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Quality and yield of grape berries of Kashmir (India) and their relationship with available and petiole nutrient content

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Abstract
Soil, plant and fruit samples were collected from 15 representative grape orchards of district Ganderbal, yield was recorded and the berries collected from the selected orchards were processed and analyzed for various quality parameters viz. total soluble salts, total sugars, acidity and anthocyanin. The total soluble salts, total sugars, acidity and anthocyanin content of grape berries varied statistically from 22.06 to 23.12, 13.84 to 14.69, 0.35 to 0.43 and 0.02 to 0.03 per cent with average values of 22.59, 14.27, 0.39 and 0.03 per cent, respectively. The yield of grape orchards statistically showed a variation from 1.80 to 1.84 t ha^{-1} with an average value of 1.82 t ha^{-1}. Soil potassium, sulphur, iron, zinc and boron and petiole potassium, manganese and boron contents revealed significant and positive correlation with total sugars. Available nitrogen, and petiole nitrogen, phosphorus, sulphur, iron, manganese, zinc, copper and boron showed positive and significant correlation with acidity. Anthocyanin content indicated positive and significant correlation with available boron and petiole boron and potassium. The fruit yield of grapes indicated a significant and positive correlation with soil available nitrogen, phosphorus, manganese, and petiole nitrogen, phosphorus, sulphur, manganese and boron contents.

Keywords: Yield of grape, petiole nutrient content, phosphorus

1. Introduction

Globally grape production contributes to about 16 per cent of the total fruit production. In India remarkable success has been achieved in table grape production and yield levels of fresh grapes are among the highest in the world. There has been large growth and import substitution in case of raisin (dried grapes) and is upcoming as a sector with good potentials for further growth. Grapes are cultivated on an area of 0.12 lakh hectares with an annual production of 24.83 lakh tonnes with a productivity of 21.1 t ha^{-1}(N.R.C,) [37] and the main grape producing states are Maharashtra, Karnataka, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Haryana and Punjab. The contribution of different states like Maharashtra, Karnataka, Andhra Pradesh, Mizoram and Tamil Nadu is 82.6, 12.9, 1.3, 0.8 and 1.7 per cent, respectively and the contribution of other states is 0.7 per cent. In Jammu and Kashmir grape is cultivated on an area of 329 ha producing 803 M tonnes and the cultivation is mainly confined to district Ganderbal having an area of 128 ha with an annual production of 231 M tonnes (Annonymous,) [6] and the two main varieties grown are Sahibi and Hussaini besides some other varieties (Anab-e-shahi, Himrod and Thomson seedless) are also cultivated on limited area.

The grape was probably used as fresh fruit by man, but it is now it is also consumed as juice and dry raisin on a large scale, so attention is to be paid to increase the product quality. The quality of grape is considered as combination of appearance (average size of clusteras uniformly large size berry, perfect berries with characteristic colour and texture of the variety) (Kamiloglu), [24], flavor characteristics, sugar concentration, acidity (Jonathan), [23]. Grape productivity and quality depends upon cultural practices like management of nutrients and water which have impact on fertility status of soil and plant. According to Mitra *et al.* [34] nutrients in soil and foliage have considerable effect on yield and quality parameters of fruits because of their role in plant metabolism. Grapevines require adequate supplies of nutrients for growth and fruiting. Nutrient deficiencies affect the quantity and quality of grape. To achieve optimum growth and fruit quality, adequate levels of all the nutrients must be present in the petioles.

Nitrogen and potassium are the most important nutrient elements required by grapevines. These two nutrients have considerable effect on grape bud production. Nitrogen supports vine and fruit growth and therefore the yield of grape berries but excessive nitrogen to vines results in delayed ripening (Keller) *et al.* [25] and poor coloured fruits (Kliewer), [28]. In grape berries potassium is the most abundant cation which contributes to charge balance and sugar transport (Spayd*et al.* 1993). According to Martin *et al.* [32] increased potassium supply increases total soluble solid content and decreases total acidity of berries. Furher adequate potassium supply increases colouring and polyphenol content of grape berries (Sommers), [49], but even with optimum levels of nitrogen and potassium low levels of magnesium, calcium, zinc, boron or other nutrients can result in poor growth of vineyards. Robinson [45] reported that zinc and boron affect fruit set, and potassium, calcium and magnesium affect bunch stem necrosis and thereby number of clusters per vine and number of berries per cluster.

