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# Growth and yield of grape as influenced by soil-site parameters in Nasik district of Maharashtra

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## Abstract

Six grape growing typical pedons in Nasik district, Maharashtra were characterised and soil-site parameters were correlated with yield and yield attributes of the crop. These soils were very shallow (Darana), moderately deep (Mahiravani, Kothure), shallow (Shivdi), deep (Talegaon) and very deep (Andersool) and characterised by well drained (Darana, Mahiravani, Shivdi) and moderately well drained (Talegaon, Kothure, Andersool). The height, stem girth, spread volume, bunch per plant, berries per bunch were very much related with soil depth, drainage, pH, available water content and DTPA extractable micronutrient cations.

**Key words**: Grape, soil characterstics, growth, yield, drainage, depth, available water content

## Introduction

The grape (*Vitis vinifera* L.) is one of the important commercial export oriented horticultural crop mostly grown in the state of Maharashtra, Andhra Pradesh, Karnataka, Tamilnadu, Haryana and Punjab in India under varied pedo-edaphic environments of sub-tropical to hot tropical regions. The hot tropical region is major viticulture region accounting for 70 per cent of the area under grape in the country. It occupies 44.3 thousand hectares of area associated with production of 1137.8 thousand MT and productivity of 25.7 MT/ha. About 85 per cent of the total production, irrespective of the variety, is consumed fresh. In Maharashtra, grape cultivation is mostly confined to Nasik, Ahemadnagar, Pune, Satara, Sangli and Osmanabad districts which contribute major share in grape production of the country., although a significant variation in productivity was observed among districts. Nasik district emerged as a grape district in Maharashtra with large area and high productivity. However, there is a wide variation in productivity of grape, owing to varied landscape, soil characteristics (Jagdish Prasad *et al.,* 1995) and agro-managements.

Through present study, an attempt has been made to characterize the typical grape growing soils of Nasik district to understand their potential and constraints in grape production. The relationship between plant characterstics and soil parameters like soil depth, drainage, pH, available water content and DTPA extractable micronutrient cations have been worked out.

## Materials and methods

Nasik district falls under sub region AER 6.2 associated with dry sub-humid to semi-arid ecosystem in the grape growing areas. The mean minimum and maximum temperatures are 25.9 and 30.9°C, respectively and represent *Ustic* moisture and *Isohyperthermic* temperature regimes. To ascertain the variability in grape yield *vis-à-vis* the soil-site characteristics, six typical soils in the villages of *viz.* Darana ($P_1$), Talegaon ($P_2$), Mahiravani ($P_3$), Shivdi ($P_4$), Kothure ($P_5$), and Andersool ($P_6$) under grape orchards of 5-7 yrs old were investigated (Soil Survey Division Staff, 1995) from Satana, Dindori, Nasik, Niphad and Yeola tehsils of Nasik district.

The growth and growth parameters *viz.,* height, stem girth (15 cm above ground), canopy (spread volume), average number of bunches/plant and berries/bunch were recorded (mean value of 5 plants). The horizon-wise soil samples were analysed for soil properties (coarse fragments, sand, silt, clay, bulk density, water retention, pH, EC, organic carbon, $CaCO_3$, exchangeable Ca, Mg, Na, K, micronutrient cations and CEC) following the standard procedures and soils were taxonomically classified (Soil Survey Staff, 1998).

## Results and discussion

The climate, landscape and soil characteristics and their range reported by different research workers against resources available (yield also) in present study (Table 1) were considered

