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ASSESSMENT OF YIELD AND QUALITY OF GRAPES ON DIFFERENT SOILS IN BULDANA DISTRICT OF MAHARASHTRA

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ABSTRACT
Grape orchards are established in different soil types in Buldana district of Maharashtra and therefore there is a wide gap in productivity of grapes. Hence, a field survey was undertaken to study the suitability of soils for commercial production of grapes. Thirty three grape orchards on different soil types along with ten typiphying pedons were selected based on morphological characteristics and categorized in various blocks of Buldana district. The soil samples collected from these grape orchards were analyzed for their physico-chemical properties and fruit samples were analyzed for quality parameters as per standard procedures and yield of grape was recorded. The results indicate that most of the soils were neutral to slightly alkaline in reaction with pH value ranging from 7.17 to 8.49., low to moderate in available nitrogen (150.5 to 280.5 kg ha^{-1}), medium to moderate in available phosphorus(14.70 to 26.50 kg ha^{-1}) and high to very high in potassium(281.28 to 598.68 kg ha^{-1}). The soils have been classified as Typic Ustorthents (Entisols), Typic Haplustepts (Inceptisols) and Typic Haplusterts (Vertisols). The highest TSS(23.32º) and reducing sugar (22.30%) was observed in the Sonaka cultivar followed by Sharad seedless. Based on the soil site characteristics, it has been observed that the grape yield was positively correlated with increase in organic carbon in soil, while it was negatively correlated with free calcium carbonate in the soil.

INTRODUCTION

Grape is one of the important commercial, sub-tropical fruit crop grown in different parts of the world and is accounting about 16% of total fruit production. France, Spain, USA, China, Brazil, Bulgaria, Japan, Australia etc. are the main grape growing countries. In India, grape is mostly grown in Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu (Anonymous, 2009). Maharashtra accounts for more than 80% of total production from Nasik, Ahmednagar, Pune, Satara, Sangli and Osmanabad districts. As per data available with Maharashtra State Agriculture Marketing Board, around 70 to 80% export of grapes from India is from Maharashtra (Anonymous, 2010).

In Vidarbha especially in Buldana district, grape cultivation is an emerging practice and farmers are attracted towards this fruit crop. In spite of variability in soil conditions, the orchards are well established in the different locations and situation. However, there is a wide variation in productivity of grape, owing to varied landscape, soil characteristics (Jagdish Prasad *et al.,* 1995) and agro-managements. The suitability of soils and economic viability are the two important aspects, which can guide the farmers in proper site selection and management of grape orchards to bring down the cost of production. In order to increase the area under production of grape, it is necessary to take up the intensive study of soil to ascertain soil site parameters responsible for influencing its productivity. For increasing productivity of grape, it should have suitable growing environment. For this it is of prime importance to characterize, classify and evaluate the climate, soil site condition and the land qualities which are dynamic and complex attributes that directly influence the growth and performance of grapes. Balpande *et al.*(2007& 2008) characterized and classified the soils of Nasik district in Maharashtra and observed that soil depth, drainage, organic carbon and calcium carbonate content in soil are the important parameters influencing other soil properties and yield of grape.

Keeping in view the importance of land resource information in grape cultivation, an attempt was made to study the land resource to characterize, classify and assess the yield and quality of grape on different soils in Buldana district of Maharashtra.

MATERIALS AND METHODS

Buldana district lie between 19º 51′ to 21º17′ North latitudes and 76º38" to 76º40" east longitudes .It is surrounded by Satpuda mountain ranges. The climate of the district is hot and humid. In some parts of the districts *i.*e. Khamgaon, Jalgaon (Jamod) and Shegaon area the climate is very hot in summer, which reaches to 42ºC in the month of May and is much cold in winter during the month of December which come down to 8º to 10 ºC. Buldana district falls in the rainfall zone between 700-800 mm per annum.

The grape orchards in various soil types of Buldana district were surveyed and representative orchards were selected. Surface (0-20 cm) soil samples collected from thirty three selected orchards were analyzed for various properties as per standard procedures (Black, 1965; Jackson, 1973). In addition to this; yield data of grapes in respective orchards were also

recorded. The data was compiled as per the blocks defined based on the location of the orchard.