The quality of Ganderbal grapes is considered to be one of best in the world according to reports of horticultural department Ganderbal and besides Italy the Kashmir is the only place where the fresh grapes are available in the offseason. Thus the present investigation was carried out to study the quality attributes and yield of grapes grown in different villages of Ganderbal district of Jammu and Kashmir and also to study the relationship of the grape quality parameters with available and petiole nutrient content.

2. Material and Methods

Soil, petiole and fruit samples were collected from 15 grape orchards of uniform age and vigour from district Ganderbal of Jammu and Kashmir. The fruit samples were collected as per the procedure of Waller [55]. After collecting, the fruit samples were washed thoroughly with tap water then dipped in dilute HCl, and further washed with single and double distilled water. The moisture was whipped with filter paper and muslin cloth. Randomly selected berries were taken for juice extraction and total soluble solids of the juice were determined by using Zeis's hand refractometer. The readings were corrected at 20 ºC and expressed as per cent soluble salts (A.O.A.C, 1). Total sugar content was determined in terms of glucose after acid hydrolysis as per 15th addition of Officials Agriculture Chemists (A.O.A.C, 2) on per cent basis. Acidity was determined by diluting a known volume of fruit juice and titrating it against 0.1 N sodium hydrioxide solution, using Phenopthaline as indicator. The result were explained in terms of per cent malic acid (Annonymous), [5]. Ethanol, 1.5 N HCL (85:15) was used for anthocyanin extraction and estimation were made by hycalori procedure as suggested by Ranganna [44]. Fruit yield from vines of same orchards where from soil, petiole and fruit samples were collected was recorded at the time of harvesting of fruits.

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 [51]. Available phosphorus content of the soil was extracted by 0.5 N sodium bicarbonate at pH 8.5 (Olesen) *et al.* [40]. Available potassium was estimated by flame photometer (Jackson), [19]. Available sulphur in soil was determined by Chesnin and Yien [12] method. Calcium and magnesium content in the soil samples were determined by versenate titration method (Jackson), [19]. The available iron, zinc, copper and manganese were determined by atomic absorption spectrophotometer after extracting with DTPA solution as described by Lindsay and Norvell [30]. Available boron in the soil samples was determined by hot water treatment method of Berger and Truog [9]. Available Mo in soil samples was estimated as per the procedure outlined by Johnson and Arkley [22].

Petiole samples were collected from the same orchards and same vines from where soil samples were collected as per the procedure of Chapman [11]. The samples were washed, dried, ground and digested for analysis. Petiole nitrogen, phosphorus, potassium, calcium and magnesium were determined as per the procedure outlined by Jackson [19]. Plant sulphur was determined by turbidometric method (Chesnin and Yien), [12]. The micronutrient cations like Zn, Cu, Fe and Mn were estimated on atomic absorption spectrophotometer. The boron was estimated by azomethine-H method (Berger and Truog), [9]. The molybdenum (Mo) was estimated by method outlined by Johnson and Arkley [22].The 95% confidence interval (C.I) was worked out using the procedure of Neyman [38]. Simple coefficient of correlation were worked available nutrients, petiole nutrient content and fruit yield and quality as per the procedure followed by Gomez and Gomez [18].

3. Results and Discussion

The total soluble salts of grape berries varied statistically from 22.06 to 23.12 per cent with mean value of 22.59 per cent (Table 2). The data further revealed that total sugars in the grape berries of different orchards ranged statistically from 13.84 to 14.69 per cent with an average value of 14.27 per cent. The variation in T.S.S and total sugars might be due to variation in soil fertility and petiole nutrient composition, particularly potassium as it maintains the assimilatory power of leaves over a large period thus increasing the T.S.S and sugar content of fruits. The results are supported by the findings of Yogeeshappa [59].

