LIMITING FACTORS FOR VITIS VINIFERA L., ALBARIÑO VARIETY PRODUCTION IN SOILS DEDICATED TO THE VINEYARD SINGLE-CROP SYSTEM

FACTEURS LIMITANTS POUR LA PRODUCTION VÉGÉTALE EN SOLS CONSACRÉS Á LA MONOCULTURE DE *VITIS VINIFERA* L., VARIÉTÉ ALBARIÑO

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Abstract: With the purpose of studying the influence of *Vitis vinifera* L. (Albariño variety) single-crop system on the limiting edaphic factors for the grape production four plots dedicated to this single-crop during 6, 12, and 100 years were selected. The most usual limitations for the chemical fertility are the low CECe in the youngest vineyards (<4 $cmol^{(+)}.kg^{-1}$ and 4-7 $cmol^{(+)}.kg^{-1}$ in the rest) and the low contents of Mg in sixty per cent of the surface samples and 90 % of the subsurface ones and deficit of Ca in 90 % of the subsurface samples (0.96 cmol. kg^{-1}). It is remarkable also the Fe deficit in all the samples and the Cu and Zn excess in the surface layer of the oldest vineyards. It is evident the presence of DDT and its metabolites (DDD and DDE) in the youngest vineyards, though in low quantities.

Résumé: Ces deux dernières décades, le secteur viti-vinicole a acquis une grande importance en Galice (Espagne), et en particulier dans la région de dénomination d'origine Rias Baixas. La région de Rosal est du point de vue climatique unique en l'Europe par la douceur de l'hiver et de l'été. L'absence quasi totale de gelées, la haute humidité relative et l'insolation adéquat font une région très favorable pour la culture de *Vitis vinifera* L. var. Albariño. Elle produit des raisins d'une teneur en sucres suffisante. Les valeurs des index climatiques par rapport à la productivité végétale, comme la potentielle agricole ou les intensités bioclimatiques potentielle et libre sont les plus élevées d'Europe. L'augmentation des surfaces destinées à la culture de vigne dans cette région rend necessaire la connaissance de la qualité des sols des vignobles et des facteurs limitants pour la production.
L'objectif de ce travail est l'étude de l'influence de la monoculture de *Vitis vinifera* L., varieté Albariño sur les facteurs limitants pour la production végétale afin de, proposer si nécessaire, des mesures de correction des techniques culturales actuelles dans le but d'améliorer la qualité des vins, de soutenir et s'il est possible d'augmenter la production tout en évitant les dommages à l'écosystème.
On a sélectionné quatre parcelles destinées à la culture de *Vitis vinifera* L., varieté Albariño depuis 6, 12 et 100 ans. D'autre part, et afin de les utiliser comme contrôles de référence, on a choisi trois sols recouverts de végétation naturelle, contigüs aux différents vignobles. On a prélevé des échantillons pour déterminer les caractéristiques physiques : humidité, densité, porosité, texture, point de flétrissement permanent, réserve d'eau utile, ainsi que les caracteristiques chimiques : pH, teneurs en matière organique et en phosphore assimilable, capacité d'échange cationique effective, teneurs en Fe, Mn, Cu et Zn échangeables et en pesticides organochlorés et organophosphorés. Toutes les analyses ont été répétées trois fois et, avec les résultats obtenus, on a realisé des analyses statistiques : test de Levene, ANOVAS ou test de Kruskal-Wallis et DMS ou test "t". On a aussi établi des corrélations partielles entre les différents paramètres étudiés afin d'observer de possibles relations entre eux.
Pour chaque paramètre physique ou chimique on a determiné des valeurs critiques, suivant le modèle de la SFCC (Soil Fertility Capability Classification) proposées par BUOL *et al.* (1975) et adapteès pour la Galice (MACIAS et CALVO, 1983 et 1987; CALVO et MACIAS, 1987 a et b). On y a introduit quelques modifications spécifiques pour les sols viticoles.
Les résultats obtenus montrent que les facteurs limitants les plus fréquents pour la fertilité chimique sont la faible capacité d'échange cationique effective (<4 $cmol(+).kg^{-1}$ dans le vignoble le plus jeune et 4-7 $cmol_{(+)}.kg^{-1}$ dans les autres) ainsi que la faible teneur en Mg (<4 $cmol(+).kg^{-1}$) dans 60 % des échantillons superficiels et dans 90 % des échantillons profonds, et un déficit en Ca dans 90 % des échantillons profonds (0,96 $cmol_{(+)}.kg^{-1}$). Il faut aussi remarquer le déficit en Fe dans tous les échantillons, l'excès de Cu et Zn dans la couche superficielle des vignobles les plus anciens et la présence de DDT et de ses métabolites (DDD et DDE) dans le jeune vignoble, bien que la teneur soit faible.

