# WHAT IS THE BEST SOIL FOR SANGIOVESE QUALITY WINE?

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## ABSTRACT

Sangiovese is one of the main cultivar in the Italian ampelographic outline and it occupies more than 60% of total vineyard surface in the Tuscany region. It is also well known that the environmental variability causes an important influence over the viticultural and oenological results of Sangiovese, which does not have strict genetic control over the vegetal-productive behaviour.

The aim of this work was to single out the best soil characteristics for Sangiovese quality, on the basis of the vine performance of Sangiovese (VPS). For this purpose, a matching table, considering eight viticultural parameters, was utilized. The matching table permitted to classify the selected parameters into three classes of decreasing vine performance. A set of 79 experimental plots, sited on 47 farms, were utilized during a time span varying from two to five years (1989-1992; 1993-1994; 1997-2000; 2002-2007 and 2008-2009). Two datasets were created. One considering all the invariant soil and topography characteristics of the plots. The second, storing the year-depended variables. The data were submitted to principal component analysis (PCA) to highlight those invariant and year-depended climate and pedoclimate variables which were significantly correlated with the average values of the VPS of each vineyard. Discriminant Analysis was employed to identify the most significant variables and their discriminating power on VPS.

The results highlighted that invariant site characteristics are the most discriminant at the province level, while climate and pedoclimate show their influence on VPS at more detailed scales. At the province level, VPS is significantly influenced by rock fragments, stoniness, available water capacity (AWC), and elevation. The ideal soil for Sangiovese in the province of Siena is placed between 315 and 335 m asl, has an AWC ranging from 110 and 120 mm, shows a limited surficial stoniness of about 8-10%, and it is rather skeletal (rock fragments content 12-16%).

These results can be used in land evaluation and vine zoning, in particular, for the selection of the best crus of the province, they may help the choice of land for a new vine planting, but they might be also used in pedotechnique, that is, in the creation of vineyard soils by means of earth movements.

## KEY-WORDS

soil, climate, grape, red wine**,** Tuscany

## INTRODUCTION

Sangiovese is the main cultivar in the ampelographic outline of Tuscany. The territory of Siena has a prominent viticultural vocation, but its high environmental variability has huge influence over the viticultural and oenological results, mainly in the case of those varieties, such as Sangiovese, which have no strict genetic control over their vegetal-productive behaviours (Storchi *et al*., 1995). On account of that, the quality of Sangiovese is very dependent on the interaction between meteorology of the year and soil

characteristics. Differences in yield and analytical parameters of grape, correspond to distinctions in wine characteristics and quality.

The research was aimed to evaluate the best soil characteristics for Sangiovese quality vine, on the basis of the vine performance of Sangiovese (VPS), that is the vegetative and productive behaviour of the vine variety in a specific year and soil.

## MATERIALS AND METHODS

The study was conducted in the province of Siena (central Italy) on some of the most renowned wines in the world, i.e. the "Brunello di Montalcino", the "Chianti" and the "Nobile di Montepulciano". The reference variety was the Sangiovese vine, the basic constituent of those wines.

To compare functional and response variables, a matching table was utilized (FAO, 1976; Carey, 2009). In the proposed matching table for Sangiovese, selected measurable parameters of vine and grape were classed according to their assumed influence on the quality of Sangiovese wine (Storchi *et al.*, 1995; 2005; Costantini *et al.*, 1996; Bucelli *et al.*, 2006). The viticultural parameters selected for the achievement of high quality Sangiovese wine are reported in table 1. The values of the selected parameters were then used to classify three classes of VPS, corresponding to three levels of potential wine quality (Bucelli et al., submitted). Moreover, for each variable and vineyard, the mean value of the class was determined.

