PLANT SCIENCE TODAY
Vol 12(sp4): 01–08
https://doi.org/10.14719/pst.10402

eISSN 2348-1900

RESEARCH ARTICLE

Characterisation and classification of grape-supporting soils of the northern dry zones of Karnataka

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Received: 02 July 2025; Accepted: 30 October 2025; Available online: Version 1.0: 08 December 2025

Cite this article: Harsha BR, Anil KKS, Kaushik S, Jagdish P, Lalitha M, Parvathy S, Nandeesha CV, Rajneesh S, Karthik DR, Gamit MK, Jyothi MS, Arti K. Characterisation and classification of grape-supporting soils of the northern dry zones of Karnataka. Plant Science Today. 2025;12(sp4):01–08. https://doi.org/10.14719/pst.10402

Abstract

The soils of the Northern Dry Zone (NDZ) of Karnataka have great potential for quality grapes for their sweetness and nutraceutical properties. Nine (09) pedons occurring on different pedo-edaphic environments under grape cultivation were randomly selected, scientifically studied and analysed for characterisation and classification of the NDZ, Karnataka. The pedons studied were moderately deep to deep and had more than 30 % clay in most of the horizons, barring a few exceptions, but clay content increased in sub-soils. These soils were neutral to strongly alkaline and had relatively higher organic carbon content (0.5 % to >1.0 %) in the surface layers of pedons. The cation exchange capacity of these soils ranged from 7.7 to 47.96 cmol (p$^+$) kg^{-1}, mainly related to clay and organic matter content. These clayey soils were dark reddish brown/dark brown, moderate to well-drained and well aggregated with or without free calcium carbonate content and possess relevant diagnostic horizon/properties and accordingly classified as Aridic Paleustalfs, Typic Rhodustalfs, Aridic Haplustalfs, Aridic Haplusterts, Vertic Haplocalcids, Vertic Haplocambids, Vertic Haplustepts and Aridic Haplustepts. This study would help to understand the variability in soils and their pedo-edaphic properties for the delineation of suitable sites and formulation of best management practices.

Keywords: grape-supporting soils; northern dry zone soils; soil characterisation; soil classification

Introduction

In India, grapes (*Vitis vinifera*) stand fifth in cultivation with a high remunerative value of foreign exchange through export. The total area of grapes cultivated in India is 1.40 lakh ha with a production of 3.13 million tonnes (9th rank in the world) and Karnataka ranks second with superior quality of grapes with a production of 3.39 lakh tonnes from an area of 29110 ha, behind Maharashtra with 7.74 lakh tonnes from 86000 ha (1, 2). The raisin and table purpose varieties of grape vines, such as Thompson Seedless, Sharad Seedless, 2A clone, etc. are frequently cultivated in the NDZ of Karnataka. The superior quality and higher productivity in Karnataka are mainly due to the favourable conditions, such as the soils and climate prevailing in the region. However, in recent years, the yield of grape-supporting areas has been declining exponentially (3).

Grapes can be cultivated on various soils, having coarser to finer textures. The soil should be well-drained with good water-holding capacity and devoid of any hard pan or impervious layer in the top 90 cm, with a 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 a pH range of 6.5-8.0 are considered ideal. Characterising and classifying major grape-supporting soils will provide and long-term solution for identifying the potentials and limitations of soils related to crop production. The characterisation and classification of grape-supporting soils in the Nashik district of Maharashtra, India, revealed that soil depth, drainage, pH and available water content significantly influenced the soil properties, while DTPA-extractable micronutrient cations were closely associated with grapevine growth and yield (4, 5).

Similarly, research indicates that grape yield and quality in the Buldana district of Maharashtra are positively correlated with soil organic carbon content and negatively correlated with free calcium carbonate (6). Light-textured soils and too heavy-textured soils with high concentrations of salts of alkali metals or other toxic substances might not be favourable for grapes (7). Even crop injury may be expected if the soil conductivity values cross 2.5 dS m^{-1}. The study area comes under hot and dry arid climate conditions where the chances of accumulation of salts in the sub-surface soils are high, particularly the sulphate and carbonates of sodium and calcium, which may harm the root activity of grapes.

While grape-supporting soils have been characterised in regions like Maharashtra, systematic studies focusing on the NDZ of Karnataka are scarce, particularly with respect to both surface and sub-surface soil properties. This study addresses this gap by providing a comprehensive assessment of soil physical, chemical and fertility parameters, identifying site-specific constraints such as salinity, calcareousness and organic carbon variability, thereby offering a more detailed understanding of soil suitability for sustainable grape cultivation in the region. In view of the above, the present study was undertaken to characterise the soils of grape-supporting soils in the NDZ of Karnataka to identify the surface and sub-surface soil properties that limit the crop productivity potential.

