Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 3625-3629
Received: 10-03-2019
Accepted: 12-04-2019

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Effect of foliar nutrition of calcium and boron on the yield and quality attributes of grape

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Abstract
Role of calcium and boron are well known for the development and maintenance of structural properties. The present study was conducted during 2018 in a vineyard of farmer's field at Matthipalyam, Coimbatore district, Tamil Nadu. Grape cultivar was tested with ten foliar treatments at different doses of calcium and boron, which was given twice at 45 and 55 days after pruning along with the existing recommendation of 0.1% boric acid + 0.2% zinc sulphate + 1% urea. And other treatments were T_2-0.5% calcium nitrate; T_3-1% calcium nitrate; T_4-0.1% boric acid; T_5-0.2% boric acid; T_6-0.5% calcium nitrate + 0.1% boric acid; T_7-1% calcium nitrate + 0.1% boric acid; T_8-0.5% calcium nitrate + 0.2% boric acid; T_9-1% calcium nitrate + 0.2% boric acid and T_{10}-water spray. The effect of calcium and boron on yield and quality of grapes was investigated with three replicates in a randomised block design. Calcium and boron treatments positively influenced the number of bunches/vines (22 to 31 nos), yield/vine (5.32 to 6.13 kg/vine) and yield per hectare (21.7 t ha^{-1}). Besides, they also showed positive influence on TSS (17.9 to 15.9 $Brix^0$), juice pH (3.92 to 3.75), titrable acidity (0.91 to 1.19%), total solids (1.32 to 1.07%), berry firmness (11.9 to 7.95 N) and total sugars (15.6 to 11.2%). Foliar spray of 0.5% calcium nitrate and 0.2% boric acid twice at 45 and 55 days after pruning increased the yield by 11.1% over control besides increasing the quality parameters of grape variety Paneer.

Keywords: Grape, calcium nitrate, boric acid, foliar spray, yield, quality

Introduction
Grape (*Vitis vinifera* L.) is one of the most important commercial fruit crop of subtropical regions in the world and grown successfully in tropical and temperate regions. It is a refreshing table fruit, rich in sugars, acids and minerals like nitrogenous compounds, iron, calcium, magnesium and vitamins like B1, B2, C and tannins. Grape production and quality depend on a variety of factors, which includes climate, vine yard maintenance, mineral nutrition, irrigation etc. Integrated nutrient management plays a vital role in increasing the yield of crop. Particularly the role of secondary and micronutrients are very important for vine growth and productivity. Role of calcium and boron are well known for the development and maintenance of structural properties. They are most commonly applied as foliar spray and are applied to correct the deficiency of specific element rather than complete requirement of that element and they are essential for cell wall development and many enzymatic reactions (Dris and Niskanen, 1996) [5].

Calcium is an essential secondary nutrient, required as a divalent cation (Ca^{2+}) plays important role, such as structural integrity in the cell wall and membranes, counter ion for inorganic and organic anions in the vacuole, cytoplasmic secondary messenger related to environmental stimuli to their physiological responses (White, 2003) [27]. Calcium is a nutrient considered important in determining the storage quality of fruits (Raese *et al*., 1990) [17]. Deficiency of calcium in grape causes blossom end rot (Peryea and Neilsen, 2006) [14] which leads to poor bunch yield and fruit quality. Boron is also an important micronutrient, plays major role in plant metabolism: which includes, the processes of flowering and fruiting, germination of pollen grains, cell division, cell wall synthesis, metabolism of nitrogen, carbohydrates and pectic substances (Ahmad *et al*., 2009) [25]. Grapes require an adequate and continuous supply of available boron, during important stages especially flowering and fruit set. It is known to be critical in the elongation of pollen tube, translocation of sugars and nutrients from leaves to fruit, pollination, cell wall strength, cell division and seed development (Ahmad *et al*., 2009) [25]. Boron deficiency causes hen and chicken disorder in grapes. Hence, the current study was conducted to study the effect of calcium and boron fertilization on yield and quality of grapes.