Key words : soil, vineyard, quality, fertility, limiting factors

Mots clés : sol, vignoble, qualité, fertilité, facteurs limitants

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INTRODUCTION

Galician grape growing area has acquired great importance in the last two decades, mainly the one under the origin denomination Rias Baixas. That is why it is extraordinarily important to know the characteristics of the soils devoted to *Vitis vinifera* L., Albariño variety, as well as intrinsic and extrinsic limiting factors for vine production.

Rosal area has a climate unique in Europe due to its winter and summer mildness, characterised by the absence of frost, relative high humidity and adequate sunshine which is very favourable for *Vitis vinifera* L, Albariño variety, to produce grape with sufficient sugar concentration. The values of climatic indexes related with vegetable productivity, such as agricultural potentiality or bioclimatic intensities : potential and freeware the highest in Europe.

The high vineyard surface in this area claims for a better understanding of soil parameters as well as the production limiting factors.

The determination of suitable areas is of great interest in viticulture, where a remarkable influence is conferred to the effects of environmental conditions on the vineyard growing and the final product (Origin Denomination concept).

It is available nowadays a methodology for the characterization of vineyard areas (SOTÉS RUIZ *et al.*, 1990) that is based on the study of several aspects of the environment including those factors that contribute to determine the vineyard potentiality (topography, mesoclimate, physicochemical characteristics, rooting type, hydric alimentation conditions, etc.).

In order to improve agronomical properties of a particular soil and the harvest efficiency, we must first evaluate the soil potential capacity (fertility), and the most adequate cultural strategy will be planned, taking into account the existing restrictions due to technical, agronomical and socio-economical limitations (SAÑA VILASECA *et al.*, 1985).

The improvement of agronomical properties before mentioned can be translated, concerning to exploration, suppressing the limiting factors and optimisation of production edaphic means (RÉMY, 1985).

Due to the great importance of the demarcation of zones in viticulture, most zoning works are characterised by a soil survey (CERVEAU, 1991; EPA-608, 1980; GAGNARD *et al.*, 1988 ; HERAS *et al.*,1978; SCIENZA *et al.*, 1992).

Soil characteristics and limitations associated with the vineyard development on acid soils have been studied in a number of publications (BONFILS, 1984; FREGONI, 1985 ; RODRÍGUEZ LOVELLE *et al.*, 1991 ; TRUJILLO *et al*, 1987). Yet, few are the studies related with the soils of vineyard areas in Galicia.

That is why this work has been carried out where we study the limiting factors for the vine production in Rosal area soils where both the antiquity of the single-crop system and the cultural practices are different.

The aim is to study the influence of *Vitis vinifera* L. single-crop system Albariño variety on the limiting edaphic factors for the plant growing and to propose, if necessary, corrective cultural practices to improve the wine quality and maintain or even increase the production, avoiding damages in the ecosystem.

MATERIAL AND METHODS

I - MATERIAL

Four plots were selected (6S : six years without irrigation, 6SI : six years with irrigation, 12S : twelve years without irrigation, 100S : one hundred years without irrigation) dedicated to the single-crop of *Vitis vinifera* Albariño variety during 6, 12 and 100 years. As control, uncultivating sampling points in adjacent zones to each ground were taken. Six sampling points in each plot and in controls have been selected.