The fruit samples were also collected and analyzed for various quality parameters.The total soluble solids (^{0}Brix) were determined with the help of digital refractometer and values were corrected to 20ºC with the help of temperature correction chart and the acidity of fruit was determined by titrating a known quantity of sample diluted with water against standard sodium solution, using phenolphthalein as an indicator and was expressed in percentage as citric acid (AOAC, 1975).

For estimation of reducing sugars extract was prepared from grape fruit pulp by filtering the fresh pulp through Whatman 4 filter paper using 80 per cent hot ethanol and estimated by using Nelson-Smogyi method (Sadasivam and Manickam, 1996).

RESULTS AND DISCUSSION

The data on chemical characteristics of surface soils in different blocks and selected pedons are presented in Table 1 and 2 respectively.

Soil reaction (pH)

The most important characteristic of the soil is its reaction. Based on the pH, the soils are categorized as acidic, alkaline or neutral. Higher plants respond markedly to the soil reaction (pH) because it tends to control much of their chemical environment and nutrient availability.

The data indicate that the soils are neutral to moderately alkaline in reaction with pH value ranging from 7.17 to 8.49. Similar results were observed by Bharambe and Ghonsikar (1985). The higher pH values were observed in Mangrul

Table 1: Chemical characteristics of surface soils

Orchard code	pH (1:2.5)	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	$CaCO_3$ (%)
Godhri block				
1	8.19	0.14	4.5	15.25
2	7.87	0.47	3.9	4.5
3	8.0	0.27	4.5	6.25
4	7.17	0.57	6.8	6.75
5	7.81	0.24	4.0	16.5
Mean	7.61	0.44	4.74	9.85
Amdapur block				
6	8.31	0.19	6.1	1.75
7	7.95	0.33	7.2	1.0
8	8.43	0.16	5.9	9.75
9	8.35	0.19	6.9	8.75
Mean	8.36	0.22	6.53	5.31
Mangrul Navghare block				
10	8.49	0.13	5.2	6.75
11	8.04	0.21	3.9	12.25
12	8.40	0.18	6.9	1.75
13	8.32	0.17	4.7	3.25
Mean	8.31	0.17	5.18	6.00
Sawargaon Dukre block				
14	7.96	0.23	5.6	4.5
15	8.07	0.22	7.6	9.55
16	7.92	0.26	6.6	4.83
17	8.12	0.22	7.0	13.45
18	8.10	0.18	6.2	11.97
19	7.64	0.24	5.4	4.75
20	8.31	0.26	6.7	12.58
21	8.16	0.15	6.5	11.02
22	8.26	0.22	8.6	9.65
23	8.0	0.19	6.6	6.93
Mean	8.05	0.22	6.68	8.92
Chandhai block				
24	8.15	0.25	5.7	7.35
25	8.35	0.14	6.8	6.95
26	8.31	0.26	6.7	16.58
27	8.0	0.16	8.1	10.7
28	8.26	0.17	5.9	15.64
29	8.15	0.14	5.4	11.13
Mean	8.20	0.19	6.17	11.39
Palaskhed Block				
30	8.26	0.18	4.2	7.9
31	8.20	0.17	5.3	13.64
32	8.19	0.20	7.4	9.97
33	8.08	0.22	6.6	16.69
Mean	8.21	0.19	5.88	12.05

