__Original Research Article__

ASSESSMENT OF SOIL FERTILITY, PHYSICAL CHARACTERISTICS AND CROP SUITABILITY OF PROFILES IN AMBACH VILLAGE, NAVSARI DISTRICT, GUJARAT

ABSTRACT

A study assessed the major nutrients, chemical and physical properties of soils in Ambach village, Chikhli taluka, Navsari district, Gujarat, using five profiles from which 26 soil samples were collected up to 100 cm deep. Soil colors ranged from dark brown (10YR 3/3) to yellowish brown (10YR 5/6) and dark greyish brown (10YR 4/2) to light yellowish brown (10YR 6/4). Drainage varied from moderately to excessively drained, with textures from silty loam to heavy clay. Most pedons had medium sub-angular blocky structures, with bulk density between 1.25 g cc^{-1} and 1.72 g cc^{-1} (mean 1.46 g cc^{-1}) and particle density ranging from 2.09 g cc^{-1} (PN 1) to 2.58 g cc^{-1} (PN 4, mean 2.37 g cc^{-1}). Available moisture content was 3.23% to 16.57% (mean 10.57%), while hydraulic conductivity varied from 0.06 cm hr^{-1} (PN 2) to 8.04 cm hr^{-1} (PN 4). Soil pH ranged from 6.56 (PN 5) to 8.34 (PN 4), and electrical conductivity ($EC_{1:2.5}$) was 0.08 dS m^{-1} (PN 2) to 0.50 dS m^{-1} (PN 5). The exchangeable sodium percentage (ESP) varied from 0.61 to 1.32 (mean 1.01), and cation exchange capacity (CEC) ranged from 39.86 to 52.49 cmol(p+) kg^{-1}, with base saturation between 82.95% and 97.95% (mean 92.31%). Organic carbon levels ranged from 0.1% (PN 4) to 0.5% (PN 1, PN 2, PN 3). Nitrogen levels varied from 40.1 kg ha^{-1} (PN 4) to 225.2 kg ha^{-1} (PN 3, mean 141.0 kg ha^{-1}), phosphorus from 6.6 kg ha^{-1} (PN 4) to 105.4 kg ha^{-1} (PN 3), and potassium from 227.6 kg ha^{-1} (PN 4) to 527.2 kg ha^{-1} (PN 3). Available iron was high except in PN 4, zinc was medium in PN 1 and PN 2, high in PN 3 and PN 5, and low in PN 4, while all pedons showed high levels of available copper. The crop suitability evaluation in the study area indicates that *kharif* rice is moderately to marginally suitable across different profiles, with profiles 1, 2, 3, and5 being moderately suitable (S2) and profile 4 being marginally suitable (S3). Sugarcane shows high suitability in profiles 1, 3, and 4 (S1), and moderate suitability in profiles 2 and5 (S2). Sorghum is highly suitable (S1) across all profiles, while pearl millet is moderately suitable (S2) in profiles 1, 2, 3, and 5, and highly suitable (S1) in profile 4. For mango cultivation, profiles 1, 2, and 4 are moderately suitable (S2), whereas profiles 3 and 5 are highly suitable (S1).

Key words- Soil nutrients, Physical properties, Chemical properties, Bulk density, Cation exchange capacity (CEC), Hydraulic conductivity, soil site suitability.

1. INTRODUCTION

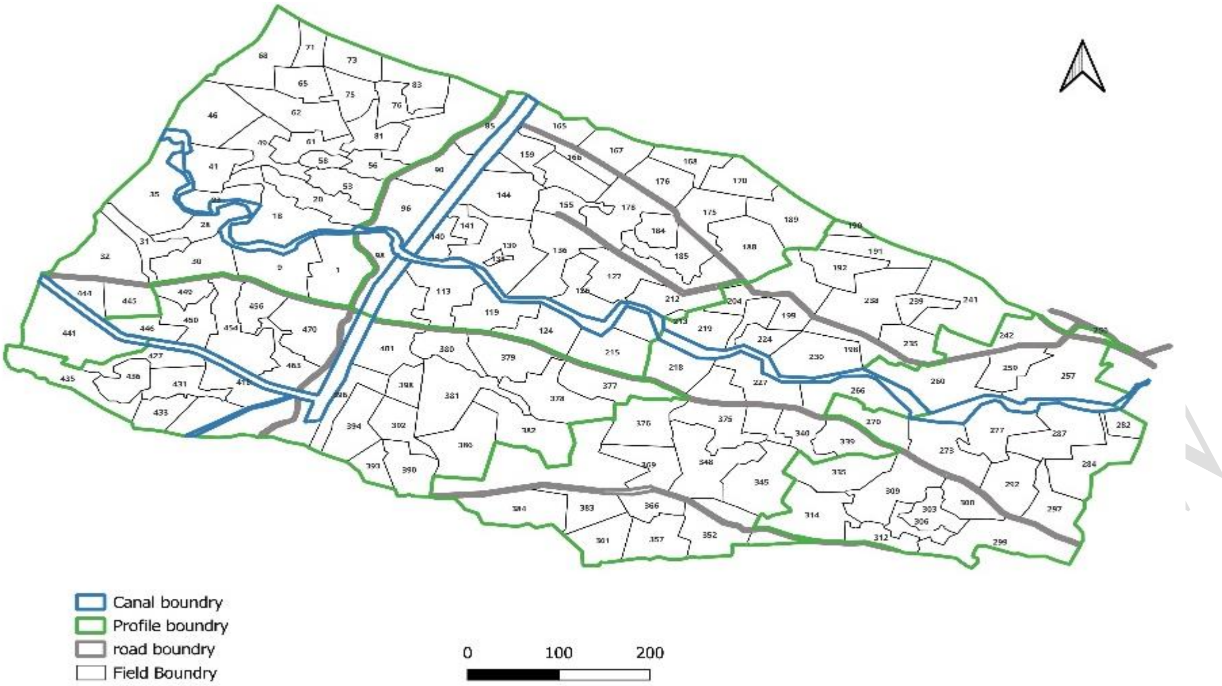
Soil characteristics and properties stem from transformations affecting the Earth's crust material. Joffe (1949) suggests that soil formation in a region occurs over time, influenced by geological material, climate changes, topography, and biological and human activities. These factors' impacts depend on the nature of rocks and their derived formations, as well as landscape relief and the movement of matter in water, either dissolved or suspended (Arnold, 2006). Consequently, topography or relief plays a crucial role in soil formation, influencing water and energy addition and loss in soil. The study also documented natural vegetation, including trees and weeds, all of which had commercial value. Further research is needed to explore the economic potential of various tree species in the study area. Certain fruit-bearing trees, such as karonda, jamun, ber, jackfruit, and dhamna, show significant promise for future use. Crop productivity is determined by soil type, climate conditions, topography, and management practices in a region. Cultivating crops without considering soil and site characteristics can lead to reduced yields and soil health deterioration. To meet population needs sustainably, land resources must be utilized according to their capacity. This goal can be achieved through comprehensive land resource assessments and systematic, scientific evaluation. Land suitability evaluation is the process of estimating land potential for land use planning (Sys *et al*., 1991). To examine the soils of Ambach, researchers selected five sites based on topography and land use variations. Soil profiles were excavated at each site, and samples were collected from every horizon within the pits. These samples underwent analysis to assess their physical, chemical, and fertility characteristics. During sampling, crucial data such as land use, geographic coordinates (latitude and longitude), slope percentage, and other relevant details were carefully recorded on a standardized data sheet. Additionally, the research aimed to evaluate soil-site suitability for growing rice, sugarcane, sorghum, pearl millet, and mango crops.

