

Nutrient status of grape orchard soils of Jammu and Kashmir, India

Abstract

A Survey was carried out to study available nutrient status of grape orchard soils Kashmir. Fifteen orchards with uniform age and vigour were selected and surveyed (simple random survey) for the purpose of collection of soil samples. The samples were processed and analyzed for different nutrients. In general the soils were medium in available nitrogen and phosphorus with mean values of 161.0 and 11.7 ppm, respectively in surface soils (0-30 cm) and mean values of 82.2 and 8.9 ppm, respectively in sub-surface soils (30-90 cm). All the soils under investigation were high in available potassium, calcium and magnesium showing average values of 133.1, 1854.3, 282.2 ppm and 112.5, 1872.1 and 254.3 ppm in surface and sub-soils, respectively. The mean available iron, manganese, zinc, copper, boron and molybdenum content of surface soils was 33.84, 35.14, 1.32, 1.62, 0.58 and 0.22 ppm, respectively and in sub-surface soils of 32.08, 33.42, 1.20, 1.39, 0.48 and 0.14 ppm, respectively. Further it was observed that majority of soils were high in available iron, manganese and zinc and medium in available copper, boron and molybdenum content.

Keywords: grape orchards, macronutrients, micronutrients, fertility status, Kashmir

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Introduction

Grape (*Vitis vinifera* L.) is one of the most important commercial fruit crops of temperate to tropical regions.¹ Grapes production occupies significance in the context that it is the third most widely cultivated fruit after citrus and banana. Globally grape production contributes to about 16 per cent of the total fruit production. Total area of grapes in world is 7.50 lakh ha with a production of 66 million tonnes.² In India grapes are cultivated on an area of 0.12 lakh hectares with an annual production of 24.83 lakh tonnes with a productivity of 21.1t/ha⁻¹,³ and the main grape producing states are Maharashtra, Karnataka, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Haryana and Punjab. In Jammu and Kashmir it is cultivated on an area of 329ha producing 803M tonnes and the cultivation is mainly confined to district Gander bal having an area of 128ha with an annual production of 231 M tonnes.⁴ In J&K the main varieties grown are Anab-e-shahi, Sahibi, Himrod, Hussaini and Thomson seedless.

Mineral nutritional requirement evaluation of fruit trees is different from that of annual crops, as tree crops are perennial, large and deep rooted and therefore, require more exact evaluation of their nutritional needs. Nutrient deficiencies can be accessed through visual symptoms, soil test or plant analysis (El-Fouly *et al.* 1982). Identification and quantification of nutrient deficiencies from visual symptoms is not easy and therefore either soil test or plant analysis is widely used for the same. The soil fertility and its productivity is affected by various physical, chemical and biological properties of soil, such as pH, lime, electrical conductivity, organic matter content, concentrations of macro- micronutrients etc. Adequate supply of nutrients is required by grapevines for proper growth and fruiting as nutrient deficiencies affect the quantity and quality of grape. It is well known that N and K, in particular, influence fruit and wine quality,^{5,6} so it is important to determine the content of these available nutrients in soil. Even with

optimum levels of these nutrients, poor growth can be attributed to low levels of calcium, magnesium, boron, zinc or other micronutrients. For example, Zn and B affect fruit set, and Mg affect bunch stem necrosis and thereby the number of clusters per vine and number of berries per cluster.⁷ Nutrient management is one of the largest shares of cost with its impact on potential yield and crop quality. Nutritional surveys carried out in different grape growing regions of the country have revealed that the growers are applying as high as 600 to 800kg each of N, P₂O₅ and K₂O per ha every year accounting for 30 to 40 per cent of an annual recurring costs. The fertility status of vineyards is very important in the management of nutrient programmes for maximizing vine growth production and fruit quality improvement, so it is very important to determine the fertility status of the soil for the optimum use of land to increase crop production. Since fertility status of main grape producing area of Kashmir has not been documented so far therefore, the present investigation undertaken to evaluate the nutrient status of vine orchard soils.