Materials and Methods

The study area was chosen based on the area, production and productivity (2013-2014) of major grape-supporting regions of north Karnataka falling under the NDZ (1). The primary objective of this study was to characterise and classify the grape-supporting soils of the NDZs of Karnataka based on their morphological, physical, chemical and physicochemical properties, to assess their fertility status and identify the soil constraints influencing grape productivity. The major soil orders occurring in the NDZ of Karnataka are Vertisols, Inceptisols, Entisols and Alfisols. The sampling locations are presented in Table 1. The study location falls in a hot and dry arid climate with an average rainfall range of 509.0 (Athani) to 662.3 mm (Basavana Bagewadi). The respective mean annual minimum and maximum temperatures are 25.0 °C and 27.1 °C in Jamkhandi and Indi, respectively and the mean minimum and maximum relative humidity are 52 % in Jamkhandi and 69.9 % in Yelaburga. Climatic parameters were collected from the India Meteorological Department for Karnataka (1966 to 2002).

Representative sampling sites were selected based on yield levels, geology and physiography of the study area. Nine typical pedons (Fig. 1) were studied for colour, texture, gravel percentage and horizon sequence representing the major soil groups supporting grape cultivation in Northern Karnataka. At each typifying site, a soil profile pit measuring 1.5 × 1.5 × 1.5 m was excavated. The profiles were oriented to ensure adequate illumination for clear horizon demarcation. Horizon boundaries were identified based on variations in texture, structure, colour and detailed observations on depth, texture, colour, consistency, rock fragments, presence of mottles and structural features were recorded following the standard proforma for soil profile description. The morphological properties of the soils were studied following the procedure explained in the USDA Soil Survey Manual (8). Horizon-wise soil samples collected from different pedons were processed and analysed for understanding relevant physical and chemical properties. All the analyses were done following standard procedures (9).

Soil colour was determined by using the standard Munsell soil colour chart. The international pipette method was used for particle size analysis (9). Air-dry soil particles of < 2 mm size fraction were treated with H_2O_2 to dissolve organic matter and completely dispersed using sodium hexa-meta phosphate with an ultrasonicator. The sand particles were separated by passing the dispersed solution through the 300-mesh sieve and the obtained solution after sieving is analysed for silt and clay fractions. Bulk density was determined gravimetrically by the core method.

Soil pH was determined through the potentiometric method by taking a freshly stirred 1:2.5 soil: water suspension (9). For organic carbon determination, the wet digestion method was followed, where a known weight of powdered (0.2 mm sieved) sample was treated with a known volume of standard potassium dichromate and concentrated H_2SO_4 (10). The unreacted potassium dichromate ($K_2Cr_2O_7$) was analysed with standard ferrous ammonium sulfate using ferroin indicator. Cation Exchange Capacity (CEC) was determined by the ammonium acetate leaching method (9). Using a 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 micro-Kjeldahl distillation technique determined the NH_4^+ ions adsorbed in the exchangeable soil surface. The ammonium acetate extract was used for determining the exchangeable bases as Ca^{2+} and Mg^{2+} determined through the Atomic Absorption Spectrophotometry and Na^+ and K^+ by flame photometry. The cation exchange capacity by the sum of cations was estimated by summing up the total of $BaCl_2$

Table 1. Area, production and productivity of grapes in different taluk of Northern Dry Zone, Karnataka

Pedon	Location	Taluk	District	Area (ha)	Production (t)	Productivity (t ha^{-1})
P_1	15° 07' 23.3" N; 76° 08' 59.6" E	Hagaribommanahalli	Bellari	477	7942	16.65
P_2	15° 33' 25.2" N; 76° 10' 32.3" E	Yelaburga	Koppal	325	5270	16.22
P_3	16° 10' 05.3" N; 75° 38' 34.5" E	UHS farm (Bagalkote)	Bagalkote	177	3006	17.00
P_4	16° 31' 00.9" N; 75° 18' 58.8" E	Jamkhandi	Bagalkote	1164	30945	26.59
P_5	16° 45' 43.9" N; 74° 57' 05.4" E	Athani	Belagavi	1809	27590	15.25
P_6	16° 52' 52.1" N; 75° 28' 09.3" E	Vijayapura	Vijayapura	7452	149040	20.00
P_7	16° 37' 27.5" N; 75° 58' 15.7" E	B. Bagewadi cv. Thompson seedless	Vijayapura	357	7140	20.00
P_8	16° 37' 15.1" N; 75° 58' 31.1" E	B. Bagewadi cv. Manikchaman	Vijayapura	357	7140	20.00
P_9	17° 09' 16.3" N; 75° 56' 37.4" E	Indi	Vijayapura	732	14640	20.00