Table 1. Growth and yield parameters in selected vineyards

| Pedon/ Location | $P_1$ Darana village (Satana) | $P_2$ Talegaon village (Dindori) | $P_3$ Shivdi village (Niphad) | $P_4$ Mahiravani village (Nasik) | $P_5$ Kothure village (Niphad) | $P_6$ Andersool village (Yeola) |
|---|---|---|---|---|---|---|
| Height (m) | 1.52 | 1.64 | 1.49 | 1.74 | 1.40 | 1.40 |
| Stem girth (cm) | 18.20 | 18.00 | 20.00 | 14.40 | 20.30 | 18.50 |
| Spread ($m^2$) | 2.26 | 3.33 | 3.14 | 2.65 | 3.93 | 4.00 |
| Average bunches $plant^{-1}$ | 35.00 | 52.00 | 46.00 | 45.00 | 43.00 | 40.00 |
| Average berries $bunch^{-1}$ | 68.00 | 115.00 | 68.00 | 86.00 | 122.00 | 85.00 |
| Yield $plant^{-1}$ (kg) | 7.14 | 17.90 | 9.30 | 11.60 | 15.70 | 10.20 |
| Yield (t $ha^{-1}$) | 12.50 | 36.80 | 14.89 | 23.80 | 21.50 | 23.60 |

Table. 2. Physical properties of soils

| Horizon | Depth (cm) | Coarse fragments (%) | Particle-size distribution (%) | | | Bulk density (mg $m^{-3}$) | Water retention | | AWC (%) | AWC (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | v/v | Sand | Silt | Clay | | 33 kPa | 1500 kPa | | |
| Pedon 1:Clayey, smectitic (calcareous) Typic Ustorthents | | | | | | | | | | |
| Ap | 0-10 | 9.44 | 25.9 | 21.6 | 52.5 | 1.62 | 31.56 | 29.4 | 12.16 | 197.0 |
| Pedon 2: Fine, smectitic (calcareous) Typic Haplustepts | | | | | | | | | | |
| Ap | 0-20 | 6.3 | 20.0 | 25.5 | 54.5 | 1.53 | 38.08 | 15.54 | 22.50 | 377.2 |
| Bw1 | 20-49 | 4.7 | 24.4 | 23.6 | 52.0 | 1.65 | 34.30 | 17.75 | 16.50 | 272.2 |
| Bw2 | 49-91 | 12.8 | 21.3 | 25.2 | 53.5 | 1.70 | 34.70 | 16.01 | 18.69 | 217.7 |
| BC | 91-150+ | 10.7 | 48.4 | 20.1 | 31.5 | 1.72 | 22.46 | 9.81 | 12.65 | 217.5 |
| Pedon 3: Loamy over sandy, mixed (calcareous) Typic Ustorthents | | | | | | | | | | |
| Ap | 0-15 | 4.3 | 41.4 | 18.7 | 39.9 | 1.23 | 24.34 | 11.28 | 13.06 | 160.6 |
| AC | 15-30 | 9.8 | 45.0 | 26.5 | 28.5 | 1.26 | 19.56 | 10.64 | 8.92 | 112.3 |
| Pedon 4: Clayey, smectitic (calcareous) Typic Haplustepts | | | | | | | | | | |
| Ap | 0-11 | 8.3 | 22.6 | 24.9 | 52.5 | 1.36 | 31.98 | 21.35 | 10.63 | 144.5 |
| Bw | 11-29 | 8.4 | 19.3 | 26.7 | 54.0 | 1.39 | 39.95 | 28.94 | 13.10 | 182.0 |
| Pedon 5: Very- fine smectitic (calcareous) Leptic Haplusterts | | | | | | | | | | |
| Ap | 0-16 | 9.8 | 12.2 | 21.8 | 66.0 | 1.59 | 46.19 | 30.94 | 15.25 | 242.4 |
| Bw | 16-36 | 11.7 | 10.2 | 25.3 | 64.5 | 1.69 | 39.6 | 29.36 | 10.21 | 172.5 |
| Bss | 36-69 | 3.2 | 9.8 | 26.2 | 64.0 | 1.72 | 40.6 | 29.93 | 10.67 | 183.5 |
| Pedon 6: Very- fine smectitic (calcareous) Typic Haplusterts | | | | | | | | | | |
| Ap | 0-14 | 2.7 | 19.6 | 22.9 | 58.5 | 1.57 | 40.47 | 25.09 | 15.38 | 241.4 |
| Bw | 14-43 | 3.2 | 10.2 | 28.3 | 61.5 | 1.64 | 38.77 | 25.71 | 13.06 | 241.1 |
| Bss1 | 43-83 | 1.2 | 10.4 | 28.6 | 61.0 | 1.69 | 45.98 | 22.47 | 22.51 | 397.3 |
| Bss2 | 83-125 | 1.4 | 8.4 | 27.1 | 64.5 | 1.73 | 51.23 | 32.60 | 18.83 | 325.7 |
| Bss3 | 125-155 | - | 7.7 | 25.3 | 67.0 | 1.73 | 50.22 | 21.22 | 29.00 | 501.7 |

