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Studies on physical, morphological and chemical properties of pedon and soil fertility of vineyard of Devanahalli, Karnataka, India

Harsha BR, Prashanth DV, Nandeesha CV and Anil Kumar KS

Abstract
India is gifted with advantages like soil variation and different types of climate. Hence This heterogeneous climatic condition has formed potential area for grapes cultivation zones. In Karnataka, its cultivation is seen in Krishna valley of northern parts and Nandi valley of southern parts of the state. Almost all the areas of major grapes-growing soils, fall under dry climatic conditions in Karnataka and contribute significantly for the state economy. Karnataka is the second largest grapes producing state in India and Devanahalli sub-division of Bangalore Rural district of Karnataka is well known area for production of Bangalore Blue variety which is predominantly grown in this region. Soil physical, morphological and fertility parameters were studied. Soils of Devanahalli vineyard was coarser in texture in surface and fine comparatively in sub-surface, The surface horizon was reddish brown and dark reddish brown in colour when dry and moist condition, respectively with a thickness of 11 cm. Soil reaction was slightly acid to neutral in soil water suspension ranging from 6.28 to 6.49 pH. There was no harmful effects of salts (EC) noticed in the pedon (0.07 to 0.11 dS m^{-1}). Soil reaction was slightly acid to neutral in soil water suspension ranging from 6.28 to 6.49 pH. There was no harmful effects of salts (EC) noticed in the pedon (0.07 to 0.11 dS m^{-1}). Available Cu, Fe, Mn, Zn, and B in the soil varied from 1.90-21.68, 9.1-18.98, 25.6-28.42, 1.2-5.12 and 1.71-5.18 mg kg^{-1} soil, respectively in fertility samples.

Keywords: Vineyard soils, fertility status, Bangalore blue, available nutrients, pedon

Introduction
Grapes generally require a hot and dry climate during its growth and fruiting periods. It is successfully grown in areas where the temperature range is from 15-40 °C. High temperatures above 40 °C during the fruit growth and development reduce fruit set and consequently the berry size. Low temperatures below 15 °C followed by forward pruning impair the bud break leading to crop failure. The fruitfulness of buds is influenced by light. Light intensity of 2,400 ft. candle is essential for optimum growth. However, low light intensities during the active growth stage (45-75 days after pruning) and fruit bud formation adversely affects the crop. It is most successfully grown at elevations ranging from 200-250 m above MSL. Area with annual rainfall not exceeding 900 mm well distributed throughout the year is ideal. However, rainfall during flowering and fruit ripening is not favourable as it leads to the spread of downy mildew disease. High atmospheric humidity is detrimental during vegetative growth and fruiting. At a high humidity the vegetative growth of vines is vigorous which affects the fruit size and quality. Similarly high humidity during 30-110 days after forward pruning favours the development of fungal diseases. Total area of grapes cultivated in India is 1.11 lakh ha with a production of 1.24 million tonnes (9th rank in the world) and Karnataka ranks second with a highlighting superior quality of grapes with a production of 3.39 lakh tonnes from an area of 29,110 ha, behind Maharashtra with 7.74 lakh tonnes from 86,000 ha (NHB & DOH-GOK, 2019; NHB, 2015). The most commonly grown grapes varieties are *Thompson Seedless*, *Bangalore Blue*, *Anab-e-Shahi*; however, *Bangalore Blue* and *Anab-e-Shahi* and its clones are the most popular varieties in southern districts of Karnataka. The superior quality and high productivity obtained in Karnataka is mainly due to the favourable conditions, such as soils and climate prevailing in the region.

Grapes can be cultivated in variety of soils including sandy loams, sandy clay loams, red sandy soils, shallow to medium black soils and red loams. The soil should be well drained, having good water holding capacity and devoid of any hard pan or impervious layer in the top 90 cm, with water table at least 6.5 m below. Grapes can also be grown successfully over a wide range of soil pH (4.0-9.5) however, soils having pH range of 6.5-8.0 are considered as ideal.

The different grapes varieties are being cultivated in Karnataka and variety such as *Bangalore Blue* has got GI tag which is extensively grown in Devanahalli sub-division of Karnataka. *Bangalore Blue* is a moderate yielder and the vines are medium in vigour. Bunches are medium to small in size and compact. The berries are bluish black or dark purple in colour, seeded, medium in size and spherical in shape, pulp is green and juicy. The juice is purple coloured, foxy flavoured having Total Soluble Solids (TSS) of about 16 to 18 °Brix and about 0.8 to 1.0 per cent acidity (Winkler *et al*., 1974) [20]. It is a mid-season variety and ripening of berries is sometimes uneven. It is less preferred for table purpose as the berries are acidic in nature and thick skinned; however, *Bangalore Blue* grapes are commonly used for juice and wine making, apart from its wide use for making black raisins. The variety is quite hardy for mildews and other diseases compared to other varieties of grapes. By staggered pruning two crops in a year can be taken.