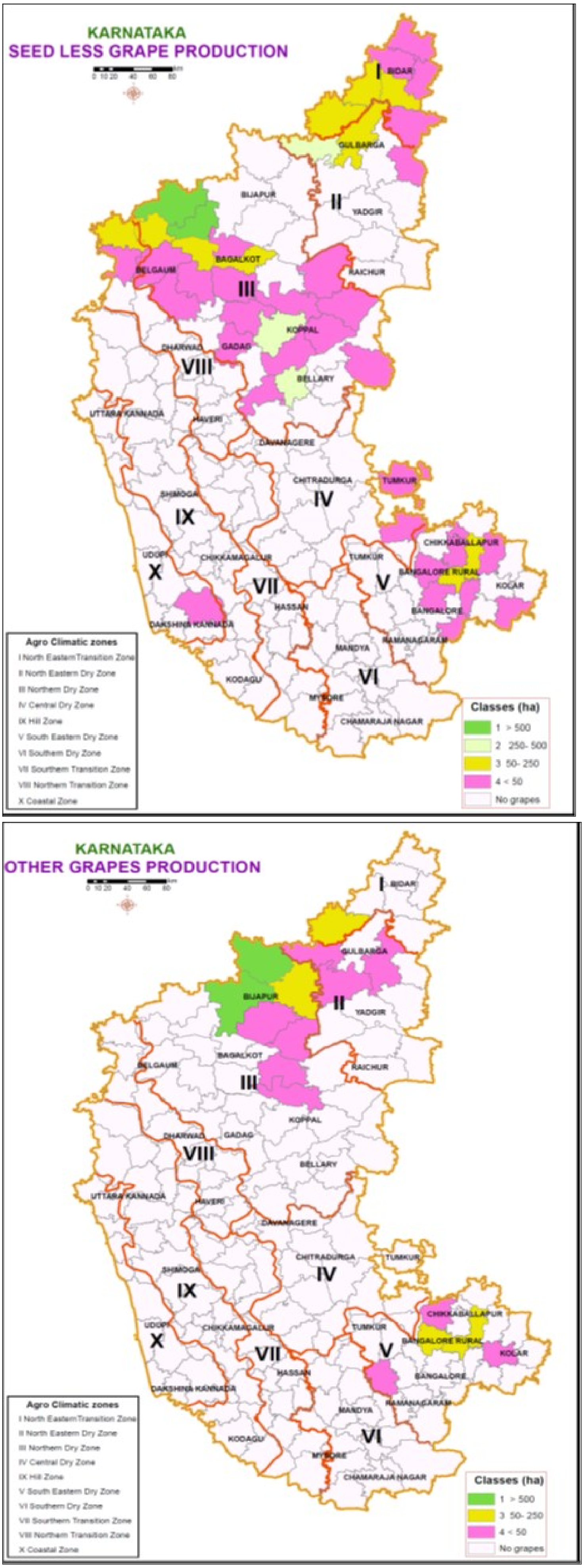

Fig. 1. Concentration per taluk of seedless and other dominant grapes varieties (raisin and wine varieties) grown in Northern Karnataka.

extractable acidity and total exchangeable bases. Carbonate dissolution determines that calcium carbonate concentration is in excess of 1N HCl, followed by back titration of the remaining acid using 1N NaOH (11). Base saturation (%) was calculated using the formula in Equation 1.

$$\text{Base saturation (\% B.S)} = \frac{\text{sum of exchangeable bases}}{\text{CEC}} \times 100 \quad \text{(Eqn. 1)}$$

Results and Discussion

Morphological characteristics

The site and morphological characteristics of the pedon studied are presented in Table 2 & suppl Table 1. The pedons were moderately deep (UHS farm, Bagalkote) to very deep (Yelaburga), varying from 95 to more than 151 cm. The topography and slope gradient have resulted in the depth variation (12). Among the pedons, the distinctness of the soil boundary varied from clear to gradual and topography was smooth. These pedons had their colour in 2.5YR to 10YR hues with values ranging from 2.5 to 6 and chromas 1 to 4. Soil colour in the surface layer varied from dark reddish brown to dark brown and lower horizons had yellowish brown to dark brown (Suppl Table 1). The colour variation is attributed to the differential degrees of erosion, low organic matter content and rubrification by iron oxide and haematite (13, 14). The textural class varied from sand to clay, possibly due to differential soil formation processes, i.e. *in-situ* weathering and clay illuviation (15, 16). The soil structure varied from weak to massive, coarse to fine and granular to angular blocky in different horizons. The soil structure was massive in the horizons of the UHS farm (Bagalkote) (BC horizon), B. Bagewadi cv. Manikchaman (Bwk4 horizon), Vijayapura (CB horizon) and Indi (CBk horizon) soils due to the lack of aggregation in the layers. The consistency of soil varied from extremely hard to soft when dry, very friable to very firm when moist and non-sticky to very sticky and non-plastic to very plastic when wet.

