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Secondary and Micronutrient Status in Soils of Grape Orchards of Vijayapura Taluka in Northern Karnataka, India

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A B S T R A C T

A survey based study was carried out to assess the secondary and micronutrient availability in grape orchards of Vijayapura taluka of northern Karnataka. Based on the fertilizer nutrient inputs, the grape orchards were grouped into three categories namely, low fertilizer users (n=19), medium fertilizer users (n=26) and high fertilizer users (n=15). The grape orchard soils recorded slightly to medium alkaline soil reactions. Majority of grape orchards soils were observed with high soil organic-C (>0.75%) and none of the soils were found in lower ranges. Among different categories of grape orchards, the available-Ca and Mg contents were found in the order: high fertilizers > medium fertilizer = low fertilizer applied grape orchards. However, available-S contents in three different grape orchard groups were found on par with each other with high available-S contents (> 20 ppm). None of the grape soils showed deficiency of micronutrients except for DTPA-Fe in half of the samples. Distribution of micronutrients in grape soils were found in the order Mn > Zn > Cu > Fe.

Introduction

Grape (*Vitis vinifera* L.) is an important commercial crop of some districts in Maharashtra (90,000 ha) and Karnataka (20,500 ha). In Karnataka, its cultivation is seen in Krishna valley of northern parts and Nandi valley of southern parts of the state. Vijayapura and Bagalkot districts, falling under dry climatic conditions, are the major grape growing areas of Karnataka and contribute significantly for the state economy. Grape cultivation in these dry tracts is made mostly with drip irrigations. In terms of plant nutrition, much of the nutrients (macro, secondary and micronutrients) are applied to soil in the form of basal application (through organic manures and fertilizers) and fertigation (through water soluble fertilizers). Foliar nutrition is also practiced by most of the grape growers especially for secondary and micronutrients. Intensive nutrient management practices are observed in grape cultivation and hence, the soil properties *viz.* chemical and fertility parameters are altered to a great extent. High dose of nutrient applications associated with low nutrient utilization efficiencies are likely to result in their accumulations. Considering the above facts, a study was carried out to assess the secondary

and micronutrient availability status and the factors determining their availability in grape orchard soils.

Materials and Methods

Study area

Vijayapura comes under semi-arid regions with climatic conditions of low rainfall and high PET. The mean temperature during summer associated with cold winter makes the area more suitable for grape cultivation. In Vijayapura taluka, grape cultivation is seen mostly in black soils though, they are also being grown in red soils. The mean annual rainfall in Vijayapura taluka was 553 mm and mean annual temperature ranged from 28.5 to 31.6 ^{o}C.

Survey and categorization of grape orchards

Sixty grape orchards in Vijayapura taluka were selected for this survey based study. The study was proposed initially as a survey work to assess the nutrient applications and their influence on soil properties and the yields. These grape growers were interviewed individually to estimate the quantity of nutrients added and the fertilizers used. Based on the fertilizer nutrients added, the 60 grape orchards were categorized into 3 different groups after subjecting the fertilizer inputs data for cluster analysis using K-factorization techniques for grouping of 60 farmers into 3 different categories.

Based on the final cluster centre data and distance between the clusters, the grape orchards were categorized into 3 groups namely, Category-1: Low fertilizer applied orchards (n=15); Category-2: Medium fertilizer applied orchards (n=26) and Ctegory-3: High fertilizer applied orchards (n=19). Total quantity of nutrients added among 3 categories of grape growers and crop management practices adopted are given in Table 1.

Soil samples collection

Soil samples were collected from the active root zone areas lying between the plant and the drip point at 1 ft away from the plant row / drip line so as to avoid the points of fertilizer applications. Soil samples of about 1 kg each from the root zone at three different points and made into one composite sample of about 500g as representative soil sample. These representative soil samples were air dried, sieved and analyzed for soil reaction, soil organic-C and secondary and micronutrients status by adopting standard procedures.