Perusal data in the Table 2 showed that acidity and anthocyanin content of grape berries varied statistically from 0.35 to 0.43 and 0.02 to 0.03 per cent with values of 0.39 and 0.03 per cent, respectively. The differences in acidity and anthocyanin could be attributed to difference in nutrient status vineyards, particularly nitrogen; the other factors include temperature, light etc. The higher levels of ammonical nitrogen content are responsible for increased fruit acidity and also high nitrogen content causes shading effect and increased shoot growth; both these are responsible for low carbohydrate content due to which low anthocyanin content results. The results are in conformity with the observations of Singram and Prabhu [48].

Data pertaining to yield of grape berries (Table 2) revealed that yield of different grape orchards of district Ganderbal statistically showed a variation from 1.80 to 1.84 t ha^{-1} with an average value of 1.82 t ha^{-1}. The highest yield (1.90 t ha^{-1}) was found at Waliwar and lowest yield (1.75 t ha^{-1}) was recorded from Benihama grape orchards.The yield was influenced by fertility status of soil and cultural practices of farmers. The results were in conformity with those obtained by Janaki *et al.* [20] and Dar *et al.* [16].

4. Relationship of available nutrient elements and petiole nutrients with quality and yield of grape

The nutrients in soil and foliage have considerable effect on yield and quality parameters of fruits because of their role in plant metabolism (Mitra*et al.* 34). Grapevines require adequate supplies of nutrients for growth and fruiting. Nutrient deficiencies affect the quantity and quality of grape.

For a particular nutrient, there exists a relationship between its concentration in soil and leaf, as well as quality attributes of fruits and this serves as a guide to obtain maximum productivity of quality fruits. The relationship between various nutrients with quality parameters and yield of grapes in presented in Table 5 and 6 and discussed below:

The available soil nutrients failed to exhibit any significant relationship with total soluble salts of grape berries, however, a positive and significant correlation coefficient was observed between petiole potassium and total soluble salts of grape berries, but rest of leaf nutrients failed to establish any significant relationship with total soluble salts. The significant and positive correlation of total soluble salts with leaf potassium content might be attributed to the fact that potassium being a quality nutrient (Usherwood), [53] is involved in enzyme activation and cell hydration and maintains the assimilatory power of leaves over a large period thus resulting in higher total soluble salt concentration. Similar results were reported by Dar *et al*. [16] and Martin *et al*. [32].

The total sugar content of grape berries showed significant and positive correlation with available soil potassium, sulphur, iron, zinc, boron and petiole potassium, manganese and boron contents. The rest of nutrients failed to exhibit any significant relationship with total sugar content (Table 5 and 6). The significant and positive relationship between soil and leaf potassium content with total sugars might be attributed to the fact that potassium is the most abundant cation which contributes to charge balance and may be involved in sugar transport in grape berries (Spayd) *et al*. [50] and is also involved in degradation of soluble pectin thus resulting in softening of fruit and consequently increasing the total sugar content. The results are in line with those of Ramming *et al*. [43] and Kumar *et al*. [29]. The significant and positive relationship between available sulphur and total fruit sugar content might be attributed to the role of sulphur in plant metabolism especially enhancing biosynthesis of organic food and cell division. Mostafa and Abdl El-Kader [36] reported similar results. As mentioned earlier total sugar content showed significant and positive correlation with available iron content, which might be due to the fact that iron is essentially required for early leaf production and photosynthesis to ensure better berry development and quality. The results are in accordance with those of Dar *et al*. [15]. The available zinc was significantly and positively correlated with total sugar content which could be due to role of zinc in berry development and fruit set, shoot elongation and pollen formation. The results are in close conformity with the findings of Dar *et al*. [15] and Singh *et al*. [47]. The fruit sugar content showed significant and positive relation with both soil and petiole boron content, which might be ascribed to the fact that boron is the most important micronutrient element so far as the fruit quality of grape is concerned, it is involved in pollen germination, growth of pollen tube and normal fruit set. The similar results were observed by Chokha*et al*. [13]. The positive and significant correlation between leaf manganese and total fruit sugar content might be due to involvement of manganese in physiological processes of plant encouraging growth and productivity. This is in agreement with the findings of Babu and Yadav [8].

