Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(2): 181-185
Received: 11-01-2017
Accepted: 12-02-2017

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Correlation of available nutrients with physico-chemical properties and nutrient content of grape orchards of Kashmir

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Abstract
Soil and petiole samples were collected from fifteen grape orchards of Kashmir. The pH of surface soils showed significant and negative correlation with nitrogen (r = -0.722) and phosphorus (r = -0.590) and significant and positive correlation with calcium(r = 0.571). Soil surface organic carbon showed positive and significant correlation with available nitrogen (r = 0.904), phosphorus (r = 0.856), sulphur (r = 0.566) and iron(r = 0.592).The petiole nitrogen, phosphorus and sulphur content of vineyards exhibited significant and positive correlation coefficients (r = 0.650, 0.899 and 0.538) with available nitrogen, phosphorus and sulphur content in surface (0-30 cm) soils, respectively. A significant and positive correlation (r = 0.672 and r = 0.715) was observed between petiole manganese and boron with available manganese and boron in surface soils, respectively. Soil and leaf analysis must be used for proper diagnostic and prognostic work for determination of nutritional needs of vineyards.

Keywords: Correlation, Nutrients, Physico-chemical properties, Grape Orchards

Introduction
Nutrient deficiencies affect the quantity and quality of grapes through vine growth. Nutrient management is one of the largest shares of cost with its impact on potential yield and crop quality. Judicious use of nutrients envisages saving on natural resources for future use and protecting soil, water and air from pollution. Growth and yield of a grapevines is determined through soil fertility and soil fertility is determined by the availability of macro and micronutrients. For sustainable grape production soil and petiole nutrient characterization in relation to fertility status of soils of the region will be useful.

The availability of nutrients in soil depends upon soil pH, organic matter, adsorptive surfaces and other physical, chemical and biological conditions in the rhizosphere (Jiang *et al.* 2009) [15]. Soil quality of is controlled by physical, chemical and biological properties of soil and their interaction (Papendick and Parr, 1992) [25]. The deficiency of nutrients are the major constraints to productivity, stability and sustainability of soils (Chaudhari *et al*. 2012) [7]. Soil organic matter (OM), cation exchange capacity (CEC), soil pH and soil texture are the major indicators of soil fertility.In grape, petiole serves as a sensitive indicator of nutrient status (Chapman, 1964) [6]. Research work and nutritional survey conducted by the scientists of Indian institute of horticultural research, Bangalore have shown that the pollution to soil and water in the vineyards of peninsular India, on account, of heavy fertilization (Bhargava and Chadha, 1993) [5] is enormous, whereas crops like mango and guava receive nutrients rarely (Bhargava, 1999) [4]. Nutritional surveys carried out in different grape growing regions of the country have revealed that the growers are applying as high as 600 to 800 kg each of N, P_2O_5 and K_2O per ha every year accounting for 30 to 40 per cent of an annual recurring costs. Indian grape is under constant scrutiny of the environment and health protection agencies worldwide, as in India, the cultivation of grapes receives frequent application of large number of pesticides and further, grape is mostly consumed as fresh fruit in intact form without any processing.

The information on the nutritional status of grape orchards is important to serve as a guide for fertilizer recommendations for economic grape production and hence to assess the performance of vineyards. Since the information on the availability of nutrients in relation to the soil properties of the area is meager, therefore the present investigation was carried out to with the objective, to study relationship of available nutrient elements with soil physico-chemical properties and petiole nutrient content of grapevines.

Material and Methods
Representative soil and petiole samples were collected from fifteen grape orchards of uniform

age and vigour from main grape growing district (Ganderbal) of Jammu and Kashmir. The soil samples were processed and analysed for different nutrients. Available nitrogen was determined by alkaline potassium permanganate distillation method as described by Subbiah and Asija (1956) [32]. Available phosphorus content of the soil was extracted by 0.5 N sodium bicarbonate at pH 8.5 (Olesen *et al*. 1954) [24] and was estimated by ammonium molybdate method as outlined by Jackson (1973) [13]. Available potassium was extracted with neutral normal ammonium acetate at 1:5 soil to extract ratio and the content of potassium was estimated by flame photometer (Jackson, 1973) [13]. Available sulphur in soil was determined by Chesnin and Yien (1950) [8] method after extracting the soil with Morgan's reagent having pH 4.8. Calcium and magnesium content in the soil samples were determined by versenate titration method (Jackson, 1973) [13]. The available iron, zinc, copper and manganese were determined by atomic absorption spectrophotometer (Issac and Kerber, 1971) [12], after extracting with DTPA solution as described by Lindsay and Norvell (1978) [19]. Available boron in the soil samples was determined by hot water treatment method of Berger and Truog (1944) [3]. Available Mo in soil samples was estimated as per the procedure outlined by Johnson and Arkley (1950) [16].