Soil analysis

Soil pH was determined for 1:2.5 soil: water suspension by using digital pH meter (Systronics, Model 361) fitted with combined electrodes (Jackson, 1973). Soil organic carbon was estimated by wet oxidation method (Walkley and Black, 1934). Exchangeable-Ca and Mg were determined by adopting Versanate titration method (Jackson, 1973). The available -S content was determined by turbidometric method using spectrophotometer at 420 nm after extracting with 0.15 % CaCl2 solution (Black, 1965). The micronutrient cations were extracted with DTPA buffer at1:2 soil to extractant ratio (Lindsay and Norvell, 1978) and measured using atomic absorption spectrophotometer. Their availability status was grouped into deficient and sufficient ranges as suggested by Arora (2002).

Statistical analysis

The categories obtained by cluster analysis were subjected to statistical tests using unequal replication single factor ANOVA

technique. Simple correlation analysis was also carried out to understand their relation between each parameter.

Results and Discussion

Soil reaction and organic-C

Most of the grape orchard soils were observed in slightly alkaline to medium alkaline with a pH of 7.50 – 8.50 (Table 2). The grape orchards supplemented with less amounts of fertilizers (category-1) recorded significantly lower pH (7.76 ± 0.17) compared to other two categories (Figure 2). The soil reactions in categories 2 and 3 orchards remained on par with each other. High applications of fertilizer nutrients with frequent irrigations (fertigation) might have altered the pH in medium fertilizer and high fertilizer added grape orchards. Alkaline pH of grape soils may also be attributed to calcareous soils existing in and around Vijayapura soils (Pujar *et al.,* 2010). The ground water used for irrigation are known to have high RSC values and thus, the soil pH might have been altered depending on quality and quantity of irrigation water used (Kiran, 2014).

The soil organic-C were found in higher ranges (> 0.75 %) in most of the grape orchards (n = 58; 96.7 %). Mean soil organic-C contents of all the three categories were found to be more than 1.00 % in the active root zone and all the three categories were found on par with each other. Higher amounts of soil organic-C among grape orchards could be attributed to high use of organic manures (Anita, 2016).

Buildup of soil organic-C is likely to be observed in soils with high organic matter applications (Bandari *et al.,* 1992). Similar magnitudes of high soil organic-C contents have been reported by Yogeeshappa (2007) and Kumar *et al.,* (2009).

Availability of secondary nutrients

Most of the soil sample were observed with high availability of calcium (n=52 with more than 60% of CEC; > 24 meq $100g^{-1}$), magnesium (n=55 with more than 20% of CEC; >8 meq $100g^{-1}$) and sulphur (n=54 with > 20 ppm) as given in Table 3. None of the soil samples showed deficiencies of secondary nutrients. Among different categories of grape orchards, high fertilizer applied orchards belonging to category-3 recorded significantly higher available calcium (45.0 ± 5.6 meq 100^{-1}) compared to low and medium fertilizer applied orchards (Table 3) with respective values of 37.0 ± 4.9 meq 100^{-1} (Category-1) and 37.5 ± 6.5 meq 100^{-1} (Category-2). The available magnesium contents were also found significantly higher in high fertilizer applied orchards compared to low fertilizer applied orchards (13.0 ± 3.5 meq 100^{-1}).

However, no significant differences were observed among 3 categories *w.r.t.* available-S contents. Similar magnitudes of available secondary nutrients were reported by Bhargava and Raghupathi (2001) and Yogeeshappa (2007). Generally, these black soils are known to exhibit higher exchangeable Ca^{2+} closer to their exchange capacities (Dhir *et al.,* 1979).

High use of water soluble fertilizers such as $CaNO_3$, $MgSO_4$ etc. might have altered the exchangeable cations (Morlat and Chaussad, 2008; Anita, 2016). Higher availability of sulphur may be attributed to use of organic manure and suphur containing fertilizers namely, K_2SO_4, $(NH_4)_2SO_4$, $ZnSO_4$, $MgSO_4$ etc. Excess use of Bordeaux mixture in grapes also might have contributed for higher sulphur availability in soils. Thus, the above factors might have contributed for observing differential amounts of secondary nutrients among different groups of grape orchards (Fig. 3).