The per cent fruit acidity exhibited a significant and positive correlation with soil available nitrogen and, petiole nitrogen, phosphorus, sulphur, iron, manganese, zinc, copper and boron, whereas, it showed a significant and negative correlation with petiole calcium, magnesium and molybdenum (Table 5 and 6). The significant and positive correlation of fruit acidity with available and leaf nitrogen content might be attributed to the fact that in grape clusters, nitrogen is primarily found as ammonium cations and organic compounds such as amino acids, hexose amines, peptides, nucleic acids and proteins and only traces of nitrate nitrogen are found in the berries (Winkler) *et al*. [57]. Bybordi [10] and Diehl *et al*. [17] observed similar relationship between nitrogen and per cent fruit acidity. Jivan and Sala [21] also observed positive correlation between leaf phosphorus, sulphur, iron, zinc and copper with titratable fruit acidity in apple. An increase in per cent fruit acidity in grape berries with micro and macronutrient sprays was also reported by Chokha*et al*. [13]. Significant and negative correlation of leaf calcium with per cent fruit acidity is in accordance with the findings of Awasthi*et al*. [7], whereas, the same correlation of leaf calcium with fruit acidity is supported by the findings of Dabas and Jindal [14]. The significant and negative correlation of petiole molybdenum with per cent acidity is in accordance with the result of Williams *et al*. [56].

The anthocyanin content of grape berries indicated a significant and positive correlation with available boron and, petiole boron and potassium content only, whereas, rest of soil and petiole nutrients were non-significantly related with total anthocyanin content. Although boron plays an important role for increasing pollen grains germination, pollen tube elongation, consequently, fruit set and total yield, cell division, biosynthesis and translocation of sugars water and nutrient uptake (Ahmad) *et al*. [3], however, there is no indication of boron as an enzymatic component nor that it affects the activity of any enzyme during anthocyanin synthesis (Marschner), [31], but its role might be related to the metabolism and transport of carbohydrates, since anthocyanins are formed by an anthocyanidin and a carbohydrate (Saure), [46], or by stimulating sugar synthesis during the anthocyanin synthesis (Vestrheim), [54], which might be a reason for positive and significant correlation of available and leaf boron with total anthocyanin content. Similar relationship of soil and leaf boron with anthocyanin was also observed by Mashayekhi*et al*. [33]. Positive and significant correlation of anthocyanin with petiole potassium content might be ascribed to the fact that potassiumappears to enhance anthocyanin accumulation and red colouration of grapes by promoting normal fruit development through translocation of complex sugars to the fruit and throughout the tree. The observations are in line with the findings of Pal and Ghosh [41] and Mosa*et al*. [35].

The fruit yield of grapes indicated a significant and positive correlation with soil available nitrogen, phosphorus, manganese and petiole nitrogen, phosphorus, sulphur, manganese and boron. The positive and significant correlation of soil and petiole nitrogen with fruit yield might be ascribed to the fact that nitrogen is essential to enhance plants biological processes (normal cell division, growth and respiration) and enables plants to use the energy of sunlight to form sugars from carbon dioxide and water (Abbas and Fares), [2], it is most important nutrient to manage in vineyards as it has a great impact on vine vegetative and reproductive development, according to Pessarakli [42] nitrogen affects plant growth by influencing leaf area and by affecting the photosynthetic capacity of foliage, thus nitrogen can be expected to affect photosynthesis rates and carbohydrate allocation, and consequently promote a higher fruit growth and yield. Similar relationship of soil and leaf nitrogen was also recorded by Kirimi *et al*. [27]. Similar correlation of fruit yield with soil and petiole phosphorus could be due to its role in fruit bud differentiation in grapevines. The results are in close conformity with the observations of Yogeeshappa, [59]. The soil and leaf manganese was also significantly and positively related with fruit yield, which might be due to its involvement in physiological processes of plant encouraging growth and productivity. The results are supported by the findings of Babu and Yadav [8]. Significant and positive relation between petiole boron and fruit yield might be probably due to role of boron in pollen germination and pollen tube growth, which is likely to increase fruit set (Wojcik) *et al.* [58] and therefore the yield of vineyards. These results are in harmony with the findings of Nikkhah *et al.* [39] and Ali *et al.* [4]. The positive correlation of leaf sulphur with fruit yield might be because sulphur plays a vital role in the synthesis of amino acids (methionine, cystein and cystine), proteins, chlorophyll and certain vitamins (Tiwari and Gupta), [52]. The results are in close conformity with those of Dar *et al.* [16] and Khalid *et al.* [26].

