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## PART 2

## MINERAL NUTRITION AND GRAPE AND WINE QUALITY
## NUTRITION MANAGEMENT TO OPTIMIZE FRUIT QUALITY

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J.V. Possingham
G.H. Neilsen

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# NITROGEN EFFECTS ON YIELD AND CANOPY OF 'WHITE MUSCAT' GRAPEVINE

Gay Eynard, G.
Grapevine Breeding and Biology Research Center, CNR
Via Leonardo da Vinci 44,
10095 Grugliasco TO
Italy
Tel: +39/011/4117304 Fax: +39/011/6708658 E-Mail: gay@cvt.to.cnr.it

Morando A., Lovisolo C. and Bovio M.
Department of Arboriculture, University of Turin
Via L. da Vinci 44,
10095 Grugliasco TO
Italy
Tel: +39/011/6708655 Fax. +39/011/6708658

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## Abstract

Nitrogen was spread as ammonium sulphate in a single application each spring for 3 years at 4 N rates: 0, 40, 80 and 160 kg/ha. Weed development increased since the first application but chopping of cover crop was effective. In treated plots, in June of the third year the botanical composition was shifted from clover to grasses. Botrytis damaged more severely grapes fertilised with 160 kg/ha than with 0 or 40 since the first year of fertilisation. Differences in grapevine yield and vigour appeared small and not significant for two first years. In the third year canopy differences were evident at the highest N rates making a continuous wall, more open at the top, with larger and greener leaves than at 0 and 40 kg/ha. Net photosynthesis was lower at the lowest N rates than at 80 and 160 kg/ha according to changes in substomatal C dioxide concentration, without significant changes in stomatal conductance.

## Résumé

Dans un vignoble enherbé de 'Muscat blanc à petits grains' sur 'Kober 5BB' pendant 3 ans on a comparé 4 apports d'azote: 0-40-80 et 160 kg/ha, distribués en mai. Les espèces herbacées en ont profité, mais les broyages fréquents ont permis de limiter leur développement. Après deux ans la flore était modifiée avec réduction du trèfle au profit des graminées. Les effets sur la production et sur la vigueur de la vigne ont été moindres pour les deux premières années, mais les grappes des parcelles traitées avec 160 kg/ha d'N étaient plus affectées par le Botrytis que celles des parcelles avec 0 ou 40 kg/ha déjà la première année. Au cours de la troisième année les effets des doses supérieures d'N sur la végétation de la vigne étaient évidents. La paroi de 1.6 m était presque continue et plus ouverte vers le haut, avec des feuilles plus grandes et plus riches en chlorophylle que celles de 0 et de 40 kg/ha d'N. Dans ces dernières parcelles la photosynthèse nette était inférieure qu'avec 80 et 160 kg/ha d'N et la concentration de dioxide de C était très supérieure sans changements significatifs dans la conductance stomatique.

## 1. Introduction

In the middle of this century, the target of viticulture was maximising grape yield by deep tillage before planting, followed by regular cultivation and fertilisation. When the market was going well, sometimes excess use of fertilisers in vineyards resulted in groundwater pollution, excessive vine vigour, delayed ripening and increased susceptibility to diseases.

Since an inter-row grass cover can reduce erosion and improve trafficability, chopping weeds has recently taken the place of cultivation or chemical weed control. Weed competition for water may be limited by chopping often, but grape N nutrition may be hindered by root competition (Morlat, 1993).

In Northwestern Italy 'White Muscat' is widely grown, but its grapes are very susceptible to *Botrytis* bunch rot. In order to reduce this effect, since the middle eighties fertilisation and tillage has been avoided. As a consequence the grapevine vigour was lowered. From 1995 the response to N fertilisation on three wine grape cultivars, among which 'White Muscat', has been studied (Gay *et al.*, 1998)

## 2. Materials and methods

The experiment was carried out in a 17 year-old sloping vineyard on the NE side of a hill at 220 m a.s.l., close to Calosso in NW Italy. Vines, grafted on 'Kober 5BB' and planted at 2.20 x 1 m, were Guyot trained with one spur and one gently arched cane. Native weeds were chopped between rows, whereas herbicides were applied only along the rows. Nitrogen was spread for three years as ammonium sulphate in a single spring application (each May) on the whole surface of the plot. Four N rates were tested in a completely randomised block experiment with 4 replications of 40 plants: 0, 40 (maximum allowed by EU sustainable agriculture), 80 and 160 kg $ha^{-1}$.