2. MATERIALS AND METHODS

2.1 Description of The Study Area

The Ambach village of Chikhli taluka in Navsari district was selected for the present study. It lies between 20°73’50” to 20°70’88” North latitude and 73°20’66” to 73°23’71” East longitude, covering a geographical area of 606.06 ha. The landforms in the selected village consist of a nearly level to gently sloping alluvial plain. The ridges extend from Kakadvel in the East to Fadvel in the West, bordered by Saravni to the North and Godthal to the South. The general slope is North-East to South-West, with uplands gently sloping (1-3%) and lowlands nearly level (0-1%). Soils are well-drained but have moderately restricted permeability, and the area is drained by a creek network that flows from the East to the South downstream, alongside

poorly maintained field drains.



Map 1 : Map showing study location

2.2 Soil Sampling and Profile Description

During initial traversing, different landforms having identical topography, soil type, *etc*., were marked on the cadastral maps of the villages. From each landform, a profile was excavated at a representative spot by following the prescribed procedure and subsequently, horizon-wise soil samples were collected. Along with this, the soil survey form prescribed by NBSS and LUP, Nagpur was also filled by recording the physical features, vegetation, colour and present land use, *etc*. For estimating bulk density, horizon-wise soil samples were collected with the help of a core sampler. Depth wise profile soil samples were collected from 5 locations based on the land transverse, relief characteristics and depth wise soil layer formation. In all 26 soil samples were collected from 5 profile locations.

2.3 Soil Physico-Chemical Analysis

After soil samples collection, they were air-dried and passed through a 2 mm sieve, soil colour was determined by Munsell soil color chart, bulk density by core method, particle density by pycnometer, total porosity calculated from the particle density and bulk density using formula $S_t = (1-D_b/D_p)100$, hydraulic conductivity by constant water head method, mechanical analysis by international pipette method, available water capacity by pressure plate membrane and water stable aggregates by wet sieving method. Soil chemical parameters, soil pH and EC was determined by potentiometric method, organic carbon by walkey and black titration method, available N by alkaline permanganate method, available P by Extraction with 0.5M $NaHCO_3$ (pH 8.5) and estimated by spectrometric, available K by Extraction with 1 N NH_4OAc (pH 7) and estimated by flame photometric, micronutrients by DTPA, base saturation by Calculated using formula BS (%) = (Total Exch. Cations/CEC) x 100, CEC by extraction with 1N NaOAc (pH 8.2) and ESP Calculated using formula ESP= (Na/Total Exch. Cations) x100.

Table 1: location, landscape characteristics and land use of profiles of Ambach village, Chikhli taluka, Navsari district, Gujrat

Pedon Village	Location	Elevation above Mean Sea Level (m)	Slope (%)	Drainage	Land use
PN 1	20.7167961° 73.2269579°	66	0-1	Moderately slow-slow	Sugarcane
PN 2	20.73331° 73.22377°	69	0-1	Very slow-slow	Paddy and mango plantation
PN 3	20.715216° 73.22624°	68	0-1	Moderate-Moderately slow	Mango plantation with vegetables
PN 4	20.715216° 73.22624°	68	0-1	Moderately slow-Moderate	Vegetables
PN 5	20.715216° 73.22624°	68	1-3	Moderately slow-Moderate	Forest land

3. RESULT AND DISCUSSION

3.1 Morphological characteristics

The table 1 provides insights into the landscape characteristics and land use of soil profiles (pedons) in Ambach village, Chikhli taluka, Navsari district, Gujarat. Most of the profiles (PN 1 to PN 4) are situated on flat to nearly flat terrain with slopes ranging from 0-1%, while PN 5 has a slightly steeper slope of 1-3%. Drainage characteristics vary among the pedons, influencing their land use. PN 1 exhibits moderately slow to slow drainage due to silty clay texture, and PN 2, classified as very slow to slow which contains high clay particle, represents the slowest drainage conditions. PN 3 and PN 4 have moderate to moderately slow drainage (silty clay loam to loamy soil texture), similar to PN 5 having clay loam texture. Land use across the region is predominantly agricultural, with PN 1 allocated for sugarcane cultivation, PN 2 supporting paddy fields and mango plantations, PN 3 combining mango plantations with vegetable farming, and PN 4 primarily dedicated to vegetable cultivation. In contrast, PN 5 is under forest cover, reflecting its natural vegetation. The region surrounding the soil profile study areas showcases a mix of intensive agricultural practices and natural ecosystems, with drainage conditions playing a significant role in determining land use. Areas with slower drainage are utilized for water-intensive crops like paddy, while sloped areas, such as PN 5, are maintained under forest cover to prevent erosion and sustain ecological balance. This highlights the thoughtful land management practices in the area, adapted to its landscape and drainage characteristics.