Materials and Methods

Experimental vineyard

About 8-year-old grape vine variety paneer was selected for the study and vines were planted in quincunx system, with a spacing of 4 x 3 m. The field was located in western zone of Tamil Nadu at 76^0 49' East longitude and 11^0 00' North latitude. Initial soil sample was collected from 0-15 cm depth and analysed for various physical and chemical characteristics. The soil texture was sandy loam (Piper, 1944) [15] with neutral in pH (7.88, Jackson, 2005) [9], low in EC (0.07 dS m^{-1}, Jackson, 2005) [9], high in organic carbon content (1.25 g kg^{-1}, Wakley and Black, 1934) [26], low available N status (227 kg ha^{-1}, Subbiah and Asija, 1956) [23], medium in available K (183 kg ha^{-1}, Stanford and English, 1949) [22] and P (27 kg ha^{-1}, Olsen *et al*., 1954) [13]. With regards to available micronutrients, all the micronutrients were found to be sufficient except boron which was deficient with 0.39 mg kg^{-1}, (Lindsay and Norwell, 1978) [11]. The details were given in Table. 1.

Table 1: Physico chemical characteristics of experimental soil

Depth (cm)	pH	EC	OC	Macro (kg ha^{-1})			Micro (mg kg^{-1})				
		dS m^{-1}	(%)	N	P	K	Fe	Mn	Zn	Cu	B
0-15	7.88	0.07	1.25	227	27	183	4.49	16.8	5.37	4.9	0.39

Experimental design

Experiment was conducted during rabi 2018 vegetative season, treatments were imposed in a randomized block design with three replications comprising 4 vines in each replication (12 vines were maintained for each treatment). Calcium nitrate at 0.5% and 1% and boric acid at 0.1% and 0.2%, were applied as foliar sprays at 45 days after pruning and after10 days of the first foliar spray. Urea @ 0.1 kg nitrogen and 0.3 kg K_2O and 0.08 kg P_2O_5 as single super phosphate band application was applied to all vines immediately after pruning. Manual weed control was practiced and pests and disease control measurements were taken up regularly as and when needed.

Yield and quality parameters

The crop was cultivated to maturity and the ripened bunches were harvested from each treatment separately and number of bunches per vine and bunch weight per vine were recorded. From each treatment representative bunch was selected and total number of berries in the bunch was recorded by manual counting. Cluster weight was determined and expressed in grams. Cluster length (cm) and width (cm) were measured with a ruler by using thread. Berry length and width (cm) were measured with a digital calliper. Soluble solids (SS) was estimated with a digital refractometer and juice pH was measured with a pH meter. The titrable acidity (% tartaric acid/100g of grape juice) was measured with 0.1 N sodium hydroxide titration method. Berry firmness was measured using Effegi's penetrometer. Number of seeds per berry and fresh seed weight was also recorded. Juice percentage of grapes was calculated, reducing, non-reducing and total sugar content in the fruit was estimated as per the procedure described by Ranganna (1997) [19] using Fehling's solution.

Statistical analysis

Data were subjected to ANOVA and means were compared with LSD test at 5% level. Statistical analyses were performed with AGRES statistical software.