Table 2: Chemical characteristics of typifying pedons

Pedon	Horizon	Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	$CaCO_3$ (%)
Pedon 1	Ap	0-22	7.11	0.14	5.2	10.1
	C	22-50	-	-	-	-
Pedon 2	Ap	0-14	7.84	0.13	4.6	10.46
	C	14.50	-	-	-	-
Pedon 3	Ap	0-18	7.86	0.13	5.9	2.8
	A	18-30	8.12	0.18	4.7	3.2
	Bss1	30-49	8.20	0.21	4.9	5.9
	Bss2	49-68	8.31	0.20	4.7	7.8
Pedon 4	Ap	0-13	8.10	0.29	5.4	7.14
	C	13-50	-	-	-	-
Pedon 5	Ap	0-16	8.12	0.25	5.7	4.26
	A	16-28	8.21	0.27	4.9	6.72
	Bw	28-50	8.26	0.26	4.7	10.71
Pedon 6	Ap	0-16	8.21	0.26	6.3	4.28
	A	16-34	8.26	0.25	5.9	8.39
	Bw	34-52	8.40	0.15	5.1	10.1
Pedon 7	Ap	0-15	8.21	0.20	5.2	9.7
	A	15-31	8.26	0.21	4.6	10.65
	Bss	31-58	8.12	0.26	4.3	12.13
Pedon 8	Ap	0-17	8.26	0.26	5.6	8.24
	A	17-28	8.32	0.24	5.4	10.70
	Bss1	28-42	8.39	0.28	5.5	11.29
	Bss2	42-65	8.30	0.21	4.9	16.92
Pedon 9	Ap	0-14	8.20	0.27	4.1	6.02
	C	14-48	-	-	-	-
Pedon 10	Ap	0-16	8.10	0.16	3.4	9.75
	C	16-47	-	-	-	-

Navghare block.

The pH of selected pedons indicated that the soils are neutral to moderately alkaline in reaction with values ranging from 7.11 to 8.40 and it increased with depth. In general pH increased with depth which may be due to increase in calcium carbonate, and may be due to increase in bases (Ca, Mg, Na, K) on the exchange complex (Kaushal *et al.*, 1986).

Electrical conductivity (EC)

The electrical conductivity is a measure of soluble salt concentration in the soils. Higher amount of salt in the soils restrict the nutrient uptake and thus affect the plant growth. Grape is a moderately salt tolerant crop and yield decreases when EC is more than 2.5 dS m^{-1} (FAO, 1979). The EC of the studied surface soils ranged from 0.13 to 0.57 dSm^{-1}, which is well within the acceptable limit of EC range for normal soils (Richard, 1954).

The electrical conductivity of selected pedons (Table 2) ranged from 0.13 to 0.29 dS m^{-1} indicating that all the soils are non-saline in nature. Electrical conductivity was found to be increased down the profile (pedon 3,5,7,8) may be due to the leaching of salts from surface to sub-surface horizon.

Organic carbon

Organic carbon content is often a good expression of the natural fertility of the soil. In addition to this, it also improves soil structure porosity infiltration rate water and nutrient retention capacity and reduces soil erosion (Smith and Ellioth, 1990).

Organic matter acts as a major factor regulating the availability of organic forms of nitrogen, phosphorus, sulphur and trace elements in soils. Organic carbon is an indication of organic fractions in soils formed from the microbial decomposition of organic residues. Organic matter content is often a good expression of natural fertility of the soils as it provides nitrogen, phosphorus, sulphur and other trace elements in soils.

The organic carbon content of the surface samples varied from 3.9 to 8.6 g kg^{-1}. It is observed that among the six blocks 36% soil samples are having medium organic carbon and 49% are in moderately high range, 6% are high whereas 9% are low in organic carbon content.

The organic carbon content of the typifying pedons varied from 3.4 to 6.3 g kg^{-1}, which is medium to moderately high. The organic carbon was more in surface horizon than sub-surface hirozon. This may be due to the addition of organic manure. In general, organic carbon decreased with depth. This may be due to higher rate of decomposition and accumulation in the surface horizon as compared to sub-surface horizons. Similar observations were also reported by Nimkar (1990) and Mohekar (1997).

Calcium carbonate

Calcium carbonate occurs in both nodular and powdery form in the soil. The calcium carbonate nodules are inert coarse fraction, which help in improving the physical characteristics of soils. While the calcium carbonate in powdery form mixed with fine earth fraction of soils affects both physical and chemical characteristics of soils.

In the study area it is observed that, most of the soils were low to medium in calcium carbonate content while 30% (ten orchards) soil samples were found to be highly calcareous.