The Petiole samples were collected from the same vine orchards as per the procedure of Chapman (1964) [6]. Total nitrogen was determined by micro-kjeldahl method by involving digestion, distillation and titration of plant samples as described by Jackson (1973) [13]. To estimate nutrient elements other than nitrogen viz; phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, zinc and copper, petiole samples were digested separately in diacid mixture of nitric acid and perchloric acid. The digested material was diluted in double distilled water and filtered in 100 ml volumetric flask. To ensure complete transfer of digested material, about six washings were given with double distilled water and final volume was made to 100 ml. For the determination of molybdenum and boron in plant samples dry ashing was carried out at a temperature of 500 ºC for 4 hours and the dry ashed samples were dissolved in dilute HCL and then carried away for analysis.

Phosphorus content was estimated from digested samples by the vanadomolybdate colour reaction method with the help of the spectrophotometer (Jackson, 1973) [13]. Potassium content was determined by flame photometer (Jackson, 1973) [13]. Calcium and magnesium content were determined by versenate titration method (Jackson, 1973) [13]. Plant sulphur was determined by turbidimetric method (Chesnin and Yien, 1950) [8]. The micronutrient cations like Zn, Cu, Fe and Mn were estimated on atomic absorption spectrophotometer (Issac and Kerber, 1971) [12]. The boron was estimated by azomethine-H method (Berger and Truog, 1944) [3]. The molybdenum (Mo) was estimated by method outlined by Johnson and Arkley (1950) [16].

The 95% confidence interval (C.I) was worked out using the procedure of Neyman (1937) [23]. Simple coefficients of correlation were worked available nutrients, petiole nutrient content and fruit yield and quality as per the procedure followed by Gomez and Gomez (1984) [11].

Results and Discussion

The correlation coefficient values of physico-chemical properties viz; soil pH, organic carbon, calcium carbonate and clay with available nutrient elements were worked out for both surface and sub-surface soils and are presented in Table 1 and the relationship between available and petiole nutrient contents are presented in Table 2. The regression coefficient for significant correlation are presented in Table 3 and range of available and petiole nutrient content of different grape orchards are represented in Table 4 and 5. The results of correlations studies of available nutrient elements are detailed and discussed as under;

Relationship of available nutrient elements with physico-chemical characteristics of the soils

Perusal of the Table 1 revealed that pH of surface soils showed significant negative correlation with nitrogen (r = -0.722) and phosphorus (r = -0.590) and non-significant negative correlation with available potassium, sulphur, iron, manganese, zinc, copper and boron. On the other hand, soil pH of surface layers exhibited significant and positive correlation (r = 0.571) with available calcium and non-significant positive correlation with magnesium and molybdenum. Data presented in the Table 1 revealed that sub-surface soil pH showed a significant and negative correlation with nitrogen (r = -0.521) and iron (r = -0.553) only, however, its relationship with all other nutrients was observed to be non-significant. The significant and negative correlation between soil pH and available nitrogen indicated that increase in soil pH decreased available nitrogen, which might be due to volatilization loss of nitrogen with rise pH of soil. Khokar *et al*. (2012) [17] and Patil *et al*. (2015) [27] have also found significant and negative correlations between soil pH and available nitrogen. The negative significant relationship between soil pH and available phosphorus may be due to conversion of soluble phosphorus to insoluble calcium and magnesium phosphate thus reducing its availability with the rise in soil pH. Similar results were reported Patil *et al*. (2015) [27]. The increase in availability of calcium with rise in soil pH is obvious, because of basic nature of calcium cation. The results are in line with those of Medhe *et al*. (2012) [20].