Results and Discussion

Yield attributes

Foliar application of different doses of calcium nitrate and boric acid on crop growth and yield attributes *viz*., number of fruit bunches per plant, fruit yield per plant were recorded and presented in table. 2. Foliar application of calcium and boron had significant effect on number of fruit bunches per vine and the values ranged from 22 to 31, yield per vine varied from 5.32 to 6.13 kg and yield per hectare was from 21.7 to 24.1 t ha^{-1}. Highest number of bunches were recorded with the foliar spraying of 0.5% calcium nitrate + 0.2% boric acid (31 Nos) followed by 1% calcium nitrate + 0.2% boric acid (30 Nos) and the lowest was recorded in water spray (22 Nos). Similarly, highest yield per vine was recorded in 0.5% calcium nitrate + 0.2% boric acid (6.13 kg) followed by 1% calcium nitrate + 0.2% boric acid (6.1 kg) and the lowest was recorded in control (5.32 kg). Similar trend was observed with maximum yield per hectare and also higher yield per vine was noted with 0.5% calcium nitrate + 0.2% boric acid (24.1 t ha^{-1}), followed by 1% calcium nitrate + 0.2% boric acid (23.9 t ha^{-1}) and the lowest yield was recorded in the water spray (21.7 t ha^{-1}). The increased yield might be due to the positive effect of calcium and boron on the growth and yield as well physiology and metabolism of crops and the role of calcium in structural development and boron in pollen fertility and berry development. Increase fruit set was relevant to the important role of B in pollen germination and pollen tube growth (Wojcik and Wojcik., 2003) [28]. In this study, number of bunches per vine, yield per vine and yield per hectare increased with increased application of boric acid and calcium. Similar findings were also reported for yield and yield parameters in grapes by Mustafa *et al*. (2006) [12], Bilir Ekbic *et al*. (2018) [3], Sala *et al*. (2015) [6] and Usha *et al*. (2002) [24]. The details were given in Table. 2.

Table 2: Effect foliar application of calcium and boron on yield characteristics of grapes

Treatments	Number of bunches per vine	Yield per vine (kg ha^{-1})	Yield per hectare (t ha^{-1})
T_1–0.1% boric acid + 0.2% zinc sulphate + 1% urea (Recommended RDF)	26	5.82	23.0
T_2 - 0.50 % calcium nitrate	23	5.41	21.9
T_3 - 1.0 % calcium nitrate	24	5.53	22.2
T_4 - 0.1 % boric acid	25	5.66	22.5
T_5 - 0.2 % boric acid	25	5.74	22.8
T_6 - 0.50 % calcium nitrate+ 0.1 % boric acid	27	5.87	23.2
T_7 - 1.0 % calcium nitrate+ 0.1 % boric acid	28	5.94	23.5
T_8 - 0.50 % calcium nitrate+ 0.2 % boric acid	31	6.13	24.1
T_9 - 1.0 % calcium nitrate+ 0.2 % boric acid	30	6.10	23.9
T_{10} - water spray	22	5.32	21.7
SEd	1.33	0.20	0.35
CD (P =0.05)	2.80	0.43	0.74

All the treatments receive foliar spraying on 45 and 55 days after pruning

Quality parameters

Foliar application of calcium nitrate and boric acid at different doses had significantly influenced the quality parameters of grapes, particularly the juice content (%), pH, TSS (Brix^0), titrable acidity (% tartaric acid/100g of fruit), total solids (%), berry firmness (N), total sugars (%), reducing sugars (%) and non-reducing sugars (%). Juice content (%) ranged from 81.3 to 86.7%, and the highest juice content was recorded in 0.5% calcium nitrate + 0.2% boric acid spray (86.7%), followed by 1% calcium nitrate + 0.2% boric acid spray (86.4%). The least juice content was recorded in water spray (81.3%). This is due to higher photo synthetic activity, biomass production in the vine which might have resulted in more metabolites in the vine. As the growth and development of berries advances large amount of water and other metabolites move in to the berries (Gopalswamy and Rao, 1972) [7]. Juice pH varied from 3.75 to 3.92, and slightly higher with the spray of 0.5% calcium nitrate + 0.2% boric acid (3.92) followed by 1% calcium nitrate + 0.2% boric acid (3.91) and minimum pH was recorded in the water spray (3.75). The details were given in Table. 3.

