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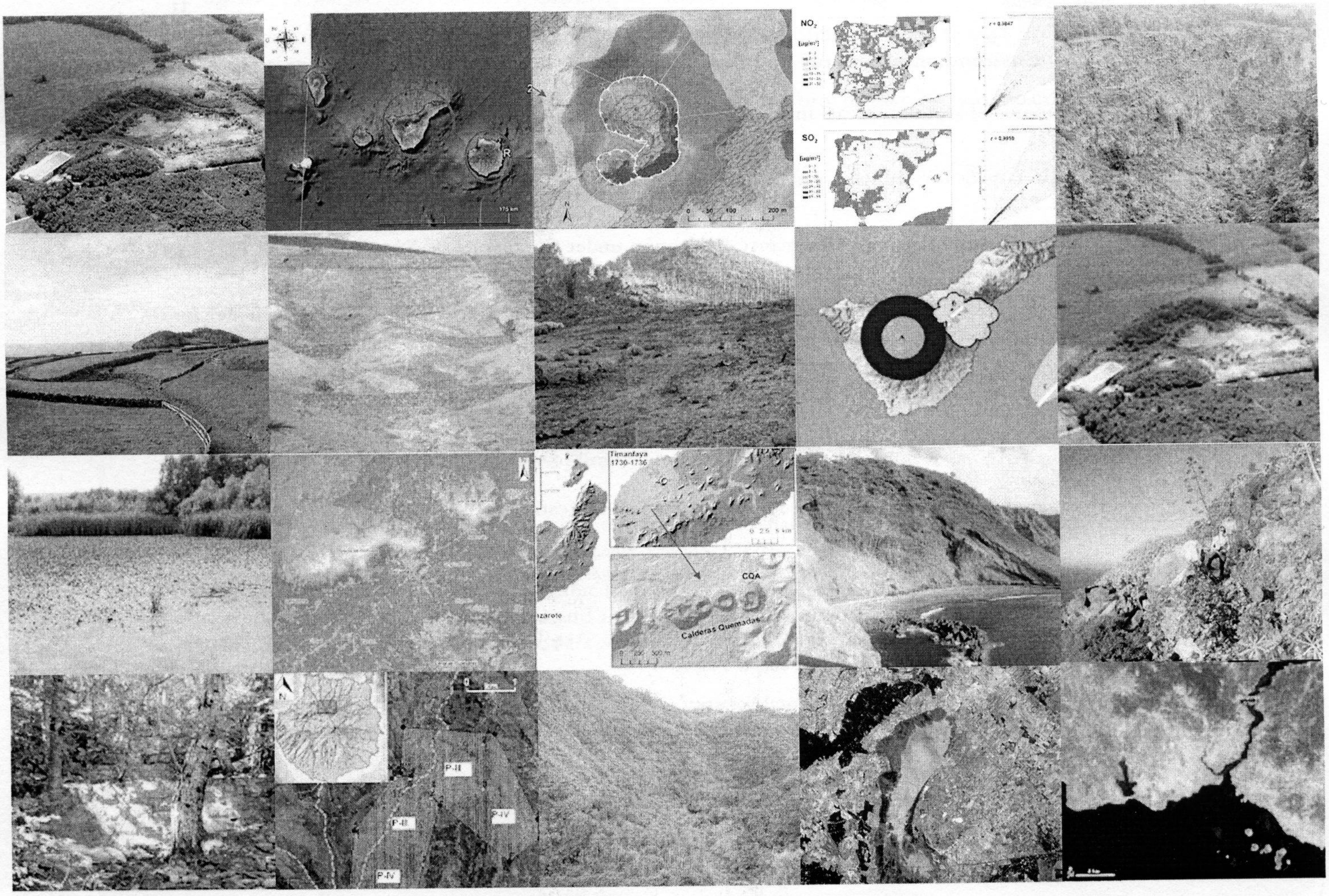
ENVIRONMENTAL SECURITY, GEOLOGICAL HAZARDS AND MANAGEMENT



