al., 2009; Popescu et al., 2010).

2.5. Statistical Analysis

Statistical analyses were carrying out using Student t-test. The correlation coefficient was determined for individual pollutant mean concentrations and the mean four days values around the given phenological stage for every physiological parameter studied. The significance criteria adopted were values of $\alpha > 0.1$, $\alpha < 0.01$, $\alpha < 0.05$.

3. RESULTS AND DISCUSSIONS

In this study the plants were grown in similar edaphic and climate conditions and thus observed differences in plant physiology may be attributed to atmospheric pollutants, and high temperature during the growing season of the grapevine (*V. vinifera* L., cv. *Merlot*), for the year of 2010.

Table 1. Climatic parameters obtained from metereological station at Craiova City during blooming at rippening vintage 2010. Data are average values for the specific phenological period (May-September).

Phenophase	Maximum air temperature (°C)	Minimum air temperature (°C)	Average RH (%)	Precipitation (Σ, mm)	Insolation (hours)
Blooming (31.05 - 9.06)	24.0	12.7	76	22.4	82.7
Shoot growth (13.06 -25.07)	29.7	17.4	74	119.6	410.2
Véraison (29.07 -31.08)	32.5	18.2	63	29.2	289.0
Rippening (6.09 - 25.09)	28.2	14.4	60	6.4	121.4

The blooming, shoot growth, véraison and rippening events are considered to occur when, for a given varietal, 50% of the plants exhibit the physiological response (Rodríguez et al., 2010). In the temperate climate, the annual course and the duration of the main phenophases of the grapevine annual biological cycle, varies from one variety to another, being strongly influenced by climatic factors, soil and agro-phyto-technical factors.

The average data for the given phenological stage, indicate that the grapevine (*V. vinifera* L., cv. *Merlot*) grown in the vicinity of the power plant face a significant serious set back in all the physiological parameters studied, compared to the control site, although the data registered from the rural site are also below the average data obtained by Costea (2006).

Table 2. The individual values and averages of the measured air pollutants at the urban and rural site during the vegetation season of the grapevine (May - September) and the maximum admissibile concentration of the pollutants

Pollutant	**Phenophase**								**CMA (Maximum Admissibile Concentration) ORD. 592/2002**
	Urban site				**Rural site**				
	Bloming (4 days between 31.05 - 9.06)	Shoot growth (4 days between 13.06 - 25.07)	Véraison (4 days between 29.07 - 31.08)	Ripening (4 days between 6.09 - 25.09)	Bloming (4 days between 31.05 - 9.06)	Shoot growth (4 days between 13.06 - 25.07)	Véraison (4 days between 29.07 - 31.08)	Ripening (4 days between 6.09 - 25.09)	
SO_2 (µg/m^3)	22.2	26.2	35.0	39.1	10.0	10.2	15.0	12.0	**125 µg/m^3** – daily limit for human health **20 µg/m^3** – anual critical level for vegetation protection
	24.2	24.3	36.0	36.2	8.4	12.2	11.4	10.0	
	26.4	26.1	36.2	34.3	10.2	12.0	12.0	8.0	
	24.0	29.4	40.0	30.0	12.2	14.0	18.1	8.5	
Average	**24.2**	**26.5**	**36.8**	**34.9**	**10.2**	**12.1**	**14.1**	**9.6**	
NO_2 (µg/m^3)	20.4	26.2	22.1	26.2	8.0	10.2	10.1	10.2	**40 µg/m^3** - daily limit for human health **30 µg/m^3** – anual critical level for vegetation protection
	18.2	27.0	21.2	29.2	8.2	10.0	10.0	12.0	
	22.2	28.1	22.8	34.0	9.2	10.4	12.0	14.0	
	20.0	30.3	24.1	28.4	10.2	10.2	12.0	15.0	
Average	**20.2**	**27.9**	**22.5**	**29.4**	**8.9**	**10.2**	**11.0**	**12.8**	
O_3 (µg/m^3)	66.2	82.2	100.2	93.0	30.5	41.0	58.0	62.0	**120 µg/m^3** – target value for human health **18.000 µg/m^{3}xh (AOT40)** – target value for vegetation protection
	68.2	76.2	105.2	95.2	33.1	39.5	62.2	60.5	
	70.0	80.0	106.0	94.0	36.3	43.0	60.0	56.0	
	68.2	74.0	110.2	100.0	40.0	45.0	63.0	52.0	
Average	**68.1**	**78.1**	**105.4**	**95.5**	**34.9**	**42.1**	**60.8**	**57.6**	