for grouping the soils/sites into different suitability classes for growing grape in these sites.

These soil pedons had their development over basalt or basaltic alluvium ($P_3$) and occur at an elevation of 550 to 700 m above MSL but within a similar climatic zone. These soil pedons were very shallow ($P_1$), shallow ($P_4$), moderately deep ($P_3$ & $P_5$), deep ($P_2$) and very deep ($P_6$) and were endowed with well drained ($P_1$, $P_3$ and $P_4$) and moderately well drained ($P_2$, $P_5$ & $P_6$) environment. These soil pedons exhibited dark grayish brown (10YR) matrix colour barring two pedons ($P_1$ & $P_4$) that had brown (7.5YR) matrix colour.

**Soil properties and grape yield**: Pedon 1 soil being very shallow, strongly alkaline (pH 8.7) associated with ESP 5.0 had vine height of 1.52 m, stem girth 18.2 cm, number of bunches 35 per plant and number of berries 68 per bunch. It seems that soil constraints particularly of depth and ESP are managed by manure/agro management which has been reflected in high organic carbon content of the soil (Table 3) also. The height, stem girth, spread volume, bunches per plant, berries per bunch were 1.64 m, 18cm, 3.33 $m^3$, 52 and 115, respectively in vineyard of pedon 2 which clearly demonstrates the effect of soil solum, favourable DTPA -extractable micronutrients, pH than the soil of pedon 1. Shallow solum, sandy substratum, low AWC are the factors, which caused low yield in pedon 3, but girth was more than the pedon 1 and 2. Although pedon 4 had lower values with respect to stem girth and spread volume per plant, yield was better than pedon 1 and 3 owing to well drained soil, neutral to slightly alkaline pH favouring availability of nutrients and more particularly of DTPA-extractable micronutrients.

The very-fine (more than 60 % clay) Vertisols (pedons 5 & 6) associated with moderately well drained drainage and sodicity impairing the hydraulic conductivity (Kadu *et al.,* 2003) and $CaCO_3$ (pedon 6) seems to be the factors (Table 2 and 3) responsible for lower yield of grape expressed through other growth factors.

The correlation study indicated that the plant height had significant negative relationship with pH and ESP. Negative correlations were also observed between stem girth and AWC, however, spread volume and berries/bunch had significant negative correlation with DTPA- extractable Cu but positive with DTPA-Mn. $CaCO_3$ content adversely affected bunch per plant owing to its adverse effect on nutrient availability (Kadao *et al.,* 2002). The multiple regression analysis related with plant parameters had the following relationship with different soil parameters.

**Plant height (m)** = 60.54 + (-9.523 x depth) + (-0.546 x pH) + (-0.31 x EC) + (0.209 x $CaCO_3$ + (-120 x C4) + (-0.009 x Mn) + (0.017 x CEC) + (0.306 x ESP) + (-0.014 x clay) $R^2$ = 86

**Stem girth (cm)** = -42.181 + (-0.013 x depth) + (8.030 x pH) + (13.642 x EC) + (-0.052 x Mn) + (-0.192 x Cu) + (-1.421 x ESP) + (0.124 x clay) $R^2$= 0.69

**Spread ($m^2$)** = 12.097 + (0.004 x depth) + (-1.055 x pH) + (3.763 x EC) + (-0.018 x $CaCO_3$) + (-0.036 x Cu) + (0.066 x Mn) + (0.054 x CEC) + (0.017 x ESP) + (-0.075 x clay) $R^2$ = 0.68

