APPLICATION OF NITROGEN SOURCES ON GRAPEVINES AND EFFECT ON YIELD AND MUST COMPOSITION[1]

GUSTAVO BRUNETTO[2], CARLOS ALBERTO CERETTA[2],
GEORGE WELLINGTON BASTOS DE MELO[3], EDUARDO GIROTTO[4]
PAULO ADEMAR AVELAR FERREIRA[5]

ABSTRACT- This study was carried out to evaluate the yield, total N content in leaves and must composition of grapes from the Cabernet Sauvignon variety subjected to the application of urea and organic compost. Cabernet Sauvignon grapevines in Rosário do Sul, RS, Brazil, in 2008, 2009 and 2010 were subjected to annual application of 40 kg N ha^{-1} in the form of organic compost and urea, and compared to unfertilized grapevines. In the 2008/09, 2009/10 and 2010/11 crop seasons, leaves were collected for analysis of total N content. At maturation of the grapes, the yield and quality attributes of the must were evaluated. The application of N sources, especially organic compost, increased the N content in the whole leaf at full flowering. Application of organic compost and urea has little effect on grape yield and does not affect the total nutrient content in the must, nor the enological attributes.
Index terms: Urea, organic compost, leaf analysis, must quality, *Vitis vinifera*.

APLICAÇÃO DE FONTES DE NITROGÊNIO EM VIDEIRAS E EFEITO NA PRODUÇÃO E COMPOSIÇÃO DO MOSTO

RESUMO- O trabalho objetivou avaliar a produção, o teor de N total nas folhas e a composição do mosto de uvas da cultivar Cabernet Sauvignon submetidas à aplicação de ureia e composto orgânico. Videiras Cabernet Sauvignon, em Rosário do Sul (RS), em 2008, 2009 e 2010, foram submetidas à aplicação anual de 40 kg N ha^{-1} na forma de composto orgânico e ureia, e comparadas com videiras não adubadas. Nas safras de 2008/2009, 2009/2010 e 2010/2011 foram coletadas folhas no pleno florescimento e na mudança da cor das bagas para a análise do teor de N total. Na maturação das uvas, foram avaliados a produção e os atributos de qualidade do mosto. A aplicação de fontes de N, especialmente composto orgânico, aumenta o teor de N na folha completa, no pleno florescimento. A aplicação de composto orgânico e de ureia pouco afeta a produção de uva e não interfere no teor de nutrientes totais no mosto nem tampouco nos atributos enológicos.
Termos de indexação: Ureia, composto orgânico, análise foliar, qualidade do mosto, *Vitis vinifera*.

[1](Trabalho 091-13). Recebido em: 01-03-2013. Aceito para publicação em: 02-10-2013.
[2]Agronomist, Doctor of Soil Science, Professor of the Departament of Soils and of the Graduate Studies Program in Soil Science of the Universidade Federal de Santa Maria (UFSM) [Federal University of Santa Maria], Scholarship holder of Productivity in Research from the CNPq. E-mail: brunetto.gustavo@gmail.com; carlosceretta@ufsm.br
[3]Agronomist, Doctor of Soil, Researcher at Embrapa Uva e Vinho. E-mail: wellington.melo@embrapa.br
[4]Agronomist, Doctor in Soil Science, Professor of the Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Sul, Campus Ibirubá. E-mail: girottosolos@gmail.com
[5]Agronomist, Doctor in Soil Science, Pos-Doctor of the Program in Soil Science of the UFSM. E-mail: avelarufla@gmail.com

INTRODUCTION

The Campanha Gaucha region of the state of Rio Grande do Sul (RS), Brazil, located in the southeast of the state, is one of the main wine-growing regions of Brazil, with especially red wine-producing grapes like Cabernet Sauvignon being grown. In this region, soils generally have a sandy surface horizon and low or medium organic matter content, which gives them low capacity for supplying mineral nitrogen (N) to plants (BRUNETTO et al., 2007). Species of cover crops are intercropped, especially between the rows in the vineyards, and if they are leguminous or gramineous plants, they may biologically fix atmospheric N and promote cycling of this and other nutrients. Throughout decomposition of their litter from the above ground part deposited on the soil surface and decaying roots in decomposition within the soil, the N contained in the plant tissue may be released near the root system of the grapevines, which at times may be taken up in small quantities by the plants. Thus, N application, especially urea is usually necessary in vineyards.