Table.1 Details of management practices adopted by grape growers in Vijayapura taluka

Grape Orchards Category	Org. manure added (t ha^{-1})	Fertilizer nutrients added N : P_2O_5 : K_2O (kg ha^{-1})	Fertilizers used
Cat-I : Less Fertilized (n = 19)	5-20 t ha^{-1}	198.8: 365.2: 679.4	Urea (46% N), DAP (18% N, 46% P_2O_5), MOP (60 % K_2O), Ammonium Sulphate (21% N, 24% S), Mono Potassium Phosphate (0:52:34), 19:19:19, Potassium Nitrate (13:0:45), Mono Ammonium Phosphate (12% N, 61 P_2O_5), SOP (0:0:50).
Cat-II : Medium Fertilized (n-26)	10-20 t ha^{-1}	222.3:434.5:820.9	
Cat-III : High Fertilized (n= 15)	10-25 t ha^{-1}	243.2: 450: 999.6	

*Note: Grapes were grown on 'Y' trelle's method with a spacing of 3.0 x 1.5 mtrs; Orchards were under drip irrigation with intermittent fertigation; The nutrients were supplemented with organic manures and fertilizers. The fertilizers were applied directly and through fertigation to soil and through foliar sprays. Backward and forward pruning were practiced during April and October respectively.

Table.4 Extent of DTPA extractable iron, manganese, zinc and copper contents in soils of different categories of grape orchards

Grape Orchards Category	No. of samples with DTPA-Fe range			No. of samples with DTPA-Mn range		
	Low (<2.5)	Medium (2.5 – 4.5)	High (>4.5)	Low (< 2.0)	Medium (2.0 – 4.0)	High (> 4.0)
Cat-I : Less Fertilized (n = 19)	7 (11.7)	8 (13.3)	4 (6.7)	0 (0)	0 (0)	19 (31.7)
Cat-II : Medium Fertilized (n = 26)	15 (25.0)	9 (15.0)	2 (3.3)	0 (0)	0 (0)	26 (43.3)
Cat-III : High Fertilized (n = 15)	5 (8.3)	8 (13.3)	2 (3.3)	0 (0)	0 (0)	15 (25.0)
Total	**27 (45)**	**25 (41.6)**	**8 (13.33)**	**0 (0)**	**0 (0)**	**60 (100)**
Grape Orchards Category	**No. of samples with DTPA-Zn range**			**No. of samples with DTPA-Cu range**		
	Low (< 0.6)	**Medium (0.6 – 1.5)**	**High (>1.5)**	**Low (<0.2)**	**Medium (0.2–5.0)**	**High (>5.0)**
Cat-I : Less Fertilized (n = 19)	0 (0)	0 (0)	19 (31.7)	0 (0)	7 (11.7)	12 (20.0)
Cat-II : Medium Fertilized (n = 26)	0 (0)	0 (0)	26 (43.3)	0 (0)	4 (6.7)	22 (36.7)
Cat-III : High Fertilized (n = 15)	0 (0)	0 (0)	15 (25.0)	0 (0)	2 (3.3)	13 (21.6)
Total	**0 (0)**	**0 (0)**	**60 (100)**	**0 (0)**	**13 (21.7)**	**47 (78.3)**

Note: Values in parenthesis depict per cent of total number of samples analysed

Table.2 Extent of Soil reaction and soil organic-C contents in soils of different categories of grape orchards

Grape Orchards Category	No. of samples representing pH range of		
	Neutral (7.00 - 7.50)	Slightly-alkaline 7.50 - 8.00	Medium-alkaline 8.00 - 8.50
Cat-I : Less Fertilized (n = 19)	0 (0)	11 (18.3)	8 (13.3)
Cat-II : Medium Fertilized (n = 26)	1 (1.7)	14 (23.3)	11 (18.3)
Cat-III : High Fertilized (n = 15)	1 (1.7)	9 (15.0)	5 (8.4)
Total	**2 (3.4)**	**34 (56.6)**	**24 (40)**
Grape Orchards Category	**No. of samples representing SOC range of**		
	Low <0.50 %	**Medium 0.50 – 0.75 %**	**High > 0.75 %**
Cat-I : Less Fertilized (n = 19)	0 (0)	0 (0)	19 (31.7)
Cat-II : Medium Fertilized (n = 26)	0 (0)	2 (3.3)	24 (40.0)
Cat-III : High Fertilized (n = 15)	0 (0)	0 (0)	15 (25.0)
Total	**0 (0)**	**2(3.3)**	**58 (96.7)**