Material and methods

A survey was conducted to study the fertility status of vineyards in Gander bal district of Jammu and Kashmir (J&K). District Gander bal is located at 34o23' N latitude, 74o78' E longitude at an altitude of 1619 m above the mean sea level. It is bordered by district Srinagar in South, Bandipora to the North, Kargil in North-East, Anantnag to the South-East and Baramulla in South-West. Soil samples from 15 orchards of uniform age and vigour were collected depth wise with an increment of 30cm to a depth of 90cm following simple random sampling. The collected soil samples were air-dried in shade. The air dried samples were ground with wooden pestle and mortar and passed through 2mm sieve to separate the coarse fragments (>2mm). The soil sample were analysed for various physical and chemical

parameters. Available nitrogen was determined by alkaline potassium permanganate distillation method as described by Subbiah and Asija.⁸ Available phosphorus content of the soil was extracted by 0.5N sodium bicarbonate at pH 8.5⁹ and was estimated by ammonium molybdate method as outlined by Jackson.¹⁰ 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. Available sulphur in soil was determined by Chesnin and Yien¹¹ 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.¹⁰ The available iron, zinc, copper and manganese were determined by atomic absorption spectrophotometer after extracting with DTPA solution as described by Lindsay and Norvell.¹² Available boron in the soil samples was determined by hot water treatment method of Berger and Truog.¹³ Available Mo in soil samples was estimated as per the procedure outlined by Johnson and Arkley.¹⁴

Soil pH was determined in 1:2.5 soil:water suspension using pH

meter with glass electrode and electrical conductivity was measured in the supernatant solution of 1:2.5 soil: water suspension using digital conductivity meter.¹⁰ The organic carbon content was determined by wet digestion method of Walkley and Black.¹⁵ Schollenberger's method of leaching the soil with neutral ammonium acetate and determination of ammonical nitrogen (Jackson, 1973) was followed to determine cation exchange capacity of the soils. Calcium carbonate was estimated by adopting the rapid titration method as outlined by Piper.¹⁶ The 95% confidence interval (C.I) was worked out using the procedure of Neyman.¹⁷ The coefficient of variation (C.V) was worked out by using Microsoft Excel Worksheet.

Results and discussion

The data pertaining to available macro and micronutrient status of soils is presented in Table 1 & Table 2, respectively and the data regarding soil fertility status of soils is presented in Table 3. The Physico-chemical characteristics of studied orchard soils are shown in Table 4.

Table 1 Available macronutrient status of grape orchard soils of district Ganderbal (Jammu and Kashmir)

Sampled Location	Depth (cm)	Ppm					
		N	P	K	Ca	Mg	S
1	2	3	4	5	6	7	8
1	0-30	140	10.7	128	1850	265	10.2
	30-90	89	8.2	108.5	1861	257	9.9
2	0-30	157	11.7	133	1864	272	10.4
	30-90	90	9.2	114	1859	252	9.5
3	0-30	140	10.5	132	1844	259	9.9
	30-90	87	9.1	109	1899	258	9.3
4	0-30	160	11.1	128	1846	269	9.7
	30-90	77	8.3	112	1896	254	8.7
5	0-30	183	12.6	139	1842	289	10.9
	30-90	100	9.9	125	1887	261	9.8
6	0-30	168	11.8	134	1875	283	11.4
	30-90	81	8.7	116	1877	259	10.2
7	0-30	170	12.7	135	1865	287	10.7
	30-90	82	8.7	111	1854	252	9.9
8	0-30	160	11.4	126	1843	279	10
	30-90	68	7.9	107	1870	236	8.6
9	0-30	176	12.5	130	1869	283	10.5
	30-90	84	8.9	107	1895	259	9.3
10	0-30	195	13.4	141	1819	295	10.8
	30-90	96	9.7	120	1818	240	9.8
11	0-30	165	11.8	134	1832	273	10.7
	30-90	81	8.4	110	1873	245	9.6
12	0-30	154	11.9	131	1835	270	10.2
	30-90	81	8.9	106	1888	269	9.8
13	0-30	143	11.6	133	1872	310	10.6
	30-90	68	9.4	112	1882	255	9.8
14	0-30	148	11.2	135	1875	294	10.5
	30-90	70	9.2	116	1865	254	9.9
15	0-30	156	11.3	138	1883	305	10.3
	30-90	80	9.2	115	1857	263	9.8
Surface Soil (0-30cm)							
	Mean	161	11.7	133.1	1854.3	282.2	10.5
	95% C.I	152.3-169.7	11.3-12.2	130.8-135.5	1843.8-1864.7	274.1-290.3	10.2-10.7
	C.V (%)	9.8	6.8	3.2	1.2	5.2	4.1
Sub-surface Soil (30-90cm)							
	Mean	82.2	8.9	112.5	1872.1	254.3	9.6
	95% C.I	76.0-88.5	8.6-9.2	109.3-115.8	1862.0-1882.3	250.4-258.3	9.3-9.9
	C.V (%)	20.5	1.2	7.8	1.5	3.9	7.9