The total soluble solids (TSS) of grape berries were also considerably influenced by foliar spraying of calcium and boron, which ranged from 15.9 to 17.9 Brix^0 (Figure1). Highest TSS (17.9° B) was recorded in 0.5 % calcium nitrate + 0.2% boric acid spray which was followed by 1 % calcium nitrate + 0.2% boric acid spray (17.7° B), in contrary to the lowest TSS (15.9° B) observed in water spray. Boron is considered to increase the phloem carbohydrate and sugar movement which may resulted in the increase of fruit soluble solid content (Kliewer, 1966) [10]. Similar results were reported by Ravel and Leela (2000) [20], Policarpo and Stefanini (2006) [16], Usha (2002) [24] and Claudia Bonomelli and Rafael Ruiz (2010) [4]. Titrable acidity of grape ranged from 0.91 to 1.19%, low acidity (Figure1) (0.91%) was recorded in 0.5 % calcium nitrate + 0.2% boric acid spray and highest titrable acidity of 1.19% was recorded in the water spray. Aksentyuk and Zhuravel (1983) [1], Singh and Rethy (1996) [21] and Bhakare *et al*. (2006) [2] reported increasing soluble solid content and decreased acidity with increasing boric acid treatments. Hernandez-Munoz *et al*. (2006) [8] reported similar results in strawberries with fewer soluble solids and higher acidity than the control. Berry firmness showed significant differences among the treatments and ranged from 7.95 to 11.9 Newton, 0.5% calcium nitrate + 0.2% boric acid spray showed highest berry firmness (11.92 Newton) among all the treatments, followed by 1% calcium nitrate + 0.2% boric acid spray (10.05 Newton). Lowest berry firmness was recorded in water spray (7.95 Newton). Fruits with higher B and Ca uptake have better firmness than the control because these elements may lead to strengthening of pectin bonding to stabilize cell -wall structure (Hernandez-Munoz *et al*., 2006) [8]. The sugar content ranged 15.6 to 11.2%, with the maximum total sugars (15.6%) (Figure 2) in 0.5 % calcium nitrate + 0.2% boric acid spray followed by 1 % calcium nitrate + 0.2% boric acid spray (15.29%). The minimum total sugar content (11.2%) was recorded in water spray. These results show the dependence of these quality parameters with nutrition factors and amount of fertilization. Similar observations were made by Ravel and Leela (2000) [20], Bonomelli and Rafael Ruiz (2010) [4] and Rahim Nikkah *et al.* (2013) [18]. The details were given in Table. 4 and 5.

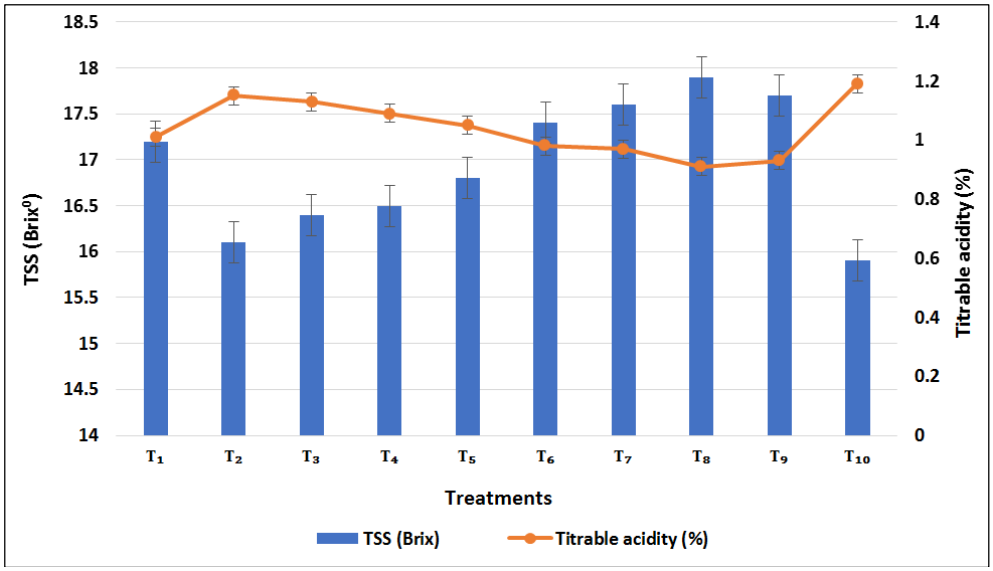

Fig 1: Foliar spraying of calcium and boron on quality parameters of grapes (Titrable acidity and TSS)

