Grape Leaf Diagnosis Standards in Comparison to Pedological Factors

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Abstract

Piedmont, North-Western Italy, is the third largest Italian region in terms of grape and wine production. About 90% of the product is obtained from vineyards managed by integrated production methods where the evaluation of nutritional status is mainly based on foliar diagnostic. This is due to the broad offer of foliar fertilizers and to a not common use of periodical soil analysis. The study was aimed to upgrade the standard values of soil and leaf analyses in order to allow a better interpretation of the vineyard nutritional status in the different growing areas of Piedmont Region. Soil and leaf analyses were carried out on samples gathered from 120 vineyards of the two main cultivars grown in Piedmont, 'Nebbiolo' and 'Barbera'. Data from leaf analyses were analyzed statistically to determine leaf standard values of the two cultivars. Data of soil analyses were elaborated also with principal component analysis attempting to discriminate the vineyards according to proposed zonation.

INTRODUCTION

In Piedmont, the third largest wine grape production region in Italy, about 90% of the grape production is in vineyards managed by integrated production methods. Leaf diagnosis, along with soil analysis, is used in the process of fertilization planning. However, for proper interpretation of leaf analysis it is necessary to define reference standards which take into account soil fertility, vine genotype (cultivar and rootstock) and the local climate (Bogoni et al., 1995). For grapevines, the importance of soil is emphasized in the recognition of its contribution to determining the quality of the product (Lulli and Costantini, 1989; Costantini, 2001), and studies have been carried out to better define the influence of "terroir" on the organoleptic characteristics of wines produced from the same cultivar (Lulli et al., 1989; Morlat, 1997).

In Piedmont there is a need to adjust the standard limits of mineral elements in soil and leaves, and to try to correlate them to proposed production zones (IPLA, 2001). Many growers use values developed for other Italian zones, but find that interpretation of the analyses is difficult.

This paper reports the results of a study aimed at determining and upgrading the standard values for soil and leaf analyses in the main grape growing areas of the Piedmont Region.

MATERIALS AND METHODS

The study was conducted on 120 vineyards of the most representative varieties in Piedmont, 'Barbera' and 'Nebbiolo'. The vineyards were selected to have standard vegetative growth, yield, must composition and absence of nutrient deficiency symptoms. The vineyards were located in different growing areas of the two cultivars, according to the VQPRD delimited wine zones.

Leaf Analysis

Analyses were on leaf samples from the 120 vineyards in the survey and from the database of the Phytosanitary Sector of Piedmont Region (years 1991-1993). All samples were gathered at fruit set and were analysed by atomic absorption spectrometry at the

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agro-chemical laboratory of Piedmont Region. Samples were from three areas of quality wine production: Albese, Astigiano and Alessandrino. There were 1276 analysis results which were analyzed statistically by frequency distribution, Student-t test or ANOVA, followed by Newman-Keuls test, to evaluate differences among the three production areas and cultivars. Standard leaf diagnosis values were determined according to the method of Stringari et al. (1997).

Soil Analysis

Soil sampling was carried out at two depth levels (0-30 and 30-60 cm) in the 120 vineyards. Soil analyses were conducted to determine: texture, cation exchange capacity (CEC), total content of calcium carbonate, organic matter, nitrogen, phosphorous, potassium, calcium and magnesium (Violante, 2000).

Data were analyzed separately for the two sampling depth levels. Differences in the content of the different elements between the two depth levels were detected via Student-t test. Soil granulometric composition, the contents of calcium, magnesium and calcium carbonate, and CEC were used to discriminate soils though principal components analysis.

RESULTS

Leaf Analysis

Macro and microelements in leaves differed significantly among areas (Table 1). Nitrogen and calcium concentrations were higher in Astigiano and Albese than in Alessandrino. The content of P differed significantly among all three regions. Alessandrino had the highest K and Mg levels, while lower levels were found in Astigiano and Albese, respectively. Generally, grape leaves grown in Astigiano and Albese had a higher microelement contents than those in Alessandrino (Table 1).

The comparison between ‘Barbera’ and ‘Nebbiolo’, the most frequent varieties in these areas, shows remarkable differences: ‘Nebbiolo’ leaves had higher N, P, K, Fe and Mn concentrations than did ‘Barbera’ leaves (Table 2). On the other hand, Ca, Mg, B and Zn concentrations were comparable. As ‘Nebbiolo’ is the variety most common in the Albese area, and ‘Barbera’ is the major variety of the Astigiano area, these results also suggest a link between variety and growing area.

Differences among areas and varieties led us to develop standard values specific for the two cultivars that are displayed in Tables 3 and 4.