Soil management practices are becoming common in vine-growing regions around the world in response to an increased awareness of the value of soil health to maintain environmental quality, crop yield and grapes quality. In spite of this, little information is available on the meaning of soil health within viticulture context, the effects of soil management practices on soil health and the consequences on grape quality. In this context a precise knowledge of soil and land resources in relation to the crop with respect to their characteristics, morphology and fertility status of soils plays a very important role in modern agriculture. It becomes more important when it comes to the commercial fruit crops, such as grapes for making the strategies to obtain higher productivity over a sustainable basis. Keeping these points in view, a vineyard from Devanahalli sub-division of Bangalore Rural district was selected to study physical, morphological and fertility status of soils.

Materials and Methods

Soil sampling

The sampling site, which is representative of the area was chosen on the basis of yield level, geology and physiography of Devanahalli sub-division of Bangalore Rural, Karnataka, India. One typifying pedon was selected each of which representing the study area that are falling under grapes cultivation in Devanahalli sub-division. Profile pit was dug in the dimension of 1.5 × 1.5 × 1.5 m, and the orientation of the profile was in such a way that its face got well lit for demarcation of horizons. Demarcation was done on the basis of texture, structure, colour and the details like depth, texture, colour, consistency, rock fragments, presence of mottles and structure were recorded and studied according to standard performa of soil profile description.

Collection of the soil sample (2-3 kg) from each horizon of profile was done in polythene bags with proper labeling and it was brought to the laboratory for processing and analysis. After arrival of sample, shade drying was done in laboratory and then ground in wooden mortar and wooden pestle, to separate the coarse fragments, the soil sample passed through 2 mm sieve and coarse and fine fragments were collected for further analysis. Around 500 g of 2 mm sieved soil sample was used for analysis of physico-chemical parameters.

Soil colour was arrived by suing the standard Munsell soil colour chart. Particle size analysis was carried out by the international pipette method (Jackson, 1973) [5]. Air dry soil particles of <2 mm size fraction was treated with H_2O_2 for dissolution of organic matter and completely dispersed using sodium hexa-meta phosphate with ultra-sound sonicator. The sand particles were separated by passing the dispersed solution through the 300 mesh sieve and obtained solution after sieving is analyzed for silt and clay fractions. Soil pH was determined through potentiometric method (Jackson, 1973) [5] by taking freshly stirred 1:2.5 soil:water suspension. For organic carbon determination, wet digestion method (Walkley and Black, 1934) [18] was followed where a known weight of powered (0.2 mm sieved) sample was treated with known volume of standard potassium dichromate and conc. H_2SO_4. The unreacted $K_2Cr_2O_7$ was analyzed with standard ferrous ammonium sulphate using ferroin indicator. CEC was determined by the ammonium acetate leaching method described by Jackson (1973) [5]. By using neutral normal ammonium acetate solution, a known quantity of soil was saturated with the ammonium ions and repeated leaching was done with alcohol and KCl through filter paper. The NH_4^+ ions adsorbed in the soil exchangeable surface were determined through micro-Kjeldahl distillation technique. The ammonium acetate extract was used for determining the exchangeable bases like Ca^{2+} and Mg^{2+} determined through the AAS and Na^+ and K^+ by flame photometry. Through Kjeldahl distillation method the available N was determined by taking known amount of soil in alkaline oxidizing agent (0.32 % $KMnO_4$) in presence of 2.5 per cent NaOH and distilled. Liberated ammonia is collected in 4 per cent boric acid absorbent with mixed indicator which is titrated against standard 0.01 N H_2SO_4 solution (Subbaiah and Asija, 1956) [17]. For available P_2O_5 determination, both the Bray and Kurtz reagent (for acid soils) and Olsen's reagent (for neutral and alkaline soils) was used. The phosphorus content in the soil extract was estimated by the blue colour formed by ascorbic acid-molybdate complex and the intensity of colour was determined at 660 nm in spectro-photometer (Jackson, 1973) [5]. Known quantity of soil was taken for determining the exchangeable potassium which was extracted with neutral normal ammonium acetate and the filtered extract was fed to flame photometer to determine the solution potassium content (Page *et al.*, 1982) [11]. The cation exchange capacity by sum of cations was estimated by summing up the total of $BaCl_2$ extractable acidity and total exchangeable bases. Calcium carbonate concentration is determined by dissolution of carbonate is on excess of 1N HCl, followed by back titration of the remaining acid using 1*N* NaOH (Horvath *et al*., 2005) [4]. Base saturation (%) was calculated using the formula;