The three samples taken at each sampling point and at two different depths (from 0 to 20 cm and from 20 to 40 cm). A total of 126 samples from each depth were taken.

In the laboratory the samples were air-dried and passed through a 2 mm sieve. The three samples from each sampling point and from each depth were mixed and homogenized and after three subsamples were taken for different analyses.

II - PLOT CHARACTERISTICS

1) Plots six years with and without irrigation

Original material : slates and schist.
Slope : class 2.
Sheet composting : Mg, Lithothane and P_2O_5.
Pesticides and fungicides : Antimildew, Botritys, Insecticides.
Sampling taken : high, middle and low part of the slope.

2) Plot 12 years without irrigation

Original material : granite.
Slope : class 2.

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Sheet composting : Mg, Lithothane and P_2O_5.
Pesticides and fungicides : Antimildew, Insecticides, Botritys.
Sampling taken : high, middle and low part of the slope.

3) Plot 100 years without irrigation.

Original material : granite.
Slope : class1.
Sheet composting : Mg, Lithothane and P_2O_5.
Pesticides and fungicides : Antimildew, Insecticides, Botritys.
Sampling taken : Middle of the plot.

METHODS

The pH of the soil was determined using a soil : water ratio of 1 gr/2,5 ml with an equilibrium period of 10 min (GÓMEZ-MIGUEL and SOTÉS, 1992). The granulometric analysis was conducted after the oxidation of organic matter with hydrogen peroxide, separating the upper fractions to 50 mm by means of sieves, and the lower fractions using the international procedure (DAY, 1965). The hydraulic conductivity was determined according to the method of RICHARDS (1973). The method by WALKLEY and BLACK (1934) was used, to analyse the content of organic matter.

The total nitrogen was determined following Kjedahl method modified by GUITIAN and CARBALLAS (1976). The bases and Al of the exchange were extracted with barium chloride according to HENDERSHOT and DUQUETTE (1986). K and Na were through flame photometry and Ca, Mg and Al by means of atomic absorption spectrophotometry. The effective cationic exchange capacity were calculated by the sum of the bases and the exchangeable aluminium. The available phosphorous were determined according to OLSEN *et al.* (1954), recommended for acid soils by KAMPRATH (1973). The determination was made through colorimetry of the phosphomolybdic blue complex, as is described in MURPHY and RYLEY (1962) modified by ALEXANDER and ROBERTSON (1968). The available content of Fe and Mn was estimated by HENDERSHOT and DUQUETTE method (1986). Available Cu and Zn were extracted by the DTPA method of LINDSAY and NORWELL (1978). The analysis of Fe, Mn, Cu and Zn was carried out by a flame atomic absorption spectrophotometer (AA 250-Plus Varian).

The pesticides were determined according to the methodology recommended by the EPA (1980) by extraction with methylene chlorine, the extract is dried and exchanged to hexane by Aluminium column and gas chromatography analysis with EC (63_{Ni}) .

From all the determinations made, three were replicas. The following statistical analysis made were : Levene test, ANOVAS or Kruskas-Wallis test and DMS or test "t". Partial correlations between different parameters studied were made to observe possible relations among them.

RESULTS AND DISCUSSION

I - RESULTS

The predominant texture of the studied soils is loam-sandy and its porosity varies between 40 and 72 % (table I).

Soil reaction, in most of the samples oscillate between faintly acid to neutral in the surface layer, while pH values decrease in the subsoil; being weakly acid, except in the 100 years sample that would correspond to an acid soil (table I). The controls present strongly acid character in the plowing layer and acid in the subsoil.