Table 3: Fertility status (major nutrients) of surface soils

Orchard code	Available nutrients (kg ha^{-1})		
	N	P	K
Godhri block			
1	151	19.3	282
2	166	15.6	327.6
3	172	21.03	555.6
4	241	26.5	584.4
5	171	17.8	477.6
Mean	180.2	20.05	445.44
Amdapur block			
6	194	17.86	442.8
7	249	26.34	446.4
8	201	21.03	466.8
9	206	22.08	529.2
Mean	212.5	21.83	471.3
Mangrul Navghare block			
10	182	16.10	445.2
11	168	16.8	428.4
12	211	21.25	463.2
13	164	14.7	346.8
Mean	181.3	17.21	420.9
Sawargaon Dukre block			
14	198	15.4	387.6
15	210.3	18.45	510.6
16	205.4	20.35	570.6
17	213.2	14.19	417.12
18	200.7	17.22	540.24
19	189	19.7	482.4
20	215.4	23.12	547.92
21	199.3	17.22	309.12
22	220.8	23.54	598.68
23	198.6	23.5	513.12
Mean	205.1	19.27	487.17
Chandhai block			
24	188.4	17.35	369.72
25	211.1	19.32	453.84
26	188.2	23.12	508.14
27	280.5	26.3	389.76
28	186.3	14.7	510.72
29	176	17.5	470.76
Mean	205.1	19.72	450.49
Palaskhed Block			
30	155.4	15.06	281.28
31	165.5	16.7	309.12
32	225.8	21.09	349.44
33	150.5	17.22	538.32
Mean	174.3	17.51	369.54

The highest calcium carbonate was observed in Chandhai block followed by Palaskhed block. In Chandhai block the calcium carbonate contain varied from 6.95 to 16.58%.

The calcium carbonate content of the typifying pedons ranged from 2.8 to 16.92% indicating that soils are slightly calcareous to calcareous in nature. The $CaCO_3$ content in the subsurface horizon was higher as compared to surface horizon. This might be due to accumulation of displaced calcium from the exchange complex to the upper layer or due to precipitation of $CaCO_3$. However, in most of pedons the calcium carbonate in soil profiles invariably showed an increasing pattern with increase in soil depth, which indicates the process of leaching down of calcium and subsequent precipitation at lower depth due to high pH level. Similar results were observed by Pal *et al*. (1999) and Challa *et al*. (2000).In general, in the study area, the performance of the vines was found to be low in soils with high lime as compared to the soils with low lime content.

Fertility status of soil

The data in respect of fertility status (available N, P, K) of soil are presented in Table 3 and 4.

Available nitrogen

Data regarding the available nitrogen content of soils (Table 3) revealed that average nitrogen content ranged from 150.5 to 280.5 kg ha^{-1}. Most of the grape orchards are low to moderate in available nitrogen. The highest nitrogen content was observed in Amdapur block followed by Sawargaon Dukre block. The available nitrogen content in the pedons(Table 4)

Table 4: Soil fertility status of typifying pedons

Pedon	Horizon	Depth (cm)	Available nutrients (kg ha^{-1})		
			N	P	K
Pedon 1	Ap	0-22	215.4	23.12	447.92
	C	22-50	-	-	-
Pedon 2	Ap	0-14	170.70	19.85	395.80
	C	14-50	-	-	-
Pedon 3	Ap	0-18	186.3	24.26	410.72
	A	18-30	172.52	22.06	407.68
	Bss1	30-49	156.80	18.23	391.84
	Bss2	49-68	149.16	17.64	356.00
Pedon 4	Ap	0-13	144.25	19.85	371.84
	C	13-50	-	-	-
Pedon 5	Ap	0-16	188.4	21.20	369.72
	A	16-28	175.61	17.35	319.20
	Bw	28-50	150.52	15.44	304.64
Pedon 6	Ap	0-16	213.2	20.18	417.12
	A	16-34	172.80	16.33	403.84
	Bw	34-52	148.58	16.36	390.32
Pedon 7	Ap	0-15	175.61	21.89	319.20
	A	15-31	150.52	15.44	304.60
	Bss	31-58	149.32	15.20	377.03
Pedon 8	Ap	0-17	242.3	24.70	450.24
	A	17-28	210.11	22.06	426.72
	Bss1	28-42	175.61	17.65	359.52
	Bss2	42-65	168.05	15.44	341.60
Pedon 9	Ap	0-14	169.34	19.85	389.60
	C	14-48	-	-	-
Pedon 10	Ap	0-16	194.43	25.32	380.26
	C	16-47	-	-	-