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Proceedings from the 1st International Workshop, San Cristobal de La Laguna, Tenerife (Canary Islands), Spain, 10-12 April 2013

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EFFECT OF VINEYARD MANAGEMENT ON THE SOIL QUALITY, *'VINO DE TORO'* DISTRICT, WESTERN SPAIN

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1. INTRODUCTION

In recent years the surface dedicated to vineyards has significantly increased in areas with designations of origin (with high added value). This entails new managements, eliminating some measures of conservation because costs, affecting the physical and chemical properties of the soil. There are few references to the effect of the cultivation (shallow ploughing) and the chemicals addition on the vineyards, especially in relation to soil compaction and contamination during the annual cycle of the vine (Van Dyck & Van Asch, 2002; Ferrero *et al.*, 2005) and, moreover, specifically related to vineyards of Western Spain. Five areas have appellation of origin for wines in the *Castilla y León* Plateau; for that reason, there is strong pressure for expansion and increasing production of vineyards, especially close to the village of Toro (Province of Zamora); furthermore, there is a marked improvement of the quality of the wines in recent years.

Additions of chemicals for preventing emergency or removing parasites are common in vineyards. Among most common parasites should be highlight the fungi including: downy mildew (*Plasmopara viticola*), powdery mildew (*Uncinula necator*), and tinder (*Stereum hirsutum* Per. and *Phellinus igniarius* Fr.). The use of inorganic pesticides, such as the 'Bordeaux broth' (Cu sulphate with lime), is very common for the treatment of mildew; in some cases S is also added for preventing the powdery mildew. Then, a substantial amount of Cu added annually as sulphate and should remain in the soil, where it is often adsorbed on the soil epipedons (Deluisa *et al.*, 1996; Florez-Vélez *et al.*, 1996; Brun *et al.*, 1998), either in the subsurface (depending on the soil clay and SOM contents). Therefore, there is a risk of environmental pollution that affects the quality of the soil (Besnard *et al.*, 2001), but the behaviour of Cu in soil differs depending on the soil characteristics. The Cu is adsorbed by soils, according to their pH and texture; its soil accumulation is favoured by recurrent annual treatments. Thus, in calcareous soils an important part of the Cu is retained by the $CaCO_3$, although this retention is also influenced by the presence of SOM or clay (with capacity of adsorption or complexation). Likewise, the presence of organic compounds added (such as manures or fungicides) alters the chemical balance of the soil, causing differences in the type of contamination.

The **objective** of this study was to assess the soil changes produced by the vineyard management in the area of appellation of origin '*Vino de Toro*' (province of Zamora, Western Spain). Physicochemical and biochemical properties of vineyard soils were determinate and compared with those from a site with natural vegetation as reference, were performed to check the possible soil changes.