$$\%\ \mathrm{B.S.} = \frac{\text{Sum of exchangeable bases}}{\text{CEC}} \times 100$$

Exchangeable sodium percentage was calculated by formula;

$$\mathrm{ESP} = \frac{\text{Exchangeable Na}}{\text{CEC}} \times 100$$

Estimation of soil fertility parameters

Available nitrogen

Through Kjeldahl distillation method the available N was determined by taking known amount of soil in alkaline oxidizing agent (0.32 % $KMnO_4$) in presence of 2.5 per cent NaOH and distilled. Liberated ammonia is collected in 4 per cent boric acid absorbent with mixed indicator which is titrated against standard 0.01 N H_2SO_4 solution (Subbaiah and Asija, 1956) [17].

Available phosphorus

For available P_2O_5 determination, both the Bray and Kurtz reagent (for acid soils) and Olsen's reagent (for neutral and alkaline soils) were used for extraction as the collected soils belonged to wide range of pH. The phosphorus content in the soil extract was estimated by the blue colour formed by ascorbic acid-molybdate complex and the intensity of colour was determined at 660 nm in spectro-photometer (Jackson, 1973) [5].

Available potassium

Known quantity of soil was taken for determining the exchangeable potassium which was extracted with neutral normal ammonium acetate and the filtered extract was fed to flame photometer to determine the solution potassium content (Page *et al.*, 1982) [11].

Exchangeable calcium and magnesium

The soil extract containing the different ions was also used to determine the calcium and magnesium content also by feeding the soil extract in atomic absorption spectrophotometer (Page *et al.*, 1982) [11].

Available sulphur

For determining the sulphate content, a known amount of soil was extracted by using 0.15 per cent $CaCl_2$ solution and $BaCl_2$ solution was added to the extract to produce turbidity. Turbidity was proportional to the sulphate content of soil, which was measured using spectrophotometer at 420 nm (Black, 1965) [3].

Available micronutrients

The micronutrients like Fe, Mn, Cu and Zn were estimated by extracting the soil using 0.1 N HCl for acid soils as an extractant in 1:10 ratio and 0.01 M DTPA in 1:2 ratio, shaken for 5 min and 2 hours, respectively, filtered and fed to the atomic absorption spectrophotometer. The B in the extract was estimated after development of yellow colour with Azomethine-H and the colour intensity was read at 420 nm.

Results and Discussion

Site and climatic characteristics of the study area

Devanahalli receives an average annual rainfall of 804.1 mm. The study area comes under undulating upland with 1-3 per cent slope and an elevation of 918 m above mean sea level. Surface attribute indicated slight erosion with slow run off, slope length of >600 m and soils are well drained.

Morphological properties of pedons

Morphological properties of the pedon have been presented in Table 4.26. Excavation of the soil profile was done up to depth of 151 cm. The diagnostic horizon termed as kandic horizon indicating argillic horizon with illuviated clay having very low cation exchange capacity and sub-active exchangeable cation exchange capacity clay ratio. Soils are deep due to the less erosion and gentle slopes (Kaushik Saha, 2020) [6].

The surface horizon was reddish brown and dark reddish brown in colour when dry and moist condition, respectively with a thickness of 11 cm. Dark hue might be due to high organic matter content (Wani *et al.*, 2016) [19]. Texture was sandy clay loam with moderate, fine, sub-angular blocky structure. Consistency was slightly hard, friable, slightly sticky and slightly plastic. The horizon was having common fine roots and few medium pores (Table 1).