varied from 144.25 to 242.3 kg ha^{-1} indicating that the soils are low to moderate in available nitrogen content. Further it was observed that the available nitrogen was higher in surface soils as compared to subsoil layers. This might be due to the higher content of organic carbon in surface soils. Similar results were reported by Todmal *et al*. (2008). The sufficient amount of nitrogen content was found in Sawargaon Dukre block while the soils of Palaskhed block are found low in available nitrogen.

Available phosphorus

The available P_2O_5 content of the soils varied from 14.70 to 26.50 kg ha^{-1} indicating that the soils are low in phosphorus. Low available phosphorus content of these soils could be attributed to their high P-fixing capacity which prevents phosphorus to come into readily available form in the soil solution. Among the grape orchards studied, 9% orchards were found to be very low in available phosphorus, whereas 91% were low in available phosphorus. The available phosphorus in the pedons(Table 4) varied from 15.20 to 25.32 kg ha^{-1} and it decreased with depth.

Available potassium

The available K_2O content varied from 281.28 to 598.68 kg ha^{-1}. On the basis of soil test ratings (surface layer) all the soils were categorized as high in available potassium content. Among the grape orchards, about 79% orchards were found to be very high in K content whereas 15% orchards were high in K content and remaining 6% orchards were moderately high in K content. The available potassium content in the pedons (Table 4) varied from 304.60 to 450.24 kg ha^{-1} indicating that soils were high to very high in available potassium and it decreased with depth. This may be attributed to the K-rich minerals occurring in the soil (Pal, 1985) and the relative immobility of this element on account of fixation by clay and the higher available potassium content in surface soils might be due to more intense weathering of potash bearing minerals, release of labile K from organic residues, application of K fertilizers and upward translocation of K from lower depth with capillary rise of ground water (Hirekurbar *et al*., 2000 and Patil *et al.,* 2008).

Available micronutrients

Grape requires both major and minor nutrients for proper growth and development. Out of many micronutrients available Fe, Mn, Cu, Zn are the four important nutrients which are found to influence the growth and yield of the grape crop.

Though iron is not a constituent of chlorophyll, it is essential for its synthesis. It acts as catalyst in enzyme action. Manganese is essential for chlorophyll synthesis. Copper is a constituent of several enzymes participation in the cellular oxidation reduction processes while zinc is involved in the bio-synthesis of a plant hormone and a component of variety of enzymes. It also plays a vital role in nucleic acid, protein and chlorophyll synthesis.

The deficiency of Fe, Mn and Zn causes chlorosis of leaves. In all the cases affected leaves exhibit a network of green veins on a very light green background in young leaves. In the advanced stage of Fe deficiency vein also loose green colour. If the deficiency is continued, the leaves become progressive smaller and are shed, so the lower portion of tree should have

Table 5: DTPA extractable micronutrients

Orchard code	Available micronutrients (mg kg^{-1})			
	Fe	Mn	Zn	Cu
Godhri block				
1	2.81	6.10	0.89	2.23
2	4.62	6.18	0.56	1.20
3	4.02	7.55	2.45	4.48
4	5.98	7.50	0.66	1.99
5	4.60	7.06	1.37	2.78
Mean	4.41	6.88	1.19	2.54
Amdapur block				
6	3.40	7.40	2.80	4.90
7	5.68	6.00	0.92	3.49
8	5.15	6.38	0.77	3.99
9	4.03	7.55	1.51	4.87
Mean	4.57	6.83	1.50	4.31
Mangrul Navghare block				
10	4.22	5.68	0.71	4.88
11	5.97	7.55	2.72	4.90
12	3.43	7.51	0.61	1.15
13	4.90	6.45	1.64	3.02
Mean	4.63	3.49	1.12	1.42
Sawargaon Dukre block				
14	4.20	5.90	0.70	1.54
15	3.68	6.20	0.95	1.65
16	4.78	6.17	1.47	2.45
17	3.87	5.72	0.73	1.21
18	3.62	5.10	0.82	1.33
19	4.21	4.90	1.52	2.15
20	3.58	4.72	1.10	1.72
21	5.10	4.92	1.66	2.22
22	4.89	6.21	0.98	1.49
23	3.99	4.25	1.62	1.21
Mean	4.192	5.409	1.155	1.697
Chandhai block				
24	4.10	5.23	1.32	1.26
25	5.42	4.88	1.81	1.38
26	4.23	5.11	1.42	0.92
27	4.72	4.23	1.23	0.88
28	3.66	2.74	1.22	1.05
29	4.10	2.52	1.42	1.18
Mean	4.37	4.12	1.40	1.11
Palaskhed Block				
30	5.72	3.62	1.87	1.52
31	4.89	3.32	2.10	1.51
32	4.62	2.81	1.78	1.12
33	4.98	3.10	1.69	1.32
Mean	5.05	3.21	1.86	1.37