It can be concluded from the present study that yield and quality of grape is directly dependent upon the available nutrient status and nutrient concentration in the petioles of vineyards, alsopotassium, zinc and boron are the most important essential nutrients needed by vineyards as far as quality parameters of grape are concerned.

Table 1: Quality attributes and yield of grape orchards of district Ganderbal

Sampled Location	TSS (%)	Total sugars (%)	Acidity (%)	Anthocyanin (%)	Yield (t/ha)
1	21.79	13.84	0.28	0.024	1.75
2	20.95	12.98	0.32	0.021	1.84
3	22.53	13.12	0.43	0.026	1.78
4	22.67	13.61	0.37	0.022	1.79
5	23.28	14.9	0.44	0.034	1.83
6	23.12	14.51	0.50	0.023	1.84
7	23.95	14.56	0.47	0.018	1.81
8	21.49	13.24	0.39	0.025	1.79
9	21.18	14.50	0.45	0.025	1.83
10	23.00	14.82	0.47	0.022	1.90
11	23.47	14.96	0.43	0.032	1.88
12	23.74	15.12	0.41	0.035	1.85
13	21.59	13.87	0.27	0.031	1.79
14	23.11	15.42	0.35	0.033	1.83
15	22.97	14.54	0.29	0.030	1.78
Mean	22.59	14.27	0.39	0.03	1.82
95% C.I	22.06-23.12	13.84-14.69	0.35-0.43	0.02-0.03	1.80-1.84

Table 2: 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 3: 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

Table 4: Relationship of available nutrient elements with fruit yield and quality attributes of grape berries

Nutrient	TSS	Total sugars	Acidity	Anthocyanin	Yield
N	0.209	0.255	0.567*	-0.207	0.548*
P	0.222	0.454	0.322	0.145	0.587*
K	0.358	0.616*	0.175	0.139	0.398
Ca	-0.192	-0.182	-0.116	0.274	-0.461
Mg	0.212	0.449	-0.226	0.444	-0.130
S	0.416	0.611*	0.182	0.166	0.373
Fe	0.270	0.552*	0.410	-0.047	0.592*
Mn	0.388	0.459	0.409	0.019	0.663**
Zn	0.396	0.764**	0.219	0.274	0.419
Cu	0.128	0.156	0.250	-0.080	0.366
B	0.005	0.528*	0.058	0.667**	0.280
Mo	0.210	0.506	0.026	0.407	0.493

** Significant at 5 per cent level

* Significant at 1 per cent level

Table 5: Relationship of petiole nutrient elements with fruit yield and quality attributes of grape berries

Nutrient	TSS	Total sugars	Acidity	Anthocyanin	Yield
N	0.213	0.141	0.785**	-0.330	0.592*
P	0.299	0.407	0.712**	-0.241	0.599*
K	0.539*	0.548*	-0.137	0.554*	0.019
Ca	-0.396	-0.110	-0.787**	0.472	-0.401
Mg	-0.204	-0.094	-0.793**	0.513	-0.350
S	0.421	0.448	0.750**	-0.179	0.642**
Fe	0.260	0.194	0.733**	-0.337	0.510
Mn	0.390	0.673**	0.646**	0.068	0.613*
Zn	0.368	0.296	0.793**	-0.312	0.508
Cu	0.138	0.191	0.536*	-0.425	0.253
B	0.328	0.573*	0.588*	0.524*	0.595*
Mo	-0.301	-0.086	-0.839**	0.382	-0.424

** Significant at 5 per cent level

* Significant at 1 per cent level

Table 6: Regression coefficients of significant correlations of available nutrient elements with fruit yield and quality attributes of grape berries

Nutrient	Quality Parameters	Intercept	Slope	R^2
N	Acidity	78.78	75.93	0.42
N	Yield	137.99	135.48	0.67
P	Yield	4.63	7.96	0.50
K	Total Sugars	84.64	2.44	0.56
S	Total Sugars	5.15	0.33	0.37
Fe	Total Sugars	5.14	1.93	0.21
Fe	Yield	-53.49	47.36	0.35
Mn	Yield	-55.79	49.35	0.44
Zn	Total Sugars	-0.064	0.091	0.59
B	Total Sugars	-0.13	0.031	0.21
B	Anthocyanin	0.18	5.14	0.27