Table 2 Available micronutrient status of grape orchard soils of district Ganderbal (Jammu and Kashmir)

Sampled location	Depth (cm)	Ppm					
		Fe	Mn	Zn	Cu	B	Mo
1	2	3	4	5	6	7	8
1	0-30	29.21	30.12	1.21	1.57	0.51	0.12
	30-90	28.89	30.61	1.15	1.31	0.47	0.08
2	0-30	36.48	36.02	1.33	1.66	0.49	0.22
	30-90	33.65	33.8	1.03	1.43	0.43	0.14
3	0-30	30.5	29.92	1.23	1.62	0.53	0.09
	30-90	26.63	27.91	1.01	1.37	0.42	0.09
4	0-30	31.08	32.56	1.18	1.61	0.57	0.18
	30-90	28.37	30.16	1.14	1.38	0.45	0.14
5	0-30	39.84	37.58	1.36	1.73	0.59	0.22
	30-90	37.94	36.25	1.33	1.49	0.52	0.16
6	0-30	36.53	39.93	1.39	1.67	0.63	0.27
	30-90	35.37	36.42	1.26	1.46	0.47	0.19
7	0-30	35.63	36.17	1.33	1.59	0.46	0.21
	30-90	34.9	37.94	1.28	1.36	0.4	0.11
8	0-30	30.52	32.03	1.27	1.55	0.61	0.17
	30-90	28.28	28.55	0.99	1.36	0.5	0.14
9	0-30	33.54	35.13	1.3	1.57	0.67	0.22
	30-90	33.08	33.83	1.32	1.36	0.53	0.12
10	0-30	38.02	37.55	1.39	1.78	0.59	0.27
	30-90	37.86	37.63	1.27	1.46	0.49	0.14
11	0-30	33	37.67	1.42	1.56	0.62	0.25
	30-90	30.13	34.63	1.23	1.33	0.45	0.13
12	0-30	32.02	35.1	1.31	1.51	0.67	0.27
	30-90	31.68	35.18	1.15	1.34	0.52	0.15
13	0-30	32.69	36.98	1.37	1.61	0.58	0.31
	30-90	31.75	35.56	1.3	1.41	0.5	0.18
14	0-30	33.82	35.88	1.35	1.63	0.64	0.29
	30-90	30.56	30.11	1.25	1.41	0.52	0.18
15	0-30	34.67	34.52	1.34	1.61	0.58	0.25
	30-90	32.54	32.78	1.28	1.41	0.49	0.15
0-30 cm (Surface Soil)							
Mean		33.84	35.14	1.32	1.62	0.58	0.22
95% C.I		32.16-35.51	33.55-36.74	1.28-1.36	1.58-1.66	0.55-0.62	0.19-0.26
C.V (%)		8.95	8.19	5.3	4.32	12.06	27.27
30-90 cm (Sub-surface Soil)							
Mean		32.08	33.42	1.2	1.39	0.48	0.14
95% C.I		30.67-33.48	32.15-34.69	1.15-1.24	1.36-1.42	0.45-0.50	0.12-0.15
C.V (%)		11.75	10.16	10.16	5.75	11.66	26.42