fair amount of Fe for good foliage.

The main distinguishing feature between zinc deficiency and manganese deficiency is that the size and shape of leaves are normal in manganese deficiency unlike zinc deficiency the leaves in zinc deficiency are small and with acute tips. The first evidence of copper deficiency is the production of unusually dark green leaves with irregular margin on the older wood while new leaves on tender shoots are very small and are shed quickly.

The available Fe, Mn, Cu and Zn in the studied soils (Table 5) indicated that the soils are high in Mn followed by Fe, Cu and Zn. The $CaCO_3$ increase with depth of profile cause a decrease in available Zn with depth. Additionally it may also be due to high Fe and Cu that have antagonistic effect with Zn (Olsen, 1972).

Fe, Mn and Cu are found in moderate to high level, Fe ranged from 2.81 to 5.98 mg kg^{-1} and found low in the deep black and strongly calcareous soils.

The same condition was with available Mn and Cu which were in the range of 3.32 to 7.55 mg kg^{-1} and 0.82 to 4.90 mg kg^{-1} respectively. The higher Mn and Fe content in the soil may be due to the ferromagnesium parent material. High $CaCO_3$ cause low available Mn and Cu in the profile. Available Cu is high on surface layer than sub-surface layers. This may be due to the spraying of copper fungicide on vine against fungal disease (Downy mildew).

The data regarding status of DTPA extractable micronutrients

Table 6: Productivity of grape

Orchard code	Variety	Yield (t ha^{-1})
Godhri block		
1	Thompson	8.25
2	Tas A-Ganesh	8.50
3	Sonaka	14.00
4	Tas A-Ganesh	16.80
5	Sonaka	8.0
Amdapur block		
6	Thompson	12.70
7	Tas A-Ganesh	18.50
8	Tas A-Ganesh	15.20
9	Sonaka	15.80
Mangrul Navghare block		
10	Sonaka	13.20
11	Tas A-Ganesh	8.0
12	Tas A-Ganesh	15.80
13	Tas A-Ganesh	13.00
Sawargaon Dukre block		
14	Tas A-Ganesh	13.60
15	Sonaka	15.40
16	Tas A-Ganesh	16.20
17	Sonaka	11.50
18	Sonaka	12.10
19	Tas A-Ganesh	14.90
20	Sonaka	11.50
21	Tas A-Ganesh	11.60
22	Sonaka	16.50
23	Sonaka	14.20
Chandhai block		
24	Sharad Seedless	12.70
25	Sonaka	13.40
26	Sonaka	13.10
27	Tas A-Ganesh	16.90
28	Sonaka	9.50
29	Sonaka	10.00
Palaskhed Block		
30	Sonaka	10.50
31	Thompson	11.10
32	Sonaka	13.10
33	Sonaka	10.50

Table 7: Correlation between soil parameters and yield of the grape

Orchard code	Yield ('r' value)
pH (1:2.5)	-0.126
EC (dSm^{-1})	0.173
OC (g kg^{-1})	0.693**
$CaCO_3$ (%)	-0.553**
N (kg ha^{-1})	0.740**
P_2O_5 (kg ha^{-1})	0.719**
K_2O (kg ha^{-1})	0.413*
Fe (mg kg^{-1})	0.146
Mn (mg kg^{-1})	0.256
Zn (mg kg^{-1})	-0.233
Cu (mg kg^{-1})	0.083