The color of soil profiles was found to be dark brown (10YR 3/3) to yellowish brown (10YR 5/6) and dark greyish brown (10YR 4/2) to light yellowish brown (10YR 6/4). The black soils (dark greyish brown to brown) owe their color to a combination of high organic matter content, iron oxides, manganese oxides and clay minerals, with moisture content further influencing the color intensity Prathibha *et al.* (2018). Same results were reported by Hakla and Meena (2020).

The soil profile 1 varies in texture: it has silty clay (0-40 cm layer), changing to silty clay loam from 40-70 cm, and then silty loam at more than 70 cm. Its structure ranges from coarse to moderate angular blocky from 0-16 cm to coarse-fine subangular blocky at greater depth, strong in the 70-93 cm layer. Plasticity changes from friable and slightly sticky (0-40 cm) to friable and slightly plastic in the deeper horizons. Roots are medium-fine in the upper layers (0-16 cm), medium-coarse at 16-40 cm, and diminish to a few fine or absent roots in deeper layers. Boundaries are clear and smooth from 0-40 cm, becoming abrupt and broken below 40 cm. The effervescence differs between strong (0-16 cm), slight at 16-40 cm and becomes violent at 40-70 cm, gradually changing into slight in the bottommost layer (>93 cm). Lime concretions appear at 40-70 cm while calcium mottles at 0-16 cm. The drainage has been moderately slow to slow across the profile.

The soil profile 2 has a heavy clay texture all the way through, but varying structure, plasticity, stickiness, root presence, and effervescence. The upper layers (0-35 cm) have a moderate to strong angular blocky structure that is massive with depth. The texture is consistently sticky and has slight to moderate plasticity, and slight firmness in the deeper layers. Presence of roots is found as general fine roots at the top layers and further down it consists of less fine and more medium roots. The borders are mostly diffused, but they appear more pronounced in the lower layers. Effervescence is slight throughout all the depths, meaning calcium carbonate is relatively low. Drainage is very slow to slow across the profile. The deepest layer (>93 cm) shows a little reduction in stickiness and plasticity but remains firm in consistency.

The soil profile 3 illustrates a range of textures varying from silty clay loam at the surface to loamy at greater depths, accompanied by a consistent presence of medium to fine pores and root distribution. The structure varies from very fine to medium angular blocky but becomes firmer and non-sticky deeper in the profile. Plasticity is only marginal, with the top surfaces being friable and adhesive with the deeper layers firmly compacted and non-sticky. Root presence is moderate towards topsoil, but at more depths, the extent and density of roots will not be as pronounced in their layers. The interface transitions are generally sharp with undulations at the outer extremities, becoming further randomized and wavy from then on. Effervescence is slight in the topsoil, becoming more intense and violent deeper down in the profile, pointing to higher lime content. Drainage is moderate in the upper layers but moderately slow in the deeper sections of the profile, with obvious lime concretions distributed throughout.

The soil profile 4 has varying textures, with silty loam at the surface transitioning to loamy and then to sandy loam down the profile. The latter part of the profile consists of sandy clay loam. The structure is primarily coarse subangular blocky throughout but finer blocky at the surface and coarser blocky deeper down. At all depths, the soil is dry, friable, and slightly sticky with little plasticity. Root presence becomes less with depth, having fine common roots in the toposoil and becoming very fine, few roots with the deeper layers. Boundaries are mainly clear and smooth in the upper portions but become irregular and broken at greater depths. Effervescence is always strong throughout the profile, showing lime presence, being the strongest effervescence observed in the deeper layers. From the topsoil to moderate depths, it is drained slow, otherwise, it's moderately rapid overall.

The profile 5 is characterized by a range of textures that vary from heavy clay at the top to silty clay in the deeper layers. The structure is essentially angular blocky, coarsening to fine subangular blocky with depth. The topsoil is dry, firm, and plastic, becoming more firm and plastic with depth. The soil is generally friable and plastic, but quite sticky at some depths. Root presence is moderate at the surface, becoming fewer and finer with depth, and lime concretions are present deeper. The boundaries are generally smooth, with definite transitions at the surface, but more diffuse boundaries are present at greater depths. Effervescence is slight in the topsoil, increasing to strong and violent effervescence deeper in the profile and indicating high lime content. Drainage is moderate slow in the top layers, and becomes moderate in the lower sections.

3.2 Physical properties of profile sample

The soil profiles were found to have a depth of up to 100 cm. Regarding the mechanical separation, the proportion of sand ranged from 3.28 per cent in PN 2 to 68.05 per cent in PN 4. Silt content varied between 17.10 per cent in PN 4 to 57.49 per cent in PN 3, while the clay content ranged from 14.10 per cent in PN 4 to 62.45 per cent in PN 2. The overall mean values for mechanical separation were 24.35 per cent for sand, 40.88 per cent for silt and 34.75 per cent for clay. The texture of the soils in the study area, based on the proportion of mechanical separates, varied from clay-to- clay loam, with the overall mean texture class being clay. Similar results were reported by Narsaiah *et al.* (2018), Jangir *et al.* (2020) and Parmar *et al.* (2021).

The bulk density of different soils, according to the profile and depth, ranged from 1.25 g cc^{-1} in PN 5 to 1.72 g cc^{-1} in PN 4, with an overall mean bulk density of 1.46 g cc^{-1}. The overall mean of 1.46 g cc^{-1} suggests that, on average, the soil has moderate compaction, which should be suitable for most crops but may benefit from practices that improve soil structure and reduce compaction, such as organic amendments or cover cropping. Patil *et al.* (2023) reported higher values of bulk density contrary to those at lower most elevation or at slightly flat land indicating clogging of pores by dispersed clays in sub-soil layers and leaching loss of clay particle attributed to illuviation of upper surface in The Dang district. Descriptive analysis of South Gujarat zone soil by Patel *et al.* (2015) unveiled the maximum values of BD were 1.48 gm cc^{-1} (pre-monsoon), 1.20 gm cc^{-1} (post-monsoon) and 1.35 gm cc^{-1} (summer) indicating low to high organic matter content.