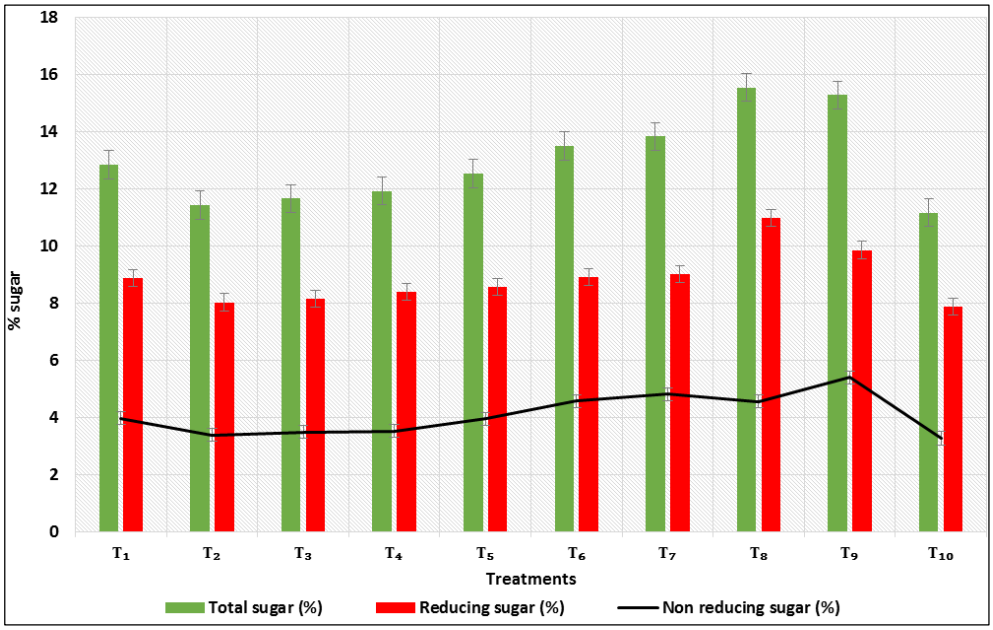

Fig 2: Foliar spraying of calcium and boron on sugar content of grapes (Percent total sugar, reducing sugar and non-reducing sugar)

Table 3: Effect of calcium and boron on Juice pH, juice content (%) and moisture (%)

Treatments	Juice content (%)	Juice pH
T_1–0.1% boric acid + 0.2% zinc sulphate + 1% urea (Recommended RDF)	84.4	3.85
T_2 - 0.50 % calcium nitrate	82.6	3.78
T_3 - 1.0 % calcium nitrate	82.9	3.80
T_4 - 0.1 % boric acid	83.2	3.82
T_5 - 0.2 % boric acid	83.6	3.83
T_6 - 0.50 % calcium nitrate+ 0.1 % boric acid	84.8	3.88
T_7 - 1.0 % calcium nitrate+ 0.1 % boric acid	85.9	3.89
T_8 - 0.50 % calcium nitrate+ 0.2 % boric acid	86.7	3.92
T_9 - 1.0 % calcium nitrate+ 0.2 % boric acid	86.4	3.91
T_{10} - water spray	81.3	3.75
SEd	0.68	0.04
CD (P =0.05)	1.44	0.09

All the treatments receive foliar spraying on 45 and 55 days after pruning

Table 4: Effect of application of calcium and boron on TSS, titrable acidity, total solids and berry firmness of grapes

Treatments	TSS ($Brix^0$)	Titrable acidity (%)	Total solids (%)	Berry firmness (Newton)
T_1–0.1% boric acid + 0.2% zinc sulphate + 1% urea (Recommended RDF)	17.2	1.01	1.19	9.03
T_2 - 0.50 % calcium nitrate	16.1	1.15	1.09	8.07
T_3 - 1.0 % calcium nitrate	16.4	1.13	1.13	8.10
T_4 - 0.1 % boric acid	16.5	1.09	1.15	8.23
T_5 - 0.2 % boric acid	16.8	1.05	1.17	8.98
T_6 - 0.50 % calcium nitrate+ 0.1 % boric acid	17.4	0.98	1.23	9.42
T_7-1.0 % calcium nitrate+ 0.1 % boric acid	17.6	0.97	1.27	9.85
T_8 - 0.50 % calcium nitrate+ 0.2 % boric acid	17.9	0.91	1.32	11.9
T_9 - 1.0 % calcium nitrate+ 0.2 % boric acid	17.7	0.93	1.28	10.1
T_{10} - water spray	15.9	1.19	1.07	7.95
SEd	0.46	0.05	0.07	0.14
CD (P =0.05)	0.98	0.11	0.15	0.30