Soil Analysis

The soil organic matter content of the 120 vineyards was generally low. In the upper soil layer around 35% of vineyards had an organic matter content below 1%, about 25% had a content between 1 and 1.5% and the remainder had a content >1.5%. In the lower soil layer, more than 70% of the samples had an organic matter content below 1% (Fig.1a).

The nitrogen content in 70% of upper soil layer samples was higher than 0.05%, while about 60% of samples of the lower layer had a nitrogen contents below 0.05% (Fig. 1b). The content of P was less than 10 ppm in 75% of the upper soil layer samples and in 90% of the samples of the lower layer (Fig.1c). The content of K was at a sufficient level (higher than 100 ppm) in about the 65% of the samples from the upper soil layer; and the overall K content was lower in the lower layer where the majority of the samples had a content between 50 and 100 ppm (Fig. 1d).

The availability of Ca and Mg were generally found to be elevated: around 90% of the vineyards had a soil Ca content of higher than 1500 ppm and a content of Mg of more than 80 ppm in both the sampled layers (Fig. 1e, f).

The two sampled layers had significantly different contents of organic matter, N, P and K (Table 5). However, the contents of Ca and Mg, elements mostly linked to the geological constitution of the soil, were similar in both sampled layers.

The principal components analysis discriminated among the different areas (Fig. 2). The first component correlated positively to the contents of clay, Ca and Mg and to the CEC, and was negatively correlated to the content of sand. The second and the third components were associated with the lime and calcium carbonate contents; however, in the second component the variables were positively correlated, while in the third the content of lime was negatively correlated allowing for a better discrimination of the single vineyards in four classes (Fig. 2). Each class was fairly distinct and was associated with soil pedological and geological characteristics. However, about a dozen of vineyards were positioned differently than expected.

The vineyards of the group A were all situated near the cities of Canale and Vezza d'Alba where soils were derived from deposition during the middle and inferior Pliocene and are constituted of marl and fossiliferous sands. The vineyards of the B group are situated in the central part of the Albese area on the orographic right of the river Tanaro, where soils originated from miocenal soils and are constituted of calcareous marl and sandstone. The vineyards of the C group are predominantly in the area south of Asti, where soils are formed from Pliocene depositions and established of sandy marl. Finally the vineyards of the D group are located in the area of the cities of Canelli and Nizza Monferrato, on soils prevalently calcareous of schistose-clay type and tertiary origin.

On the base of this classification we have evaluated the physical and chemical differences among the discriminated zones (Table 6). According to the USDA classification, soils of the B and D groups are of the same textural class, silty-medium loam. The others two groups, A and B, are classed as medium loam.

Regarding chemical characteristics, group A possesses a calcium and magnesium content significantly lower than the other three groups. The calcium contents of the B, C and D groups were not different, while magnesium content of the D group was highest, and that of the B and C groups was intermediate (Table 6). The content of phosphorous and potassium in the four groups of soil was similar; however, a significant difference was detected for the Mg/K ratio (Table 6).

DISCUSSION AND CONCLUSIONS

The differences in leaf mineral content found among the three zones studied confirm previous work conducted on the influence of area of culture on the content of mineral elements (Fregoni, 1974; Fregoni et al., 1975; Bogoni et al., 1995).

The N and P concentrations found were lower than those reported for other Italian regions (Stringari et al., 1997; Fregoni, 1998), while contents of Ca and Mg were higher and K was in the same range. The high Ca and Mg contents found are indicative of the highly calcareous soils in Piedmont vineyards (I.P.L.A., 2000; 2001).

The knowledge of local leaf nutritional status should be considered not only a useful tool for proper interpretation of analyses, but also a parameter for evaluating the factors affecting vine yield and wine quality, and thus the territory vocation for grape cultivation.

The analyses revealed remarkable differences in composition between the two soil layers. In particular, organic matter, P and K contents were lower in the deeper layer. This result indicates there is a need to analyze vineyard soil sampled at two depths, so to include the soil depth where root nutrient uptake is active.

The principal component analysis of soil data enabled discrimination of the vineyards into four different groups (group A: area around the cities Canale and Vezza d'Alba; group B: Albese to the right of the river Tanaro; group C: area south of Asti; group D: area around the cities of Canelli and Nizza Monferrato). The discrimination was achieved using chemical and physical soil characteristics as already performed in other studies (Lulli et al., 1989; Costantini, 2001). From the extension service point of view, this classification can provide important information on how to interpret analyses of soils sampled from different areas and to provide correct advice on fertilization practices.