However, grapevines grown in sandy soils with low or medium organic matter content generally utilize a small quantity of the N derived from the urea (BRUNETTO et al., 2008b). This has been attributed to N transfer through leaching, especially in the form of nitrate (NO_3^--N) in the soil profile, but also by soil surface runoff (LORENSINI et al., 2012). In addition, there is N transfer by volatilization to the atmosphere because, after the application of urea on the soil surface, it is rapidly hydrolyzed by urease extracellular enzymes, produced by microorganisms such as bacteria, actinomycetes and soil fungi. In this process, ammonium carbonate $(NH_4^+)_2CO_3$ is formed, which is not stable and is decomposed into ammonia (NH_3-N), CO_2 and water, with NH_3-N being volatilized to the atmosphere (LORENSINI et al., 2012). To minimize N transfers, N organic forms have especially (though not exclusively) been used in vineyards, like organic compost obtained from aerobic composting of residues, such as juice sludge and other residues from the winemaking process, and sawdust. Organic compost applied on the soil surface and without incorporation is expected to have a smaller area of contact with the soil and, consequently, a lower rate of N release, which may minimize its transfer to the atmosphere through soil surface runoff and through leaching into the soil profile (LORENSINI et al., 2012), probably increasing the synchronism between N release and uptake by the plant (MELO et al., 2012).

The impact of organic compost application on the nutritional state of grapevines in comparison to urea application is not sufficiently known. This may be estimated by the total N content in the whole leaf, collected at verasion (change in color of the berries) or in the full flowering stage, which may be a more sensitive period for diagnosing the increase in N content in the plant and, consequently, its availability in the soil (BRUNETTO et al., 2006; 2008b). In addition, the effect of application of N sources on grape yield and its components, such as the number and weight of clusters per plant and 100-berry weight, is not known (BRUNETTO et al., 2007; 2008a). There is likewise lack of information on indicators of must composition, among which are: total nutrient content, where, for example, N may be highlighted, which is a determining factor for must fermentation (BELTRAN et al., 2005); potassium (K), whose increase in the must may lead to the formation of K bitartrate in the wine, which, in turn, may also increase the pH values of the wine, accelerating its oxidation and reducing its quality through time (DAVIES et al., 2006); the values of soluble solids, which in the ^{o}Brix scale represents 90% of the sugars found in the must; pH; total acidity and tartaric and malic acid, which represent more than 90% of the total acids of the berry and indicate the stability and longevity of the wine (BRUNETTO et al., 2008a). Thus, undertaking regional field experiments becomes necessary, preferentially of more than one crop season, for increasing the reliability of the data so as to establish the most adequate N source to be applied on the grapevines. This study was carried out to evaluate the impact of application of organic compost and urea on yield, total N content in the leaves and must composition of grapes from Cabernet Sauvignon grapevines.

MATERIALS AND METHODS

The experiment was conducted in a commercial vineyard located in the municipality of Rosário do Sul. RS, in the Campanha Gaucha region in the south of Brazil. The vineyard was planted in 2004 in the espalier trellis training system with the Cabernet Sauvignon variety grafted on the rootstock SO4 at a density of 3704 plants per hectare (1.0 x 2.7 m spacing). Climate in the region is the Cfa type, with average temperatures ranging from 11.9 to 23.5°C and annual average rainfall of 1599 mm. Other climatic data observed throughout the months of carrying out the study are shown in Table 1. The soil was a Sandy Typic Hapludalf and before the experiment was set up, it exhibited the following attributes in the 0-20 cm layer: clay 70.0 g kg^{-1}; organic matter 10.0 g kg^{-1}; pH in water 5.5; exchangeable Al 0.0 $cmol_c$ dm^{-3} (KCl 1 mol L^{-1} extractor); exchangeable Ca 0.9 $cmol_c$ dm^{-3} (KCl 1 mol L^{-1} extractor); exchangeable Mg 0.6 $cmol_c$ dm^{-3} (KCl 1 mol L^{-1} extractor); available P 30.1 mg dm^{-3} (Mehlich 1 extractor) and available K 48.0 mg dm^{-3} (Mehlich 1 extractor) and $CEC_{pH7.0}$ 4.7 $cmol_c$ dm^{-3}.