It is certain that the urban site has high pollutant levels and correspondingly the grapevine plants have low physiological activity, while rural site of Banu Mărăcine has low pollutants and the plants have high physiological activity. Şimnic site, showed the maximum pollutant concentrations, which may be due to the presence of the power plant CET II Craiova in the vicinity. Large traffic volume in this area also may cause increased air pollutants concentration in the atmosphere. Chauhan & Joshi (2010) have also observed maximum concentrations of pollutants for the site located in an industrial area, adding also the traffic emissions.

Of the three studied air pollutants, ozone has recorded the highest values for both sites because it concentrates more in the atmosphere during summer, due to warm temperatures and sunny days in the presence of nitrogen oxides and volatile organic compounds.

For the urban site, the mean SO_2 concentration registered the minimum value of 24.2 µg/m^3 at blooming stage and the highest 36.8 µg/m^3 In the case of O_3, it was observed the same pattern as for SO_2 with the lowest value of 68.1 µg/m^3 at blooming stage and the highest at véraison 105.4 µg/m^3. Compared to the urban site, in the Banu Mărăcine vineyard, there were recorded lower values for the three studied pollutants, thus SO_2 ranged from 9.5 µg/m^3 in the ripening phenophase to 14 µg/m^3 in the veraison phenophase. Instead, the NO_2 recorded values of 8.9 µg/m^3 at blooming and a maximum of 12.8 µg/m^3 at ripening. The O_3 recorded a maximum of 60.8 µg/m^3 in the ripening phase, a minimum value of 34.9 µg/m^3, (Table 2) observed in the blooming stage, these values being relatively high for this site due to the longer duration of insolation, between 82.7 and 410.2 hours and temperatures above 35°C, recorded during the active vegetation period of the grapevine (Table 1).

Even if the concentration of the pollutants measured at both urban and rural site does not exceed the maximum admissible concentration (Table 2), the pollutants affect the physiological processes of plants by deposition on plant leaves, hindering the normal functioning of stomata and also the pollutants can enter inside the plants through the tissues where it can accumulate in various organs of the plants. The relationship between the individual pollutants levels at the urban and rural sites and photosynthesis, transpiration and stomatal conductance was found to be significantly negative.

Table 3. The individual values and averages of the main pshisiological parameters of the grapevine registered at the urban and rural site during the vegetation season (May - September)