Table I - Chemical characteristics

Caracteristiques chimiques

Sample	Porosity (%)	pH	O.M. ($g.kg^{-1}$)	N ($g.kg^{-1}$)	C/N	P ($mg.kg^{-1}$)
C (0-20 cm)	80.4a	4.4d	139.0a	4.7a	17.2b	27.9cd
C (20-40 cm)	58.6b	5.0cd	22.8e	1.0d	12.8c	5.4f
6S (0-20 cm)	61.2b	6.4b	34.0d	1.5cd	13.1c	16.4d
6S (20-40 cm)	52.0c	5.8c	19.1e	1.0d	10.6d	8.5e
6SI (0-20 cm)	51.2c	6.6ab	42.2c	2.8b	8.4e	7.2e
6SI (20-40 cm)	46.3d	5.5c	15.3f	1.0d	8.4e	5.1f
12S (0-20 cm)	58.4b	7.0a	43.6c	3.0b	8.0e	70.6a
12S (20-40 cm)	47.3d	6.3b	55.4b	1.9c	7.5f	53.5ab
100S (0-20 cm)	75.0ab	5.4c	54.6b	2.8b	11.2d	34.2c
100S (20-40 cm)	56.9bc	5.0cd	30.2d	1.9c	29.2a	42.8b

Values are the average of the three measures. Values with different letter in the same column are statistically different using Duncan's Multiple Range Test (P<0.05).

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The organic matter content varies between 18 and 57 g.kg^{-1} in the surface layer and decreases in depth, generally increases with the vineyard age though it maintains fairly below the level of the controls.

The samples present an average content in nitrogen of 2.5 g.kg^{-1} in the surface layer and 1.4 g.kg^{-1} in the subsurface which is an adequated level for the vineyard crop.

Phosphorus mean levels oscillate between 7.2 and 70.6 mg.kg^{-1}of P in first 20 cm and between 5.1 and 53.5 mg.kg^{-1} of P in the subsurface layer. The soils with less content in phosphorous support youngest vineyards (table I).

According to the results of other studies on vineyard soils in Galicia (RODRÍGUEZ LOVELLE, 1993) the values of effective $CECe_{(+)}$ low, mainly in the subsoil, as a consequence of the low clay content. All the plots present values bellow 12 cmol.kg^{-1} (table II), according to the results obtained by LOPEZ MIÑANO (1988) in sandy soils.

The values of the effective $CEC_{(+)}$ range between 2.2 and 10.5 $cmol_{(+)}kg^{-1}$. In the controls the $CEC_{(+)}$ is 2.8 $cmol_{(+)}kg^{-1}$.

The saturation percentage in Al in exchangeable cation complex range between 0 and 2.1 % in the surface layer and between 0.6 and 3.8 in the subsurface one, being, majority soils bellow 2.5 per cent. The exchangeable Na presents values ranging between 0.1 and 0.42 cmol.kg^{-1} and the K between 0.18 and 0.83 cmol.kg^{-1} in the surface layer, decreasing slightly these values in the subsurface layer (table II).

The content of exchangeable calcium in all the samples is rather high. In the surface layer varies between 1.48 and 8.81 cmol.kg^{-1}, with an average value of 3.56 cmol.kg^{-1}. It represents 73 % of the $CECe_{(+)}$, what means a desirable proportion in the complex of exchange (FREGONI. and BAVARESCO, 1984). In the subsurface layer, the average value is 0.84 cmol.kg^{-1}, and varies between 0.2 and 1.5 cmol.kg^{-1}; the saturation percentage of Ca decreases to 50 %. This means a value bellow it is recommended (FREGONI. and BAVARESCO, 1984) for this crop.

Most of the studied plots have Mg low levels (table II). The average content is 0.47 cmol.kg^{-1} in the surface zone and 0.22 cmol.kg^{-1} in the subsurface one. The saturation percentage varies between 5 and 14 % with an average value of 9 %, considered correct by GAGNARD *et al.* (1988). The saturation percentage in the subsoil rises to 15 % higher than it is recommended (FREGONI. and BAVARESCO, 1984).

The content of Fe in the surface layer reaches a maximum value of 5.27 mg.kg^{-1}, varying, in the subsoil below 3 mg.kg^{-1} (table III).

The samples from the surface zone present a Cu average concentration ranging between 17.1 and 818.3 mg.kg^{-1}, while the average content of Zn varies from 3.8 to 83.2 mg.kg^{-1} in the surface layer and ranging from 1.5 to 13.4 mg.kg^{-1} in the subsurface layer (table III).