Tab. 1. Matching table of vine performance of Sangiovese (VPS) classes and predictors of potential wine quality.

| Variable | | VPS Class | Values |
|---|---|---|---|
| Grape weight per vine | kg | 1 | 1.0 – 2.5 |
| | | 2 | 2.6 – 4.0 |
| | | 3 | > 4.0 or < 1.0 |
| Mean cluster weigth | g | 1 | < 250 |
| | | 2 | 250 - 350 |
| | | 3 | > 350 |
| Mean berry weight | g | 1 | < 1.80 or > 1.80 if EPI > 1,600 |
| | | 2 | 1.80-2.30 or > 2.30 if EPI > 1,100 |
| | | 3 | > 2.30 |
| Sugar at harvest | °Brix | 1 | > 22.0 |
| | | 2 | 22.0-20.0 |
| | | 3 | < 20.0 |
| Daily sugar accumulation rate | °Brix $day^{-1}$ | 1 | > 0.38 |
| | | 2 | 0.38-0.33 |
| | | 3 | < 0.33 |
| Titratable acidity of must | g $L^{-1}$ | 1 | 5.50 - 7.50 |
| | | 2 | 5.00 - 5.49 or 7.51 - 8.00 |
| | | 3 | < 5.00 or > 8.00 |
| Extractable polyphenols index (EPI) | mg $kg^{-1}$ | 1 | > 1,600 |
| | | 2 | 1,600-1,100 |
| | | 3 | < 1,100 |
| Extractable anthocyanins index (EAI) | mg $kg^{-1}$ | 1 | > 500 |
| | | 2 | 500-300 |
| | | 3 | < 300 |

The trial used a set of 79 experimental plots, sited on 47 farms, were utilized during a time span varying from two to five years (1989-1992; 1993-1994; 1997-2000; 2002-2007 and 2008-2009). All vineyards were not irrigated and had similar cultivation conditions, such as age, vegetation and plant homogeneity: planting density of 3,300-3,600 vines per hectare; 420A rootstock; 11-12 buds per vine; spurred cordon pruning; mechanically-tilled soil. Three plots, each made up of 10 vines of the cultivar Sangiovese, were chosen in each vineyard, which was provided with a meteorological station to record the daily trend of air temperature and rainfall. The soils of the selected vineyards were described in detail, sampled, analyzed and classified according to the World Reference Base for Soil Resources (FAO-IUSS-ISRIC, 2006). Phenological phases were recorded and grapes were sampled and analysed at harvest as for grape yield per plant, cluster and berry weight, sugar content and accumulation rate, titratable acidity, extractable phenols and anthocyanins of 100-berry.

Two datasets were created. One considering all the invariant characteristics of the experimental sites: elevation, aspect, slope, radiation, soil particle size, rock fragments, stoniness, internal drainage, runoff, rooting depth, bulk density, field capacity, wilting point, available water holding capacity (AWC), and aggregate stability. The second, storing the year-depended variables (rainfall, air and soil temperature at 50 cm, Winkler's index, number of days when the soil was dry in the moisture control section, i.e., on average, between 20 and 60 cm).

The data were submitted to principal component analysis (PCA), to highlight those invariant and year-depended climate and pedoclimate variables which were significantly correlated with the average values of the VPS of each vineyard. Discriminant Analysis was employed to identify the most significant variables and their discriminating power on three groups of VPS. The three groups were formed by the cases with VPS class from a) 1 to 1.49, b) from 1.50 to 1.99, and c) from 2.00 to 3.00. Group a), in particular, was created to highlight best sites in terms of VPS.