Table 7: Regression coefficients of significant correlations of petiole nutrient elements with fruit yield and quality attributes of grape berries

Nutrient	Quality Parameters	Intercept	Slope	R^2
N	Acidity	1.21	1.49	0.62
N	Yield	1.98	2.07	0.45
P	Acidity	0.06	1.31	0.51
P	Yield	1.69	2.48	0.36
K	TSS	6.03	3.03	0.58
K	Total Sugars	9.13	7.03	0.49
K	Anthocyanin	1.47	6.4	0.31
Ca	Acidity	2.12	-2.43	0.62
Mg	Acidity	0.63	-0.99	0.63
S	Acidity	0.02	0.35	0.56
S	Yield	-0.86	0.56	0.41
Fe	Acidity	110.15	64.86	0.54
Mn	Total Sugars	-20.22	4.10	0.45
Mn	Acidity	22.38	40.69	0.42
Mn	Yield	-91.21	71.19	0.38
Zn	Acidity	5.87	70.21	0.63
Cu	Acidity	8.68	8.65	0.29
B	Total Sugars	5.43	2.10	0.33
B	Acidity	15.81	22.23	0.35
B	Anthocyanin	17.10	277.26	0.27
B	Yield	-51.03	41.52	0.35
Mo	Acidity	0.63	-0.91	0.70