The grapevines were subjected to the application of 40kg N ha^{-1} $year^{-1}$ in the form of organic compost, which exhibited the following characteristics: dry matter, 841 g kg^{-1}; pH in water, 9.6; NO_3^--N, 4.0 g kg^{-1}; NH_4^+-N, 4.6 g kg^{-1}; total N, 19.0 g kg^{-1}; total P, 17.3 g kg^{-1}; total K, 32 g kg^{-1}; total Ca, 25 g kg^{-1}; total Mg, 2.0 g kg^{-1}; total organic carbon, 199.0 g kg^{-1}; and 40 kg N ha^{-1} $year^{-1}$ in the form of urea (45% N); plus a control treatment without fertilization. Nitrogen application in the years 2008, 2009 and 2010, both in the form of compost and urea, was always made in August, coinciding with bud break of the grapevines (BRUNETTO et al., 2008a). The N sources were applied manually on the soil surface, without incorporation, and arranged in a 0.5 m wide strip in the plant row, an area equivalent to the projection of the plant canopy. Weeds were controlled through application of Glyphosate herbicide in the strip where N was applied throughout the period of the experiment. Between the plant rows, volunteer plant growth was allowed, essentially composed of native grasses, and it was mechanically controlled with the use of a brush-cutter. In the three crop seasons, a quantity of P and K equivalent to that applied through organic compost was also added to the grapevines subjected to application of urea. The plants were subjected to short 'spur' pruning, performed in the month of July, leaving approximately eight new shoots, for a total of 16 buds per plant. A randomized block experimental design was used with five replications, each plot consisting of five plants, and evaluations were made on the three center plants on an annual basis.

In October, during full flowering of the grapevines, and in January, at verasion, in the 2008/2009, 2009/2010 and 2010/2011 crop seasons, 15 mature leaves per plant were collected on both sides of the plant row. The leaves were then dried in a laboratory oven at 65°C until constant weight and subjected to analysis of total N by the Kjedahl method. In March 2009, 2010 and 2011 at the maturation of the berries, harvest and counting of the clusters were performed, and the clusters were then weighed on a digital balance. Five clusters from each plant were selected for counting the number of berries. Next, 100 grape berries were collected, which were removed from the upper, middle and lower part of the five previously selected clusters. The berries were weighed in a digital balance and divided into two portions. Thirty berries were ground in a blender for homogenization and a subsample was removed, which was subjected to total N, P and K analysis (BRUNETTO et al., 2008a). The remaining berries were macerated and pH values in the must were determined using a digital potentiometer, soluble solids determined using a digital portable refractometer with temperature control, acidity determined by titration with 0.1 mol L^{-1} NaOH, and malic and tartaric acid determined by high efficiency liquid chromatography. Only in the 2010/2011 crop season were the tartaric and malic acid contents of the grapes not analyzed. The results obtained were subjected to analysis of variance using the Sisvar statistical program and, when the effects were significant, the mean values were compared by the Scott−Knott test (α=0.05).

RESULTS AND DISCUSSSION

Total N content in the whole leaf

Greater content of total N in the whole leaves collected at full flowering was observed in the grapevines subjected to application of organic compost in the 2008/2009 and 2009/2010 crop seasons (Table 2). This may probably be attributed to the smaller area of contact of the compost with the soil surface, which retards the activity of the microbial biomass and compost decomposition (MELO et al., 2012). For that reason, slower release of nutrients is expected, including N; its transfer to the atmosphere in the form of NH_3-N may be minimized from the soil surface runoff solution and from leaching, especially in the form of NO_3^--N in the soil profile (LORENSINI et al., 2012). This increases the synchronism between N release and N uptake by the plant (MELO et al., 2012), which may be diagnosed by the N content in the whole leaf. In contrast, the rapid hydrolysis of the lower total N contents in the whole leaves in the grapevines subjected to application of urea in comparison to those leaves with the addition of organic compost in the 2008/2009 and 2009/2010 crop seasons may be explained by extracellular urease enzymes produced by microorganisms such as bacteria, actinomycetes and soil fungi. Ammonium carbonate $(NH_4^+)_2CO_3$ is thus formed, which is not stable and decomposes into NH_3-N, CO_2 and water, with NH_3-N being emitted in the form of gas to the atmosphere in particularly greater intensity soon after the application of urea on the soil surface (LORENSINI et al., 2012). According to Lorensini et al. (2012), in 80 hours after the application of 40 kg N ha^{-1} $year^{-1}$ in the form of urea at bud break of the grapevines, in the same vineyard and soil of the present study, accumulated losses were 5.51 kg N ha^{-1} when urea was used, and only 0.35 kg N ha^{-1} when organic compost was used. In addition, the lower N content in the whole leaf of the grapevines subjected to application of urea may be explained in part by the leaching of NO_3^--N and also NH_4^+-N, even though in lower quantities, both already observed in vineyard soils (BRUNETTO et al., 2008b). According to Lorensini et al. (2012), in the Sandy Typic Hapludalf soil of the same vineyard of the present study, which has a 10.0 g kg^{-1} surface horizon of organic matter, considered as low, the greater transfer of mineral N, especially NO_3^--N, occurred when urea was used as a N source, as compared to the use of organic compost. This same study showed that the greatest losses through leaching occur in the period between bud break and full flowering of the grapevines, reducing the mineral N of the soil and, thus, its provision to plants. As for the 2010/2011 crop season, the total N contents in the leaves were equal for the grapevines subjected to the application of organic compost and urea. Such a fact may be attributed to the lower rainfall which occurred from the month of October to harvest (Table 1), which may have resulted in a smaller loss of NO_3^--N through leaching when urea was used, and also reduction in the speed of mineralization of the organic compost due to lower soil moisture.