Table 3 Soil fertility status of grape orchards of district Ganderbal (Jammu and Kashmir)

Nutrient element	Concentration (ppm)		Fertility class (per cent samples)		
	Range	Mean	Low	Medium	High
N	140.0-195.0	161	-	100	-
P	10.5-13.4	11.7	13	87	-
K	126.0-141.0	133.1	-	-	100
Ca	1819.0-1883.0	1854.3	-	-	100
Mg	259.0-310.0	282.2	-	-	100
S	9.7-11.4	10.5	7	93	-
Fe	29.21-39.84	33.84	-	-	100
Mn	29.92-39.93	35.14	-	-	100
Zn	1.18-1.42	1.32	-	7	93
Cu	1.51-1.78	1.62	-	100	-
B	0.46-0.67	0.58	13	87	-
Mo	0.09-0.31	0.22	6	87	6

Table 4 Physico-chemical characteristics of studied orchard soils

Sampled location	Depth (cm)	pH (1:2.5)	EC (dSI)	OC (%)	CaCO ₃ (%)	CEC (cmol (P+)kg ⁻¹)
1	2	3	4	5	6	7
1	0-30	6.96	0.11	1.26	0.21	13.47
2	0-30	7	0.16	1.22	0.2	14.91
3	0-30	6.73	0.12	1.22	0.18	15.04
4	0-30	6.88	0.13	1.3	0.18	13.2
5	0-30	6.62	0.11	1.7	0.21	17.82
6	0-30	6.75	0.1	1.55	0.2	16.65
7	0-30	6.65	0.13	1.65	0.1	15.43
8	0-30	6.8	0.11	1.34	0.19	14
9	0-30	6.68	0.09	1.65	0.11	14.2
10	0-30	6.6	0.09	1.78	0.08	13.2
11	0-30	6.72	0.12	1.57	0.15	17
12	0-30	6.77	0.09	1.45	0.16	14.95
13	0-30	7.18	0.15	1.14	0.23	17.5
14	0-30	7.12	0.18	1.18	0.21	17
15	0-30	7	0.15	1.26	0.19	14.21
Mean		6.83	0.12	1.42	0.17	15.24
95% C.I		6.73-6.93	0.11-0.14	1.30-1.54	0.15-0.20	14.36-16.12
C.V (%)		2.64	25	14.78	26.47	10.43

Macronutrients status of soils

Available nitrogen content of surface and sub-surface soils varied statistically from 152.3 to 169.7 and 76.0 to 88.5ppm with mean values of 161.0 and 82.2ppm, respectively (Table 1). The decrease in available nitrogen with increase in soil depth may be due to presence of higher organic matter content and favorable environmental conditions for mineralization at surface than sub-surface layers. The results are in agreement with the findings of Ranjha¹⁸ and Singh and Rathore.¹⁹ Perusal of data (Table 3) indicated that all the orchards were medium in available nitrogen content. It may be due to slower decomposition of organic matter under temperate conditions and removal of mineralized nitrogen by intensive cropping. The available phosphorus content of surface soils varied statistically from 11.3 to 12.2ppm, whereas, in sub-surface soils varied from 8.6 to 9.2ppm, with an average values of 11.7 and 8.9 ppm, respectively. The higher amount of organic matter in surface soils might be the reason for greater amount of available phosphorus in surface layers. The present findings are in line with the results obtained by Deepika and Srivastava²⁰ and Kumar.²¹ The available phosphorus status of soils under study area was low to medium. It was recorded that 13 per cent orchards were low and 87 per cent were medium in available phosphorus content. The low to medium availability of available phosphorus may also be as a result of past fertilization, pH, organic matter content, texture and various soil management practices.²² Similar results were observed by Yogeeshappa.²³ Available potassium content varied statistically from 130.8 to 135.5 and 109.3 to 115.8ppm with mean values of 133.1 and 112.5ppm in surface and sub-surface soils, respectively. Higher content of available potassium was found in surface soils than sub-surface soils, which may be attributed to higher weathering of potassium bearing minerals in surface soils, due to greater exposure of these minerals to weathering agencies at surface than sub-soils and also due to fertilizer and manure additions to surface soils. The results are supported by the findings of Fida.²⁴ Available potassium content was in high range. It might be due to prevalence of potassium rich clay minerals like illite, application of potassium fertilizers and manures. This is in agreement with the findings of Patil.²⁵