Physical and chemical characteristics

Among the studied pedons, P_4 (Jamkhandi, Bagalkote district) recorded the highest grape productivity (26.59 t ha^{-1}). This higher yield is likely due to a combination of favourable soil characteristics including better fertility status, good drainage observed, optimal texture and suitable physicochemical properties that support vine growth and nutrient uptake. Additionally, site-specific management practices such as irrigation scheduling, organic amendments and canopy management may have contributed to the superior grape yield in this pedon compared to others. The grape-supporting soils had clay content ranging from 5.3 % (Crk horizon of P_9) to 54.9 % (Ap horizon of P_6). The clay content in different horizons appears to depend on their position on the landscape and parental legacy (17). Further, the illuviation of clay resulted in increased clay content in the sub-surface horizons of some pedons (18). Silt content in soils ranged from 1.5 % to 35.0 % and sand content varied from 24.7 % to 89.8 %. The sand and silt distribution was irregular with depth due to the differential weathering of parent materials and erosion (18). The bulk density of different horizons of the pedon ranged from 1.11 to 1.94 Mg m^{-3}. The variability in bulk density could also be due to sand and gravel content in some horizons (18). The pH in soil water suspension (1:2.5 soil: water ratio) ranged from 7.0 to 8.6 (neutral to strongly alkaline) among the soils due to the accumulation of carbonates of $Ca^{2+}$and Mg^{2+}under the hot and dry arid climatic situations. Soils were non-saline with an EC range of 0.07 to 0.92 dS m^{-1}, indicating the favourable status of cations and anions essential in grape-vine nutrition (19). The organic carbon content ranged from 0.3 to 14.4 g kg^{-1} in different horizons, with the highest (14.4 g kg^{-1}) in the surface layer of the Athani pedon. The surface horizons exhibited higher organic carbon (OC) content due to the accumulation of litter, crop residues and root biomass, while OC progressively decreased with soil depth (20, 21). Across all pedons, the highest OC values were consistently observed in the Ap horizon, gradually declining in the subsoil. This vertical distribution reflects greater organic matter inputs and microbial activity near the surface, which diminish with increasing depth.

Soil classification

Hagaribommanahalli and UHS farm (Bagalkote) had an argillaceous horizon with a hue of 2.5YR in more than 50 cm thickness of pedon, the value of moist soil - 3 and dry value not more than 1 unit higher than the moist value and hence classified as Rhodustalfs at the great group level. It did not exhibit any integrations with other taxa or an extragradation from the central concept and was classified as Typic Rhodustalfs at the sub-group level. Yelaburga pedon possesses a hyperthermic and aridic soil moisture regime and thus was keyed out as an Aridic Paleustalf. Indi pedon did not meet the requirements

Table 2. Site characteristics of grapes growing soils of NDZ, Karnataka, India

Pedon No./Name	Elevation (m) M.S.L.	Rainfall (mm)	Landform	Slope (%)	Drainage	Erosion	Parent Material
P_1 (Hagari bommanahalli)	487	556.7	Very gently sloping upland	1-3	Well drained	Slight	Archaean granite-gneiss complex
P_2 (Yelaburga)	734	576	Undulating inland plateau	1-3	Well drained	Slight	Archaean granite-gneiss complex
P_3 (UHS farm (Bagalkote))	524	558.7	Very gently sloping undulating schist upland	1-3	Well drained	Moderate	Dharwar schist
P_4 (Jamkhandi)	535	539.7	Undulating upland schistose	3-5	Moderately well drained	Slight	Alluvium
P_5 (Athani)	552	509	Undulating upland upper piedmont	3-5	Well drained	Moderate	Alluvium
P_6 (Vijayapura)	540	646.5	Gently sloping plain basaltic upper piedmont	1-3	Moderately well drained	Slight	Basalt
P_7 (B. Bagewadi *cv.* Thompson seedless)	636	662.3	Undulating upland	3-5	Well drained	Moderate	Basalt
P_8 (B. Bagewadi *cv.* Manikchaman)	611	662.3	Gently sloping pediment and undulating upland	1-3	Well drained	Slight	Basalt
P_9 (Indi)	448	629.4	Undulating upland schist	3-5	Well drained	Slight	Basalt/schist complex

of all other great groups at the sub-order level of Ustalfs and was classified as Aridic Haplustalfs at the sub-group level.

The presence of more than 50 % clay close enough to intersect within 100 cm and slickensides (>25 cm thick) in Vijayapura and B. Bagewadi pedons cultivated for cv. Thomson seedless, thus grouped as Vertisols at the order level and Aridic Haplusterts at the sub-group level. These are the soils that, if not irrigated during the year, develop cracks that are 5 mm or more wide within 50 cm of the mineral soil surface for 210 or more cumulative days per year. B. Bagewadi pedon associated with cv. Manikchaman had a hyperthermic soil temperature and an aridic moisture regime and therefore, was classified as Aridisols at the order level. It has been classified at a great group level as Haplocalcids, which remains dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and has a moisture regime that borders on ustic; therefore, classified as Ustic Haplocalcids at the sub-group level.

The pedon of B. Bagewadi had a hyperthermic soil temperature and an aridic moisture regime and therefore keyed out as Aridisols at the order level. The vertical section of both the soils possessed a weakly developed cambic B horizon within 100 cm of the soil surface and the absence of duripan, petrocalcic and petrogypsic horizons within 150 cm makes it qualify for cambids at the sub-order level and Haplocambids at the great group level. Jamkhandi and Athani pedons, by having cambic horizons grouped under the Inceptisols order. Jamkhandi pedon possessed vertic properties (LE > 6 cm), thus classified as Vertic Haplustepts. Athani has an aridic moisture regime and is classified as Aridic Haplustepts up to the sub-group level.