Total N contents in the leaves collected at verasion were the same in the grapevines without the N application and those with addition of the nutrient in the form of urea and organic compost (Table 2). Thus, it can be clearly verified that the whole leaves collected at verasion are less sensitive in diagnosing the increase in the N content within the plant in comparison to the leaves collected at full flowering. Similar results were obtained by Brunetto et al. (2008a) in Bordô and Couderc cultivar grapevines grown in an Inceptisol soil, with organic matter content of 11 g kg^{-1} (similar to the organic matter content of the soil of the present study) and subjected to application of N doses in the Planalto (Plateau) region of the state of Rio Grande do Sul. The lack of sensitivity of the leaves collected at verasion for detecting the increase in the N content within the plant may be attributed to reduction of the mineral N content in the soil because of the transfer of N forms through the soil surface runoff solution and leaching in the profile (LORENSINI et al., 2012). Moreover, and especially, it is because of the dilution of N contained in the leaf and its redistribution from leaves to other organs of the plants, especially to new organs like clusters and shoots, which through their growth represent a drain on nutrients. In addition, in this stage, part of the N may be accumulated in organs more than one year old, such as branches from the previous year and stems and roots, for the next cycle (BRUNETTO et al., 2006, 2008b; 2009). However, it should be noted that even without the increase in total N content being observed in the whole leaf with the application of urea or organic compost, the N content in the leaves collected at verasion, in all the treatments and crop seasons, were considered as normal (16.0-24.0 g kg^{-1}) or above normal (>24.0 g kg^{-1}). These data indicate that even without fertilization, the soil, through the mineralization process of its organic matter, supplied the necessary quantity of N to the grapevines in a satisfactory manner.

Grape yield

The greatest grape yield per plant and per hectare in the 2008/2009 crop season was verified in the grapevines subjected to the organic compost application (Table 2), which also exhibited the greatest total N content in the whole leaf collected at full flowering (Table 2). On the other hand, in the same crop season, grape yield on the grapevines with the addition of urea was equal to those plants without the application of fertilizer. The greater yield on the grapevines with the organic compost application may be explained by the greater mean number of berries per cluster (Table 2). This probably occurred through better plant nutrition, resulting from release of nutrients in a more gradual manner, synchronized with plant needs (MELO et al., 2012).

Nevertheless, in the 2009/2010 and 2010/2011 crop seasons, grape yield per plant and per hectare, number of clusters per plant, mean weight of clusters per plant and mean weight of berries was not affected by the application of urea and organic compost (Table 2). The same yield of grapes on the grapevines with and without the application of fertilizer, urea or organic compost in crop seasons like 2009/2010, with months with more rain over the vegetative period, as well as in crop seasons (2010/2011) where the volume of rainfall in most of the months was less than the other two crop seasons evaluated (Table 1), may be attributed to the release of N derived from the labile organic matter of the soil and from the litter in decomposition on the soil surface of the vineyards, among which are the pruned leaves and branches, but also from decaying roots within the soil (BRUNETTO et al., 2011). Moreover, it may be attributed to biological fixation of N by native or planted leguminous species that cohabitate the vineyards, as well as the release of the N contained in their litter in decomposition on the soil surface (PATRICK et al., 2004). However, there is a need for the application of sources of N, such as urea or organic sources, organic compost included, in soils with a sandy texture and with low organic matter content (<25 g kg^{-1}) (and thus, low N availability) because in Cabernet Sauvignon vineyards grown in the Campanha Gaucha region of the state of Rio Grande do Sul, approximately 22.28 kg N ha^{-1} year^{-1} are exported (BRUNETTO et al., 2008b). Furthermore, it is important to highlight that in addition to the quantity exported by grape production it should add N losses to the environment in the processes of leaching, surface runoff and volatilization.