Note: Values in parenthesis depict per cent of total number of samples analysed

Table.3 Extent of calcium, magnesium and sulfur availability in soils of different categories of grape orchards

	No. of samples with available-Ca range		
Available-Ca (meq/100g)	Low <24.00	Medium 24.0-32.0	High >32.0
Cat-I : Low Fertilizers	0 (0)	3 (5)	16 (26.7)
Cat-II : Med. Fertilizers	0 (0)	5 (8.3)	21 (35.0)
Cat-III : High Fertilizers	0 (0)	0 (0)	15 (25.0)
Total	**0 (0)**	**8 (13.3)**	**52 (86.7)**
	No. of samples with available-Mg range		
Available-Mg (meq/100g)	Low (<6.0)	Medium (6.0-8.0)	High (8.0)
Cat-I : Low Fertilizers	0 (0)	3 (5)	16 (26.7)
Cat-II : Med. Fertilizers	0 (0)	2 (3.3)	24 (40.0)
Cat-III : High Fertilizers	0 (0)	0 (0)	15 (25.0)
Total	**0 (0)**	**5 (8.3)**	**55 (91.7)**
	No. of samples with available-S range		
Available-S (ppm)	Low-S (<10)	Medium-S (10-20)	High-S (>20)
Cat-I : Low Fertilizers	0 (0)	2 (3.3)	17 (28.3)
Cat-II : Med. Fertilizers	0 (0)	4 (6.7)	22 (36.7)
Cat-III : High Fertilizers	0 (0)	0 (0)	15 (25.0)
Total	**0 (0)**	**6 (10)**	**54 (90)**