Table 1: Morphological characteristics of the Devanahalli pedon

Horizon	Depth (cm)	Boundary	Colour		Texture	Structure	Consistence			Roots	Pores	Coats/ films/ stress	Iron Concentration
			Dry	Moist			Dry	Moist	Wet				
0-11	Ap	a s	5YR 4/4	5YR 3/4	scl	2F sbk	sh	fr	ss & sp	c f	f m	-	-
11-26	Bt1	c s	-	2.5YR 3/4	sc	2M sbk	-	fr	ms & sp	c m	c f	T tn p	-
26-47	Bt2	c s	-	2.5YR 3/6	c	2M sbk	-	fr	ms & mp	f m	c f	T tk p	-
47-83	Bt3	c s	-	2.5YR 3/6	c	2M sbk	-	fr	ms & mp	f f	c f	T tk p	-
83-97	Bt4	a s	-	2.5YR 4/4	vgc	1M sbk	-	fr	ms & mp	-	c f, m	T tn p	c m
97-122	Bt5C	c s	-	2.5YR 4/6	vgc	1M sbk	-	fr	ms & mp	-	c f, m	T tn p	-
122-151+	Bt6C	-	-	10R 4/6	vgc	1M sbk	-	fr	ms & mp	-	c f, m	T tn p	-

The sub soil B horizons were designated as Bt1, Bt2, Bt3, Bt4, Bt5C and Bt6C with depth interval of 11-26, 26-47, 47-83, 83-97, 97-122 and 122-151 cm, respectively. Colour varied from red to dark reddish brown in the lower horizons might be due to oxidation and intense leaching of bases leaving sesquioxide that exist in the horizons (Sharma *et al.*, 1996) [15].

Physical properties

Throughout the profile, total sand and silt content was ranging from 38.3 to 62.9 and 7.0 to 16.9 per cent, respectively, both exhibited an irregular trend with depth, which might be due to variation in weathering of parent material similar with the findings of Naidu and Hunsigi (2005) [7]. The clay content ranged from 30.1 to 46.2 per cent, variations could be attributed to the parent material, topography, *in situ* weathering and pedo-genesis and also clay translocation (Bhaskar *et al.*, 2009) [2] (Table 4.27). The textural class (USDA) was sandy clay loam in surface (Ap) horizon, for B horizons varied from sandy clay to very gravelly clay texture. The bulk density ranged from 1.60 to 1.81 Mg m^{-3} for field moist condition to 1.54 to 1.70 Mg m^{-3} under oven dried condition. Higher BD values at Bt5C horizon was due to higher gravel (%) noticed in the horizon. Available water holding capacity (AWC) of horizons was ranging from 5.74 to 30.67 mm, with 79.27 mm m^{-1} AWC in control section (Table 2).

Chemical properties

Soil reaction was slightly acid to neutral in soil water suspension ranging from 6.28 to 6.49 pH. There was no harmful effects of salts (EC) noticed in the pedon (0.07 to 0.11 dS m^{-1}). Electrical conductivity of all the pedons was very low due to the leaching caused by land slope combined with rainfall as observed by Sivasankaran *et al.* (1993) [16]. Organic carbon content ranged from 0.06 to 0.54 per cent in soil. Depth wise decrease in organic matter content might be due to addition of FYM and leaf litter supported by the results of Mahesh *et al.*, (2019). Available N, P_2O_5 and K_2O in the surface horizon were 235.20, 436.90 and 173.60 kg ha^{-1}, respectively. In surface layer, lower range of nitrogen and higher range of K and P availability was observed. Available N content was found to be higher in lower three horizons below Ap horizon possibly due to leaching of nitrate ions into lower layers. Major concentration of phosphorus was found in 0-30 cm depth and found to be decreasing with increasing depth which might be due to immobile nature of P from surface to subsurface horizons. Exchangeable Ca and Mg were 4.42 and 0.54 cmol (p^+) kg^{-1} soil, respectively and sulphur content was 15.42 mg kg^{-1} soil in Ap horizon. Calcium and magnesium did not follow any definite distribution trend of increase or decrease down the profile. The exchangeable Ca and Mg are attributed to the type and amount of clay, present in these soils (Avinash, 2017) [1]. Low sulphur content is also attributed to low sulphur bearing minerals. Available micronutrients like Fe, Mn, Cu, Zn and B ranged from 0.50 to 19.00, 1.24 to 22.18, 1.80 to 24.70, 0.06 to 11.22 and 2.20 to 3.12 mg kg^{-1}, respectively. Sum of exchangeable bases ranged from 4.21 to 5.98 cmol (p^+) kg^{-1} soil. Cation exchange capacity (CEC) was 5.61 cmol (p^+) kg^{-1} in the surface horizon, where as in the sub-surface horizon it ranged from 4.95 to 7.15 cmol (p^+) kg^{-1}. The CEC values are indicating that the red soils are moderate to highly weathered (Rajeshwar and Mani, 2013). CEC/clay ratio varied from 0.12 to 0.19, which indicates presence of sub active to semi active clay type. ECEC was lower than the CEC due to the development of pH dependent negative charges on the exchange complex (Patil and Dasog, 1999) [12]. Base saturation was 96.85 per cent in the surface horizon where as in the sub-surface horizon it ranged from 74.89 to 89.26 per cent. Depth wise irregular changes found for base saturation (Table 3 a & b). Soils were highly base saturated (>50 %) throughout the profile. According to Pillai and Natarajan (2004) [13] the base saturation of soils was medium to high due to the low to medium amount of rainfall in Bangalore rural district.