Grape yield in all the treatments in the 2008/2009 crop year was greater than that observed in the 2009/2010 and 2010/2011 crop year (Table 2). The lower yield in the 2009/2010 crop year may be explained especially because of the greater rainfall observed in practically all the months of the year, which, for example, may lead to falling of flowers and the incidence of leaf and fruit diseases (BRUNETTO et al., 2008a). But, in the 2010/2011 crop season, lower yield may be attributed to lower rainfall, which, for example, may affect soil water availability to plants.

Must composition

Neither the application of organic compost nor the application of urea affected the total P content in the must of the grapes collected in all the crop seasons evaluated, the total K in the must of the 2010/2011 crop season, or the total N in the must of the 2008/2009 harvest season (Table 3). However, in the 2009/2010 and 2010/2011 harvest seasons, the total N contents in the grape must were greater in the grapevines subjected to the application of urea. The total N contents in the must of the grapes collected on the grapevines subjected to application of organic compost and the contents from the grapevines without the application of fertilizers was equal. The increase of total N content in the must of the grapes subjected to nitrogen fertilization with urea may be attributed to the greater availability of mineral N forms in the soil, even in the occurrence of transfers of NH_3-N through volatilization to the atmosphere or, alternatively, through the soil surface runoff solution and leaching in the soil profile (LORENSINI et al., 2012). But they also agree with the results obtained by Brunetto et al. (2007) in must from Cabernet Sauvignon grapevines grown in a Sandy Typic Hapludalf soil in the Campanha Gaucha region of the state of Rio Grande do Sul and also with those of Brunetto et al. (2008a) obtained in must from grapevines of two cultivars, Bordô and Couderc 13 vines, subjected to N fertilization in the form of urea. In addition, they agree with the results reported by Ough et al. (1968) in California in the United States, who observed an increase in total N content as well as ammoniacal N and biotin in the grape must derived from grapevines subjected to the application of N. The greater N contents in the must from the berries tend to reduce the probability of stuck fermentation since the N has an impact on microbial biomass and on fermentation rate and time (BELTRAN et al., 2005), which is important for obtaining quality wines.

On the other hand, the greatest total K contents in the grape must were verified in the grapevines subjected to the application of urea and organic compost in the 2008/2009 and 2009/2010 crop seasons (Table 3). But in the 2010/2011 crop season, the K content in the grape must was not affected by the application of urea and organic compost. The increase in total K content in the grape must in two harvest seasons may be attributed to the fact that the plants subjected to the addition of N increase their leaf area. This increases transpiration, and forces K transport via xylem and translocation via phloem to the parts in growth. This K reaches the berries since the plants have an efficient system of K uptake, and its bioavailability in the soil of the present study was considered to be high ($CEC_{pH7.0}$ ≤5.0 $cmol_c$ dm^{-3} and exchangeable K 46-90 $cmol_c$ dm^{-3}). The increase of K in the must leads to possible formation of K bitartrate in the wine, which can increase the pH values of the wine, accelerating its oxidation and decreasing its quality through time (DAVIES et al., 2006).

Nitrogen application in the form of organic compost and urea did not affect the pH values, total acidity, soluble solids and tartaric and malic acid in the Cabernet Sauvignon grape must (Table 3). In the literature, there is no consensus regarding the effect of application of sources of N on the composition of grape must, specifically on the values of pH, total acidity, and malic and tartaric acid. On the other hand, two distinct situations are clearly noted. Some studies report that N fertilization in the mineral form, for example, urea, can increase the values of pH, total acidity and malic and tartaric acids (BRUNETTO et al., 2009). In contrast, other studies, like those of Spayd et al. (1994) in the central region of Washington in the United States, who applied N doses in the form of urea on grapevines, report that the malic and tartaric acid values in the must were not affected. Melo et al. (2012), working in the Serra

Gaucha region of the state of Rio Grande do Sul, report that the application or mode of N distribution in the form of organic compost did not affect the values of soluble solids, pH, titratable acidity, malic and tartaric acid of the grape must from grapevines. However, it should be noted that the variables, with the pH and acidity values, were very near to those found in the must of the Cabernet Sauvignon in experiments conducted by Rizzon & Miele (2002), in a study undertaken in the Serra Gaucha region of the state of Rio Grande do Sul.