The soil surface organic carbon showed positive and significant correlation with available nitrogen (r = 0.904), phosphorus (r = 0.856), sulphur (r = 0.566) and iron (r = 0.592), but, showed non-significant and positive correlation with other nutrients except calcium with which it showed non-significant negative correlation. Sub-surface organic carbon showed positive and significant correlation with nitrogen (r = 0.839) only its relationship with other nutrient elements was observed to be non-significant. The significant and positive correlation between organic carbon and available nitrogen could be because of release of mineralizable nitrogen from soil organic matter in proportionate amounts (Vanilarasu and Balakrishnamurthy, 2014) [33], and adsorption of NH_4 –N by humus complexes in soil. The results are in conformity with those of Kumar *et al*. (2014) [18]. The significant and positive correlation between organic carbon and available phosphorus might be due to acidulating effect of organic carbon, formation of easily accessible organophosphate complexes, release of phosphorus from organic complexes and reduction in phosphorus fixation by humus due to formation of coatings on iron and aluminum oxides. The results are in harmony with the findings of Ayele *et al*. (2013) [2] and Singh *et al*. (2014) [31]. The increase in availability of sulphur by organic carbon may be attributed to release of sulphur from organic complexes as well as acidulating action of soil organic carbon thus enhancing the weathering of minerals containing sulphur. Similar results were reported by Pareek (2007) [26]. The significant and positive correlation between soil organic carbon and available iron content might be due to formation of iron chelates by organic matter, release of iron from organic complexes, acidulating action of soil organic carbon and decrease in soil pH thus increasing the solubility of iron complexes. The results are in accordance with the observations of Nazif *et al*. (2006).

Calcium carbonate content of surface soils showed significant and negative correlation with available phosphorus (r = -0.681) only and its relationship with other nutrients was negative and non-significant except calcium and magnesium with which it revealed positive but non-significant relation. Sub-surface calcium carbonate content showed significant and negative correlation with manganese (r = -0.522) only and its relationship with other nutrients was found to be non-significant. The significant and negative correlation of calcium carbonate with available phosphorus might be due to formation of insoluble calcium phosphates thus reducing its availability. The results are supported by the findings of Minhas and Bora (1982) [21]. The significant and negative correlation between available manganese and calcium carbonate content was also reported by Ganai *et al*. (1999) [10].

A significant and positive correlation of soil surface clay content was observed with calcium (r = 0.756) and magnesium (r = 0.613), on the other hand its relationship with rest of nutrients was non-significant. It was observed from the data that sub-surface clay failed to exhibit any significant positive or negative relationship with any nutrient element. A positive and significant correlation of clay with available calcium and magnesium content was also observed by Ahmad (2003) [1].

Relationship of available nutrient elements with their petiole nutrient contents

The petiole nitrogen exhibited significant and positive correlation(r = 0.650) with available nitrogen in surface soils (0-30 cm) and positive but non-significant correlation in sub-surface soils (30-90 cm) (Table 2). The results are in accordance with those of Ranjha *et al*. (2002) [29] and Delgado *et al*. (2004) [9]. The correlation coefficient between petiole phosphorus content and available phosphorus was significant and positive (r = 0.899) for surface soils, whileas, non-significant and positive for sub-surface soils. These results are in line with findings of Perveen *et al*. (2006) [28]. Similarly, correlation coefficient of, r = 0.538, was observed between available sulphur and petiole sulphur for surface soils and non-significant and positive for sub-surface soils. The results are in line with the observations of Jaggi and Raina (2008) [14]. A significant and positive correlation was observed between petiole manganeseand boronwith available manganese and boron in surface soils and sub-surface soils, respectively. Ranjha *et al*. (2002) [29] also reported similar relationship between soil and leaf manganese content. Significant and positive correlation coefficient between soil and leaf boron was also observed by Williams *et al*. (2004) [34]. In general, the relationships between petiole and soil available nutrients for all other nutrient elements were positive but non-significant for both surface and sub-surface soils.