The need for local leaf and soil standards is widely accepted and the present work presents further support for this concept that could be associated with the definition of "terroir". Especially for vineyards, where quality is the most important production parameter, extension services should rely on standards that are fitted to the pedo-climatic conditions of the region.

Literature Cited

Bogoni, M., Failla, O., Panont, A., Scienza, A. and Falcetti, M. 1995. Leaf diagnosis in genotype x environment interaction studies for the assessment of viticultural aptitudes of a territory. Acta Hort. 383:143-158.

Costantini, E.A.C. 2001. Soil survey and chemical parameters evaluation in viticultural zoning. Atti Inst. Soil Science and Defense, Florence, Italy.

Fregoni, M. 1998. Viticoltura di qualità. Ed. Informatore Agrario, Verona.

Fregoni, M. 1974. Carta nutrizionale dei vigneti dell'alessandrino. Rassegna Economica della Provincia di Alessandria. Alessandria, Italy.

Fregoni, M., Scienza, A. and Visai, C. 1975. La carta nutritiva dei vigneti del Barolo, Barbaresco e Nebbiolo d'Alba. Amministrazione Provincia di Cuneo. Cuneo, Italy.

I.P.L.A. 2000. Caratterizzazione delle produzioni vitivinicole del Barolo. Aspetti pedologici. p.15-33. In: Regione Piemonte, Barolo. Regione Piemonte, Torino, Italy.

I.P.L.A. 2001. Aspetti pedologici. p.17-54. In: Regione Piemonte, Barbera. Regione Piemonte, Torino, Italy.

Lulli, L. and Costantini, E.A.C. 1989. Il suolo quale discriminante la qualità del vino. Il casodella Vernaccia di S. Gimignano. L'Enotecnico 11.

Lulli, L., Costantini, E.A.C., Mirabella, A., Gigliotti, A. and Bucelli, P. 1989. Influenza delsuolo sulla qualità della Vernaccia di San Gimignano. Vignevini 1/2:53-62.

Morlat, R. 1997. Eléments importants d'une méthodologie de caractérisation des facteurs naturels du terroir, en relation avec la réponse de la vigne à travers le vin. 1er Colloque Intern. "Le terroirs viticoles", Angers, INRA. France. p.17-31.

Stringari, G., Porro, D., Failla, O. and Möller, F. 1997. A method to asses and manage leaf analysis standards according to genetic and environmental variability. Acta Hort. 448:145-153.

Violante, P. 2000. Metodi di analisi chimica del suolo. Franco Angeli, Milano, Italy.

Tables

Table 1. Means and standard deviations of leaf mineral nutrients of grape from three growing areas in Piedmont Region. Values within rows followed by different letters are significantly different at p=0.05%.

	Astigiano	Alessandrino	Albese
Macroelements (% d.w.)	n = 476	n = 505	n = 295
N	2.335 ± 0.48 b	1.953 ± 0.87 a	2.370 ± 0.56 b
P	0.154 ± 0.07 a	0.173 ± 0.09 b	0.206 ± 0.09 c
K	0.965 ± 0.33 a	1.185 ± 0.64 c	1.081 ± 0.33 b
Ca	2.486 ± 0.48 b	2.376 ± 0.67 a	2.556 ± 0.52 b
Mg	0.319 ± 0.10 b	0.415 ± 0.20 c	0.276 ± 0.08 a
Microelements (ppm)			
Fe	121.2 ± 34.4 b	115.4 ± 48.6 a	130.5 ± 38.3 c
Mn	100.2 ± 42.4 b	89.5 ± 45.1 a	110.9 ± 44.6 c
B	39.3 ± 17.6 b	29.4 ± 11.7 a	41.6 ± 23.8 b
Zn	48.0 ± 27.3 b	37.8 ± 21.1 a	54.7 ± 32.7 c

Values within rows followed by different letters are significantly different at p=0.05%.

Table 2. Means and standard deviations of leaf mineral nutrients in grape cultivars ‘Barbera’ and ‘Nebbiolo’.

	‘Barbera’	‘Nebbiolo’
Macroelements (% d.w.)	n = 300	n = 191
N	2.275 ± 0.52 a	2.422 ± 0.63 b
P	0.163 ± 0.08 a	0.229 ± 0.10 b
K	0.935 ± 0.40 a	1.044 ± 0.41 b
Ca	2.415 ± 0.73 a	2.454 ± 0.47 a
Mg	0.320 ± 0.16 b	0.287 ± 0.14 a
Microelements (ppm)		
Fe	125.7 ± 34.2 a	120.8 ± 36.5 a
Mn	88.7 ± 43.1 a	105.4 ± 40.2 b
B	43.0 ± 21.0 a	44.9 ± 26.4 a
Zn	50.7 ± 29.5 a	52.0 ± 34.9 a

Values within rows followed by with different letters are significantly different at p=0.05%.