The particle density of different soils, according to the profile and depth, ranged from 2.09 g cc^{-1} in PN 1 to 2.58 g cc^{-1} in PN 4, with an overall mean 2.37 g cc^{-1}. The soil profile exhibits low particle density. It might be due to the relatively lower particle density values observed in this study suggest the presence of significant amounts of organic matter or the dominance of minerals with lower particle densities, such as quartz (2.65 g cc^{-1}) or calcite (2.71 g cc^{-1}). Similar findings were reported by Hadiya and polara (2017) and Paragi *et al.* (2024).

Porosity of the profile samples were ranged from 28.57 per cent to 50.59 per cent with mean value of 38.33 per cent, indicating variable but generally moderate to high porosity in the study area. Similar findings were reported by Rajan *et al.* (2014).

The analysis indicates a favourable soil structure characterized by significant proportions of water stable aggregates. Specifically, aggregates larger than 0.25 mm constitute 42.65 per cent, suggesting good soil stability and resistance to erosion. Additionally, the presence of aggregates between 0.1 mm and 0.25 mm at 38.26 per cent further supports soil cohesion and water infiltration capacity. These findings collectively suggest a well-structured soil environment conducive to healthy root growth, effective water retention and reduced susceptibility to erosion, highlighting favourable conditions for sustainable agricultural practices. Similar reports were recorded by Kadam *et al.* (2012).

The available moisture content, measured at 1/3 bar and 15 bar, ranged from 3.23 per cent in PN 3 to 16.57 per cent in PN 5, with an overall mean value of 10.57 per cent. The overall mean of 10.57 per cent indicates that the soils, on average, have a moderate capacity to retain moisture, which should support crop production but may need supplementary irrigation during dry spells. Hydraulic conductivity of the profile sample indicated that PN 4 have highest value 8.04 cm hr^{-1}(moderately rapid) as soil is loam to sandy loam and in PN 2 value of hydraulic conductivity was 0.06 cm hr^{-1}(very slow) as soil is clay with overall mean value of 1.67 cm hr^{-1}(moderate slow). It might be due to variability in particle size distribution as clay content is higher in these soils. Similar findings were observed by Hakla and Meena (2020). Amount of organic matter may affect the pore-size of the soil through soil structure development, which also influences hydraulic conductivity. Similar findings were reported by Jangir *et al.* (2018). Similar reports were recorded by Sarki *et al.* (2014).

3.3 Chemical properties of profile sample

Across different profiles and horizons, $pH_{1:2.5}$ values vary from 6.56 in PN 5 to 8.34 in PN 4, with an overall mean of 7.59. These values indicate that the soils in all profiles generally exhibit slightly acidic to neutral $pH_{1:2.5}$ levels. However, PN 4 and PN 1 soils show slightly alkaline $pH_{1:2.5}$ values ranging from 8.05 to 8.34 and 7.87 to 8.23, respectively, with mean values of 8.25 and 7.99. The soils are calcareous in nature with alkaline in reaction ($pH_{1:2.5}$-7.58) were reported by Yadav *et al.* (2022). The relatively high $pH_{1:2.5}$ in these soils might be due to the presence of high degree of base saturation and medium to high degree of sodium saturation which on hydrolysis gives OH^- ions and high component of carbonate and bicarbonate (Chavda *et al*., 2018a).

The electrical conductivity ($EC_{1:2.5}$) values range from 0.08 dS m^{-1} in PN 2 soils to 0.50 dS m^{-1} in PN 5 soils, averaging 0.17 dS m^{-1}. These EC values indicate that the soils salt content is generally within acceptable limits for most crops, suggesting good potential for agricultural productivity without any significant risk of salinity-related issues. It might be due to good natural drainage, irrigation water free from salt. Similar results were reported by Paragi *et al.* (2024).

The Cation Exchange Capacity (CEC) values ranged from 30.80 cmol (p^+) kg^{-1} in PN 5 soils to 57.81 cmol (p^+) kg^{-1} in PN 1 soils, averaging 47.47 cmol (p^+) kg^{-1}. This indicates that these soils possess a strong capacity for retaining both nutrients and water. Medium to high in cation exchange capacity [35.7-70.0 cmol (p^+) kg^{-1}] reported by Vasu *et al.* (2022). The highest CEC values were observed in PN 2 and PN 1. The CEC of the soils were high and it is due to the high clay content and dominance of 2:1 clay mineral such as smectite and vermiculite (Pal *et al*., 2012). Similar results were reported by Gaikwad *et al.* (2018). Variation in clay type and content, organic matter and presence of free iron oxides were responsible for variation in CEC in different pedons at varying physiographic positions reported by Anjali and Hebbara (2018).

The ESP values range from a minimum of 0.20 per cent in PN 4 to a maximum of 2.14 per cent in PN 5, with an average of 1.01 per cent. The free lime ($CaCO_3$ equivalent) in all profile samples analysed ranges from 6.83 per cent in PN 3 to 13.91 per cent in PN 4, averaging 10.15 per cent. These findings indicate that the soils in these profiles do not exhibit sodicity issues. However, they do contain a high concentration of calcium carbonate, which significantly influences their properties and management. The low ESP values suggest minimal risk of soil structural problems associated with sodicity, which is positive for crop productivity.

The base saturation (%) ranged from 82.95 per cent to 97.95 per cent, with mean value of 92.31 per cent. The high base saturation could be attributed to the presence of Ca-rich zeolites and soil modifiers (Pal *et al.,* 2006). The base saturation of pedons were >60 per cent and which varied from 67.55 to 84.17 per cent with mean value 76.29 per cent. The possible reason for higher base saturation might be due to higher amount of Ca^{2+} and Mg^{2+} ions occupying the exchange sites on the colloidal complex of soils in pedons reported by Amaresh and Shinde (2014).