Fig.1 DTPA extractable micronutrient status in soils different grape orchards

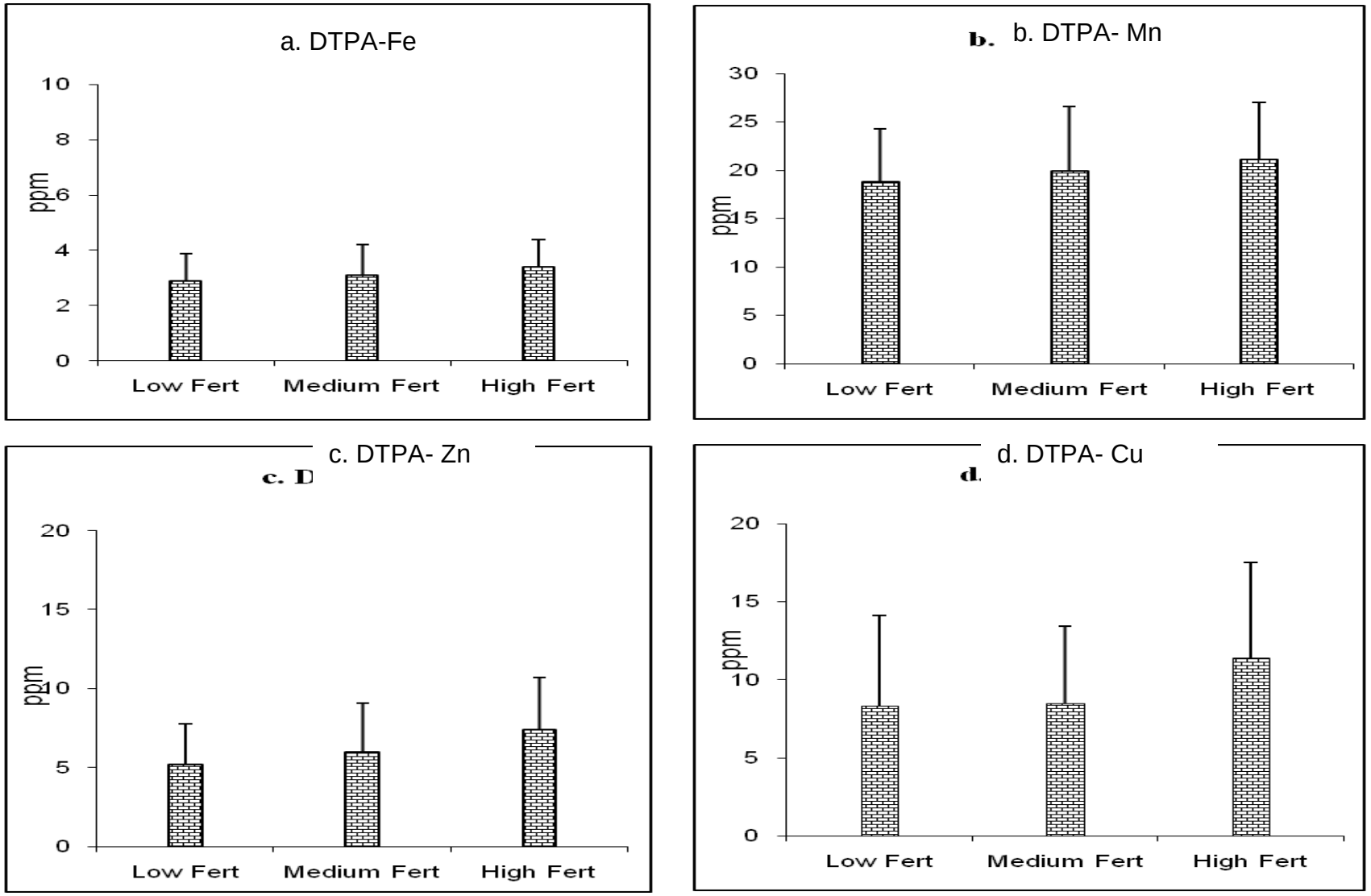


Fig.2 Soil reaction and soil organic carbon status in soils of different grape orchards