Available calcium content of surface soils ranged statistically from 1843.8 to 1864.7ppm with an average value of 1854.3ppm, whereas, in sub-surface soils it showed a variation of 1862.0 to 1882.3ppm with an average value of 1887.2.1ppm. In general calcium content of sub-surface layers was higher than the surface layers, which might be due leaching of calcium from surface to sub-surface layers. Soils under grape orchards in district Gander bal were sufficiently supplied with available calcium and it was high in all the soils. The reason may be due to presence of thick uniform layer of limestone with substantial quantities of dolomite and shale, which encircle whole valley of Kashmir in the form of cliffs (Wadia, 1981). The calcareous nature of parental material may also be a responsible for high available calcium content of these soils. The observations are supported by the findings of Dar²⁶ and Yogeeshappa.²³ The data revealed that available magnesium content of surface and sub-surface soils varied statistically from 274.1 to 290.3 and 250.4 to 258.3ppm with average values of 282.2 and 254.3, respectively. It was also observed that available magnesium content showed an inconsistent trend with soil depth. Available magnesium content was high which may be due to presence of illite and chlorite type of minerals in Kashmir as reported by Najjar.²⁷ The results are further supported by the findings of Dar.²⁶

Available sulphur content varied statistically from 10.2 to 10.7ppm with mean value of 10.5ppm in surface soils, whereas, in sub-soils varied from 9.3 to 9.9ppm with mean value of 9.6ppm. The results are supported by the findings of Arora.²⁸ The soils under grape orchards were low to medium in available sulphur content, as 7 per cent orchards were low and 93 per cent were medium in available sulphur content. The results might be attributed to the temperate environmental conditions resulting in low mineralization of organic matter, thus lower release of available sulphur. The results are in conformity with the findings of Sharma and Bhandari.²⁹

Micronutrient status of soils

Available iron content of surface and sub-surface soils varied statistically from 32.16 to 35.51 and 30.67 to 33.48ppm with mean values of 33.84 and 32.08ppm, respectively (Table 2). In general