However, the presence of free lime ($CaCO_3$) at relatively high levels can affect nutrient availability and pH balance in the soil. The distribution of calcium carbonate showed an increasing pattern with an increase in the depth of pedons. This was due to downward movement of calcium ions and precipitated in sub-surface layers at higher pH level reported by Singh *et al.* (2016).

To identify the fertility status of the soil, parameters such as organic carbon, available nitrogen (N), phosphorus (P_2O_5), potassium (K_2O) and available micronutrients (Fe, Mn, Zn and Cu) were estimated and the analysis data are reported in Table 4. Regarding soil fertility, the most crucial parameter is the organic carbon content, which ranges from 0.02 per cent in PN 4 to 0.75 per cent in PN 1, with an overall mean value of 0.33 per cent. In general, the content of organic carbon is higher at the surface, decreasing down the depth in soil profile. This was mainly due to accumulation of plant residues on the soil surface and very less opportunity to move it down the depth due to rapid decomposition at higher temperature and inadequate pedoturbation. Similar findings were observed by Singh and Rathore (2015).

The available major nutrients, nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O), fall within the ranges of 6-548 kg ha^{-1} for N, 3.83-190.06 kg ha^{-1} for P_2O_5 and 162-676 kg ha^{-1} for K_2O. Nitrogen levels vary from medium to low in PN 3, while in PN 5, surface soil has high nitrogen, while it reduces in the lower layer. PN 1, 2 and 4 shows low to very low content of available nitrogen. The reason behind low available nitrogen content might be the intensive agricultural, where high yielding varieties of paddy and sugarcane crops are grown, which have very high nutrients requirements. The values of available N decreased with the increase in profile depth. Decreasing organic matter might have contributed to the decreased available N content with depth (Mandal and Ghosh, 2021).

Phosphorus levels range from deficient to high. Phosphorus is being retained by $CaCO_3$ rich soils as higher calcium compounds of lower solubility and limit this nutrient availability to plants. Even after fertilizer application surface adsorption and precipitation are major mechanisms of phosphorus retention in soils rich in $CaCO_3$. Similar findings were reported by Shirgire *et al.* (2018). The lower status of P in the soil is attributed to intensive cropping systems resulting in absorption of plant nutrients in higher amounts (Pandey *et al*., 2000). Higher phosphorus content at surface layer and lower value at deeper layer might be due to the presence of organic matter which increases the availability of phosphorus in soil (Mandal and Ghosh, 2021)

Potassium levels are from marginally adequate to high. The high status of available K might be due to presence of potash bearing minerals (feldspar, muscovite and biotite) which upon weathering release K. The results of Ashok Kumar and Prasad (2010) and Shirgire *et al.* (2018) supports the present findings.

Table 2: Morphological characteristics of the studied pedons of Ambach village, Chikhli taluka, Navsari district

PN	Depth (cm)	Boundary[1]		Munsell colour		Texture[2]	Structure[3]			Consistence[4]		Roots[5]		Effervescence[6]
		C	T	Dry	Wet		S	G	T	Moist	Wet	S	Q	
PN 1														
P1/1	0-10	C	S	10YR 3/3	10YR 3/2	Sic	c	2	abk	fr	ss	m	f	es
P1/2	10-25	C	S	10YR 3/3	7.5YR 3/2	Sic	c	1	Sbk	fr	ss	c	m	e
P1/3	25-45	A	S	10YR 4/3	10YR 3/2	Sicl	c	1	Sbk	fr	ps	m	f	ev
P1/4	45-65	A	B	10YR 5/4	10YR 4/3	Sil	c	3	Sbk	fr	ps	m	f	es
P1/5	65-80	A	B	10YR 5/4	10YR 4/4	Sicl	m	3	sbk	fr	ps	-	-	e
PN 2														
P2/1	0-15	A	S	10YR 4/2	10YR 3/2	C	m	2	abk	vfr	s	f	c	e
P2/2	15-35	D	S	10YR 3/2	7.5YR 3/2	C	m	2	abk	fr	ps	f	c	e
P2/3	35-55	D	S	10YR 3/3	7.5YR 3/2	C	m	3	sbk	fi	s	f	c	e
P2/4	55-85	C	S	10YR 4/2	10YR 3/4	C	m	3	m	vfi	p	-	-	e
P2/5	85-100	C	S	10YR 6/4	7.5YR 4/2	Sic	m	3	m	fi	ps	-	-	e
PN 3														
P3/1	0-15	C	S	10YR 5/4	7.5YR 4/4	Sicl	vf	1	Sbk	fr	ss	m	c	e
P3/2	15-35	C	S	10YR 5/6	10YR 4/3	Cl	vf	1	Sbk	fr	ss	f	f	e
P3/3	35-50	A	W	10YR 6/6	7.5YR 3/4	Sil	m	2	Abk	fi	so	m	f	es
P3/4	50-65	G	I	10YR 6/6	10YR 6/6	L	m	2	Abk	fi	so	c	f	ev
P3/5	>65	G	I	10YR 6/6	10YR 6/6	L	m	2	abk	fi	so	c	f	ev
PN 4														
P4/1	0-10	C	S	10YR 5/4	7.5YR 4/4	Sil	f	1	abk	fr	ss	c	f	es
P4/2	10-20	C	S	10YR 6/4	10YR 5/4	Sil	f	1	sbk	fr	ss	vf	f	es
P4/3	20-38	C	I	10YR 5/6	10YR 5/8	L	c	1	sbk	fr	ss	c	f	es
P4/4	38-68	G	I	10YR 6/4	10YR 6/6	Sl	c	1	sbk	fr	ss	c	c	es
P4/5	68-90	G	I	10YR 6/8	10YR 5/8	Sl	c	2	sbk	fr	ss	c	f	es
P4/6	>90	G	B	7.5YR 6/4	7.5YR 4/4	Scl	c	2	sbk	fr	ss	c	f	es
PN 5														
P5/1	0-20	C	S	10YR 3/3	7.5YR 3/2	C	c	2	abk	fi	p	c	m	e
P5/2	20-35	C	S	10YR 4/5	7.5YR 4/4	Cl	m	2	sbk	vfi	p	m	f	es
P5/3	35-55	D	S	10YR 5/3	7.5YR 5/6	Cl	f	1	sbk	vfi	p	f	f	ev
P5/4	55-70	D	S	10YR 6/4	7.5YR 4/4	Scl	-	-	-	vfi	vp	-	-	es
P5/5	70-90	D	S	10YR 6/4	7.5YR 5/4	Sic	-	-	-	vfr	vp	-	-	es