Pshisiological parameter	**Phenophase**							
	Urban site				**Rural site**			
	Bloming (4 days between 31.05 - 9.06)	Shoot growth (4 days between 13.06 - 25.07)	Véraison (4 days between 29.07 - 31.08)	Ripening (4 days between 6.09 - 25.09)	Bloming (4 days between 31.05 - 9.06)	Shoot growth (4 days between 13.06 - 25.07)	Véraiso n (4 days betwee n 29.07 -31.08)	Ripening (4 days between 6.09 - 25.09)
Photosynthesis (µmol m^{-2}s^{-1})	4.0	3.0	-1.0	-3.0	6.0	12.0	9.2	6.4
	3.0	2.3	-1.2	-2.1	6.2	11.6	11.0	6.4
	2.1	2.2	-1.4	-2.0	5.2	11.2	10.5	7.0
	2.9	2.1	-1.4	-1.0	5.0	11.0	9.3	7.4
Average	**3**	**2.4**	**-1.2**	**-2.0**	**5.6**	**11.4**	**10**	**6.8**
Transpiration (mmol m^{-2}s^{-1})	1.2	1.9	1.1	0.04	5.2	5.0	3.2	1.0
	1.1	2.1	1.0	0.2	5.0	4.6	4.2	2.2
	2.2	1.8	1.2	0.2	4.2	4.2	3.8	1.2
	3.0	2.2	1.3	0.6	4.0	3.0	4.0	2.0
Average	**1.8**	**2**	**1.1**	**0.2**	**4.6**	**4.2**	**3.8**	**1.6**
Stomatal conductance (mol m^{-2}s^{-1})	0.08	0.04	0.02	0.02	0.6	0.3	0.3	0.2
	0.06	0.06	0.04	0.01	0.4	0.5	0.2	0.1
	0.04	0.04	0.03	0.01	0.4	0.2	0.2	0.3
	0.06	0.02	0.03	0.01	0.2	0.2	0.1	0.2
Average	**0.06**	**0.04**	**0.03**	**0.01**	**0.4**	**0.3**	**0.2**	**0.2**

Upon comparison of the correlation coefficient values it is evident that the relationship between the individual levels of SO_2 and O_3 and photosynthesis and stomatal conductance was found to be significantly negative whilst NO_2 has a greater impact only on transpiration and stomatal conductance at the rural site (Table 4).

Ozone, sulfur dioxide and nitrogen dioxide, individually and in combination are known to affect many crop plants (Agrawal et al., 2006), these gaseous pollutants entering through the stomata on plant leaves, following the same path and diffusion as CO_2.

The harmful effects of SO_2 in the atmosphere are manifested through the destruction of chlorophyll and passing into phaeophytins, brown spots and necrosis appearing on leaves, and at the powerful attacks the leaves became crumbly, ultimately leading to the decrease of foliar surface and implicitly of photosynthesis, the nitrogen oxides inducing to the plants symptoms similar to sulfur oxides to which they act synergistically (Cotigă, 2008).

The tropospheric ozone is a photochemical oxidant, which affects the plants by suppressing the photosynthesis, through accelerated senescence and reduced growth and yield (Booker et al., 2009).

Thus, in this study, the photosynthesis showed the same pattern for all the studied pollutants, the lower values were recorded at blooming stage, and the maximum was recorded in the shoot growth, then they decreased at véraison and ripening, the pattern being observed for both urban and rural site.

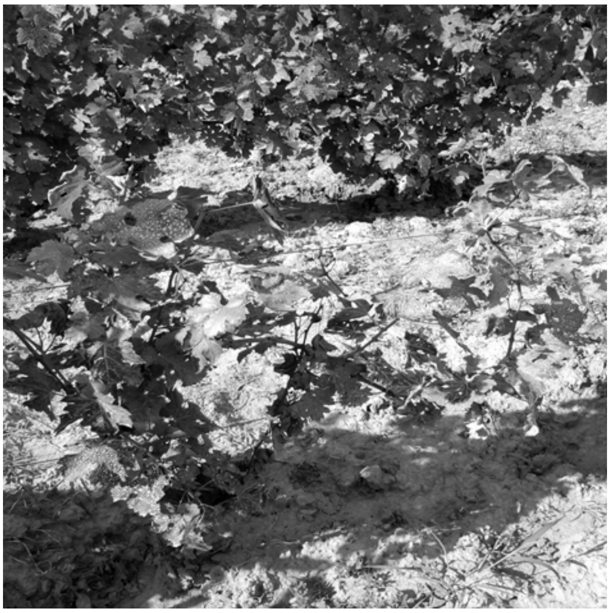
The results show that photosynthesis has recorded in the Şimnic vineyard a decrease with 88.1% in the blooming phenophase, with 47.9% in the stage of shoot growth, with 98.8% at véraison and 34.2% at ripening, rather than the net rate of photosynthesis recorded at Banu Mărăcine were it registered higher values (Table 3, Figure 3).