The following parameters were measured: weed development in June; grape yield, cluster number and mass, berry mass; *Botrytis* bunch rot (50 clusters per plot); juice soluble solids, acidity and pH; winter pruning wood; canopy total height and leaf layer number (LLN) at 0.5, 1.1 and 1.7 meters above the ground; leaf area, mass and nutrient content were measured on samples collected at veraison by the OIV procedure (Fregoni, 1998).

On August 12, 1997 gas exchange of full sun exposed leaves was measured twice a day (between 9:30 and 11:30 a.m., solar time). The photon flux density incident on the leaves was higher than 1200 µmol $m^{-2}$ $s^{-1}$; 2 minutes before measurements leaves were oriented to a 90°angle with incident light to eliminate stomatal variations due to light intensity. Gas exchange was measured on one leaf per vine at the $8^{th}$-$10^{th}$ node of the $3^{rd}$ shoot in three vines per plot, using an ADC LCA3 infrared gas analyser equipped with a Parkinson Leaf Chamber. The parameters calculated by the ADC LCA3 internal software were corrected for a hypostomatous leaf (Lovisolo *et al.*, 1996).

All data were processed by ANOVA and Duncan's multiple range test.

## 3. Results

Weed development (height and cover percentage) increased immediately after the first N application, but careful repeated chopping (Table 1) controlled it. The flora shifted from clover to grasses where over 40-kg $ha^{-1}$ N was applied for 3 years.

Differences of grapevine yield were limited, and not significant for two years (Table 2). In the second year just a slight increase of cluster number was noticed in 160 kg $ha^{-1}$ N plots, without changes of berry or cluster mass. In the third year in these plots cluster mass and therefore yield increased while grape ripening was delayed (Table 3) as shown by °Brix/acidity ratio decreasing from 2.19 (0 N) to 1.45 (160 N).



Leaf N concentration was low even after high rates of N fertilisation (Table 4). P and K leaf content was normal, but it was reduced by the highest N application. Vine vigour measured as pruning wood was not affected until the third year, when canopy differences were clear (Table 5). At the highest rate the canopy formed a continuous wall, more open on top, with larger and greener leaves than at 0 and 40 kg $ha^{-1}$.

Grey mould did not severely affect grapes although a larger number of clusters showed symptoms of bunch rot and higher intensity of *Botrytis* damage was noticed with160 N kg $ha^{-1}$ than with the other N rates throughout the experiment (Table 6).

Net photosynthesis (PN) was lower at lowest N rates than at 80 and 160 kg $ha^{-1}$ (Figure 1), according to strong changes in sub stomatal $CO_2$ concentration (CI). Also stomatal conductance (gs) and transpiration rate (E) seem to decrease as N rate decreases, but differences between treatments were not significant.

## 4. Discussion

High rates of N decreased the native clover in the vineyard. Leguminosae are considered an important source of N in sustainable agriculture but in case of grapevine they may provide N late in summer decreasing the wine quality (Larchevêque *et al.*, 1998).

In other experiments (Ruhl and Fuda, 1991; Larchevêque *et al.*, 1998) N applied to vineyards with a grass cover was not very effective and sometimes it was negative on yield (Delas *et al.*, 1991). Berry mass may be reduced by 150 kg $ha^{-1}$ (Porro *et al.*, 1992). Ripening was delayed up to 22 days by N application rates as high as 224 kg $ha^{-1}$ in a previously well fertilised vineyard (Spayd *et al.*, 1993); it was not the case of Calosso vineyard, where the must was only just more acid in 1997. However, if severe water stress does not occur, grass cover may increase the sugar accumulation in the berry by limiting excess of vigour. On the other hand N deficiency may be induced by the grass cover so that yield may decrease without improvements of berry quality with risk of a bitter taste in the grape and wine (Maigre *et al.*, 1995). In Calosso experiment sugar content didn't change significantly, although the initial low leaf N content may suggest a juice improvement.