DISCUSSION

It is observed an increment of Cu and Zn content with the antiquity of the vineyard, due to the agrochemical treatments, it confirmed by the statistical analysis, there have been found significant differences ($p<0.005$) in the Cu and Zn content depending on the different vineyard age (table III). The effects of the applications are accumulated in the time of implantation of the crop. This content decreases, generally, by increasing the depth and is higher than in the controls. This accumulation, caused by the continuous contri-

Table II - Effective cationic exchange capacity and exchange bases ($cmol_{(+)}.kg^{-1}$)
$CECe_{(+)}$ et bases d'échange ($cmol_{(+)}.kg^{-1}$)

Sample	Na^+	Mg^+	Ca^{+2}	K^+ cmol(+).kg^{-1}	Al^{+3}	CECe(+)	(Al^{+3}/CECe).
C (0-20 cm)	0.51a	0.31bc	0.03e	0.45b	1.53a	2.83d	54.10a
C (20-40 cm)	0.19de	0.06e	0.03e	0.25c	0.32b	0.85f	37.60b
6S (0-20 cm)	0.15e	0.27c	2.33b	0.21c	0.01d	2.99d	0.33f
6S (20-40 cm)	0.10e	0.34b	1.20b	0.12d	0.01d	1.78e	0.56ef
6SI (0-20 cm)	0.33c	0.39b	2.55b	0.42b	0.01d	3.72c	0.27f
6SI (20-40 cm)	0.26cd	0.17d	0.30d	0.25c	0.04cd	1.05f	3.80c
12S (0-20 cm)	0.26cd	0.50a	6.75a	0.63a	0.00d	8.15a	-
12S (20-40 cm)	0.23d	0.32c	1.59c	0.28c	0.02d	2.46de	0.80e
100S (0-20 cm)	0.39b	0.53a	2.61b	0.60a	0.09c	4.22b	2.13d
100S (20-40 cm)	0.41b	0.06e	0.26d	0.44b	0.03cd	1.46e	2.05d

Values are the average of the three measures. Values with different letter in the same column are statistically different using Duncan's Multiple Range Test ($P<0.05$).

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Table III - Average concentration ($mg.kg^{-1}$) of available Cu, Zn, Mn and Fe

Concentration moyenne ($mg.kg^{-1}$) du Cu, Zn, Mn et Fe

Sample	Cu	Zn	Mn	Fe
C (0-20 cm)	5.3dc	4.2de	1.2d	42.8a
C (20-40 cm)	0.7f	0.7g	0.2f	3.4c
6S (0-20 cm)	17.2cd	5.8d	0.7e	0.3e
6S (20-40 cm)	2.9e	1.5f	0.9e	1.0d
6SI (0-20 cm)	19.1c	3.8e	4.4b	0.0f
6SI (20-40 cm)	3.0e	0.5g	9.2a	0.4d
12S (0-20 cm)	88.2b	38.8b	2.0cd	0.3e
12S (20-40 cm)	16.6d	6.2d	1.5d	0.3d
100S (0-20 cm)	818.3ab	83.2a	7.2a	5.3b
100S (20-40 cm)	932.3a	13.4c	2.8c	3.0c

Values are the average of the three measures. Values with different letter in the same column are statistically different using Duncan's Multiple Range Test

Table IV - Organochlorine and organophosphorous pesticides ($\mu g.kg^{-1}$)

Contenus totaux en pesticides organochlorés et organophosphorés ($\mu g.kg^{-1}$)