The significant decrease in photosynthesis in the Şimnic site is due to the presence of pollutants into the atmosphere emitted from the thermal power plant, and, by deposition on leaves, obstructing the normal functioning of stomata, determining a low intensity of photosynthesis and transpiration, stomata being recognized as an important modifier of plant responses to air pollution (Mandal, 2006).

A reduction in leaf areas, due to leaves injury caused by pollutants, like necrosis, clorosis (Figure 2), could be also an additional factor contributing to the decline in net photosynthesis rate per plant (Saquib et al., 2010).

Also changes in photosynthesis rate caused by air pollution may be reflected by deterioration of photosynthetic pigments and reduced efficiency of photochemical reactions, because photosynthetic pigments are fairly sensitive to air pollutants and their sensitivity may determine the response of plants to pollutants (Chauhan & Joshi, 2010).

A.



B.

Figure 2. Vizible injury of *Merlot* cultivar due to air pollutants and high temperature, observed at the urban site for the véraison stage (A) and ripening (B).

The negative values of photosynthesis registered during the véraison and ripening phenophases, at the urban site (Şimnic vineyard) are most likely due to a greater consumption of organic substances by the plants and the production of a smaller quantity of organic substances assimilated in the leaves as a response of plants to unfavorable environmental conditions like air pollution.

The lower values of photosynthesis from the véraison and ripening phenophases can be caused also by the higher temperatures and lower atmospheric