**Bunches per plant** = -139.902 + (0.165 x depth) + (-11.36 x pH) + (56.24 x EC) + (1.629 x $CaCO_3$) + (-0.68 x Cu) + (-0.913 x Mn) + (0.892 x EC) + (-2.325 x ESP) + (-9.556 x clay) $R^2$ = 0.80

Table 3. Chemical properties of soils

| Horizon | Depth (cm) | pH (1:2.5) | EC (1:2.5) $dSm^{-1}$ | Organic carbon g $kg^{-1}$ | $CaCO_3$ g $kg^{-1}$ | DTPA-extractable (mg $kg^{-1}$) | | | | Exchangeable cations cmol ($p^+$) $kg^{-1}$ | | | | CEC cmol ($p^+$) $kg^{-1}$ | Base saturation (%) | ESP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Cu | Fe | Zn | Mn | $Ca^{++}$ | $Mg^{++}$ | $Na^+$ | $K^+$ | | | |
| Pedon 1: Clayey, smectitic (calcareous) Typic Ustorthents | | | | | | | | | | | | | | | | |
| Ap | 0-10 | 8.7 | 0.20 | 9.0 | 74.9 | 7.9 | 5.20 | 1.3 | 5.94 | 36.5 | 6.00 | 2.87 | 0.72 | 49 | 94.0 | 5.8 |
| Pedon 2: Fine, smectitic (calcareous) Typic Haplustepts | | | | | | | | | | | | | | | | |
| Ap | 0-20 | 8.2 | 0.26 | 6.6 | 101.9 | 11.64 | 5.22 | 1.70 | 11.84 | 42.5 | 5.16 | 0.54 | 0.82 | 51 | 96.1 | 1.0 |
| Bw 1 | 20-49 | 8.3 | 0.25 | 5.5 | 177.1 | 2.50 | 2.52 | 0.80 | 10.80 | 37.0 | 4.50 | 0.48 | 0.35 | 45 | 94.5 | 1.0 |
| Bw 2 | 49-91 | 8.4 | 0.18 | 2.4 | 217.1 | 1.94 | 3.82 | 0.18 | 7.36 | 25.5 | 2.66 | 0.46 | 0.28 | 32 | 90.3 | 1.4 |
| BC | 91-150 | 8.5 | 0.15 | 2.3 | 227.1 | 1.16 | 4.50 | 0.16 | 4.33 | 19.2 | 2.16 | 0.76 | 0.22 | 25 | 89.3 | 3.0 |
| Pedon 3 : Loamy over sandy, mixed (calcareous) Typic Ustorthents | | | | | | | | | | | | | | | | |
| Ap | 0-15 | 8.3 | 0.17 | 7.3 | 174.3 | 22.0 | 5.5 | 1.58 | 12.84 | 21.1 | 4.33 | 0.55 | 1.33 | 32 | 85.3 | 1.7 |
| AC | 15-30 | 8.4 | 0.13 | 5.6 | 169.4 | 2.84 | 6.18 | 0.16 | 18.4 | 15.3 | 3.33 | 0.65 | 0.66 | 23 | 86.0 | 2.8 |
| Pedon 4: Clayey, smectitic (calcareous) Typic Haplustepts | | | | | | | | | | | | | | | | |
| Ap | 0-11 | 7.4 | 0.11 | 3.5 | 28.0 | 19.04 | 7.82 | 3.06 | 5.78 | 22.2 | 6.83 | 0.36 | 0.92 | 33 | 87.9 | 1.0 |
| Bw | 11-29 | 7.2 | 0.08 | 1.2 | 41.0 | 5.92 | 9.92 | 0.68 | 3.44 | 14.8 | 8.0 | 0.39 | 0.49 | 29 | 74.7 | 1.3 |
| Pedon 5: Very- fine smectitic (calcareous) Leptic Haplusterts | | | | | | | | | | | | | | | | |
| Ap | 0-16 | 8.4 | 0.17 | 9.0 | 41.0 | 2.12 | 6.40 | 0.40 | 32.1 | 44.1 | 8.16 | 0.90 | 0.88 | 59 | 91.5 | 1.5 |
| Bw | 16-36 | 8.5 | 0.20 | 5.0 | 40.7 | 1.52 | 8.74 | 0.06 | 16.3 | 43.9 | 7.83 | 1.36 | 0.66 | 54 | 98.1 | 2.5 |
| Bss | 36-69 | 8.0 | 0.23 | 3.1 | 73.5 | 1.50 | 8.16 | 0.16 | 15.7 | 38.5 | 6.83 | 1.34 | 0.65 | 52 | 91.0 | 2.5 |
| Pedon 6: Very- fine smectitic (calcareous) Typic Haplusterts | | | | | | | | | | | | | | | | |
| Ap | 0-14 | 8.2 | 0.38 | 7.6 | 162.2 | 11.52 | 3.10 | 1.66 | 24.2 | 24.6 | 8.0 | 1.08 | 2.91 | 38 | 94.3 | 2.8 |
| Bw | 14-43 | 8.4 | 0.37 | 6.5 | 215.3 | 2.46 | 3.94 | 0.30 | 16.9 | 18.4 | 13.5 | 2.31 | 0.62 | 38 | 91.6 | 6.0 |
| Bss1 | 43-83 | 8.6 | 0.40 | 2.5 | 217.0 | 2.92 | 3.92 | 0.20 | 25.5 | 16.3 | 17.83 | 4.59 | 0.46 | 43 | 91.1 | 10.7 |
| Bss2 | 83-125 | 8.8 | 0.53 | 3.6 | 216.3 | 2.10 | 4.92 | 0.16 | 8.66 | 14.9 | 20.0 | 3.28 | 0.51 | 42 | 92.1 | 7.8 |
| Bss3 | 125-150+ | 8.9 | 1.22 | 1.1 | 227.0 | 1.74 | 4.62 | 0.06 | 7.16 | 13.7 | 17.83 | 3.07 | 0.48 | 40 | 87.7 | 7.6 |