Fertility status of composite soil samples of Devanahalli

The pH of soil water suspension ranged from 5.34-6.34 (strongly acid to slightly acid) with a mean of 5.93. The EC value ranged from 0.07-0.60 dS m^{-1} with the mean of 0.29 dS m^{-1}. Organic carbon content ranged from 0.35-0.57 per cent with a mean 0.46 per cent. Available N, P_2O_5 and K_2O ranged from 232.9-284.8, 68.56-189.81 and 72.80-417.76 kg ha^{-1} soil, respectively. Nitrogen was found to be low in status. Potassium ranged between low and medium in status. Phosphorus was found to be high in available status. Exchangeable Ca and Mg and available S ranged from 8.1-12.8, 2.7-5.7 cmol (p^+) kg^{-1} and 72.50-123.33 mg kg^{-1}, respectively. Available Cu, Fe, Mn, Zn, and B in the soil varied from 1.90-21.68, 9.1-18.98, 25.6-28.42, 1.2-5.12 and 1.71-5.18 mg kg^{-1} soil, respectively (Table 4 a & b).

Table 2: Physical and chemical properties of Devanahalli pedon (*Dilkush* variety)

Depth (cm)	Horizon	Sand					Total			Texture (USDA)	Gravel (% Volume)
		V. Coarse (2.0-1.0)	Coarse (1.0-0.5)	Medium (0.5-0.25)	fine (0.25-0.1)	V. fine (0.1-0.05)	Sand (2.0-.05)	Silt (0.05-0.002)	Clay (<0.002)		
		% of <2 mm									
0-11	Ap	6.6	5.3	17.9	23.4	9.7	62.9	7.0	30.1	scl	5.0
11-26	Bt1	9.2	11.3	9.1	11.6	4.7	45.9	13.3	40.8	sc	1.0
26-47	Bt2	4.0	5.5	10.5	15.2	9.1	44.3	11.8	43.9	c	0.5
47-83	Bt3	9.8	9.4	5.2	11.0	8.3	43.7	10.4	45.9	c	2.5
83-97	Bt4	12.1	7.3	2.7	7.9	8.3	38.3	16.9	44.8	vgc	50.0
97-122	Bt5C	6.9	9.3	4.9	14.6	6.9	42.6	11.2	46.2	vgc	40.0
122-151+	Bt6C	16.8	9.5	7.3	8.8	5.3	47.7	12.2	40.1	vgc	50.0

Depth (cm)	Horizon	pH (1:2.5) Water	E.C. ($dS\ m^{-1}$)	OC (%)	B.D. ($Mg\ m^{-3}$) Field moist	B.D. ($Mg\ m^{-3}$) Oven dried	FC (mm)	PWP (mm)	AWC (mm)	AWC ($mm\ m^{-1}$)
0-11	Ap	6.30	0.10	0.54	1.69	1.66	17.15	11.41	5.74	79.27
11-26	Bt1	6.37	0.07	0.42	1.75	1.68	25.18	13.91	11.27	
26-47	Bt2	6.31	0.07	0.24	1.60	1.54	49.78	33.01	16.77	
47-83	Bt3	6.28	0.09	0.21	1.66	1.58	91.24	60.57	30.67	
83-97	Bt4	6.35	0.08	0.15	1.70	1.60	34.76	21.97	12.79	
97-122	Bt5C	6.49	0.11	0.06	1.81	1.70	61.05	44.05	17.00	
122-151+	Bt6C	6.36	0.10	0.06	1.75	1.68	64.71	46.32	18.39	

Table 3a: Soil fertility of Devanahalli pedon (*Dilkush* variety)