In other experiments an increase of N leaf concentration was observed (Spayd *et al.*, 1993; Maigre, 1998), but not always (Bell, 1991). Since leaves became larger after fertilisation, the total N leaf content of plants, which received 160 kg $ha^{-1}$, was increased in the present experiment from 3.76 mg to 5.96 in 1996 and from 7.27 to 8.86 mg in 1997 in comparison to not fertilised plants. On the whole leaf nutrients seem to become less concentrated with the highest N rates because leaf surface increased.

As expected (Bell, 1991; Spayd *et al.*, 1993; Larchevêque *et al.*, 1998) leaf P concentration decreased with increasing N rates. In past studies the data concerning the effect of N fertilisation on leaf and must K content were erratic, so that when the juice pH was increased, it was attributed either to K increase (Ruhl and Fuda, 1991) or to $NH^+_4$ increase (Spayd *et al.*, 1994).

In the present experiment N fertilisation did not increase canopy density because laterals were carefully pruned around the clusters, maintaining only one or two leaf layers on each side of the canopy.

In agreement with Maigre (1998) observations, at the same date, net photosynthesis was higher in the morning in N fertilised plants than in the rest. Maigre showed a reversed photosynthetic behaviour in the afternoon, due to stomatal limitations in N fertilised plants. In our assay water uptake did not seem a limiting factor for stomata at least till noon. The limitations to photosynthesis may depend on stomatal conductance and/or on the reduction of efficiency of the carboxylating system (Farquhar and Sharkey, 1982). In Calosso vineyard, the substomatal $CO_2$ concentration decreased while photosynthesis increased in relation to increased N availability. However at the same time stomatal conductance changes were not significantly related to N. These results suggest that N fertilisation affected grapevine photosynthesis not only through stomatal control.

Susceptibility to grey-mould rot, evident from the first year in the present experiment, may be related to increased berry N content (Fregoni, 1998). On the other hand since grass cover in the vineyard may limit N content in grapes even to depress wine quality (Maigre *et al.*, 1995), N fertilisation may improve must quality assuring also a good fermentation during wine making (Dukes *et al.*, 1991).

N uptake by grapevine ranges from 60 to 80 kg ha$^{-1}$ year$^{-1}$ as shown from analysises of whole plant and from contents of leaves new shoots and fruits (Hanson and Howell, 1995). The delayted response of the Calosso vineyard suggests that 40-kg ha$^{-1}$ N in the long term is not enough to provide vines with a good nutrient status, even though we must consider the special susceptibility of 'White Muscat' to *Botrytis* rot.

## 5. Conclusions

In the present experiment after three years of application of 160 kg ha$^{-1}$ N, yield increased slightly and ripening was delayed. *Botrytis* damaged more severely grapes fertilised with this high N rate than with 40 or 0 from the first year of fertilisation. No differences were found between 0 and 40 N kg ha$^{-1}$. In the conditions of this experiment, 40 kg ha$^{-1}$ N may be useful if applied continuously and together with a very careful management of weeds in order to prevent water stress and N deficiency, which is difficult to correct once established in a vineyard with grass cover.

## References

Bell, S.-J. 1991. The Effect of Nitrogen Fertilization on Growth, Yield, and Juice Composition of *Vitis vinifera* cv Cabernet Sauvignon grapevines. Proc. Int. Symp. Nitrogen in Grapes and Wine.. Rantz J.M. Ed.: 206-210.