TABLE 1- Average air temperature, rainfall and sunlight hours in the experimental area in the 2008/2009, 2009/2010 and 2010/2011 crop seasons.

Month	2008/2009			2009/2010			2010/2011			Climatologically normal		
	Min	Mean	Max.	Min	Mean	Max.	Min	Mean	Max.	Min	Mean	Max.
	Temperature (C°)											
July	11.0	14.9	19.6	6.3	10.2	15.1	6.9	10.9	17.0	9.1	12.9	18.2
August	9.8	14.1	19.5	10.3	15.2	20.8	7.3	11.6	17.7	9.3	13.6	19.2
September	8.8	13.2	18.5	10.2	14.6	19.2	9.8	14.4	20.2	10.6	14.9	20.4
October	13.1	16.8	21.2	12.0	16.7	22.6	10.7	16.2	23.2	12.3	17.0	22.8
November	14.7	19.4	25.0	17.6	21.6	26.7	12.9	19.7	27.7	14.2	18.9	24.8
December	15.6	20.3	26.2	17.0	21.2	26.4	16.7	23.7	31.2	16.0	20.7	26.7
January	16.1	20.4	25.7	18.1	22.0	26.8	19.7	25.0	31.6	17.3	21.8	27.8
February	17.8	21.7	26.6	19.1	23.0	28.4	18.0	22.8	29.3	17.3	21.7	27.5
March	17.1	21.0	26.2	16.8	20.7	25.6	15.5	21.0	27.9	16.1	20.3	26.0
April	13.7	18.4	24.1	13.4	17.5	22.4	13.9	18.5	25.1	13.3	17.5	22.9
May	11.1	15.6	20.8	11.1	14.2	17.7	9.7	13.8	19.8	10.4	14.5	20.0
June	7.5	11.2	15.9	9.0	13.1	18.0	7.5	11.2	16.8	8.6	12.8	17.9
Total	13.0	17.3	22.4	13.4	17.5	22.5	12.4	17.4	24.0	12.9	17.2	22.9

Month	2008/2009	2009/2010	2010/2011	Climatologically normal	2008/2009	2009/2010	2010/2011	Climatologically normal
	Rainfall (mm)				sunlight hours			
July	73.0	97.8	295.3	161.0	175.7	144.9	166.7	154.0
August	198.5	257.9	53.3	165.0	193.5	183.0	135.9	159.0
September	144.1	411.7	182.6	185.0	185.8	134.4	183.7	162.0
October	309.6	145.1	19.4	156.0	154.8	194.1	273.8	192.0
November	70.3	359.5	29.0	140.0	240.8	141.1	281.1	219.0
December	85.8	232.6	56.0	144.0	261.7	224.3	293.2	239.0
January	269.6	296.4	61.6	140.0	235.7	189.2	259.1	231.0
February	144.5	167.1	67.8	139.0	174.0	205.3	219.7	199.0
March	90.6	57.2	82.8	128.0	228.1	192.5	250.5	208.0
April	24.2	142.1	103.5	114.0	243.4	180.1	212.4	173.0
May	134.7	154.7	42.6	107.0	162.3	98.4	176.6	162.0
June	82.9	129.9	118.4	157.0	155.4	142.4	146.0	142.0
Total	1627.8	2452.0	1112.3	1736.0	2411.2	2029.7	2598.7	2240.0

TABLE 2- Total nitrogen (N) content in whole leaves collected in full flowering and verasion, grape yield per plant and hectare, number of clusters per plant, mean weight of the clusters and mean 100-berry weight, in grapevines subjected to the application of organic compost and urea.

Nitrogen source	Crop Season		
	2008/2009	2009/2010	2010/2011
---Total N in the leaf collected in full flowering (g kg^{-1})---			
Control	35.5 c[(1)]	24.1 c	20.6 b
Organic compost	43.2 a	30.7 a	24.0 a
Urea	38.8 b	26.8 b	24.4 a
CV%		7.43	
---Total N in the leaf collected at verasion (g kg^{-1})---			
Control	29.3 a	20.7 a	20.1 a
Organic compost	29.2 a	20.2 a	20.4 a
Urea	31.5 a	22.0 a	21.3 a
CV%		14.58	
---Grape yield per plant (kg^{-1})---			
Control	2.41 b	1.00 a	1.05 a
Organic compost	3.29 a	1.14 a	1.14 a
Urea	2.40 b	1.23 a	1.23 a
CV%		25.18	
---Grape yield per hectare (Mg ha^{-1})---			
Control	8,04 b	3,73 a	3,88 a
Organic compost	12,21 a	4,25 a	4,25 a
Urea	8,89 b	4,57 a	4,57 a
CV%		28.17	
---Number of clusters per plant^{-1}---			
Control	25.11 a	34.11 a	31.67 a
Organic compost	28.89 a	30.22 a	30.22 a
Urea	23.00 a	32.88 a	32.88 a
CV%		24.75	
---Mean weight of clusters per plant^{-1} (g)---			
Control	94.27 a	30.60 a	33.00 a
Organic compost	116.59 a	38.08 a	38.08 a
Urea	105.94 a	35.70 a	35.70 a
CV%		26.29	
---Mean 100-berry weight---			
Control	154.12 a	118.01 a	157.94 a
Organic compost	154.17 a	126.94 a	160.45 a
Urea	163.08 a	108.61 a	151.62 a
CV%		14.10	