5. References

1. AOAC. Methods of analysis. 14th edition. Association of Official Analytical Chemistry, Washington DC, U.S.A, 1980, 484.
2. Abbas F, Fares A. Best management practices in citrus production. Tree and For. Sci. and Biotech. 2008; 3:1-11.
3. Ahmad W, Niaz A, Kanwal S, Rahmatullah A. Role of boron in plant growth. A Rev. J Agri. and Res. 2009; 47(3):329-338.
4. Ali A, Perveen S, Shah SNM, Zhang Z, Wahid F, Shah M *et al*. Effect of foliar application of micronutrients on fruit quality of peach. Amer. J Pl. Sci. 2014; 5:1258-1264.
5. Annonymous. Official method of analysis. 10th edition. Association of Official Analytical Chemistry, Washington, DC, U.S.A, 1970.
6. Annonymous. Area and production of horticultural crops in Jammu and Kashmir state. Department of Horticulture Jammu and Kashmir Government, 2014.
7. Awasthi RP, Bhutani VP, Kaith NS, Sharma JS. Mineral nutrient status of apple orchards in Shimla district of Himachal Pradesh. Ind. J. Hort. 1999; 56(3):194-200.
8. Babu KD, Yadav DS. Foliar spray of micro-nutrients for yield and quality improvement in Khasi mandarin (Citrus reticulate Blanco.). Ind. J. Hort. 2005; 62(3):280-281.
9. Berger KC, Troug K. Boron determined by using the quinalizarin reaction. J. Inds. Eng. Chem. 1944; 2:540-545.
10. Bybordi A. Quantitative and qualitative effects of nutrient applications and irrigation methods on apricot. Middle-East J Sci. Res. 2013; 14(3):423-431.
11. Chapman HD. Suggested foliar sampling and handling techniques for determining the nutrient status of some field, horticultural and plantation crops. Ind. J Hort. 1964; 21(2):97-119.
12. Chesnin L, Yien CH. Turbidimetric determination of available sulphur. Proceed. Soil Sci. Soc. Amer. 1951; 15:149-151.
13. Chokha S, Sharma VP, Usha K, Sagar VR. Effect of macro and micronutrients on physico-chemical characters of grape cv. Perlette. Ind. J Hort. 2002; 59(3):258-260.
14. Dabas AS, Jindal PC. Effect of B and Mg sprays on fruit bud formation, berry set, berry drop and quality of Thompson Seedless grapes. Ind. J Agri. Res. 1985; 19(1):40-44.
15. Dar MA, Wani JA, Raina SK, Bhat MY, Dar MA. Effect of available nutrients on yield and quality of pear fruit Bartlett in Kashmir valley India. J Environ. Biol. 2012; 33:1011-1014.
16. Dar MA, Wani JA, Raina SK, Bhat MY, Malik MA. Relationship of leaf nutrient content with fruit yield and quality of pear. J Environ. Biol. 2015; 36:649-653.
17. Diehl DC, Sloan N, Bruhn CM, Simonne AH, Brecht JK, Mitcham EJ. Exploring produce industry attitudes: relationships between postharvest handling, fruit flavor, and consumer purchasing. Horti. Technol., Alexand. 2013; 23(5):642-650.
18. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd edition. An International Rice Research Institute Book. Wiley-Inter Science Publication, New York, USA, 1984, 680.
19. Jackson ML. Soil Chemical Analysis. 2nd edition. Printice Hall of India, New Delhi, 1973, 498.
20. Janaki D, Velu V, Savithri P. Yield and quality of grapes cv. Mascat as affected by boron application. Mad. Agri. J. 2002; 89(7-9):386-389.
21. Jivan C, Sala F. Relationship between tree nutritional status and apple quality.Hort. Sci. 2014; 41(1):1-9.
22. Johnson CM, Arkley TH. Determination of molybdenum in plant tissue. Anal. Chem. 1950; 26:573-580.
23. Jonathan M. Impact of marine extracts application on cv Syrah grape yield componants, harvest juice quality parameter and nutrient uptake. Msc thesis. Polytechnic State University, California, 2012.
24. Kamiloglu O. Influence of some cultural practices on yield, fruit quality and individual anthocyanins of table grape cv. HorozKarasi. J Anim. Plant Sci. 2011; 21:240-245.
25. Keller M, Pool RM, Henick-Kling T. Excessive nitrogen supply and shoot trimming can impair color development in Piont Noir grapes and wine. Austr. J. Grape Vine Res. 1999; 5:45-55.
26. Khalid R, Khan KS, Akram Z, Qureshi R, Gulfraz M. Relationship of plant available sulphur with soil characteristics, rainfall and yield levels of oilseed crops in Pothwar Pakistan. Pak. J Bot. 2011; 43(6):2929-2935.
27. Kirimi JK, Itulya FM, Mwaja VN. Effects of nitrogen and spacing on fruit yield of tomato. Afric. J Hort. Sci. 2011; 5(1):50-60.
28. Kliewer WM. Influence of temperature, solar radiation and nitrogen on coloration and composition of Emperor grapes. Amer. J Enol. Vitic. 1977; 28:69-103.
29. Kumar TS, Kumar J, Kumar M. Effect of leaf nutrient status on yield and quality of kiwi fruit (Actinidiadeliciosa Chev.). Ind. J Hort. 2007; 64(1):77-78.
30. Lindsay WL, Norvell WA. Development of DTPA soil test for Zn, Fe, Mn and Cu. Soil Sci. Soc. Amer. J. 1978; 42(3):421-428.
31. Marschner H. Mineral nutrition of high plants. 2nd edition. Academic Press, London UK, 1995, 330-355.
32. Martín P, Delgado R, González MR, Gallegos JI. Colour of 'Tempranillo' Grapes as Affected by Different