surface soils were richer in available iron than sub-surface soils and iron content decreased with soil depth showing an unusual trend at few locations. This may be due to sufficient organic matter and low pH of surface soils. The results are in accordance with the observations of Patiram³⁰ and Sharma.²⁹ A perusal of data in Table 4 indicated that all the soils under study were high in available iron content, which may be due to presence high organic matter and due formation of iron chelates. The results are in agreement with those of Nazif³¹ and Samiullah.³² Available manganese content of surface layers ranged statistically from 33.55 to 36.74ppm with an average value of 35.14ppm, whereas, in sub-surface soils it varied from 32.15 to 34.69ppm with a mean value of 33.42ppm. Available manganese content of surface soils was higher than sub-surface soils and showed a decreasing trend the increase in depth of soil, which may be due to low pH and high organic matter in surface soil layers. The results are in accordance with those of Demire.³³ Grape orchards were sufficiently supplied with available manganese as all the samples fall in the high range. The adequacy of available manganese might be attributed to the positive effect of organic matter and suitable soil pH for manganese availability. The results are supported by the observations of Nazif.³¹ Zinc content varied from 1.28 to 1.36 and 1.15 to 1.24ppm with average values of 1.32 and 1.20ppm in surface and sub-surface soil layers, respectively. The surface soils showed higher content of zinc than sub-surface soils, which exhibited a decreasing trend with increase in soil depth, which might be due to higher organic carbon at surface soils, as organic carbon is a major contributor of available zinc in soils. The results are in conformity with those of Shah.³⁴ The present study indicated that the available zinc content was medium to high, as 7 per cent soils were medium and 93 per cent were high in available zinc. The results might be attributed to the fact that organic matter to some extent reduces the pH of soils which increases the solubility of zinc besides its effect on weathering of zinc containing minerals and formation of chelated zinc. The results are in accordance with the findings Samiullah.³² Data revealed that available copper content varied statistically from 1.58 to 1.66ppm with mean value of 1.62 ppm in surface soils, whereas, it varied from 1.36 to 1.42ppm with mean value of 1.39ppm in sub-surface soils. A decreasing trend of available copper content was observed with increase in depth and surface soils were richer in copper content, which might be due to higher organic matter and regular addition of fertilizers and manures to surface soils. The results are in agreement with findings of Khokhar.³⁵ All the soils under study were medium in available copper content, which might be due to the fact that copper is most strongly adsorbed divalent metal to iron and aluminum oxides which might have resulted in medium extraction of soil available copper.³⁶ The results are in accordance with those of Shaaban and El-Fouly.³⁷ Available boron content varied statistically in surface and sub-surface soils from 0.55 to 0.62 and 0.45 to 0.50ppm with average values of 0.58 and 0.48 ppm, respectively. Available boron content showed a decreasing trend in its vertical distribution and surface soils showed higher boron content than sub-surface layers, which might be attributed to high organic matter and addition of fertilizers to surface soils. Similar results were reported by Shah.³⁴

The available boron content in soils of grape orchards was low to medium, as 13 per cent orchards were low and 87 per cent orchards were medium in available boron content. The low to medium content of available boron might be due to high rainfall which resulted in leaching of soluble boron from soil, as boron is only nutrient element which is present as non-ionized specie over pH range suitable for plant growth³⁸ and due to adsorption of soluble boron on freshly precipitated Al(OH)₃ at pH>6.3 to 6.5.³⁹ Available molybdenum content of surface

soils varied statistically from 0.19 to 0.26ppm, whereas, in sub-surface soil layers, it ranged from 0.12 to 0.15ppm with mean values of 0.22 and 0.14ppm, respectively. It was observed that molybdenum content showed a decreasing trend with increase in soil depth, which might be due to direct association of available molybdenum with soil organic matter. The results are supported by the findings of Pandey.⁴⁰ The molybdenum content of soils ranged from low to high with 6 per cent orchards low, 87 per cent orchards medium and 6 per cent orchards high in available molybdenum. A soil pH range of 6.60 to 7.18 may be partly responsible for low to high soil available molybdenum range. These results are in line with those of Chen.⁴¹ The grape orchards of district Ganderbal were adequately supplied with nitrogen, potassium, copper, iron, manganese. Further soil analysis revealed that available phosphorus, sulphur, molybdenum and boron were low in 13, 7, 13 and 6 per cent grape orchards, respectively. The present investigation though first of its kind is expected to be quite useful for horticulturists for formulation of further research and development programmes for increasing grape production.⁴²⁻⁴⁴

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Conflicts of interest

The authors declare there is no conflict of interests.