* Significant at 5% and ** Significant at 1%

in grape orchards varied as per soil type. The maximum amount of Fe was observed in Palaskhed block and minimum was in Sawargaon Dukre block. In respect of Zn and Mn maximum availability was noticed at Mangrul and Godhri block respectively. The soils of Godhri are having good amount of copper. Among the total samples analyzed for their micronutrients from different blocks it is observed that Godhri, Sawargaon and Chandhai blocks are deficient in available Fe, while all the blocks are sufficient in Zn. The data (Table 5) indicated that the average contents of all micronutrients were higher in most of the soils which may be attributed to higher clay and organic matter content in these soils. An increasing content of micronutrient was observed with increase in the fineness of texture and organic carbon. Similar findings were also reported by Gajbhiye *et al*. (1993) on shallow to deep black soils of Maharashtra.

Soil classification

Soil classification is a method of systematically organizing the knowledge and perception about the attributes of soils to facilitate the communication and understanding on national and international levels uniformly. Based on the field morphology and laboratory data, the soils of the study area have been classified according to the U.S. comprehensive system of soil classification (Soil Survey Staff, 1998). The soils of the study area belongs to three orders viz., Entisols, Inceptisols and Vertisols .

Entisols

Entisols are the shallow soils (< 50 cm) that occupy plains, undulating lands and dissected table lands. The Entisols of the study area have ochric epipedon and qualify for sub-order orthents. Due to presence of Ustic moisture regime these soils are grouped as Ustorthens and further classified as Typic Ustorthents. The pedons P_1, P_2, P_4, P_9 and P_{10} are classified as Entisols and further classified as Typic Ustorthents.

Inceptisols

Inceptisols are observed on upper and lower plateaus. Due to presence of cambic horizon and Ustic moisture regime, they are classified as Ustepts and Haplustepts. The pedons P_5 and P_6 are classified as Inceptisols and further classified as Typic Haplustepts.

Vertisols

Vertisols, occur on lower plateau and are deep, very dark grayish brown to very dark gray, clayey with cracks and intersecting slickensides. These soils qualify for the order Vertisols and meet all the requirements for the sub-group Typic Haplusterts (Pedons 3,7, 8).

Productivity of grape

Yield is an important attribute of any crop and the variation in yield may be due to management practices, selection of cultivars and climatic factors. But management of any crop is the key of profit.

In the grape orchards of study area it has been observed that there is a wide variation in soil type of the orchards. The data in respect of yield of grape are presented in Table 6. The yield of grape slightly varied according to its cultivar. But in general yield ranged between 8.00 to 18.50 t ha^{-1} in the study area. The block wise yield range of Godhri (8.25 to 16.80 t ha^{-1}), Amdapur (12.70 to 18.50 t ha^{-1}), Mangrul (8.0 to 15.80 t ha^{-1}), Sawargaon Dukare (11.50 to 16.50 t ha^{-1}), Chandhai (9.50 to 13.40 t ha^{-1}), Palaskhed (10.50 to 13.10 t ha^{-1}) indicate that the highest yield was observed in the Amdapur block. This is due to good soil type, management practices, selection of cultivar, irrigation facilities present in the area.