Sample	HCH,s	Lindane	Hep-Clor	Aldrin	HCl-epox	Endosulf	DDE	Dieldrin	DDD	Endrin	DDT	Clordan	Me-Pth	Malath
6S (0-20 cm)	2.29b	0.34b	0.75b	u.l.	0.13b	0.06a	1.16a	0.25c	0.75a	u.l.	0.10d	0.51b	0.06b	u.l.
6S (20-40 cm)	3.55a	3.38a	1.21a	0.39a	0.48a	u.l.	u.l.	0.61a	0.06d	u.l.	0.33bc	0.39c	0.32a	u.l.
6SI (0-20 cm)	0.35c	0.18c	0.67b	0.02c	0.03c	0.03b	u.l.	0.09d	0.05d	0.07b	0.20c	0.02e	u.l.	u.l.
6SI (20-40 cm)	0.11d	0.07d	0.25c	0.18b	0.06bc	u.l..	0.10c	0.06de	u.l.	0.12a	2.54a	0.01e	u.l.	u.l.
12S (0-20 cm)	0.06de	0.27bc	0.06d	0.04c	0.13b	u.l.	0.17b	0.09d	0.17c	0.13a	0.40b	1.21a	0.01b	0.01a
12S (20-40 cm)	0.02e	u.l.	0.03de	0.23ab	u.l.	u.l.	0.01d	u.l.	0.32b	u.l.	u.l.	0.11d	u.l.	u.l.
100S (0-20 cm)	0.09d	0.11cd	0.22c	u.l.	0.06bc	u.l.	u.l.	0.42b	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.
100S (20-40 cm)	0.00e	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.	u.l.

Values are the average of the three measures. Values with different letter in the same column are statistically different using Duncan's Multiple Range Test ($P<0.05$). (u.l.: undetectable level).

butions, can give rise to toxicity that worsens because of the higher acidity of the oldest plots.

The adequate pH in every sample is due to the use of liming corrections that increase the pH and the content of exchangeable Ca and decrease the Al one.

The successive fertilisations provoke, in time, an increasing in phosphorous content K, Mg, Na exchangeable contents, also increase with the antiquity of the vineyard, and as it was confirmed with the statistical analysis, where significant differences in the P, K, Mg and Na content are clear depending on the vineyard age. It is remarkable that the $CECe_{(+)}$ increases in 12 years vineyards where the Ca is outstandingly higher than the others and the pH closer to neutrality (table II).

It is observed that the content of every pesticide analysed is, in general, quite low and there are not toxicities that can be dangerous (table IV).

Soils supporting the youngest vineyards present greater contents of pesticides, both organochlorine and organophosphorous, due to the inadequate treatments that were carried out in the preparation of the ground. We must emphasize the presence of DDT and its metabolites (DDD and DDE) in these vineyards.

It has been established the existence of strong correlation, both in 0-20 cm depth and 20-40 cm depth : 1) between pH and Fe available content (R = -0.92 and 0.76, respectively) ; 2) between organic matter and Fe available content (R = 0.98 and 0.91 respectively) what shows the fixation me by the organic matter of the soil; 3) between Cu and Zn available contents (R =0.84 and 0.71, respectively) what shows the anthropic source in both, probably through fertilizers and pesticides containing them and 4) between Zn and Ca contents (R = 0.84 and 0.51, respectively) what probably shows the joint apportion of these elements with superphosphate and other fertilizers commonly used, as rock phosphate, what included highest levels of Zn.

For every one of the physical or chemical parameters some critic values were assigned, following the SFCC model (Soil Fertility Capability Classification) proposed by BUOL *et al.*, (1975) and adapted by MACIAS and CALVO for Galicia (CALVO DE ANTA and MACÍAS VAZQUEZ, 1987 a and b, MACÍAS F.

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et al., 1983). Some specific changes for vineyard soils have been introduced by these different authors. From the application of these criteria it was deduced that the intrinsic limiting factors are (table V) :

P factor. Phosphorous content. We took as a reference the values proposed by LÓPEZ and LÓPEZ (1985) that mark excesses and deficit. Most of 6 year plots present deficit both in the surface layer and the subsurface one (<18 $mg.kg^{-1}$). In the 12 year ones appears excess (>72 $mg.kg^{-1}$) mainly in the ploughing layer.

mo factor. Content in organic matter. Most of the samples have an optimum level (2 %-5 %) recommended in the bibliography. The controls have a content in organic matter superior to 10 %, it means an excessive level.

N factor. The limits have been stablished for vineyard soils by HERAS *et al.* (1978) and FREGONI (1980). In the surface layer no sample presents this factor because of defect of N total (<0.1 % of saturation in cation exchange complex, N1). Yet it does appear excess (>0.30 %, N_2) in some samples. In the subsurface layer it appears lack, in the youngest plots.