[1]Boundary: D- distinctness: C= clear, A= abrupt, D=diffuse, G=gradual, T-topography s=smooth, B=broken, W=wavy, I=irregular,

[2]Texture: sl= sandy loam, l=loam, sic=silt clay, sicl=silt clay loam, c=clay, sil= silt loam and cl=clay loam, scl= sandy clay loam

[3]Structure: (Size: vf = very fine, f = fine, c = coarse, m = medium), (Grade: 1 = weak, 2 = moderate, 3 = strong): (Type: gr = granular, abk = angular blocky, sbk = subangular blocky, m = massive)

[4]Consistence: Moist: vfr = very friable fr = friable, fi = firm, vfi = very firm, Wet: so = non sticky ss = slightly sticky s = sticky, vs – very sticky, p – plastic, vp – very plastic ps = slightly plastic

[5]Roots: (Size (S): vf = very fine, f = fine, m = medium, c = course), (Quantity (Q): f = few, c = common, m = many)

[6]Reaction to diluted HCl

Pedon	Depth (cm)	Sand	Silt	Clay	Texture	BD (g cc^{-1})	PD (g cc^{-1})	Porosity (%)	WSA (%)		Moisture (%)		AMC (%)	k (cm hr^{-1})
		%							> 0.25 (mm)	0.1-0.25 (mm)	1/3 bar	15 bar		
							PN 1							
P1/1	0-10	6.75	49.60	43.65	Sic	1.34	2.09	35.89	39.16	35.70	31.74	21.64	10.10	1.27
P1/2	10-25	9.93	43.87	46.20	Sic	1.47	2.34	37.18	49.25	31.73	30.58	22.86	7.71	1.29
P1/3	25-45	14.06	55.69	30.25	Sicl	1.55	2.54	38.98	51.33	33.86	32.40	20.76	11.64	0.82
P1/4	45-65	23.43	51.22	25.35	Sil	1.60	2.27	29.52	44.27	38.25	30.23	19.48	10.75	0.18
P1/5	65-80	13.15	50.35	36.50	Sicl	1.46	2.23	34.53	30.70	47.86	38.15	23.76	14.38	0.14
							PN 2							
P2/1	0-15	4.09	38.06	57.85	C	1.48	2.26	34.51	26.96	37.44	42.47	27.83	14.64	0.08
P2/2	15-35	3.28	37.67	59.05	C	1.37	2.28	39.91	22.24	49.98	43.02	27.63	15.39	0.06
P2/3	35-55	5.25	32.30	62.45	C	1.40	2.21	36.65	10.99	45.38	45.05	31.38	13.67	0.15
P2/4	55-85	4.43	38.02	57.55	C	1.62	2.33	30.47	23.69	46.31	44.31	29.54	14.77	0.10
P2/5	85-100	3.67	49.83	46.50	Sic	1.52	2.44	37.70	13.31	65.53	42.17	27.53	14.65	0.24
							PN 3							
P3/1	0-15	18.73	50.57	30.70	Sicl	1.36	2.38	42.86	59.63	31.04	27.62	24.07	3.23	2.30
P3/2	15-35	21.56	49.25	29.20	Cl	1.65	2.31	28.57	53.88	34.23	27.82	22.38	5.44	2.96
P3/3	35-50	18.96	57.49	23.55	Sil	1.49	2.27	42.29	45.31	42.32	31.41	20.80	10.61	1.46
P3/4	50-65	31.35	43.30	25.35	L	1.47	2.55	42.35	76.94	14.86	30.43	18.39	12.04	4.61
P3/5	>65	37.86	41.44	20.70	L	1.49	2.32	35.78	71.68	19.93	28.24	16.51	11.73	0.54
							PN 4							
P4/1	0-10	20.40	56.40	23.20	Sil	1.32	2.55	48.24	44.13	38.01	29.70	17.51	12.19	0.21
P4/2	10-20	31.47	54.53	14.00	Sil	1.44	2.58	44.19	42.64	36.83	26.46	14.83	11.63	1.76
P4/3	20-38	49.67	35.33	15.00	L	1.57	2.58	39.15	55.98	29.86	23.07	12.96	10.12	3.90
P4/4	38-68	68.05	17.10	14.85	Sl	1.40	2.49	43.78	34.82	42.38	16.24	12.84	3.39	8.04

P4/5	68-90	56.41	26.80	16.80	Sl	1.44	2.51	42.63	37.39	47.81	21.42	14.05	7.37	2.77
P4/6	>90	52.59	23.56	23.85	Scl	1.72	2.49	30.92	66.26	23.10	20.56	15.44	5.12	3.41
							PN 5							
P5/1	0-20	17.21	35.99	46.80	C	1.25	2.53	50.59	49.25	31.37	32.07	21.74	10.33	1.29
P5/2	20-35	39.19	22.66	38.15	Cl	1.45	2.34	38.03	51.33	33.86	31.46	21.00	10.46	1.50
P5/3	35-55	44.49	26.91	28.60	Cl	1.30	2.17	40.09	44.27	38.25	27.51	21.18	6.34	2.11
P5/4	55-70	49.23	20.57	30.20	Scl	1.53	2.26	32.30	30.70	47.86	27.31	18.96	8.35	3.08
P5/5	70-90	10.17	49.39	40.45	Sic	1.41	2.46	42.68	37.07	49.06	37.45	20.90	16.57	0.79
Min						**1.25**	**2.09**	**28.57**	**10.99**	**14.86**	**16.24**	**12.84**	**3.23**	**0.06**
Max						**1.72**	**2.58**	**50.59**	**76.94**	**65.53**	**45.05**	**31.38**	**16.57**	**8.04**
Mean						**1.46**	**2.37**	**38.33**	**42.65**	**38.26**	**31.83**	**21.25**	**10.57**	**1.67**