Table 3. Standard values for leaf nutrient diagnosis of grape cultivar ‘Barbera’.

	Very Low	Low	Normal	High	Very High
N	< 1.74	1.74 – 1.92	1.93 – 2.62	2.63 – 2.81	> 2.81
P	< 0.08	0.08 – 0.10	0.11 – 0.22	0.23 – 0.25	> 0.25
K	< 0.52	0.52 – 0.66	0.67 – 1.20	1.21 – 1.35	> 1.35
Ca	< 1.66	1.66 – 1.92	1.93 – 2.90	2.91 – 3.17	> 3.17
Mg	< 0.15	0.15 – 0.20	0.21 – 0.43	0.44 – 0.49	> 0.49
Fe	< 63	63 - 86	85 - 167	168 – 189	> 189

Table 4. Standard values for leaf nutrient diagnosis of grape cultivar ‘Nebbiolo’.

	Very Low	Low	Normal	High	Very High
N	< 1.77	1.77 – 1.99	2.00 – 2.84	2.84 – 3.07	> 3.07
P	< 0.13	0.13 – 0.15	0.16 – 0.30	0.31 – 0.33	> 0.33
K	< 0.62	0.62 – 0.76	0.77 – 1.32	1.33 – 1.47	> 1.47
Ca	< 1.97	1.97 – 2.13	2.14 – 2.77	2.78 – 2.94	> 2.94
Mg	< 0.14	0.14 – 0.19	0.20 – 0.38	0.38 – 0.43	> 0.43
Fe	< 37	37 - 65	66 - 176	177 – 200	> 200

Table 5. Comparisons of the chemical characteristics of soil sampled at two depths. Means ± SD, n=120.

	0-30 cm	30-60 cm
Organic matter (%)	1.57 ± 0.71 a	1.14 ± 0.43 b
Total Nitrogen (%)	0.098 ± 0.04 a	0.074 ± 0.03 b
Phosphorous (ppm)	11.41 ± 9.37 a	7.59 ± 8.48 b
Potassium (ppm)	133 ± 65 a	96 ± 45 b
Calcium (ppm)	2679 ± 816 a	2606 ± 858 a
Magnesium (ppm)	177 ± 104 a	198 ± 122 a

Values within rows followed by different letters are significantly different at p=0.05%.

Table 6. Comparisons of soil chemical characteristics among the four groups of vineyards defined by principal component analysis. Means ± SD.

	Group A	Group B	Group C	Group D
Calcium carbonate (%)	11 ± 2.4 c	25 ± 5.0 b	11 ± 4.0 c	29 ± 6.1 a
Phosphorous (ppm)	9.9 ± 6.7	9.6 ± 6.1	12.6 ± 10.9	11.7 ± 8.7
Potassium (ppm)	118 ± 26	150 ± 63	162 ± 82	161 ± 63
Calcium (ppm)	1810 ± 225 b	2828 ± 365 a	2820 ± 461 a	3185 ± 496 a
Magnesium (ppm)	64 ± 23 c	165 ± 55 b	150 ± 52 b	322 ± 100 a
Mg/K	1.83 ± 1.2 b	4.05 ±2.3 b	4.13 ± 3.1 b	7.22 ± 3.0 a

Values within in rows followed by different letters are significantly different at p=0.05%.