2. MATERIALS AND METHODS

The study area is located to the South of the province of Zamora, being comprised between the Douro River to the South and West of the province of Valladolid and having as central to the city of Toro (Western Spain). The region is nearly flat (*Castilla y León* Plateau), with gentle slopes and small mounds; mean altitude is 700 m a.s.l. The climate is typically continental semiarid character, with Atlantic influences. The annual rainfall ranges from 350 to 400 mm yr^{-1}. Temperatures are extreme (hot summers and very cold winters, with a thermal oscillation from +42 °C to -15 °C). Helio-thermic index is 4.23 and the number of effective hours of sunshine is 2,600 h (up to 3,000 h). Vineyards sit on several materials (gravel, gravel or sandy-clayey sediments) of Quaternary terraces, Pliocene sediments (sandstones, clays, and limestone) or Miocene unconsolidated materials (silty sediments, sandstones, and sometimes levels of limestone or marls). Dominant soils are calcareous *Cambisols*, calcic *Luvisols* (more developed North of the area), and *Arenosols* (on low terraces of the rivers) or *Fluvisols* (approaching to the Douro River or one of its tributaries). The natural vegetation is *Pinus pinaster* or *P. pinea* in sandy areas and *Quercus rotundifolia* in limestone areas. In the wine-growing areas extend the *Vitis vinifera* L. dominating the native variety '*tinta de Toro*' planted in pots or frames, depending on the quality desired. Within the cultivated areas were considered three different vineyard ages: (a) less than 10 years; (b) between 10 and 40 years; and (c) more than 40 years. Twenty soil composed samples were collected from the most superficial part of the soil floor (0-20 cm). One soil sampled has natural vegetation (reference) and the other three soils (always with similar soil characteristics) belong each one to the three different areas of culture indicated (according the vineyard age). Soil samples collected in the field were analyzed in the 'Laboratory of Soil Science' of the Faculty of Agrarian & Environmental Sciences (University of Salamanca). The methodology followed was the usual for soil analysis; an Analyzer LECO 2000 was used for analyzing soil C, N and S. Acid digestion proposed by Harstein *et al.* (1973) was followed for determination of total metals; and for available nutrient determination, EDTA extraction was performed. The final determinations were done using atomic absorption Spectrotometry and I.C.P. For statistical analysis of the data the Kolmogorov-Smirnov test was performed and for comparative data analysis between the areas of natural vegetation and vineyards an ANOVA was applied, looking for differences between the different ages of the vineyards, and between them and the natural vegetation. These treatments have been carried out with the program SPSS 17.0 (level of significance: $P < 0.05$).

3. RESULTS AND DISCUSSION

Results are presented in Table 1. Soil sample numbers 1 to 3 correspond to soils with natural vegetation; numbers 4 to 8 are soil samples from young vineyards (<10 years); numbers 9 to 13 corresponded to soil samples from mature vineyards 10 to 40 yr old; and 14 to 19 are soil samples with old vineyards more than 40 yr old. All soils are poor in SOM (< 10 C g kg^{-1}), with lower SOC values than those found by other authors (Besnard *et al.*, 2001; Fernández *et al.*, 2008), but with similar values to those found in other regions of Spain (Ramos & Martínez, 2006). There are significant differences between the SOC contents of natural soils and cultivated soils ($F = 20.21$ & $P < 0.001$); also significant differences between SOC contents found to vineyards with different ages ($F = 8.03$ & $P < 0.005$) were found. Total soil N contents did not follow similar trend to that presented by the COS. Significant difference ($F = 7.13$ & $P < 0.05$) between soil N content in natural and in the old vineyard was only found. The C/N ratio decreased significantly by the effect of the vineyard to very low values (7.0 ±1.2), but it recovered in the old vineyard (10.5 ±2.4). The available P, as expected, reached very high values in the oldest cultivated soils (39 ±10.0) by the successive additions of fertilizers (Probst & Joergensen, 2008). They are significant differences considering different ages or systems ($F = 4.85$ & $P < 0.001$), but not when young and mature vineyards are compared between. The soil pH decreased in the old vineyards, downing 4 decimals with cultivation, which indicates that ammonia fertilization should influence this parameter. In some soil samples high values of pH were found, due to the presence of carbonates of some sediment; despite of this, when the statistical analysis is performed significant differences by age ($F = 18.87$ & $P < 0.001$) were found. Only some vineyards the available and total Cu values in vineyards exceeded that found in natural soils, not arising differences concerning available Cu according to age; but total Cu shows significant differences (statistical Games-Holwell) when soils with natural vegetation and from old vineyards are compared. Besnard *et al.* (2001) found similar results and justify that by the possible loss of Cu by erosion.