All the treatments receive foliar spraying on 45 and 55 days after pruning

Table 5: Effect of foliar application of calcium and boron on sugar content of grapes

Treatments	Total sugars (%)	Reducing sugars (%)	Non reducing sugars (%)
T_1–0.1% boric acid + 0.2% zinc sulphate + 1% urea (Recommended RDF)	12.86	8.88	3.98
T_2 - 0.50 % calcium nitrate	11.44	8.04	3.40
T_3 - 1.0 % calcium nitrate	11.67	8.17	3.49
T_4 - 0.1 % boric acid	11.94	8.41	3.53
T_5 - 0.2 % boric acid	12.55	8.59	3.96
T_6 - 0.50 % calcium nitrate+ 0.1 % boric acid	13.51	8.93	4.58
T_7 - 1.0 % calcium nitrate+ 0.1 % boric acid	13.84	9.02	4.82
T_8 - 0.50 % calcium nitrate+ 0.2 % boric acid	15.56	10.99	4.57
T_9 - 1.0 % calcium nitrate+ 0.2 % boric acid	15.29	9.87	5.42
T_{10} - water spray	11.18	7.90	3.28
SEd	0.29	0.11	0.20
CD (P =0.05)	0.61	0.24	0.56

All the treatments receive foliar spraying on 45 and 55 days after pruning

Conclusion

Present study was conducted to know the effect of calcium and boron on the yield and quality of grapes. Number of bunches per vine, yield per vine and yield per hectare were increased with increasing boron and calcium doses. Boric acid and calcium nitrate spraying after pruning positively influenced the quality attributes of grapes such as TSS (17.9 $Brix^0$), sugars, berry firmness (11.9 Newton) and total solids (1.32%). Titrable acidity of grapes decreased with increased spray of calcium and boron. Among all treatments, foliar spraying of 0.5% calcium nitrate + 0.2% boric acid twice at 45 and 55 days after pruning, recorded higher yield (24.1 t ha^{-1}) as well as quality attributes. Boric acid and calcium nitrate application yielded better appearance and sizes. Considering the yield parameters, yield and quality parameters, from the present study, it was concluded that foliar spraying of 0.5% calcium nitrate + 0.2% boric acid twice at 45 and 55 days after pruning recorded 11.1 per cent yield increase over

recommended NPK, besides increasing the quality parameters in grape variety Paneer.