Nitrogen and Potassium Fertilization Rates. ActaHorticul. 2004; 652:153-159.
33. Mashayekhi K, Dehkordi AG, Kamkar B, Azbarmi R. Foliar spray of sucrose and boron on some characters of leaf and fruit of tomato var. supera. Inter. J Anal., Phar. Biomed. Sci. 2015; 4(4):51-61.
34. Mitra SK, Rathore DS, Bose TK. Temperate Fruits, Nay Prakash, Calcutta, 1991, 123-134.
35. Mosa WFAE, El-Mageed NAA, Pastz LS. The effect of foliar application of potassium, calcium, boron and humic acid on vegetative growth, fruit set, leaf mineral, yield and quality of Anna apple trees. Amer. J. Exper. Agri. 2015; 8(4):224-234.
36. Mostafa EAM, Abd El-Kader AA. Sulphur fertilization effects on growth, yield and fruit quality of Grand Nain banana cultivar. J. App. Sci. Res. 2006; 2(8):470-476.
37. NRC. Grape profile. National Research Centre for Grapes, Manjari Farm, Solanpur road, Pune, 2013, 4-5.
38. Neyman J. Outline of a Theory of Statistical Estimation Based on the Classical Theory of Probability. Philosophical Transactions of the Royal Society. 1937; 236:333-380.
39. Nikkhah R, Nafar H, Rastgoo S, Dorostkar M. Effect of foliar application of boron and zinc on qualitative and quantitative fruit characteristics of grapevine (Vitisvinifera L.). Inter. J Agri. Crop Sci. 2013; 6(9):485-492.
40. Olesen SR, Koul CV, Watanabe FS, Dean LA. Estimation of available phosphorus by extracting with sodium bicarbonate. United States Department of Agriculture Circular. 1954; 939:315-326.
41. Pal P, Ghosh P. Effect of different sources and levels of potassium on growth, flowering and yield of African marigold (TageteserectaLinn.) cv. Siracole. Ind. J. Nat. Pr.Resour. 2010; 1(3):371-375.
42. Pessarakli M. Handbook of plant and crop physiology. 3rd edition. New York, Marcel Dekker, 2014, 1031.
43. Ramming DW, Roland T, Badr SA. Crimson Seedless': a new late-maturing, red seedless grape. Hort. Sci. 1995; 30:1473-1474.
44. Ranganna S. Handbook of Analysis and Quality Control for Fruit and Vegetable Products. 2nd edition. Tata McGraw Hill Publishing Company Limited, New Delhi, India, 1986, 634.
45. Robinson JB. Grapevine Nutrition. Viticulture, Volume 2, Practices. B.G. Coombe and P.R.Dry, Eds. Winetitles, Aelaide, South Australia, 1992, 178-208.
46. Saure MC. External control of anthocyanin formation in apple. Scien. Hort. 1990; 42:181-218.
47. Singh JK, Prasad J, Singh HK. Effect of micronutrients and plant growth regulators on yield and physico-chemical characteristics of anola fruits cv. Narendra Anola-10. Ind. J. Hort. 2007; 38(4):733-735.
48. Singram P, Prabhu PC. Effect of zinc and boron on growth and quality of grapes cv. Muscat. Mad. Agri. J 2001; 88(4-6):233-236.
49. Sommers TC. A connection between potassuim levels in the harvest and relative quality in Australlian red winesAustrallian Wine, Brewing and Spirit Rev. 1977; 24:32-34.
50. Spayd SE, Wample E, Stevens BL, Evans RG, Kawakami AK. Nitrogen fertilization of White Riesling in Washington: Effect on petiole nutrient concentration, yield components, and vegetative growth. American J. Enol. Vit. 1993; 44:378-386.
51. Subbaiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 1956; 25:259-260.
52. Tiwari KN, Gupta BR. Sulphur for sustainable high yield agriculture in Uttar Pradesh. Ind. J Fert. 2006; 1:37-52.
53. Usherwood NR. The role of potassium in crop quality. In: Potassium in Agriculture. Ed. Munson, R.S., ASA, Madison, WI, 1985, 489-513.
54. Vestrheim S. Effects of chemical compounds on anthocyanin formation in 'McIntosh' apple skin. Journal of Amer. Soc. Horti. Sci. 1970; 95:712-715.
55. Waller WM. Use of apple analysis. Act.Horti. 1980; 92:71- 82.
56. Williams CMJ, Maier NA, Bartlett L. Effect of molybdenum foliar sprays on yield, berry size, seed formation, and petiolar nutrient composition of "Merlot" grapevines. J Pl. Nutr. 2004; 24(11):1891-1916.
57. Winkler AJ, Cook JA, Kliewer WM, Lider LA. General Viticulture. 2ndEditon. University of California Press, 1962.
58. Wojcik P, Wojcik M, Klamkowski K. Response of apple trees to boron fertilization under conditions of low soil boron availability. Scien. Horti. 2008; 116:58-64.
59. Yogeeshappa H. Yield and quality of grapes (cv. Thompson Seedless) in relation to soil fertility status of vineyards in Bijapur Taluka of Karnataka. M.Sc. thesis submitted to the University of Agricultural Sciences, Dharwad, 2007.