Figures

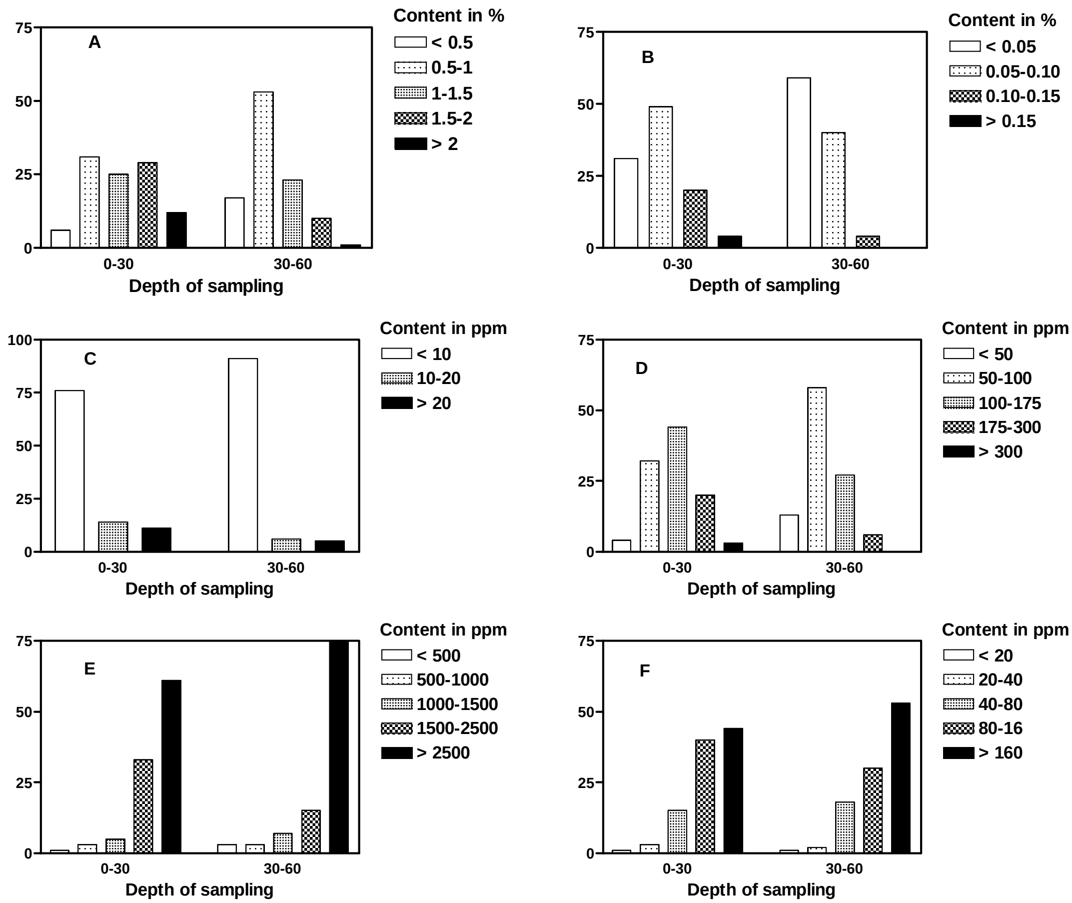

Fig. 1. Frequency distribution of soil chemical constituents at two sampling depths. A) organic matter; B) nitrogen; C) phosphorous; D) potassium; E) calcium; F) magnesium.

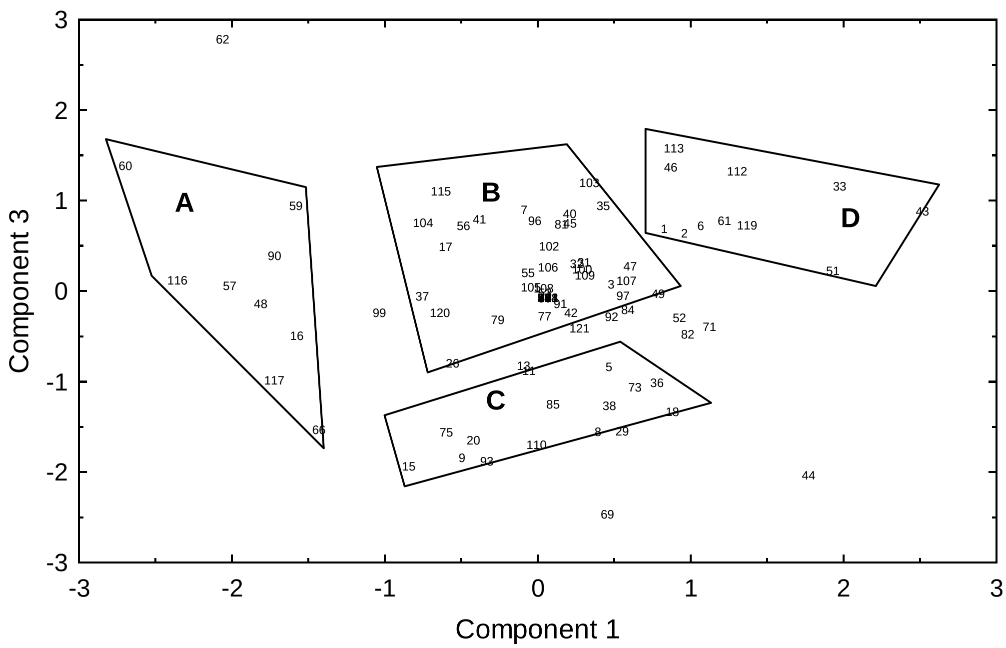

Fig. 2. Distribution of vineyards in the space defined by components 1 and 3. The polygons include vineyards with homogeneous chemical and physical soil characteristics located in four different areas.