Delas, J., Molot, C., Soyer, J.P. 1991. Effects of Nitrogen Fertilization and Grafting on the Yield and Quality of the Crop of *Vitis vinifera* cv Merlot. Proc. Int. Symp. Nitrogen in Grapes and Wine. Rantz, J.M. (Ed.): 242-248, Seattle (USA), Am. Soc. Enol. Vitic

Delas, J., Molot, C., Soyer, J.P. 1992. Influence du Porte-greffe et de la Fertilisation Azotée sur la Composition des Baies de 'Merlot'. Proc. 4th Int. Symp. Grapevine Physiol.: 397-400, Turin (I), Fondazione G. Dalmasso

Dukes, B., Goldspink, B., Elliott, J., Frayne R. 1991. Time of Nitrogenous Fertilization Can Reduce Fermentation Time and Improve Wine Quality. Proc. Int. Symp. Nitrogen in Grapes and Wine. Rantz J.M. (Ed.): 249-254, Seattle (USA), Am. Soc. Enol Vitic

Farquhar, G.D., Sharkey, T.D. 1982. Stomatal Conductance and Photosynthesis. Ann. Rev. Plant Physiol., Annual Review Plant Physiology, 33: 317-345

Fregoni, M. 1998. Viticoltura di Qualità: 1-708, Verona (I), Informatore Agrario

Gay, G., Morando, A., Lembo, S. 1998. Effetti Diretti e Collaterali di tre Dosaggi di Azoto sull'Ecosistema Vigneto. Atti Giorn. Fitopatol., 1: 269-274, Bologna (I), Baiesi

Hanson, E.J., Howell, G.S. 1995. Nitrogen Accumulation and Fertilizer Use Efficiency by Grapevines in Short-season Growing Areas. HortScience, 30: 504-507.

Larchevêque, C., Casanova, A., Dupuch, V., Renard, R. 1998. Influence de la Fumure Azotée sur la Vigne de *Vitis vinifera* L. var. Merlot avec Enherbement Permanent (Composition Azotée, Nature et Teneur des Acides Aminés des Moûts et des Vins. J. Int. Sci. Vigne Vin, 32: 27-43

Lovisolo, C., Schubert, A., Restagno, M. 1996. Photosynthesis of Grapevine Leaves of Different Age at High and Low Light Intensity. Acta Horticulturae, 427: 171-175.

Maigre, D. 1998. Comportement Physiologique de la Vigne et Microclimat Lumineux des Grappes: Influence de l'Enherbement Permanent. C.R. 10èmes Journées GESCO: 266-273., Changins (CH), RAC



Maigre, D., Aerny, J., Murisier, F. 1995. Entretien des Sols Viticoles et Qualité des Vins de Chasselas: Influence de l'Enherbement Permanent et de la Fumure Azotée. Revue Suisse Arboric. Hortic., 27: 237-251.

~~Morando A.; Lovisolo C.; Bovio M., Bell, S.-J. 1991. The Effect of Nitrogen Fertilization on Growth, Yield, and Juice Composition of *Vitis vinifera* cv Cabernet Sauvignon grapevines. Proc. Int. Symp. Nitrogen in Grapes and Wine.. Rantz J.M. Ed.: 206-210.~~

Morlat, R., Jacquet, A., Asselin C. 1993. Principaux Effets de l'Enherbement Permanent Contrôlé du Sol, dans un Essai de Longue Durée en Anjou. Progr. Agric. Vitic., 110: 406-410

Porro, D., Tardágula, J., Failla, O., Stefani, R., Scienza, A. 1992. Effect of Nitrogen Nutrition on Vegetative Growth and Organic Acids in Berries and Leaves. Proc. 4th Int. Symp. Grapevine Physiol.: 235-238., Turin (I), Fondazione G. Dalmasso

Ruhl, E.H., Fuda, A.P. 1991. Effect of Potassium and Nitrogen Supply on Organic Acid Concentration and pH of Grape Juice: Preliminary Results. Proc. Int. Symp. Nitrogen in Grapes and Wine. Rantz, J.M.: 312-314, Seattle (USA), Am. Soc. Enol. Vitic

Spayd, S.E., Wample, R.L., Stevens, R.G., Evans, R.G., Kawakami, A.K. 1993. Nitrogen Fertilization of White Riesling in Washington: Effects on Petiole Nutrient Concentration, Yield, Yield Components, and Vegetative Growth. Am. J. Enol. Vitic., 44: 378-386.