Soil samples	Soil pH	SOC	Soil N	C/N	Soil S	Avail. P	CEC	Ca^{2+}	Mg^{2+}	K^+	Total Cu	Avail. Cu
Units	Soil:H_2O 1:2,5	mg C g^{-1}	mg N g^{-1}		mg S kg^{-1}	mg P kg^{-1}	cmol$_c$ kg^{-1}		mg kg^{-1}			
Natural vegetation												
1	6.8	6.7	0.7	9.4	20	4.8	7.7	14.3	6.7	0.3	5.8	0.9
2	6.7	4.4	0.5	8.6	35	2.3	2.8	4.8	3.8	0.1	4.0	0.6
3	5.9	6.3	0.6	10.8	61	1.3	6.2	7.3	4.3	0.2	5.5	1.0
Mean	6.5	5.8	0.6	9.6	39	2.8	5.6	8.8	4.9	0.2	5.1	0.8
±Standard deviation	0.5	1.2 **b**	0.1**a**	1.1	21	1.8	2.5	4.9	1.6	0.1	0.8 **b**	0.2
Young vineyards												
4	6.5	4.4	0.6	7.0	39	18.1	4.5	0.9	0.7	0.3	8.5	1.9
5	7.0	3.3	0.5	6.4	17	26.9	5.1	7.5	4.5	0.4	6.0	1.5
6	7.2	3.4	0.5	6.9	32	2.7	4.9	9.1	6.3	0.3	6.2	3.5
7	6.6	3.4	0.4	9.1	34	17.7	5.0	8.3	4.8	0.2	7.7	1.7
8	7.0	5.4	0.5	11.6	67	3.6	4.7	13.1	5.1	0.4	9.9	2.5

Mean	6.8	4.0	0.5	8.2	38	14	4.8	7.8	4.3	0.3	8.8	4.2
±Standard deviation	0.3	0.9 **ab**	0.1 **ab**	2.2	18	10.4	0.2	4.4	2.1	0.1	2.2 **a**	3.9
Mature vineyards												
9	6.3	2.7	0.4	6.7	38	22.9	2.5	6.5	5.3	0.3	6.1	1.5
10	7.4	3.4	0.6	6.1	37	3.4	7.8	20.6	15.6	0.5	8.2	1.4
11	5.5	2.5	0.4	6.6	36	8.3	2.9	5.3	3.0	0.1	5.1	0.7
12	6.7	3.2	0.5	7.1	69	31.1	7.7	11.2	8.4	0.2	27.9	1.2
13	7.0	4.1	0.4	9.4	101	25.7	5.7	9.3	7.3	0.3	6.2	0.9
Mean	6.6	3.2	0.4	7.0	56	18	5.3	11	7.2	0.3	11	1.2
±Standard deviation	0.7	0.6 **a**	0.1 **b**	1.3	29	11.9	2.5	6.0	4.8	0.1	9.7 **a**	0.3
Old vineyards												
14	4.5	4.2	0.5	8.8	71	44.0	5.3	2.8	3.2	0.2	7.7	3.9
15	4.7	3.1	0.3	9.4	52	23.6	4.7	3.5	3.6	0.3	12.7	1.3
16	5.1	3.9	0.4	8.9	48	46.3	4.1	3.3	3.1	0.3	8.4	2.1
17	5.3	3.5	0.4	9.4	41	34.3	2.6	3.8	3.1	0.2	10.8	2.9
18	4.9	4.0	0.3	14.7	45	34.9	3.4	3.3	3.0	0.2	10.4	2.5
19	5.4	4.0	0.3	11.9	51	51.0	3.4	5.3	3.5	0.3	8.0	3.3
Mean	5.0	3.8	0.4	11	51	39	3.9	3.6	3.3	0.2	9.7	2.7
±Standard deviation	0.4	0.4 **ab**	0.1 **b**	2.4	10	10.0	1.0	0.9	0.2	0.0	2.0 **a**	0.9

4. CONCLUSIONS

The most important effects produced on the soil by the agriculture management of the vineyards here studied are a significant decrease of the SOC content, which affects also the quality (C/N ratio) of the SOM. There is an accumulation of available P, very strong in old vineyards; later P fertilization is not advisable. The expected Cu accumulation in soils of vineyards is produced only concerning total Cu, without knowing (according to the available data) if the soil surface erosion plays a definitive role.

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