The deep to very deep, non-saline, non-sodic, non-gravelly, well-drained, light-textured soils (loam, sandy clay loam, sandy loam and clay loam) with neutral pH (6.5-7.5) and high available nutrient content are highly suitable for grapes in attaining desirable yield (22, 23). The characterisation of grape-supporting soils showed that all the pedons were deep and non-saline. However, the soils of pedon P_4 and P_6 were heavy-textured (clay > 45 %), which might affect soil drainage and are moderately suitable for grape cultivation. Pedons 4, 7, 8 and 9 are moderately suitable for grape cultivation due to soil pH limitations, as they had a pH range of 7.6-8.4 (Table 3) and the presence of calcium carbonate in the sub-surface. High soil pH may also affect the availability and uptake of nutrients by grapes (24). Applying suitable amelioration measures with the provision of drainage facilities will improve the soil parameters, including the nutrient dynamics, for improved yield (25-28). Based on the soil characterisation, appropriate soil management strategies such as incorporation of organic manures, balanced nutrient application, adoption of soil and water conservation measures and provision of proper drainage can be suggested to improve the productivity of less suitable pedons (29). The high calcium carbonate content leading to reduced nutrient availability and poor soil structure can be ameliorated by the incorporation of large quantities of organic manures or green manures, application of acid-forming fertilisers (like ammonium sulphate) and use of gypsum or elemental sulphur in localised calcareous patches. Additionally, mulching and drip irrigation help maintain favourable soil moisture and improve nutrient uptake efficiency in grape cultivation (30). These interventions will help enhance soil health, nutrient availability and grape yield sustainability in the region.

Table 3. Physico-chemical properties of grape-supporting soils of NDZ, Karnataka, India

Horizon	Depth (cm)	Sand	Silt	Clay	B.D. ($Mg\ m^{-3}$)	pH	EC ($dS\ m^{-1}$)	OC $g\ kg^{-1}$	% Base Saturation	$CaCO_3$ Equivalent (%)
		(%)								
P_1 (Hagaribommanahalli): Clayey over coarse-loamy, mixed, hyperthermic, Typic Rhodustalfs										
0-30	**Ap**	39.1	14.0	46.9	1.50	7.57	0.13	5.7	87.64	0.00
30-55	**A2**	62.5	6.7	30.8	1.58	7.57	0.08	3.9	97.77	0.71
55-77	**AB**	78.1	5.6	16.3	1.65	7.76	0.07	1.5	87.58	1.06
77-110	**Bt1**	50.5	8.3	41.2	1.82	8.45	0.19	1.2	87.67	1.76
110-130	**Bt2**	43.9	10.9	45.2	1.34	8.50	0.17	0.9	99.15	3.53
130-151+	**CB**	43.1	10.0	46.9	1.48	8.55	0.16	0.6	98.58	1.88
Mean		52.9	9.3	37.9	1.56	-	0.13	2.3	93.07	1.49
S. D.		14.8	3.1	12.2	0.16	-	0.05	0.20	5.97	1.22
P_2 (Yelaburga): Fine, mixed, hyperthermic,Aridic Paleustalfs										
0-19	**Ap**	86.9	1.5	11.6	1.56	7.64	0.09	6.0	95.78	0.12
19-42	**AB**	63.1	8.1	28.8	1.58	7.50	0.11	4.5	98.49	0.59
42-66	**Bt1**	54.7	7.7	37.6	1.49	7.51	0.13	2.1	79.38	2.00
66-84	**Bt2**	46.9	9.3	43.8	1.42	7.34	0.15	0.9	91.30	2.00
84-101	**Bt3**	51.2	14.4	34.4	1.30	7.25	0.18	0.6	88.30	2.12
101-151+	**Bt4**	43.6	11.8	44.6	1.54	7.02	0.17	0.5	80.03	0.71
Mean		57.7	8.8	33.5	1.48	-	0.14	2.4	88.88	1.43
S. D.		15.8	4.4	12.2	0.11	-	0.03	0.23	7.93	0.69
P_3 (UHS farm (Bagalkote): Clayey-skeletal, mixed, hyperthermic, Typic Rhodustalfs										
0-14	**Ap**	32.0	30.4	37.6	1.46	7.54	0.33	6.3	98.54	0.71
14-36	**BA**	33.5	30.1	36.4	1.58	7.40	0.17	3.6	91.74	1.88
36-51	**Bt1**	26.3	27.3	46.4	1.75	7.16	0.20	1.8	90.19	3.06
51-80	**Bt2**	46.3	15.9	37.8	1.55	7.28	0.24	0.6	95.23	2.12
80-95	**CB**	51.9	9.7	38.4	1.69	7.28	0.19	0.6	96.95	3.29
Mean		38.0	22.7	39.3	1.61	-	0.23	2.6	94.53	2.21
S. D.		10.7	9.4	4.0	0.12	-	0.06	0.24	3.50	1.03