Spayd, S.E., Wample, R.L., Evans, R.G., Stevens, R.G., Seymour, B.J., Nagel, C.W. 1994. Nitrogen Fertilization of White Riesling Grapes in Washington. Must and Wine Composition. Am. J. Enol. Vitic., 45: 34-42.

## Tables

1. Weed height, cover percentage and composition

| N (kg ha$^{-1}$) | 0 | 40 | 80 | 160 |
|---|---|---|---|---|
| Weed height (m) | | | | |
| 1995 | 0.14 d | 0.17 c | 0.22 b | 0.26 a |
| 1997 | 0.11 b | 0.12 a | 0.13 a | 0.13 a |
| Weed cover (%) | | | | |
| 1995 | 75.2 c | 83.2 b | 87.0 b | 97.7 a |
| 1997 | 83.7a | 87.5 a | 88.7 a | 92.7 a |
| *Trifolium spp.* (%) | 31.6 a | 36.1 a | 14.5 b | 6.8 b |
| *Setaria viridis* (%) | 15.3 bc | 9.6 c | 19.9 ab | 26.7 a |
| Other *Gramineae* (%) | 13.0 bc | 8.4 c | 16.6 ab | 23.1 a |

2. Grape production as affected by N fertilisation

| N (kg ha$^{-1}$) | 0 | 40 | 80 | 160 |
|---|---|---|---|---|
| Yield (t ha$^{-1}$) | | | | |
| 1995 | 12.1 a | 11.7 a | 13.1 a | 12.1 a |
| 1996 | 9.6 a | 9.5 a | 9.7 a | 10.3 a |
| 1997 | 11.1 a | 10.6 a | 12.5 a | 14.4 a |
| Cluster number | | | | |
| 1995 | 16.5 a | 16.6 a | 17.0 a | 15.9 a |
| 1996 | 9.2 b | 9.6 ab | 9.5 ab | 10.9 a |
| 1997 | 11.2 a | 10.4 a | 11.5 a | 12.0 a |
| Cluster mass (g) | | | | |
| 1995 | 201 a | 191 a | 211 a | 210 a |
| 1996 | 285 a | 271 a | 281 a | 262 a |
| 1997 | 274 b | 279 b | 297 b | 329 a |
| Berry mass (g) | | | | |
| 1996 | 2.1a | 2.39 a | 2.36 a | 2.39 a |
| 1997 | 2.52 a | 2.59 a | 2.77 a | 2.67 a |

3. Juice composition at harvest as affected by N fertilisation

| N (kg ha$^{-1}$) | 0 | 40 | 80 | 160 |
|---|---|---|---|---|
| Soluble solids (°Brix) | | | | |
| 1995 | 18.1 a | 18.3 a | 18.2 a | 18.6 a |
| 1996 | 20.1 a | 20.5 a | 20.8 a | 20.8 a |
| 1997 | 18.8 a | 18.7 a | 18.1 a | 17.2 a |
| Acidity (meq L$^{-1}$) | | | | |
| 1995 | 111 a | 111 a | 108 a | 113 a |
| 1996 | 109 a | 115 a | 113 a | 111 a |
| 1997 | 86 b | 91 b | 95 b | 118 a |
| Must pH | | | | |
| 1995 | 3.12 a | 3.12 a | 3.11 ab | 3.09 b |
| 1996 | 3.07 b | 3.12 ab | 3.12 ab | 3.13 a |
| 1997 | 3.39 a | 3.39 a | 3.34 a | 3.34 a |