References

1. Aksentyuk IA, Zhuravel LN. Foliar nutrition of grapevines with complex micronutrients. Sadov. Vinograd. Vinod. Mold. 1983; 7:34-36.
2. Bhakare BD, Gawade MH, More TA. Effect of foliar application of nutrients on yield and quality of Thompson Seedless grapes. J Mahar. Agric. Univ. 2006; 31(1):109-110.
3. Bilir Ekbic H, Gokdemir N, Erdem H. Effects of boron on yield, quality and leaf nutrients of Isabella (*Vitis labrusca* L.) grape cultivar. Acta Sci. Pol. Hortorum Cultus. 2018; 17(1):149-157.
4. Claudia Bonomelli, Rafael Ruiz. Effects of Foliar and Soil Calcium Application on Yield and Quality of Table Grape cv. 'Thompson Seedless'. Journal of Plant Nutrition. 2010; 33(3):299-314.
5. Dris R, Niskanen R. Effect of calcium on the storage quality of apples grown in Finland. Acta Horticulturae. 1996; 448:323-327.
6. Florin Sala, Alin Dobre. Managing the yield and quality of grapes by calcium supplementing on foliar way. Bulletin UASVM Horticulture. 2015; 72(2).
7. Gopalswamy N, Rao VN. Effect of graded dose of boron on yield and quality of grapes Cv. Anab-e-shahi. South Indian Hort. 1972; 20:41-49.
8. Hern´andez-Mu˜noz P, Almenara E, Ociob M, Gavaraa R. Effect of calcium dips and chitosan coatings on postharvest life of strawberries (*Fragaria x ananassa*). Postharvest Biology and Technology. 2006; 39:274-253.
9. Jackson ML. Soil chemical analysis: Advanced course: UW-Madison Liraries Parallel Press, 2005.
10. Kliewer WM. Sugars and Organic Acids of Vitis Vinifera. Plant Physiol. 1966; 41(923):931.
11. Lindsay R, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil science society of American Journal. 1978; 42(3):421-428.
12. Mustafa EA, EL-Shamma MS, Laila F. Correction of boron deficiency in grape vines of Bez El-Anza cultivar. American-Eurasian J Agric. Envir. Sci. 2006; 1(3):301-305.
13. Olsen SR, Cole CV, Watanable FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Department of agriculture Circular No. 939. Banderis AD, Barter DH, Anderson K. Agricultural and Advisor, 1954.
14. Peryea FJ, Neilsen GH. Effect of very high calcium sprays just before harvest on apple fruit firmness and Calcium concentration. Acta Horticulturae. 2006; 721:199-205.
15. Piper AM. A graphic procedure in the geochemical interpretation of water analyses. Eos, Transactions American Geophysical Union. 1944; 25(6):914-928.
16. Policarpo M, Stefanini M. Foliar fertilization and bunch thinning of 'Cabernet Sauvignon' grape. Acta Hort. 2006; 721:251-256.
17. Raese J, Fletcher P, Frederick D, Ivanov S, Yazdaniha A. Effects of calcium and nitrogen on fruit quality. Good Fruit Grower. 1990; 41:15-20.
18. Rahim Nikkhah, Hoda Nafar, Sasan Rastgoo, Moslem Dorostkar. Effect of foliar application of boron and zinc on qualitative and quantitative fruit characteristics of grapevine (*Vitis vinifera* L.). Intl J Agri Crop Sci. 2013; 6(9):485-492.
19. Ranganna S. Hand Book of analysis and quality control for fruits and vegetables products. 3, & edition, Tata McGraw-Hill publishing company Ltd. New Delhi, 1997, 12-16.
20. Ravel P, Leela D. Effect of urea and boron on the quality of grape. Indian J Hort. 2000; 272:58-60.
21. Sing B, Rethy P. Response of varying concentrations of boron in yield and quality of grapes (*Vitis vinifera* L.). Department of Horticulture, North Eastern Regional Institute of Science and Tecnology, Itanagar, Arunachal Pradesh, India. 1996; 5:912.
22. Stanford G, English L. Use of the flame photometer in rapid soil tests for k and Ca. Agronomy Journal. 1949; 41(9):446-447.
23. Subbaih B, Asija G. Alkaline permanganate method of available nitrogen determination. Curr. Sci. 1956; 25:259.
24. Usha K, Singh B. Effect of macro and micro-nutrient spray on fruit yield and quality of grape (*Vitis vinifera* L.) cv. Perlette. Acta Hort. 594, ISHS, 2002.
25. Waqar Ahmad, Niar A, Kanwal S Rahmatullah, Khalid Rasheed M. Role of boron in plant growth: A Review. J Agric. Res. 2009, 47(3).
26. Wakley A, Black IA. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil science. 1934; 37(1):29-38.
27. White PJ, Broadley MR. Calcium in plants. Annals of Botany. 2003; 92:487-511.
28. Wojcik P, Wojcik M. Effects of boron fertilization on conference pear tree vigor, nutrition, and fruit yield and storability. Plant and soil. 2003; 256:413-421.