P_4 (Jamkhandi): Fine, smectitic, hyperthermic, Vertic Haplustepts										
0-19	**Ap**	40.1	12.5	47.4	1.34	7.68	0.52	11.1	98.62	11.5
19-42	**Bw1**	42.5	8.0	49.5	1.68	8.09	0.31	7.7	95.81	11.9
42-68	**Bw2**	35.3	13.4	51.3	1.71	8.24	0.29	2.4	94.40	12.5
68-83	**Bw3**	32.0	15.6	52.4	1.59	8.20	0.37	1.5	98.59	13.9
83-125	**BC**	43.2	12.4	44.4	1.68	8.10	0.42	0.8	93.58	15.5
Mean		38.6	12.4	49.0	1.60	-	0.38	4.7	96.20	13.1
S. D.		4.8	2.8	3.2	0.15	-	0.09	0.45	2.34	1.64
P_5 (Athani): Loamy-skeletal, smectitic hyperthermic, calcareous, Aridic Haplustepts										
0-13	**Ap**	29.6	24.5	45.9	1.26	7.52	0.55	14.4	94.37	5.64
13-30	**AB**	35.5	26.3	38.2	1.38	7.82	0.39	5.1	95.39	3.53
30-49	**Bw1**	37.9	26.0	36.1	1.73	7.94	0.33	3.9	92.02	9.40
49-73	**Bw2**	38.1	27.8	34.1	1.70	7.92	0.31	2.1	91.75	8.81
73-95	**Bw3**	46.4	21.1	32.5	1.57	7.95	0.29	1.5	94.19	6.93
95-122+	**CB**	54.1	8.0	37.9	1.56	7.89	0.36	1.2	93.32	1.48
Mean		40.3	22.3	37.5	1.53	-	0.37	4.7	93.51	8.19
S. D.		8.7	7.4	4.7	0.18	-	0.09	0.50	1.42	3.89
P_6 (Vijayapura): Fine, smectitic, hyperthermic, calcareous, Aridic Haplusterts										
0-11	**Ap**	24.7	20.4	54.9	1.22	7.67	0.75	6.0	96.39	19.0
11-25	**Bw**	29.7	23.6	46.7	1.21	7.81	0.58	4.5	95.56	18.3
25-41	**Bss1**	28.2	18.6	53.2	1.23	7.95	0.62	3.6	94.20	19.5
41-62	**Bss2**	26.4	22.0	51.6	1.46	8.16	0.89	2.4	94.54	19.9
62-82	**BC**	26.8	22.5	50.7	1.36	8.27	0.92	1.8	98.32	19.4
82-104+	**CB**	37.7	13.8	48.5	1.40	8.48	0.87	0.6	99.76	21.2
Mean		28.9	20.2	50.9	1.31	-	0.77	3.2	96.46	19.6
S. D.		4.6	3.6	3.0	0.11	-	0.15	0.20	2.19	0.95
P_7 (B. Bagewadi*cv*. Thompson seedless): Fine, smectitic, hyperthermic, calcareous, Aridic Haplusterts										
0-17	**Ap**	26.9	34.9	38.2	1.28	7.68	0.52	11.1	94.44	15.4
17-38	**AB**	26.0	35.0	39.0	1.53	8.09	0.31	5.7	92.43	16.5
38-64	**BA**	35.8	13.8	50.4	1.56	8.24	0.29	2.4	92.71	15.6
64-86	**Bss**	25.8	20.6	53.6	1.38	8.20	0.37	1.5	92.59	12.8
86-93	**CB**	29.4	32.3	38.3	1.54	8.10	0.42	0.8	96.20	19.9
Mean		28.8	27.3	43.9	1.46	-	0.38	4.3	93.67	16.1
S. D.		4.2	9.6	7.5	0.12	-	0.09	0.42	1.63	2.58
P_8 (B. Bagewadi*cv*. Manikchaman): Fine, smectitic, hyperthermic, calcareous, Ustic Haplocalcids										
0-19	**Ap**	46.4	20.6	33.0	1.45	8.30	0.29	6.0	98.48	21.0
19-31	**Bwk1**	45.2	19.2	35.6	1.37	8.28	0.28	2.7	95.01	19.7
31-47	**Bwk2**	48.2	13.9	37.9	1.36	8.30	0.21	2.4	95.75	21.0
47-70	**Bwk3**	51.4	12.1	36.5	1.85	8.32	0.24	1.2	94.36	20.9
70-87	**Bwk4**	45.4	17.1	37.5	1.52	8.27	0.24	1.2	94.07	19.9
87-125+	**BCk**	47.6	13.2	39.2	1.94	8.13	0.32	0.3	94.60	14.8
Mean		47.4	16.0	36.6	1.58	-	0.26	2.3	95.38	19.6
S. D.		2.3	3.5	2.2	0.25	-	0.04	0.20	1.63	2.41
P_9 (Indi): Fine, mixed, hyperthermic, calcareous, Aridic Haplustalfs										
0-17	**Ap**	51.9	14.2	33.9	1.15	7.98	0.40	7.5	94.09	16.6
17-39	**Btk1**	50.2	11.0	38.8	1.36	8.18	0.18	4.2	96.42	14.2
39-54	**Btk2**	45.2	11.0	43.8	1.37	8.15	0.21	2.7	96.96	14.3
54-72	**BCk**	45.1	14.2	40.7	1.35	8.17	0.19	2.1	95.99	19.3
72-88	**CBk**	44.2	10.4	45.4	1.22	8.31	0.17	1.8	96.76	20.2
88-115+	**Crk**	89.8	4.9	5.3	1.19	8.38	0.14	1.2	98.05	19.4
Mean		54.4	11.0	34.7	1.27	-	0.22	3.3	96.38	17.3
S. D.		17.6	3.4	14.9	0.10	-	0.09	0.23	1.32	2.66