(1) Mean values followed by the same letter in the column do not differ among themselves by the Scott−Knott test (α=0.05).

TABLE 3- Total content of nitrogen (N), phosphorus (P) and potassium (K), soluble solids, pH, total acidity, tartaric acid and malic acid in the grape must in grapevines subjected to the application of organic compost and urea.

Nitrogen source	Crop season		
	2008/2009	2009/2010	2010/2011
	---Total N in the must (%)---		
Control	0.09 a[1]	0.34 b	0.19 b
Organic compost	0.09 a	0.27 b	0.23 b
Urea	0.09 a	0.43 a	0.31 a
CV%		28.00	
	---Total P in the must (%)---		
Control	0.01 a	0.02 a	0.02 a
Organic compost	0.01 a	0.06 a	0.02 a
Urea	0.01 a	0.03 a	0.02 a
CV%		16.04	
	---Total K in the must (%)---		
Control	0.22 b	0.09 b	0.36 a
Organic compost	0.24 a	0.11 a	0.37 a
Urea	0.26 a	0.10 a	0.37 a
CV%		9.81	
	---pH---		
Control	3.74 a	3.41 a	3.74 a
Organic compost	3.83 a	3.85 a	3.69 a
Urea	3.82 a	3.66 a	3.64 a
CV%		4.32	
	---Titratable acidity (meq L^{-1})---		
Control	45.29 a	90.09 a	38.00 a
Organic compost	48.68 a	80.06 a	42.32 a
Urea	45.85 a	83.93 a	51.96 a
CV%		32.11	
	---Soluble solids (ºBrix)---		
Control	21.87 a	15.39 a	19.30 a
Organic compost	22.07 a	17.86 a	19.07 a
Urea	20.97 a	18.15 a	21.47 a
CV%		6.22	
	---Tartaric acid (g L^{-1})---		
Control	4.45 a	6.35 a	nd[2]
Organic compost	4.64 a	4.83 a	nd
Urea	4.76 a	5.54 a	nd
CV%		17.59	
	---Malic acid (g L^{-1})---		
Control	1.86 a	6.53 a	nd
Organic compost	2.03 a	4.85 a	nd
Urea	2.36 a	5.59 a	nd
CV%		29.80	

[1] Mean values followed by the same letter in the column do not differ among themselves by the Scott−Knott test (α=0.05). [2] nd = not determined.

CONCLUSIONS

1- The application of nitrogen sources, especially organic compost, on Cabernet Sauvignon wine-producing grapes grown on a soil with low organic matter content increases the nitrogen content in the whole leaf collected at full flowering.

2- The application of organic compost and of urea has little effect on grape yield and does not affect the content of total nutrients, soluble solids, pH, titratable acidity, and malic and tartaric acid.

ACKNOWLEDGEMENTS

To the FAPERGS, to the CNPq and to the Capes (Edital 034/2007) for the scholarships granted and the financial resources made available. To the Citrosul Company for making the experimental vineyards available.

REFERENCES

BELTRAN, G.; ESTEVE-ZARZOSO, B.; ROZE, N.; MAS, A.; GUILLAMOÄ, J.M. Influence of the timing of nitrogen additions during synthetic grape must fermentations on fermentation kinetics and nitrogen consumption. **Journal of Agricultural and Food Chemistry**, Easton, v. 53, p. 996-1002, 2005.

BRUNETTO, G.; BONGIORNO, C.L.; MATTIAS, J.L.; DEON, M.; MELO, G.W.B.; KAMINSKI, J.; CERETTA, C.A. Produção, composição da uva e teores de nitrogênio na folha e no pecíolo em videiras submetidas à adubação nitrogenada**. Ciência Rural**, Santa Maria, v.38, n. 9, p.2622-2625, 2008a.