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References

1. Gowda VN, Keshava SA, Shyamalamm S. Growth, yield and quality of Bangalore Blue grapes as influenced by foliar applied poly feed and multi-K. Proceedings of the International Symposium on Grape Production and Processing. *Acta Horticulturae*. 2008;785:207–211.
2. FAO. Food and Agricultural Organisation of the United Nations. FAO Statistical Year Book; 2013.
3. Anonymous. Grape profile. National Research Centre for Grapes, Manjari Farm, Solanpur road, Pune, India; 2013:4–5.
4. Anonymous. Area and production of horticultural crops in Jammu And Kashmir State. Department of Horticulture Jammu and Kashmir Government, India; 2014.
5. Mpelasoka BS, Schachtman DP, Treeby MT, et al. A review of potassium nutrition in grapevines with special emphasis on berry accumulation. *Australian Journal of Grape Wine Research*. 2003;9(3):154–168.
6. Bell S, Henschke PA. Implication of nitrogen nutrition for grapes, fermentation and wine. *Austr J Grape Wine Research*. 2005;11(3):242–295.
7. Robinson JB. Grapevine nutrition. viticulture, practices. In:BG Coombe, PR Dry, editors. *Winetitles*, Aelaide, South Australia, 1992;2:178–208.
8. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Current Science*. 1956;25:259–260.
9. Olesen SR, Koul CV, Watanabe FS, et al. Estimation of available phosphorus by extracting with sodium bicarbonate. United States Department of Agriculture Circular. 1954;939:315–326.
10. Jackson ML. Soil chemical analysis. 2nd edn. New Delhi, India:Printice Hall of India; 1973. 498 p.
11. Chesnin L, Yien CH. Turbidimetric determination of available sulphur. *Proceedings Soil Science Society of America*. 1951;15:149–151.