**Berries per bunch** = 446.915 + (0.165 x depth) + (-46.729 x pH) + (23.284 x EC) + (0.216 x $CaCO_3$) + (-1.323 x Cu) + (1.577 x Mn) + (2.864 x CEC) + (-2.232 x ESP) + (-1.962 x clay) $R^2 = 0.74$

**Yield (kg/plant)** = 136.804 + (0.057 x depth) + (-15.941 x pH) + (6.672 x EC) + (-0.134 x $CaCO_3$) + (-0.258 x Cu) + (0.567 x Mn) +(0.945 x CEC) + (-0.140 x ESP) + (-0.707 x clay) $R^2 = 0.69$

Multivariate regression analysis of the different plant parameters with soil characteristics indicated regression coefficient ($R^2$) of plant height 0.86, stem girth 0.69, spread 0.68, bunches per plant 0.80, berries per bunch 0.74 and yield 0.69. This shows that the soil parameters such as depth, pH, EC, Mn, Cu, ESP and clay combinedly express the per cent variation in plant parameters such as height, stem girth, spread, bunches per plant, berries per bunch and yield (kg $plant^{-1}$) by 86, 69, 68, 80, 74 and 69 per plant, respectively.

The suitabilities arrived are permanently not suitable for $P_1$ due to limitations of soil characteristics *viz*. pH 8.7 that limit the nutrient availability and depth (<10 cm) that limit the availability of foothold. However the yield reported at this site was 12.5 t/ha, which might be due to intensive agro-managements rather than landscape and soil characteristics. Pedons 3 and 4 have moderate limitation of pH, calcium carbonate and texture therefore they could be rated as moderately suitable. Pedons 2 and 5 have slight limitation of pH, $CaCO_3$, hence they are ranked as highly suitable. Pedon 6 is presently not suitable due to limitations in nutrient availability.

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