Conclusion

Grape-supproting soils of northern Karnataka were light to fine in texture, dark reddish brown or dark brown, moderately well-drained to well-drained and better aggregated with argillaceous or cambic sub-surface horizons exhibiting vertic properties. These soils belonged to the orders Alfisols, Aridisols, Vertisols and Inceptisols with mixed or smectitic mineralogy, showing the dominance of smectite or illite minerals. Heavy texture associated with poor soil drainage was a limitation for grape growth in a few lowland pedons. The presence of calcium carbonate in P_4, P_6, P_7, P_8 and P_9 may affect nutrient availability and, in turn, crop production. Selecting suitable varieties and implementing appropriate amelioration measures would achieve desirable yields in these soils. Understanding the variation in pedo-edaphic properties at different sites would help farmers and stakeholders in planning site-specific agro-management for sustained grape production. Compared to previous studies in Karnataka and similar regions, this study provides a more detailed pedon-level characterisation including both surface and sub-surface horizons, highlighting site-specific constraints such as calcareousness and vertic properties. These findings enhance current knowledge by identifying the spatial variability and soil limitations that were not explicitly documented in earlier work.

Acknowledgements

The authors would like to thank ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre, Bangalore, Karnataka, India and Department of Soil Science and Agricultural Chemistry, University of Agricultural Science, Bangalore, Karnataka, 560065, India.

Authors' contributions

HBR carried out field data collection, soil sampling and analysis, data interpretation, manuscript drafting and overall coordination of the research. KSAK helped in conceptualisation, field data collection, survey, GPS mapping and contributed to soil profile description and classification. KS carried out methodology standardisation, laboratory supervision and statistical analysis of soil properties. JP participated in guidance on soil taxonomy, critical inputs in soil classification and manuscript review. LM carried out laboratory soil analysis, quality control of analytical procedures, sequence alignment, manuscript review and data validation. PS carried out laboratory soil analysis, data tabulation and quality control of analytical procedures, manuscript review. AK carried out laboratory soil analysis and quality control of analytical procedures. NCV carried out laboratory visualisation of results, figures preparation and support in manuscript formatting. RS carried out statistical support, critical review of results and technical editing of the manuscript. KDR carried out Field coordination, data curation and review of soil fertility parameters. GMK contributed to soil sampling, compilation of field data and manuscript proofreading. All authors read and approved the final manuscript. JMS helped in the critical review, incorporated corrections for the reviewer's comment and the recent reference part was incorporated into the manuscript.

Compliance with ethical standards

Conflict of interest: The Authors do not have any conflicts of interest to declare.