12. Lindsay WL, Norvell WA. Development of DTPA soil test for Zn, Fe, Mn and Cu. *Soil Science Society American Journal*. 1978;42(3):421–428.
13. Berger KC, Troug K. Boron determined by using the quinalizarin reaction. *Journal of Industrial and Chemical Engineering*. 1939;11(10):540–545.
14. Johnson CM, Arkley TH. Determination of molybdenum in plant tissue. *Analytical Chemistry*. 1950;26(3):573–580.
15. Walkey A, Black JA. Estimation of organic carbon by the chromic acid titration method. *Soil Science*. 1934;47:29–38.
16. Piper CS. Soil and plant analysis. 5th edn. Bombay, India: Hans Publishers; 1966. 368 p.
17. Neyman J. Outline of a theory of statistical estimation based on the classical theory of probability. philosophical transactions of royal society of London 1937;236:333–380.
18. Ranjha AM, Akram M, Medhi SM, et al. Nutritional status of citrus orchards in Sahiwal district. *Journal of Biological Sciences*. 2002;2(7):453–458.
19. Singh DP, Rathore MS. Available nutrient status and their relationship with soil properties of Aravalli mountain ranges and Malwa plateau of Pratagarh, Rajasthan, India. *African Journal of Agricultural Research*. 2013;8(41):5096–5103.
20. Deepika D, Srivastava LK. To analyse the major nutrients (N, P, and K) in black soil of Navagarh block under Janjgir district in Chhattisgarh. *Asian Journal of Soil Science*. 2013;8(2):348–350.
21. Kumar A, Mishra VN, Srivastava LK, et al. Evaluation of soil fertility status of available major nutrients (N, P and K) and micronutrients (Fe, Mn, Cu and Zn) in vertisols of Kabeerdham district of Chhattisgarh, India. *International Journal of Interdisciplinary and Multidisciplinary Studies*. 2014;1(10):72–79.
22. Verma S, Subehia SK, Sharma SP. Phosphorous fractions in an acid soil continuously fertilized with mineral and organic fertilizers. *Biology and Fertility of Soils*. 2005;41(4):295–300.
23. Yogeeshappa H, Tolanur SI, Lakshmpathi RN, et al. Studies on physico-chemical properties of different vineyards in Bijapur Taluk, Karnataka. *African Journal of Agricultural Research*. 2013;8(16):1477–1481.
24. Fida M, Khan S, Razzaq A, et al. Fertility status of guava orchards in Kohat district of Pakistan. *Journal of Soil Science and Environmental Management*. 2011;3(9):260–268.
25. Patil RB, Saler RS, Gaikwad VB. Nutritional survey of different vineyards in Nashik district. *Maharashtra Journal of Basic Sciences*. 2015;1:6–12.
26. Dar MA, Wani JA, Raina SK, et al. Relationship of leaf nutrient content with fruit yield and quality of pear. *Journal of Environmental Biology*. 2015;36:649–653.
27. Najar GR. Studies on pedogenesis and nutrient indexing of apple (Red Delicious) growing soils of Kashmir. Ph.D. thesis, submitted to Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar, India; 2002. 204 p.
28. Arora CL, Chibba IM, Takkar PN, et al. Nutrient status of soils and plants in some peach orchards of Punjab. *Indian Journal of Horticulture*. 1989;46(3):368–375.
29. Sharma BD, Mukhopadhyaya SS, Arora H. Total and DTPA-extractable micronutrients in relation to pedogenesis in some Alfisols of Punjab, India. *Soil Science*. 2005;170(7):559–572.
30. Patiram RC, Upadhyaya, CS, Munnaram S. Micronutrient cation status of mandarin orchards of Sikkim. *Journal of Indian Society of Soil Science*. 2000;48(2):246–249.
31. Nazif W, Perveenand S, Saleem I. Status of micronutrients in soils of district Bhimber (Azad Jammu and Kashmir). *Journal of Agricultural and Biological Sciences*. 2006;1(2):35–40.
32. Samiullah, Shah MZ, Tariq M, Shah T, et al. Micronutrients status of peach orchards in swat valley. *Sarhad Journal of Agriculture*. 2013;29(4):485–492.
33. Demire T, Muftuoglu NM, Dardenizand A, et al. Determination of the nutrition standard of soil and leaf analysis of Bozcaada Cavusu grape variety grown in Canakkale, Turkey. *Asian Journal of Chemistry*. 2007;19(5):3997–4006.
34. Shah Z, Shah MZ, Tariq M, et al. Survey of citrus orchards for micronutrients deficiency in Swat valley of North Western Pakistan. *Pakistan Journal of Botany*. 2012;44(2):705–710.
35. Khokhar Y, Singh H, Rattanpal I, et al. Soil fertility and nutritional status of Kinnow orchards grown in arid soil of Punjab, India. *African Journal of Agricultural Research*. 2012;7(33):4692–4697.
36. Lindsay WL. Chemical equilibria in soils. John Wiley and Sons, New York, USA; 1979.
37. Shaaban SHA, El-Fouly MM. Impact of the nutritional status on yield of some grape (*Vitisvinifera L.*) cultivars fertilized through drip irrigation and grown on sandy soil. *Journal of American Science*. 2012;8(7):156–163.
38. Arora S, Chahal DS. Available boron status of major soil series of Punjab in relation with soil characteristics. In Proceedings of 4th Punjab Science Congress, Ludhiana, India; 2001.
39. Havlin JL, Beaton JD, Tisdale SL, et al. Soil fertility and fertilizers, an introduction to nutrient management. 7th edn. Prentice Hall, New Jersey, USA; 2007.
40. Pandey SP, Singh RS, Mishra SK. Availability of phosphorus and sulphur in Inceptisols of central Uttar Pradesh. *Journal of Indian Society of Soil Science*. 2000;48(1):118–121.
41. Chen F, Lu J, Liu D. Investigation of soil fertility in citrus orchards of Southern China. *Better Crops*. 2007;91(3):24–25.
42. El-Fouly MM, Fawzi AFA, Rezk AI. Soil and leaf analysis as a measurement for micronutrients supply and uptake in Grape. International Horticultural Congress, Hamburg, Germany, Abstract. 1982;II(XXI):2186.
43. Sharma U, Bhandari AR. Survey of the nutrient status of apple orchards in Himachal Pradesh. *Indian Journal of Horticulture*. 1992;49(3):234–241.
44. Yogeeshappa H, Tolanur SI, Gali SK, et al. A survey of soil fertility status and index tissue analysis of vineyards. *Karnataka Journal of Agricultural Sciences*. 2008;21(2):280–281.