E factor. Low capacity of exchange of cations. It is applied only to the ploughing layer. Majority of the samples present factor e. The limitation is strong (<4 cmol(+).kg-1) in most of the youngest vineyards and moderate (4-7 $cmol_{(+)}.kg^{-1}$) in the rest.

Ca factor. Deficiency of Ca. There is not lack of Ca in any of the plots in the ploughing layer (1.5 $cmol.kg^{-1}$ or Ca/Mg<1). But it does appear in the controls. Deeper in the subsoil there is deficit of Ca in the majority of the vineyards.

n factor. The studied soils are not sodic and the Na do not represent any problem.

K factor. According to the levels proposed by GUIGOU *et al.* (1989) for the content in K excessive levels of K appear in the ploughing layer in the 12 and 100 year vineyards. This give rise to deficit of Mg. In the subsoil the 6 year plots present deficit and 100 year ones excess.

Mg factor. Deficiency of Mg, either due to a low content in this element (less than 0.4 $cmol.kg^{-1}$ in the exchange complex, Mg1), or a disequilibria with the Ca (Ca/Mg>10, Mg2) or with the potassium (K/Mg>0.5) (FAO,1999; FREGONI, 1980; HERAS *et al.*, 1978; HERITIER *et al.*, 1992). Most of the studied samples present deficiency of Mg. In the surface layer numerous samples have a content of Mg lesser than 0.4 $cmol.kg^{-1}$ and all present disequilibria with K (relation K/Mg>0.5). In the subsurface layer majority present contents inferior to 0.4 $cmol.kg^{-1}$ and have a relation K/Mg>0.5, what means disequilibria with K.

Cu factor. Every 12 and 100 year samples and a 6 year one present factor Cu in excess. That is to say, 50 % of the samples have a content superior to 25 $mg.kg^{-1}$ (Cu^2) in the surface layer.

Mn factor. Values of available manganese below 1mg.kg-1 indicate deficit (Mn1) , very few samples present lack of Mn.

Zn factor. Quantities of available Zn lesser than 3.3 $mg.kg^{-1}$ are considered deficient for vineyard crops (Zn_1) (FREGONI, 1980). Contents over 15 $mg.kg^{-1}$ (Zn_2) turn out to be phytotoxic (VIETS and LINDSAY, 1973).

Concerning to the youngest vineyards, 33 % of the surface samples and all of the subsoil present lack. In 12 and 100 year samples the content of Zn in the surface layer is higher than 15 $mg.kg^{-1}$ in all cases what means excessive quantities that can give rise to toxicity.

Fe factor. It appears when the content of assimilating iron is lesser than 2.5 $mg.kg^{-1}$ (Fe1) (VIETS and LINDSAY, 1973). There is lack of Fe both in the ploughing layer and the subsoil in the majority samples, except the 100 year vineyards that do not present this factor.

Al factor. Toxicity due to Al. Contents over 50 $mg.kg^{-1}$ can result toxic affecting, mainly, to the radicle system of the vineyard (DELAS and JUSTE, 1984; FREGONI, 1980). This factor only appears in the oldest sample in the subsurface layer.

The characteristics presented by the soils that have been studied are very similar to the ones observed in other vineyard zones : sandy textures, lack of cations and frequent disequilibria of Mg and toxicity's due to metallic elements (COUTHINO *et al.*, 1984; DELAS and JUSTE, 1984; FREGONI, 1985; SEGUÍN and ARSAUT, 1984).

CONCLUSIONS

The limiting factors for the vegetable production of the studied soils are :

1. The most usual limitations of the chemical fertility are the low $CECe_{(+)}$ and the scarcity of Mg, which presents disequilibria in front of K.

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2. It is remarkable the deficit of Fe in every sample and the excess of Cu and Zn in the surface layer of the oldest vineyards.

3. The most recent plots are the ones that present strongest limitations due to low $CECe_{(+)}$, and lack of Ca, Mg, Zn and Fe. These limitations worsen in the subsurface layer where the handling effects are less marked.

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