## RESULTS AND DISCUSSION

The average VPS for the four DOCG areas ranged between VPS1 and VPS2 (Table 2). However Montalcino (1.28) and Chianti Classico (1.29) were classed better than Chianti Colli senesi (1.49) and Montepulciano (1.90)

Tab. 2. Mean classes of vine performance (VPS) for viticultural variables of DOCG areas.

| | Montepulciano | Montalcino | Chianti Classico | Chianti Colli senesi |
|---|---|---|---|---|
| sugar content | 1.03 | 0.74 | 0.80 | 0.97 |
| sugar accumaulation rate | 2.70 | 1.08 | 1.39 | 1.38 |
| grape yield/vine | 2.28 | 1.14 | 1.66 | 2.08 |
| cluster weight | 2.30 | 1.96 | 1.43 | 1.93 |
| berry weight | 1.13 | 1.23 | 1.06 | 1.03 |
| total acidity | 2.00 | 1.56 | 1.41 | 1.52 |
| mean VPS | 1.90 | 1.28 | 1.29 | 1.49 |

The results of the PCA on invariant soil and topography characteristics of the plots highlighted that, at the province level, VPS was mostly influenced by rock fragments, stoniness, AWC, and elevation. Although the large number of variables, the model

explained about 65% of the total variance. A second PCA conducted on the year-depended variables emphasized that VPS at province level is not significantly affected by climate and pedoclimate variations. The outcome confirms what found in a previous research, where the authors showed that these parameters significantly influence the VPS at the more detailed municipality level (Costantini et al., 2008).

The Discriminant Analysis was applied to the variables significantly correlated with VPS. The best VPS was obtained when the soils had the following characteristics: rock fragments and stoniness between about 12-16 and 8-10% respectively (Fig. 1 A, B) and AWC from 110 and 120 mm/m (Fig. 2 A), elevation of vineyard ranging between 315 and 335 m asl. On the basis of the Discriminant Analysis 35 vineyards were grouped in the best class a (1 – 1.49); 23 in b (1.50 -1.99), and 21 in c (2.00 – 3.00).