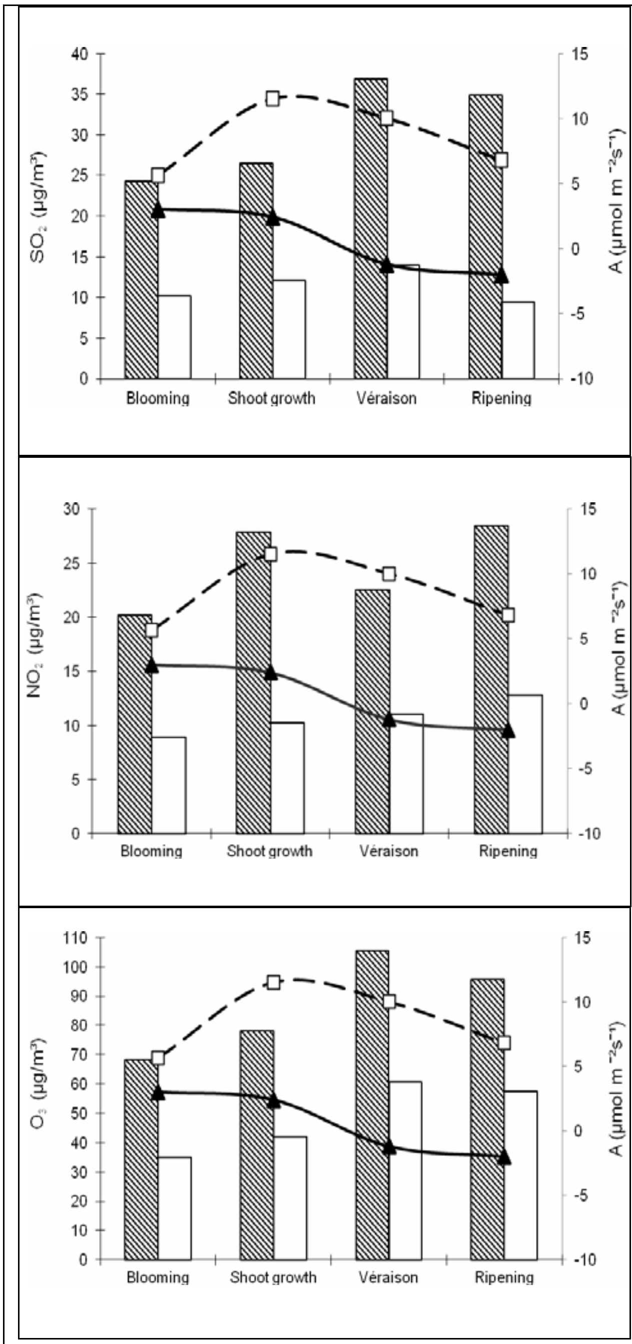


Figure 3. The effects of air pollutants on photoshyntesis, A (µmol m $^{-2}$s^{-1}), of *Merlot* cultivar grown in the field, during the active vegetation period at the urban site (▲) and rural site (□). The hatched bars indicate the mean values for the specific pollutant studied at the urban site and the white bars indicate the mean values for the specific pollutant studied at the rural site

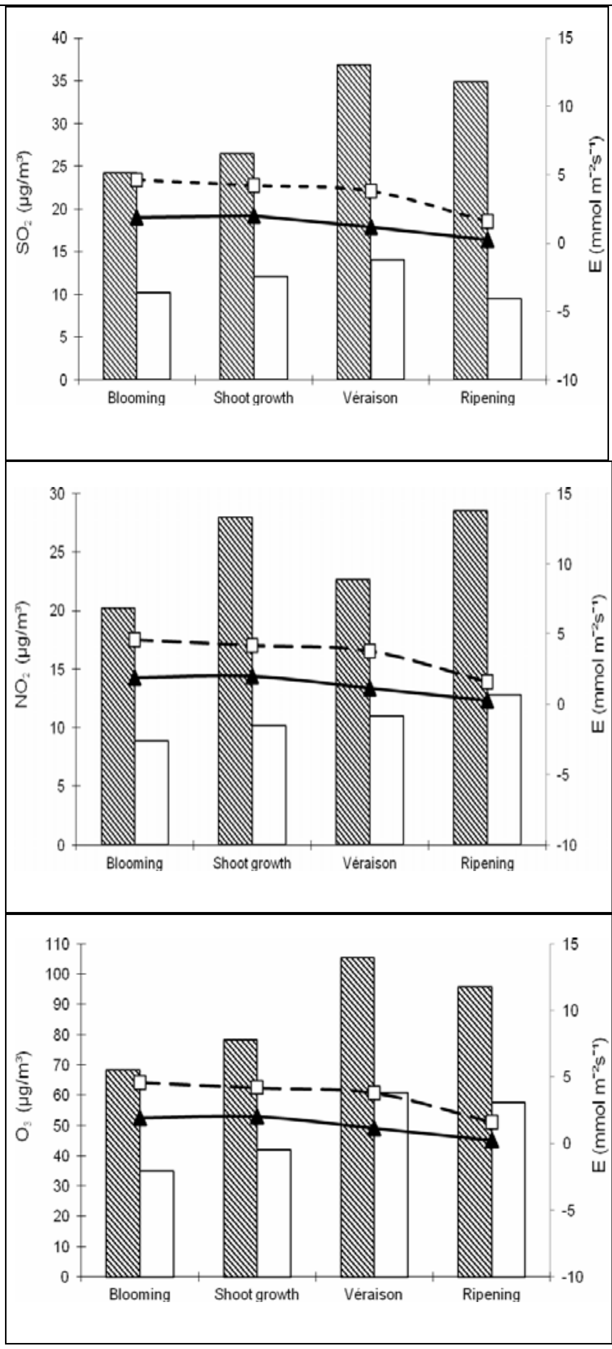


Figure 4. The effects of air pollutants on transpiration, E (mmol m^{-2}s^{-1}), of *Merlot* cultivar grown in the field, during the active vegetation period at the urban site (▲) and rural site (□). The hatched bars indicate the mean values for the specific pollutant studied at the urban site and the white bars indicate the mean values for the specific pollutant studied at the rural site

humidity recorded during studied period. In the véraison phenophase, at 32.5°C (Table 1), the rate of photosynthesis is very low, the assimilation rate is lower than the consuption of organic compounds, that means the guard cells of stomata are closing.