Table 3. Physical properties of the studied profiles in Ambach village, Chikhli taluka, Navsari district, Gujrat

Table 4. Chemical properties of the studied profiles in Ambach village, Chikhli taluka, Navsari district, Gujrat

Profile No.	Depth (cm)	pH	OC (%)	Available macro-nutrients (kg ha^{-1})			Available micronutrients (mg kg^{-1})				EC (dS m^{-1})	CEC cmol (p^{+}) kg^{-1}	ESP (%)	BS (%)	$CaCO_3$ (%)
				N	P_2O_5	K_2O	Fe	Mn	Zn	Cu					
PN 1															
P1/1	0-16	7.89	0.75	222.8	12.4	626.0	20.60	45.26	1.29	3.45	0.324	57.81	0.88	97.77	12.14
P1/2	16-40	7.87	0.66	174.6	5.4	507.0	19.74	27.56	0.82	3.72	0.220	43.53	1.17	96.90	9.36
P1/3	40-70	8.23	0.38	126.4	7.9	483.0	15.42	9.66	0.41	2.32	0.148	52.90	1.10	88.87	11.38
P1/4	70-93	8.01	0.17	78.3	4.1	426.0	16.72	12.10	0.27	1.07	0.240	57.30	0.46	82.95	12.65
P1/5	>93	7.98	0.15	54.2	10.1	375.0	11.54	13.83	0.30	0.75	0.245	50.92	1.06	97.94	13.15
PN 2															
P2/1	0–12	7.43	0.80	198.7	40.5	450.0	35.26	60.35	1.12	4.62	0.195	45.14	1.02	91.77	8.60
P2/2	12-42	7.46	0.53	150.5	11.5	429.0	22.76	20.34	0.50	3.95	0.089	46.96	0.58	92.62	9.10
P2/3	42-67	7.44	0.44	102.4	9.1	421.0	18.87	12.10	0.71	3.60	0.080	48.96	0.78	92.59	7.84
P2/4	67-90	7.48	0.36	78.3	8.4	402.0	17.15	12.91	0.59	3.08	0.091	49.01	1.05	93.24	8.34
P2/5	>90	7.69	0.20	54.2	7.7	397.0	9.39	8.54	0.37	1.91	0.085	49.24	1.13	95.86	9.36
PN 3															
P3/1	0 -12	7.79	0.66	283.0	190.1	676.0	49.07	64.06	1.81	4.15	0.152	46.45	1.39	96.51	8.60
P3/2	12-30	7.71	0.51	246.9	111.0	616.0	22.76	39.66	1.07	3.77	0.122	47.32	0.80	95.88	7.08
P3/3	30-43	6.75	0.47	222.8	107.7	558.0	18.44	86.11	1.87	4.18	0.372	45.54	1.09	96.10	6.83
P3/4	43-55	6.96	0.41	210.7	70.1	431.0	15.42	65.43	1.10	2.03	0.203	53.36	1.29	97.95	11.89
P3/5	>55	7.12	0.26	162.6	48.0	355.0	7.23	33.46	1.01	1.30	0.166	51.25	1.92	85.20	12.39
PN 4															
P4/1	0-10	8.05	0.18	114.4	11.4	361.0	7.23	12.61	0.86	1.59	0.142	56.22	0.20	84.15	13.91
P4/2	10-20	8.15	0.11	54.2	5.2	275.0	4.21	4.88	0.30	0.81	0.139	57.19	0.44	87.62	11.63
P4/3	20-38	8.25	0.05	42.1	4.0	162.0	5.50	3.35	0.40	0.64	0.113	49.42	0.33	88.62	11.89
P4/4	38-68	8.31	0.05	18.1	6.6	177.0	3.35	4.78	0.23	0.49	0.101	40.28	0.98	87.84	10.62
P4/5	68-90	8.34	0.02	6.0	6.4	176.0	3.35	4.47	0.27	0.64	0.112	46.78	0.69	90.23	12.14
P4/6	>90	8.4	0.06	6.0	6.0	215.0	2.92	5.08	0.25	0.72	0.109	40.16	1.03	90.09	9.86
PN 5															
P5/1	0-10	6.6	0.47	547.9	67.6	560.0	66.32	102.20	2.13	3.54	0.502	30.80	1.40	91.85	7.84
P5/2	10-20	6.56	0.32	258.9	46.6	504.0	37.85	37.83	1.02	1.89	0.202	38.44	2.14	92.84	9.10
P5/3	20-38	7.32	0.17	90.3	3.8	428.0	26.64	24.92	0.41	2.06	0.028	43.67	0.90	89.04	9.36
P5/4	38-68	6.91	0.09	42.1	4.7	399.0	16.29	27.97	1.31	1.57	0.086	36.99	1.49	96.67	9.87
P5/5	68-90	7.58	0.14	18.1	5.9	278.0	11.54	10.37	0.89	1.36	0.195	49.40	0.71	94.68	10.87
Overall	**Min**	**6.56**	**0.02**	**6.0**	**3.8**	**162.0**	**2.92**	**3.35**	**0.23**	**0.49**	**0.080**	**30.80**	**0.20**	**82.95**	**6.83**
	Max	**8.34**	**0.75**	**547.9**	**190.1**	**676.0**	**66.32**	**102.20**	**2.13**	**4.62**	**0.502**	**57.81**	**2.14**	**97.95**	**13.91**
	Mean	**7.59**	**0.33**	**141.0**	**32.2**	**418.3**	**19.24**	**29.75**	**0.84**	**2.34**	**0.173**	**47.47**	**1.01**	**92.31**	**10.15**

The available Fe status is medium to high. It ranged from 2.92 to 66.32 mg kg^{-1} with mean value of 19.24 mg kg^{-1}. The high content of Fe in these soils may be due to presence of minerals like magnetite. Most of the soil samples of soil profiles were found high with respect to DTPA-extractable Mn. It ranged from 3.35 to 102.20 mg kg^{-1} with a mean value of 29.75 mg kg^{-1}. The high status of Mn might be due to less mobility of Mn^{+2} in soils, which might have contributed for the accumulation of reducible and soluble forms of manganese. The available Zn status ranged from 0.23 to 2.13 mg kg^{-1} with mean value of 0.84 mg kg^{-1}. PN 4 Medium to low amount of Zn compared to other soil profiles. Overall Available status of Zn is medium to high. In general, status of available Cu status in soil profiles were High. It might be due to persistent use of copper containing fungicides. Similar results were observed by Chavda *et al.* (2018b).