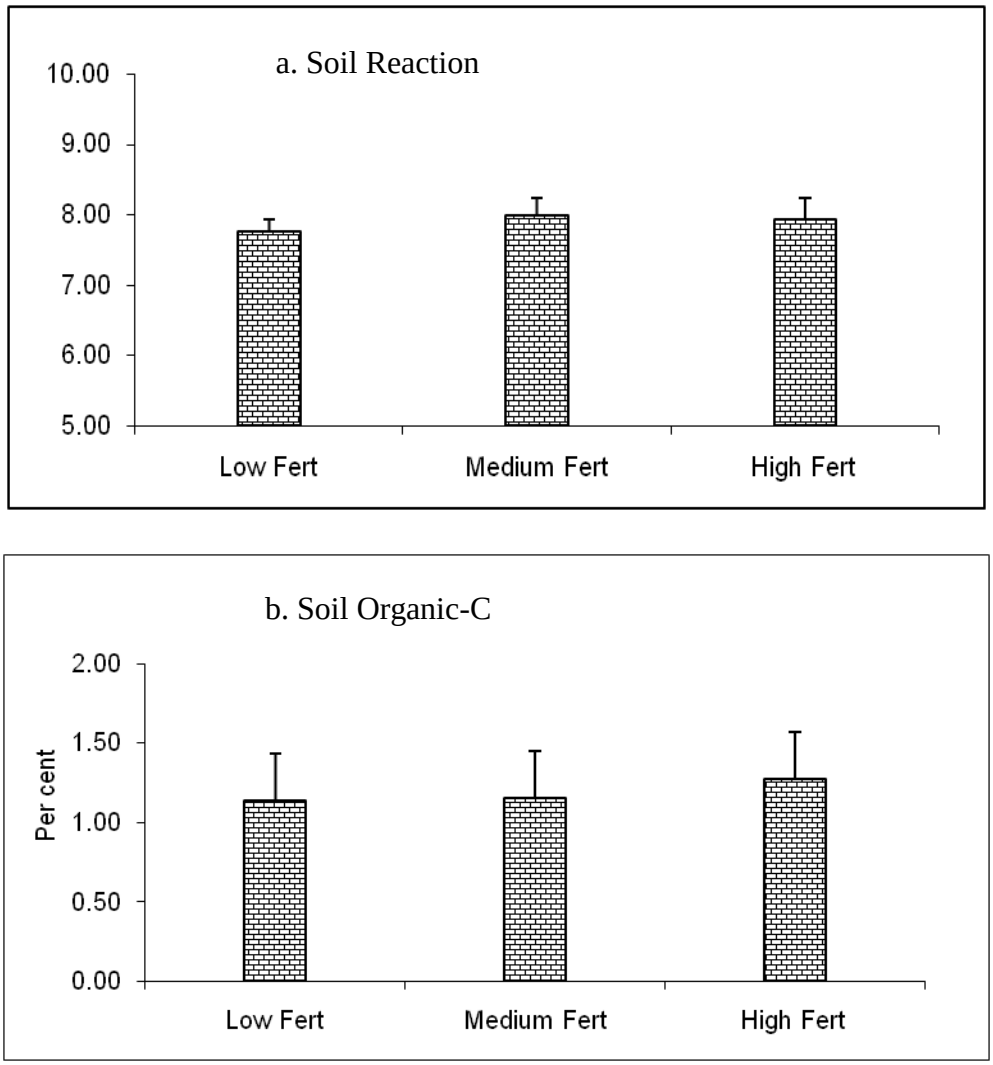
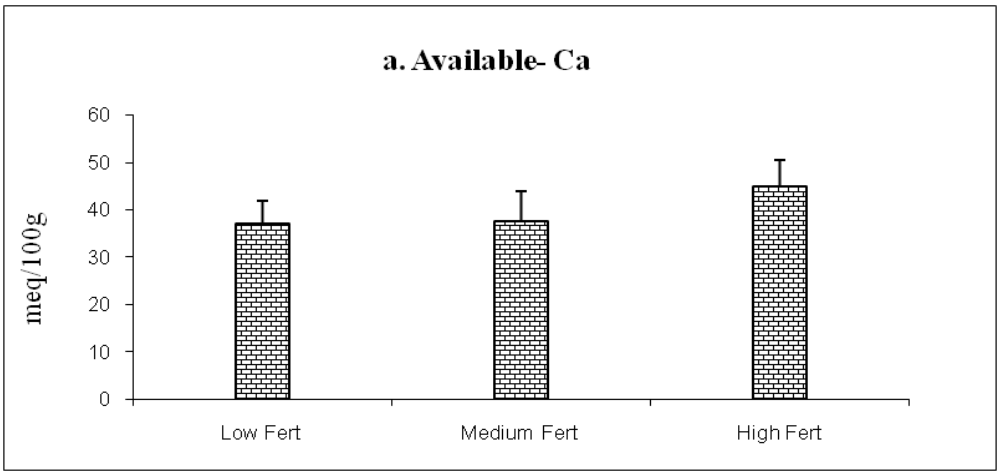
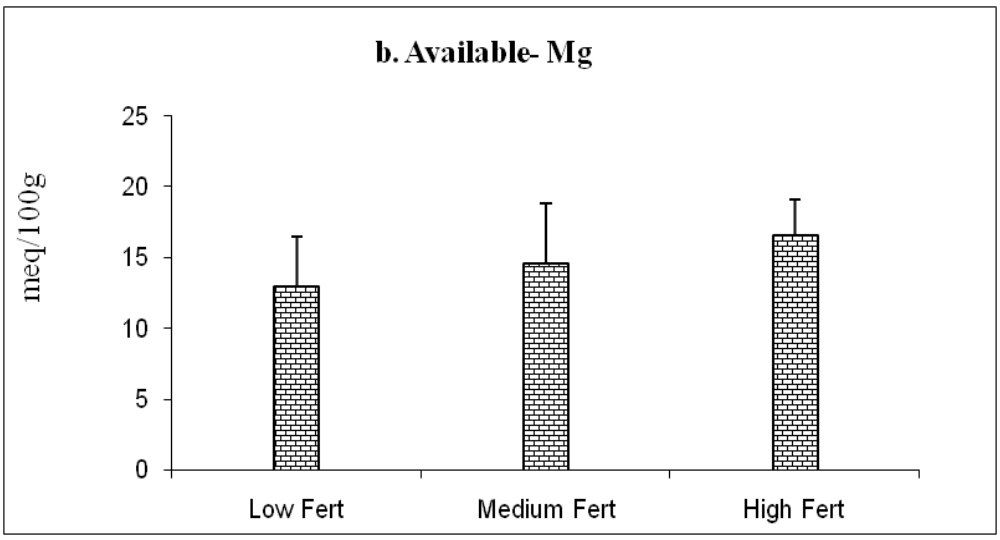
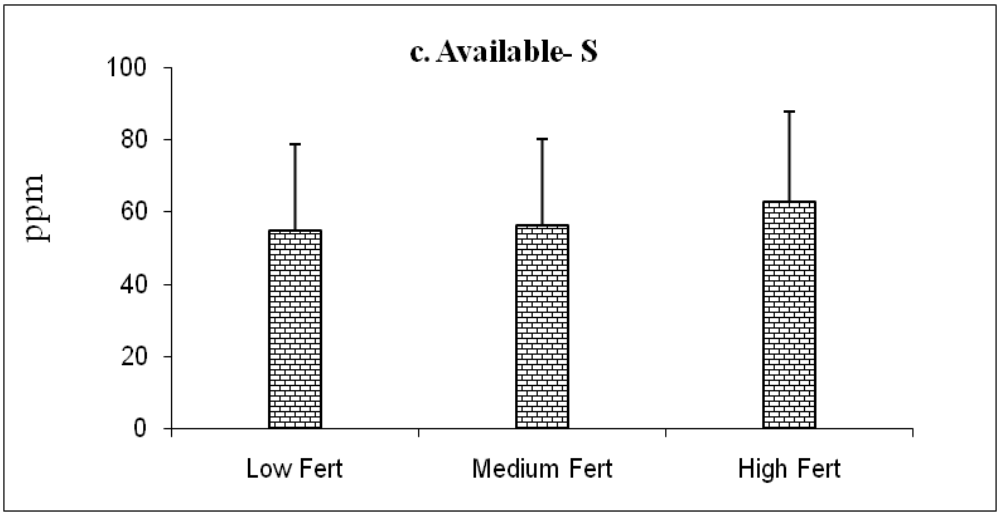