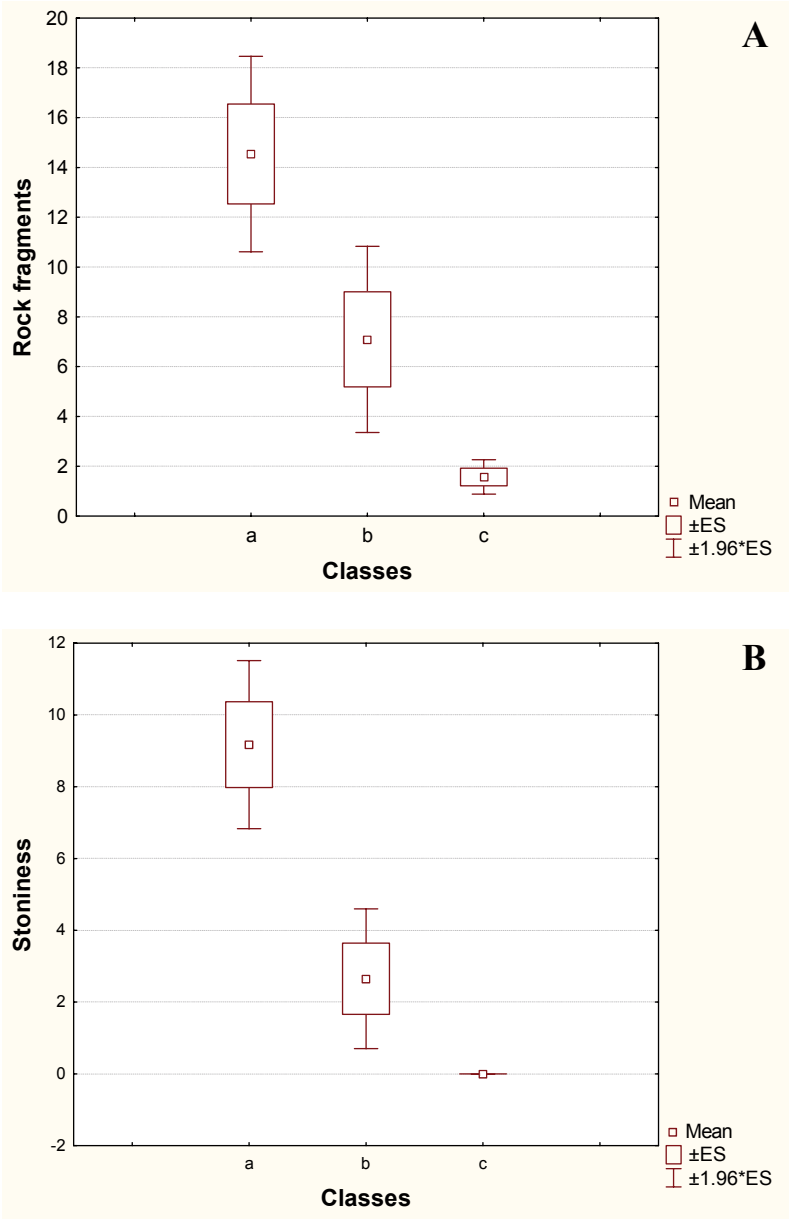


Fig. 1. Rock fragment (A) and stoniness (B) in the three different classes of VPS in the Province of Siena. Class values: a, b, and c groups experimental vineyards with decreasing performance of Sangiovese.

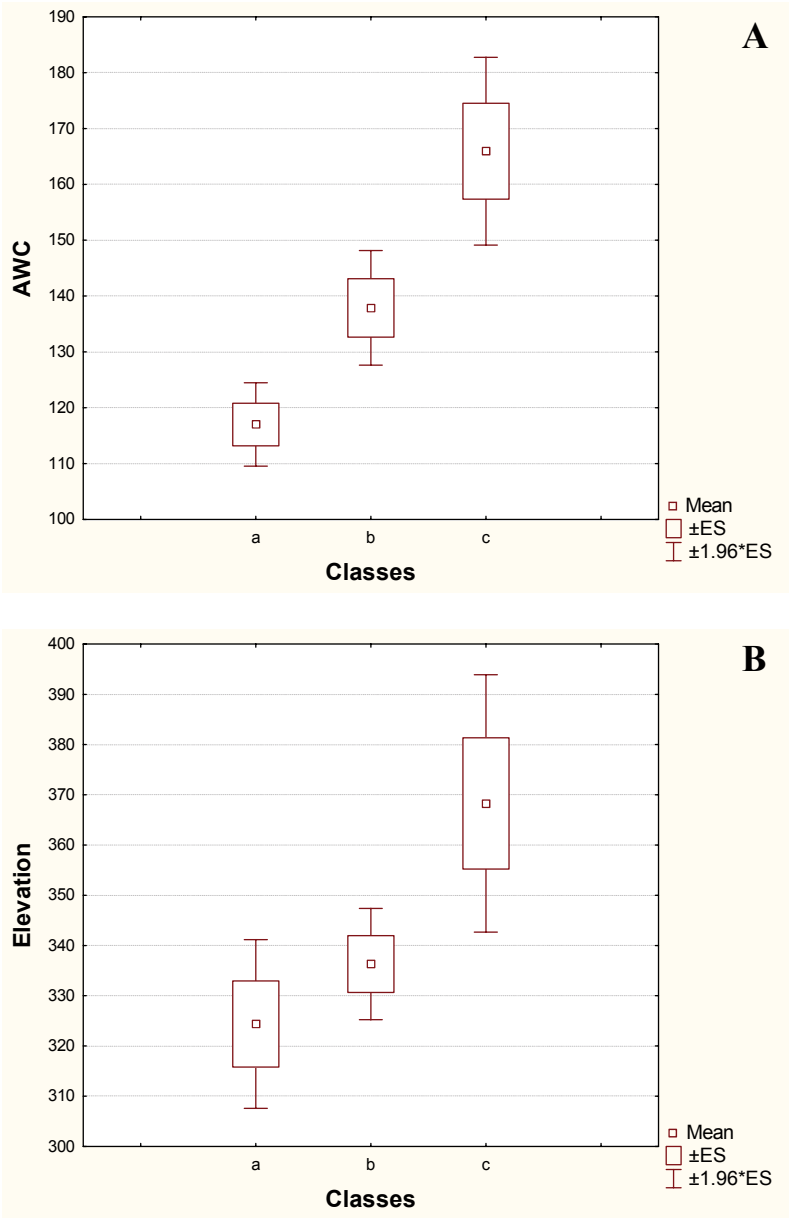


Fig. 2. Available water capacity (A) and elevation (B) in the three different classes of VPS in the Province of Siena. Class values: a, b, and c groups experimental vineyards with decreasing performance of Sangiovese.