Table 1: Relationship of available nutrients with physico-chemical characteristic of grape orchard soils

Soil properties	Available nutrients											
	Surface Soils (0-30 cm)											
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Mo
pH	-0.722**	-0.590*	-0.208	0.571*	0.296	-0.258	-0.340	-0.159	-0.105	-0.213	-0.084	0.230
OC	0.904**	0.856**	0.431	-0.412	0.072	0.566*	0.592*	0.512	0.420	0.347	0.205	0.175
$CaCO_3$	-0.283	-0.681**	-0.241	0.378	0.026	-0.125	-0.218	-0.157	-0.154	-0.084	-0.024	-0.037
Clay	-0.431	-0.298	0.270	0.756**	0.613*	0.174	0.146	0.235	0.298	0.135	-0.077	0.456
Sub-surface soils (30-90 cm)												
pH	-0.521*	-0.138	-0.285	0.107	0.137	-0.006	-0.553*	-0.507	-0.240	-0.303	-0.068	0.043
OC	0.839**	0.253	0.186	-0.110	0.115	0.105	0.494	0.370	0.013	0.222	-0.021	-0.352
CaCO3	-0.161	-0.090	0.069	0.352	0.293	-0.059	-0.417	-0.522*	-0.358	0.031	-0.108	0.502
Clay	-0.333	0.387	0.317	-0.035	0.284	0.377	0.024	-0.060	0.234	0.332	0.160	0.080

Table 2: Relationship of available nutrient elements with petiole nutrients in grape orchard soils of district Ganderbal

Nutrient element	Soil depth	Correlation coefficient	Soil depth (cm)	Correlation coefficient
N	0-30	0.650**	30-90	0.171
P	0-30	0.899**	30-90	0.286
K	0-30	0.454	30-90	0.322
Ca	0-30	0.468	30-90	0.307
Mg	0-30	0.380	30-90	0.395
S	0-30	0.538*	30-90	0.193
Fe	0-30	0.395	30-90	0.490
Mn	0-30	0.672**	30-90	0.648**
Zn	0-30	0.120	30-90	0.207
Cu	0-30	0.203	30-90	-0.075
B	0-30	0.715**	30-90	0.615*
Mo	0-30	0.294	30-90	0.313

** Significant at the 0.01 level
* Significant at the 0.05 level

Table 3: Regression coefficients of significant correlations of soil available nutrients with physico-chemical characteristic of grape orchard soils

Surface Soil (0-30 cm)				
Soil properties		Intercept	Slope	R^2
N	pH	585.68	-62.17	0.52
N	OC	66.82	66.44	0.82
P	pH	29.10	-2.54	0.35
P	OC	7.29	3.15	0.74
P	$CaCO_3$	13.82	-11.95	0.46
Ca	pH	-3.41	0.006	0.33
Ca	Clay	-288.22	0.17	0.57
Mg	Clay	229.73	2.13	0.38
S	OC	8.84	1.14	0.32
Fe	OC	21.97	8.37	0.35
Sub-surface Soil (30-90 cm)				
N	pH	282.34	-28.65	0.27
N	OC	13.61	91.34	0.71
Fe	pH	109.46	-11.08	0.31
Mn	$CaCO_3$	40.56	-35.22	0.27

Regression Coefficients for Significant Correlations

Acknowledgement
The facilities provided by division of soil science Shere-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K, Shalimar, Srinagar) during my research work are highly acknowledged.

Table 4: Range of soil available nutrients in grape orchard soils

Nutrient element	Concentration (ppm)	
	Range	Mean
N	140.0-195.0	161.0
P	10.5-13.4	11.7
K	126.0-141.0	133.1
Ca	1819.0-1883.0	1854.3
Mg	259.0-310.0	282.2
S	9.7-11.4	10.5
Fe	29.21-39.84	33.84
Mn	29.92-39.93	35.14
Zn	1.18-1.42	1.32
Cu	1.51-1.78	1.62
B	0.46-0.67	0.58
Mo	0.09-0.31	0.22

Table 5: Range of petiole nutrients in vineyards of Kashmir

Nutrient element	Range	Mean
N (per cent)	1.45-2.00	1.79
P (per cent)	0.14-0.25	0.18
K (per cent)	1.55-1.75	1.64
Ca (per cent)	0.80-1.50	1.17
Mg (per cent)	0.13-0.45	0.24
S (per cent)	0.10-0.22	0.16
Fe (ppm)	121.17-146.78	135.53
Mn (ppm)	30.21-45.25	38.80
Zn (ppm)	23.00-44.63	33.34
Cu (ppm)	10.03-13.87	12.06
B (ppm)	20.63-29.50	24.51
Mo (ppm)	0.27-0.54	0.37

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