Depth (cm)	Available nutrients											
	OC	N	P_2O_5	K_2O	Ca	Mg	S	Fe	Mn	Cu	Zn	B
	($g\ kg^{-1}$)	$kg\ ha^{-1}$			cmol (p^+) kg^{-1} soil		mg kg^{-1} soil					
0-11	5.40	235.2	436.90	173.60	4.42	0.54	15.42	19.00	22.18	24.70	11.22	3.12
11-26	4.20	533.1	319.08	142.24	3.55	0.36	13.75	4.92	9.62	22.94	3.78	2.51
26-47	2.40	219.5	293.45	267.68	4.02	0.67	14.58	1.18	2.56	13.32	0.20	2.66
47-83	2.10	188.2	30.00	216.16	4.70	0.72	17.08	0.74	1.72	8.16	0.06	3.07
83-97	1.50	141.1	12.00	175.84	3.51	0.75	13.75	0.64	2.10	7.74	0.06	2.36
97-122	0.60	78.4	15.82	150.08	4.16	0.79	2.08	0.50	1.64	1.80	0.12	2.98
122-151+	0.60	62.7	17.45	143.36	3.13	0.74	1.25	0.50	1.24	2.16	0.06	2.20

Table 3b: Cation exchange properties of Devanahalli pedon (*Dilkush* variety)

Depth (cm)	Exchangeable Bases					Extractable acidity ($BaCl_2$-TEA)	CEC		ECEC	Base saturation (%)		CEC/clay ratio	ESP
	Ca	Mg	Na	K	Total		NH_4OAc	Sum of cations		NH_4OAc	Sum of cations		
	cmol (p^+) kg^{-1} soil												
0-11	4.42	0.54	0.07	0.40	5.43	17.50	5.61	22.93	5.43	96.85	23.69	0.19	1.18
11-26	3.55	0.36	0.79	0.21	4.91	18.75	5.50	23.66	4.91	89.26	20.75	0.13	14.40
26-47	4.02	0.67	0.09	0.50	5.28	18.00	6.82	23.28	5.28	77.48	22.69	0.16	1.29
47-83	4.70	0.72	0.11	0.45	5.98	5.00	7.15	10.98	5.98	83.60	54.45	0.16	1.54
83-97	3.51	0.75	0.35	0.42	5.03	15.00	6.71	20.03	5.03	74.89	25.09	0.15	5.25
97-122	4.16	0.79	0.07	0.34	5.36	12.50	7.04	17.86	5.36	76.16	30.02	0.15	0.94
122-151+	3.13	0.74	0.09	0.32	4.28	13.75	4.95	18.03	4.28	86.37	23.72	0.12	1.78

Table 4a: Soil reaction, EC and plant available primary nutrient in surface (0-30 cm) soils of agricultural lands in Devanahalli (*Dilkush* variety)

Crop	Location	pH	EC (dS m^{-1})	OC (%)	N	P_2O_5	K_2O
					kg ha^{-1}		
Grapes	13° 21' 24.3" N, 77° 44' 06.1" E	5.52	0.07	0.38	232.9	140.72	108.64
Grapes	13° 21' 19.9" N, 77° 44' 06.7" E	5.34	0.35	0.51	260.7	189.81	72.80
Grapes	13° 21' 25.2" N, 77° 44' 08.0" E	5.9	0.40	0.48	260.0	80.73	417.76
Grapes	13° 21' 26.3" N, 77° 44' 04.2" E	6.15	0.47	0.35	251.8	74.18	157.92
Grapes	13° 21' 25.1" N, 77° 44' 03.7" E	6.34	0.14	0.39	252.9	68.56	201.60
Grapes	13° 21' 20.2" N, 77° 44' 02.8" E	5.84	0.12	0.51	266.8	94.47	402.08
Grapes	13° 21' 15.1" N, 77° 44' 06.3" E	6.12	0.60	0.48	279.5	81.38	225.12
Grapes	13° 21' 11.7" N, 77° 44' 13.1" E	6.26	0.16	0.57	284.8	81.60	230.72
Mean		5.93	0.29	0.46	261.18	101.43	227.08
Range		5.34-6.34	0.07-0.60	0.35-0.57	232.9-284.8	68.56-189.81	72.80-417.76

Conclusion

Pedon and fertility samples studied for physical, morphological and fertility parameters of vineyards of Devanahalli Sub-division of Karnataka varied substantially in their properties. Soils were having fine texture in subsurface horizons and coarser in surface layer. Fertility soils studied were slight to strongly acidic in reaction, available nitrogen and organic carbon content was low to medium, available phosphorous and boron contents were medium to high in status.

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