BRUNETTO, G.; CERETTA, C.A.; KAMINSKI, J.; MELO, G.M.; GIROTTO. E.; TRENTIN, E.E.; LOURENZI, C.R.; VIEIRA, R.C.B.; GATIBONI, L.C. Produção e composição química da uva de videiras Cabernet Sauvignon submetidas à adubação nitrogenada. **Ciência Rural**, Santa Maria, v.39, n.7, p.2035-2041, 2009.

BRUNETTO, G.; CERETTA, C.A.; KAMINSKI, J.; MELO, G.W.B.; LOURENZI, C.R.; FURLANETTO, V.; MORAES, A. Aplicação de nitrogênio em videiras na Campanha Gaúcha: produtividade e características químicas do mosto da uva. **Ciência Rural**, Santa Maria, v. 37, n. 2, p. 389-393, 2007.

BRUNETTO, G.; GIROTTO, E.; MELO, G.W.B.; SANTOS, H.P.; CERETTA, C.A.; KAMINSKI, J.; VIEIRA, R.C.B. Aplicação foliar de nitrogênio em videira: avaliação do teor na folha e das reservas nitrogenadas e de carboidratos nas gemas dos ramos do ano. **Revista Brasileira de Fruticultura**, Jaboticabal, v.30, n. 4, p.1119-1123, 2008b.

BRUNETTO, G.; KAMINSKI, J.; MELO, G.W.B.; RHEINHEIMER, D.S. Recuperação e distribuição do nitrogênio fornecido a videiras jovens. **Pesquisa Agropecuária Brasileira**, Brasília, v.41, n.8, p.1299-1304, 2006.

BRUNETTO, G.; VENTURA, M.; SCANDELLARI, F.; CERETTA, C.A.; KAMINSKI, J.; MELO, G.W.B.; TAGLIAVINI, M. Nutrients release during the decomposition of mowed perennial ryegrass and white clover and its contribution to nitrogen nutrition of grapevine. **Nutrient Cycling in Agroecosystems**, Dordrecht, v. 90, p. 299-308, 2011.

DAVIES, C.; SHIN, R.; LIU, W.; MARK, R. T.; SCHACHTMAN, D.P. Tranporters expressed during grape berry (*Vitis vinifera* L.) development are associated with na increase in berry size and berry accumulation. **Journal of Experimental Botany,** Oxford, v. 57, n. 12, p. 3209-3216, 2006.

LORENSINI, F.; CERETTA, C.A.; GIROTTO, E.; CERINI, J.B.; LOURENZI, C.R.; DE CONTI, L.; TRINDADE, M.M.; MELO, G.W.B.; BRUNETTO, G. Lixiviação e volatilização de nitrogênio em um Argissolo cultivado com videira submetida à adubação nitrogenada. **Ciência Rural**, Santa Maria, v. 42, n.7, p.1173-1179, 2012.

MELO, G.W.B.; BRUNETTO, G.; BASSO, A.; HEINZEN, J. Estado nutricional, produção e composição do mosto em videiras submetidas a modos de distribuição do composto orgânico. **Revista Brasileira de Fruticultura**, Jaboticabal, v. 34, p. 493-503, 2012.

OUGH, C.S.O.; LIDER, L.A.; COOK, J.A. Rootstock-scion interactions concerning winemaking. I. Juice composition changes and effects on fermentation rate with St George and 99-R rootstocks at two nitrogen fertilizer levels. **American Journal of Enology and Viticulture**, Davis, v. 19, p. 213-227, 1968.

PATRICK, A.E.; SMITH, R.; KECK, K.; BERRY, A.M. Grapevine uptake of 15Nlabeled nitrogen derived from a winter-annual leguminous cover-crop mix. **American Journal of Enology and Viticulture**, Davis, v. 55, p. 187-190, 2004.

RIZZON, L.A.; MIELE, A. Acidez na vinificação em vinho tinto das uvas Isabel, Cabernet Sauvignon e Cabernet Franc. **Ciência Rural**, Santa Maria, v.32, n.3, p.511-515, 2002.

SPAYD, S.E.; WAMPLE, R.L.; EVANS, R.G. Nitrogen fertilization of white Riesling grapes in Washington. Must and wine composition. **American Journal of Enology and Viticulture**, Davis, v. 45, p.34-42, 1994.