4. Leaf nutrient status (g /100 g d.w.) as affected by N fertilisation

| N (kg ha$^{-1}$) | 0 | 40 | 80 | 160 |
|---|---|---|---|---|
| N | | | | |
| 1996 | 0.66a | 0.92 a | 0.98 a | 0.97 a |
| 1997 | 1.35a | 1.24 ab | 1.17 b | 1.27 ab |
| P | | | | |
| 1996 | 0.14 a | 0.13 a | 0.13 a | 0.13 a |
| 1997 | 0.16 a | 0.16 a | 0.13 ab | 0.12 b |
| Ca | | | | |
| 1996 | 3.30 a | 3.20 a | 3.05 a | 3.20 a |
| 1997 | 2.06 a | 2.01 a | 1.99 a | 1.70 a |
| Mg | | | | |
| 1996 | 0.31 a | 0.33 a | 0.29 a | 0.34 a |
| 1997 | 0.28 a | 0.28 a | 0.30 a | 0.32 a |
| K | | | | |
| 1996 | 1.35 a | 1.30 a | 1.17 a | 1.17 a |
| 1997 | 1.30 a | 1.31 a | 1.09 ab | 1.05 b |
| Petiole K 1997 | 2.33 a | 2.45 a | 1.97 a | 1.90 a |

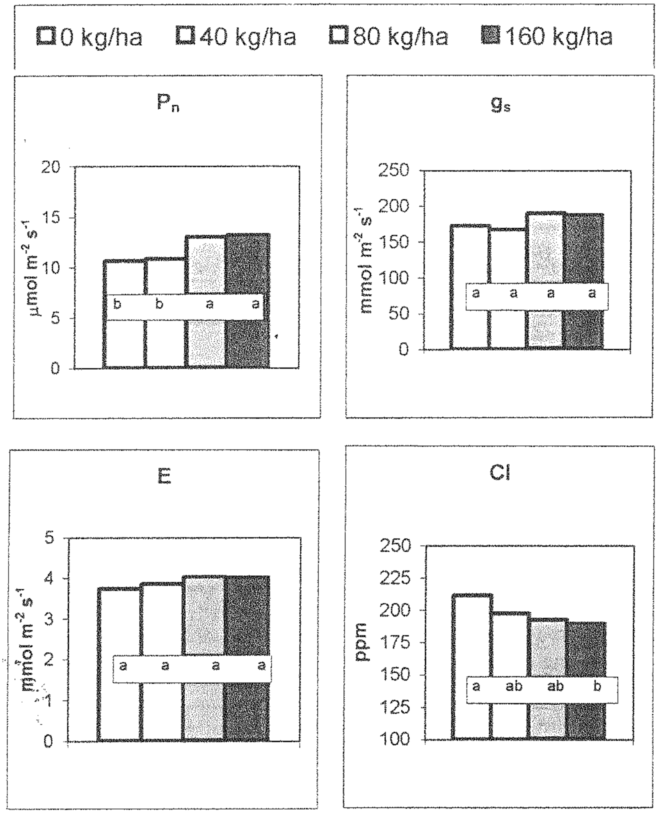
5. Vegetative parameters and Ravaz index (yield/pruning wood ratio)

| N (kg ha$^{-1}$) | 0 | 40 | 80 | 160 |
|---|---|---|---|---|
| Pruning Wood (t ha$^{-1}$) | | | | |
| 1996 | 1.68 a | 1.99 a | 1.99 a | 2.43 a |
| 1997 | 1.34 b | 1.55 ab | 1.51 ab | 1.81 a |
| Ravaz Index | | | | |
| 1996 | 5.71 | 4.77 | 4.87 | 4.24 |
| 1997 | 8.28 | 6.84 | 8.28 | 7.96 |
| Leaf Mass (g) | | | | |
| 1996 | 3.80 a | 4.00 a | 4.10 a | 4.10 a |
| 1997 | 3.59 b | 3.78 b | 3.64 b | 4.65 a |
| Leaf | | | | |
| Surface (cm$^2$) | 163 b | 177 b | 176 b | 224 a |
| Mass/Surface (mg cm$^2$) | 22.0 a | 21.4 a | 20.6 a | 20.4 a |
| Canopy height (m) | 1.51 a | 1.56 a | 1.55 a | 1.63 a |
| Top Width (m) | 0.39 b | 0.36 b | 0.41 b | 0.56 a |
| Gaps (%) | 29 a | 27 a | 21 a | 7 b |
| LLN at 1.7 m | 2.6 a | 2.7 a | 3.4 a | 3.5 a |
| Chlorophyll (SPAD unit) | 33.5 c | 35.1 bc | 38.8 ab | 41.4 a |