Table 8: Quality parameters of grape

Orchard Code	Variety	TSS(^{0}B)	Acidity (%)	Reducing sugar (%)
Godhri Block				
1	Thompson	21.42	0.54	16.30
2	Tas-A-Ganesh	20.66	0.52	15.26
3	Sonaka	23.32	0.60	16.69
4	Tas-A-Ganesh	19.58	0.50	16.29
5	Sonaka	23.30	0.67	20.12
Amdapur Block				
6	Thompson	21.84	0.55	16.78
7	Tas-A-Ganesh	21.71	0.49	16.82
8	Tas-A-Ganesh	22.32	0.55	16.32
9	Sonaka	21.38	0.62	18.30
Mangrul Navaghare Block				
10	Sonaka	22.83	0.60	17.38
11	Tas-A-Ganesh	20.36	0.53	17.02
12	Tas-A-Ganesh	21.52	0.56	15.86
13	Tas-A-Ganesh	18.78	0.59	15.85
Sawargaon Dukre Block				
14	Tas-A-Ganesh	19.39	0.52	17.35
15	Sonaka	22.66	0.68	19.76
16	Tas-A-Ganesh	20.51	0.52	17.26
17	Sonaka	23.19	0.60	18.59
18	Sonaka	22.42	0.67	16.27
19	Tas-A-Ganesh	19.64	0.51	18.77
20	Sonaka	23.72	0.62	22.78
21	Tas-A-Ganesh	18.30	0.63	15.68
22	Sonaka	22.80	0.62	21.88
23	Sonaka	21.02	0.64	20.89
Chandhai Block				
24	Sharad	22.14	0.69	21.48
25	Sonaka	21.06	0.58	20.80
26	Sonaka	22.30	0.51	22.30
27	Tas-A-Ganesh	21.10	0.48	15.42
28	Sonaka	22.70	0.65	22.12
29	Sonaka	23.1	0.66	21.37
Palaskhed Block				
30	Sonaka	22.3	0.67	20.18
31	Thompson	20.6	0.53	17.44
32	Sonaka	23.2	0.66	20.36
33	Sonaka	22.8	0.60	19.66

The correlation between various soil properties and yield of grape was worked out and the data are presented in Table 7. The correlation is a relationship between two variable qualities such that an increase or decrease of one as associated with an increase or decrease in the other.

The relation between soil characteristics and yield of grape in selected orchards indicate that pH of the soils under grape orchard was negatively correlated with yield whereas EC was positively co-related with yield. The organic carbon content in the soil was positively correlated with yield. The calcium carbonate in the soils of grape orchards had negative correlation with yield, indicating that with increase in $CaCO_3$ content, there is decrease in yield of grape.

A positive correlation was also found in availability of nitrogen, phosphorus and potassium in the soil and yield of grape. As the availability of nutrients increased, the yield of grape increased simultaneously. In case of micronutrients a negative correlation has been observed with available Zinc. The contribution of Zinc in yield of grape was not significant.

Quality of grape

The quality of table grape is judged by the various organic and inorganic components present in the juice. In grape, a variety is judged as superior or inferior depending upon the TSS content of juice and sugar acid blend for taste. The data obtained in respect of TSS, acidity and reducing sugar of the grape orchards in the study area are presented in Table 8.

Total Soluble Solids (TSS)

Total soluble solids are the good indicator of quality, the quality of fruit depends upon its TSS content. Generally the TSS of the grape juice ranging form 11.8 to 52.2 ^{0}Brix were recorded by (Kulkarni *et al.*, 1986). The grape in the study area had TSS between 18.30 to 23.32^0 Brix. The highest TSS was observed in the Sonaka grape cultivar followed by Sharad seedless). It is observed that TSS and reducing sugar increased with severity of pruning.

Titratable Acidity (%)

Titratable acidity of fruit of the study area ranged between 0.48 to 0.69%. The highest acidity observed in Sharad seedless in the Chandhai block. The acidity of the grape ranging from 0.44 to 1.11% was recorded by Sharma *et al.*, 1993.

Reducing sugar (%)

Reducing sugar of the study area ranged between 15.26 to 22.30%. The higher reducing sugar found in the Sonaka. A large variation in reducing sugar content ranging form 14.15 to 23.80% of grape has been reported by Parhad, 1983. Similar results were also observed by Tulsi Gurjar *et al.,* 2015 and Jarande *et al.,* 2016.

In general, the highest TSS and reducing sugar was observed in the Sonaka grape cultivar followed by Sharad seedless whereas the higher acidity was observed in Sharad seedless. The presence of higher calcium carbonate (> 10% $CaCO_3$) content affected the growth and productivity of grape.

In view of the above, it can be concluded that shallow to deep soils with proper management and optimum calcium carbonate (< 10% $CaCO_3$) were found to be suitable for grape cultivation.

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