## CONCLUSIONS

The research confirmed that for the Sangiovese vine there are environmental characteristics that are significantly related to qualitative vine production over the years. In province of Siena, the productive components of the Sangiovese vine, as well as the quality of grape, were closely related to invariant soil parameters and to elevation.

These results can be used in land evaluation and vine zoning, in particular, for the selection of the best crus of the province, they may help the choice of land for a new vine

planting, but they might be also used in pedotechnique, that is, in the creation of vineyard soils by means of earth movements.

## BIBLIOGRAPHY

Bucelli P., Piracci A., Faviere V., Giannetti F. and Baldi M., 2006. Attitudini enologiche di sei cloni di Sangiovese nella zona di produzione del Chianti Classico. In: Proc. 2nd Intern. Symp. "Sangiovese: typical and international vine. Identity and peculiarity". Firenze: ARSIA. 365-369.

Bucelli P., Costantini E.A.C. and Storchi P., (submitted). Prediction of Sangiovese wine quality through a limited number of variables measured on the vines.

Carey V.A., Archer E., Barbeu G. and Saayman D., 2009. Viticultural terroirs in Stellenbosch, Soth Africa. III. Spatialization of viticultural and oenological potential for Cabernet-Sauvignon and Sauvignon Blanc by means of a preliminary model. *J. Int. Sci. Vigne Vin,* 43, 1:1-12.

Costantini E.A.C., Campostrini F., Arcara P.G., Cherubini P., Storchi P. and Pierucci M., 1996. Soil and climate functional characters for grape ripening and wine quality of "Vino Nobile di Montepulciano". *Acta Horticulturae,* 427 ISHS, 45-55.

Costantini E.A.C., Barbetti R., Bucelli P., Cimato A., Franchini E., L'Abate G., Pellegrini S., Storchi P. and Vignozzi N., 2006a. Zonazione viticola ed olivicola della provincia di Siena. Colle Val d'Elsa (SI): Grafiche Boccacci.

Costantini E.A.C., Barbetti R., Bucelli P., L'Abate G., Lelli L., Pellegrini S. and Storchi P., 2006b. Land Peculiarities of the Vine Cultivation Areas in the Province of Siena (Italy), with Indications concerning the Viticultural and Oenological Results of Sangiovese Vine. *Boll. Soc. Geol. It.,* 6:147-159.

Costantini E.A.C., Barbetti R., Bucelli P., L'Abate G., Pellegrini S. and Storchi P., 2008. Scale dependence of soil and climate functional characteristics for qualitative Sangiovese vine production. In: Proc. 31^ OIV congress Verona, CD-rom computer file. Org. Int. vigne et vin. Paris, France

FAO, 1976. A framework for land evaluation. In: Soils Bulletin 32. Food and Agriculture Organization of the United Nations. Rome.

FAO, IUSS, ISRIC, 2006. World Reference Base for soil resource. In: World Soil Resource Report. Rome: FAO. 103.

Storchi P., Egger E. and Raspini L., 1995. Research on Sangiovese R10 in different Chianti Classico areas. In: Proc. Intern. Symp. Clonal selection. Portland (Oregon), 148-152.

Storchi P., Costantini E.A.C. and Bucelli P., 2005. The influence of climate and soil on viticultural and oenological parameters of Sangiovese grapevine under non-irrigated conditions. *Acta Horticulturae*, 689:333-34.