6. Cluster sanitary status as affected by N fertilisation

| N(kg $ha^{-1}$) | 0 | 40 | 80 | 160 |
|---|---|---|---|---|
| Botrytis intensity (%) | | | | |
| 1995 | 2.1 b | 1.8 b | 3.6 b | 10.4 a |
| 1996 | 1.5 ab | 1.0 b | 3.0 a | 3.3 a |
| 1997 | 0.6 b | 1.7b | 1.3 b | 5.4 a |
| Cluster affected (%) | | | | |
| 1995 | 22.1 c | 30.7 bc | 45.0 ab | 57.8 a |
| 1996 | 18.0 bc | 15.0 c | 27.0 ab | 30.5 a |
| 1997 | 15.6 b | 20.6 b | 20.6 b | 38.7 a |

**Figures**




1. Net photosynthesis ($P_n$), transpiration (E), stomatal conductance ($g_s$) and substomatal $CO_2$ concentration (Cl) in grapevines as affected by N fertilization. Bars with the same letter are not significantly different (P>0.01) according to Duncan's test.



# INFLUENCE OF N-SUPPLY AND SOIL MANAGEMENT ON THE NITROGEN COMPOSITION OF GRAPES

Löhnertz, O., Prior, B., Bleser, M. and Linsenmeier, A.
State Research Institute Geisenheim, Germany
Department of Soil Science and Plant Nutrition
von-Lade-Str. 1.
Geisenheim, D-65366
Germany
Tel: ++49/6722/502431 Fax: ++49/6722/502430
E-Mail: otmar.loehnertz@geisenheim.fa.fh-wiesbaden.de

**Keywords:** free amino nitrogen (FAN); soil management; arginine; glutamine; proline; untypical ageing;

**Abstract**

Up to now the amino acid content in grapes or must was high enough not to beor a critical factor in the fermentation process in northern, cool climate wine growing regions. However, in recent years severely reduced concentrations of free amino nitrogen (FAN) were found. These findings are relevant in connection with fermentation problems and changes in wine flavor.
There is a strong correlation between the nitrate supply of the soil and these observations. All plant production measures which intensify reduced nitrogen and water supply, increase the risk of incomplete accumulation of amino acids in berries.
In the Rheingau region (Germany) these effects were present, whether the nitrate supply of the soil was insufficient or by altering the soil management system of vineyards with the cultivar `Riesling`. Amino acid concentrations in grapes from vineyards with cover crops were significantly reduced. Furthermore a specific reduction in the concentration of arginine and glutamine occured. The proline concentration remained constant, thus the percentage amount rose with decreasing nitrate supply of the soil.
In warm, dry years musts show high protein concentrations, resulting in reduced amounts of amino acids. In northern, cool climate wine growing regions this effect of the vintage has a strong influence on the nitrogen assimilable by yeasts.
Furthermore, the described effects are influenced by N-reserves in woody vine parts, vine planting distance (plants per ha), canopy management, vintage (year), infestation with *Botrytis* sp. and the date of harvest, respectively.
Especially with regard to increasing negative aroma modifications, which are discussed in connection with abiotic and biotic stress, the amino acid concentration in grapes can serve as an important stress indicator.

## 1. Introduction

Within the scope of grape growing as well as in the field of enology particular attention has been paid to the nitrogen contents of grapes, especially to the amounts of amino acids for several years. In order to establish diagnosistic criteria to estimate the nitrogen nutrition status of the plant, the time course of mineral uptake, the deposition rates and quantities into vegetative, reproductive and woody parts of the vine were investigated for more than ten years. The formation of amino acids as storage substances in grapes as well as in woody parts of the vine constitutes the main field of the investigations. During the process of maturity in particular, the storage of N-containing substances in grapes and in woody parts of the vine have been shown.

From an enological point of view the amount of nitrogen in grapes or must

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