Fig.3 Available calcium, magnesium and sulphur status in soils different grape orchards







The data on DTPA extractable micronutrients namely, DTPA- Fe, Mn, Zn and Cu, are diagrammatically presented in Figure 1. Distribution of micronutrients in grape soils were found in the order Mn > Zn > Cu > Fe. It was interesting to note that none of the grape soils showed deficiency of micronutrients except for DTPA-Fe in half of the samples (Table 4).

DTPA- Cu was found in both higher (> 5.0 ppm) and medium (0.2 to 5.0 ppm) availability ranges. All the grape soil samples were observed with higher Zn and Mn availability. The amount of DTPA extractable micronutrients were found higher in high fertilizer added (category-3) orchards compared to low fertilizer added grape orchards. However, the concentrations of DTPA extractable micronutrients among three categories of grape orchards were found on par with each other.

The variations in concentrations of DTPA micronutrients could be attributed to the nature and behaviour of the element in soil as determined by pH and soil organic matter content. Organic matter is known to influence micronutrients availability through mineralization and chelation effects (Lindsay and Norwell, 1978). Application of higher doses of organic manures and use of micronutrient

mixtures might have induced their higher availability (Rao, 1986). High applications of fertilizer nutrients and organic manures and the quality of water used for irrigation have great influence on the secondary and micronutrient availability in grape orchard soils.

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