It is well known that plant transpiration is highly dependent on environmental factors, among the most important being temperature, relative air humidity and light.

Regarding the transpiration rate in this study, due to the high temperatures and relative high humidity in July, August and September, it presented higher values at the rural site, a significant decrease being observed in the urban site at ripening and

Table 4. Correlation coefficients between mean pollutant concentrations and physiological parameters of grapevine

Correlation between	Correlation coefficient	
	Urban Site	Rural Site
SO_2 vs. Photosynthesis	-0.96^{***}	0.76^{*}
NO_2 vs. Photosynthesis	-0.35^{NS}	0.38^{NS}
O_3 vs. Photosynthesis	-0.92^{**}	0.22^{NS}
SO_2 vs. Transpiration	-0.80^{*}	0.43^{NS}
NO_2 vs. Transpiration	-0.41^{NS}	-0.95^{**}
O_3 vs. Transpiration	-0.71^{NS}	-0.66^{NS}
SO_2 vs. Stomatal conductance	-0.82^{*}	-0.31^{NS}
NO_2 vs. Stomatal conductance	-0.71^{NS}	-0.89^{**}
O_3 vs. Stomatal conductance	-0.97^{***}	-0.78^{*}

*** $\alpha > 0.1$; ** $\alpha < 0.01$; * $\alpha < 0.05$; ^{NS} not significant

maturation phenophases with 33.04% and 61.5% most likely due to pollutants deposition on leaves obstructing the normal functioning of stomata, or by the closure of stomata in order to retain water (Table 3, Fig. 4).

The stomatal conductance was significantly lower in the urban site, dropping to 66.7% during the blooming phase, compared to the conductance obtained in the rural site (Table 3). Also, Gregg et al., (2006), found a significantly higher stomatal conductance in cottonwood for the rural site studied. The stomatal conductance values, obtained in the rural site, well below the normal average for *Merlot* variety, observed by Costea (2006), can be explained by the existence of adaptive mechanisms by which the plant responds to the stress caused by the presence of pollutants in the atmosphere, to which it is added also the thermal and hydric stress by closing and opening of stomata.

4. CONCLUSIONS

This study focused on the physiological response of the grapevine, grown in the field, to the harmful action of air pollutants.

The grapevine, grown near the thermal power plant, alters its physiological parameters, as a reaction of response to the harmful action of atmospheric pollutants. Thus, one can say that photosynthesis, transpiration and stomatal conductance have recorded significantly lower values in the vineyard exposed to the atmospheric pollutants, having high levels of SO_2, NO_2 and O_3 compared with the testing vineyard, foliar lesions being visible throughout the vineyard from the urban site.

The study highlights the fact that pollutants emitted by the thermal power plant affect the environment and the adjacent crops, resulting that the grapevine is a sensitive plant to air pollution.

The effects of air pollution on the physiological processes of grapevine are complex, relatively few and are not yet fully understood. As the pollutants discharged into the atmosphere interact with a number of biotic and abiotic factors, the responses of grapevine to their action varies widely.

Plants, including the grapevine, grown in their natural environment, develop defense mechanisms against the harmful action of pollutants, such as stomata closure, but it should be understood that these defense responses to the destructive action of a pollutant can be blocked by the presence and action of another pollutant.

In the case of areas exposed to atmospheric pollution, it is absolutely necessary to take measures of air depollution, so that the pollutants discharged into the atmosphere by various industries, as is the current case, do not affect the integrity and productivity of plants.

Because in the natural environment, the pollutants are not acting individually but in combination both with other pollutants and other environmental factors such as the climate, soil, etc., future studies carried out in a controlled environment are necessary to highlight clearly the action mode of each pollutant individually, but also in combination, on the metabolism of agricultural plants.

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