Ethical issues: None

References

1. Food and Agriculture Organization (FAO). Table and dried grapes: FAO-OIV FOCUS-2016. Food and Agriculture Organization of the United Nations and the International Organisation of Vine and Wine. 2016.
2. National Horticulture Board (NHB) and Department of Horticulture, Govt. of Karnataka (DOH-GOK). 2019.
3. Food and Agriculture Organization (FAO). Grape production statistics of India. 2020.
4. Balpande HS, Challa O, Jagdish P. Characterization and classification of grape-supporting soils in Nasik district, Maharashtra. J Indian Soc Soil Sci. 2007;55:80-3.
5. Balpande HS, Challa O, Jagdish P. Growth and yield of grape as influenced by soil-site parameters in Nasik district of Maharashtra. J Appl Hort. 2008;10:67-9. https://doi.org/10.37855/jah.2008.v10i01.14
6. Ikhe UD, Gabhane VV, Sonune BA, Damre PR. Assessment of yield and quality of grapes on different soils in Buldana district of Maharashtra. The Bioscan. 2017;12:385-93.
7. Winkler A. General viticulture. Berkeley and Los Angeles: University of California Press; 1965.
8. Soil Survey Staff. Keys to soil taxonomy. 12th ed. Washington (DC): USDA Natural Resources Conservation Service; 2014.
9. Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India Pvt. Ltd.; 1973.
10. Walkley AJ, Black IA. Estimation of soil organic carbon by the chromic acid titration method. Soil Sci. 1934;37:29-38. https://doi.org/10.1097/00010694-193401000-00003
11. Horvath B, Opara-Nadi O, Beese F. A simple method for measuring the carbonate content of soils. Soil Sci Soc Am J. 2005;69:1066-68. https://doi.org/10.2136/sssaj2004.0010
12. Vinay L. Characterization and classification of soil resource of Bhanapur micro-watershed (Koppal district) for land evaluation [MSc thesis]. Dharwad (IN): University of Agricultural Sciences; 2007.
13. Patil PL, Dasog GS. Genesis and classification of ferruginous soils in Western Ghats and coastal region of North Karnataka. Agropedology. 1999;9:1-15.
14. Jadhav LB, Jagdish P, Karthikeyan K, Tiwary P. Characterization and suitability assessment of some pomegranate-growing and associated soils of Solapur district, Maharashtra. J Indian Soc Soil Sci. 2019;67:260-71. https://doi.org/10.5958/0974-0228.2019.00029.X
15. Geetha SPV, Naidu MVS. Studies on genesis, characterization and classification of soils in semi-arid agro-ecological region: A case study in Banaganapalle Mandal of Kurnool District, Andhra Pradesh. J Indian Soc Soil Sci. 2013;61:167-78.
16. Harsha BR, Anil KKS. Characterization, classification and fertility of Bangalore blue grapes growing soils of Karnataka. Mysore J Agricl Sci. 2022;56:138-46.
17. Wilson MJ. The importance of parent material in soil classification: A review in a historical context. Catena. 2019;182:104131. https://doi.org/10.1016/j.catena.2019.104131.
18. Srinivasan R, Natarajan A, Anil KKS, Kalaivanan D. Characterization of major cashew-growing soils of Dakshina Kannada district of Karnataka. Agropedology 2013;23: 59-64.

19. Nair KM, Anil KKS, Ramesh KSC, Ramamurthy V, Lalitha M, Srinivas S, et al. Coconut-growing soils of Kerala: 1. Characteristics and classification. J Plant Crops. 2018;46:75-83. https://doi.org/10.25081/jpc.2018.v46.i2.3718

20. Lalitha M, Kumar P. Soil carbon fractions influenced by temperature sensitivity and land use management. Agrofor Syst. 2015;90:961-64. https://doi.org/10.1007/s10457-015-9876-9

21. Lalitha M, Anil KKS, Shivanand, Dharumarajan S, Kalaiselvi B, Arti K, et al. Land resources characterization of Kangayamblock in Tamil Nadu uplands under dry semiarid eco-region. Agropedology. 2020;30:19-30

22. Naidu LGK, Ramamurthy V, Challa O, Hedge R, Krishnan, P. Maunal soil–site suitability criteria for major crops. NBSS Publ. No. 12. Nagpur: National Bureau of Soil Survey and Land Use Planning; 2006. 118 p.

23. Avinash RK, Anil KKS, Karthika KS, Kalaiselvi B, Sujatha K. Coconut-growing soils in southern Karnataka: Characterization and classification. J Plant Crops. 2019;47:96-106.

24. Vaidya PH, Pawar Y, Kadam S. Characterization and classification of pomegranate growing soils of Osmanabad district Maharashtra. Int J Innov Res Dev. 2014;3(9):187-189.

25. Visalakshi DPA, Naidu MVS, Ramakrishna RA. Characterization and classification of sugarcane growing soils in southern Agro-Climatic Zone: A case study in eastern mandals of Chittoor district in Andhra Pradesh. J Indian Soc Soil Sci. 2015;63:245-258. https://doi.org/10.5958/0974-0228.2015.00034.1

26. Sekhon KS, Kaur A, Thaman S, Gupta N, Malik A, Bishnoi C, et al. Sustaining grape yield and soil health under saline-sodic irrigation through amendments and canal water application. Water. 2025;17(18):2683. https://doi.org/10.3390/w17182683

27. Kaya Ö, Yilmaz T, Ateş F, Kustutan F, Hatterman-Valenti H, Seyed HH, et al. Improving organic grape production: the effects of soil management and organic fertilizers on biogenic amine levels in *Vitis vinifera* cv. 'Royal' grapes. Chem Biol Technol Agric. 2024;11:38. https://doi.org/10.1186/s40538-024-00564-2

28. Harsha BR, Anil KKS, Nandeesha CV, Vanitha T, Karthika KS, Upadhaya Bharati, et al. Climatic analysis, soil site suitability evaluation and soil organic carbon stock studies on major grape-growing soils in the Southern Karnataka, India. Commun Soil Sci Plant Anal. 2023. https://doi.org/10.1080/00103624.2023.2254331

29. Patil SL, Reddy RS, Kumar R. Soil characterization and management interventions for enhancing productivity in dryland soils of Karnataka. J Indian Soc Soil Sci. 2024;72(1):58–66.

30. Singh SK, Meena MC, Ramulu C. Soil-site suitability and management strategies for sustainable grape production in semi-arid regions of India. Pedosphere. 2025;35(2): 189-98.

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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