3.4 SOIL SITE SUITABILITY OF EXSTING CROPS

In the profile study, the information generated was subjected to models as described by Naidu *et al*. (2006) and NBSS & LUP (1990) to assess soil suitability/suitability criteria. Using these models, the overall sustainability and suitability of soils from different profiles in the Ambach village under major cultivation were assessed and described parameter-wise in the preceding chapter.

In the study area, rice (*kharif*), sugarcane, sorghum, pearl millet and mango were the main crops, so crop suitability evaluation was carried out. For *kharif* rice, profiles No. 1, 2, 3 and 5 were evaluated as moderately suitable (S2) and profile No. 4 was marginally suitable (S3) for cultivation. Regarding sugarcane, profiles No. 1, 3 and 4 were evaluated as highly suitable (S1) and profiles No. 2 and 5 were evaluated as moderately suitable (S2) for cultivation.

For sorghum cultivation, all profiles were evaluated as highly suitable (S1) and for pearl millet cultivation, profiles No. 1, 2, 3 and 5 were evaluated as moderately suitable (S2) and 4 was evaluated as highly suitable (S1). For mango cultivation, profiles No. 1, 2 and 4 were evaluated as moderately suitable (S2), while profile No. 3 and 5 were evaluated as highly suitable (S1).

Table 5: Soil-site suitability evaluation of Rice (*kharif) (Oryza sativa* L.)

Soil-site characteristics		Rating with limitations				
		PN 1	PN 2	PN 3	PN 4	PN 5
Climate regime	Mean temperature in growing season	S2	S2	S2	S2	S2
	Total rainfall	S1	S1	S1	S1	S1
Oxygen availability to roots	Soil drainage	S1	S1	S1	S2	S1
Nutrient availability	Texture	S1	S1	S1	S2	S1
	pH	S3	S3	S3	S3	S3
	$CaCO_3$ (%) in root zone	S1	S1	S1	S1	S1
Soil toxicity	Salinity (EC_e)	S1	S1	S1	S1	S1
	Sodicity (ESP)	S1	S1	S1	S1	S1
Erosion hazard	Slope (%)	S1	S1	S1	S1	S1

Overall suitability	**S2**	**S2**	**S2**	**S3**	**S2**

Table 6: Soil-site suitability evaluation of Sugarcane (*Saccharum officinarum* L.)

Soil-site characteristics		Rating with limitations				
		PN 1	PN 2	PN 3	PN 4	PN 5
Climate regime	Mean temp. in growing season	S2	S2	S2	S2	S2
	Mean min. temp. in growing season	S2	S2	S2	S2	S2
	Mean RH (%) in Ripening season Ripening stage	S1	S1	S1	S1	S1
Oxygen availability to roots	Soil drainage	S1	S2	S1	S1	S2
Nutrient availability	Texture	S1	S1	S1	S1	S1
	pH	S1	S1	S1	S1	S1
	CEC	S1	S1	S1	S1	S1
	Base saturation (%)	S1	S1	S1	S1	S1
Soil toxicity	Salinity (EC_e)	S1	S1	S1	S1	S1
	Sodicity (ESP)	S1	S1	S1	S1	S1
Erosion hazard	Slope (%)	S1	S1	S1	S1	S1
	Overall suitability	**S1**	**S2**	**S1**	**S1**	**S2**

Table 7: Soil-site suitability evaluation for Sorghum *(Sorghum bicolor L.)*

Soil-site characterization		Rating with limitations				
		PN 1	PN 2	PN 3	PN 4	PN 5
Climate regime	Mean temp. in growing season	S1	S1	S1	S1	S1
	Mean max. temp. in growing season	S1	S1	S1	S1	S1
	Mean min. tempt. In growing season	S1	S1	S1	S1	S1
Moisture availability	Length of growing period	S1	S1	S1	S1	S1
Oxygen availability to roots	Soil drainage	S2	S1	S1	S2	S1
Nutrient availability	Texture	S2	S1	S1	S2	S1
	pH	S1	S1	S1	S1	S1
	CEC	S1	S1	S1	S1	S1
	Base saturation (%)	S1	S1	S1	S1	S1
	OC (%)	S1	S1	S1	S1	S1
Soil toxicity	Salinity (EC_e)	S1	S1	S1	S1	S1
	Sodicity (ESP)	S1	S1	S1	S1	S1

Erosion hazard	Slope (%)	S1	S1	S1	S1	S1
	Overall suitability	**S1**	**S1**	**S1**	**S1**	**S1**

Table 8: Soil-site suitability evaluation for Pearl millet *(Pennisetum glaucum)*

Soil-site characterization		Rating with limitations				
		PN 1	PN 2	PN 3	PN 4	PN 5
Climate regime	Mean temp. in growing season	S2	S2	S2	S2	S2
Moisture availability	Length of growing period	S1	S1	S1	S1	S1
Oxygen availability to roots	Soil drainage	S2	S2	S2	S1	S2
Nutrient availability	Texture	S2	S2	S2	S1	S2
	pH	S1	S1	S1	S1	S1
Soil toxicity	Salinity (EC_e)	S1	S1	S1	S1	S1
	Sodicity (ESP)	S1	S1	S1	S1	S1
Erosion hazard	Slope (%)	S1	S1	S1	S1	S1
	Overall suitability	**S2**	**S2**	**S2**	**S1**	**S2**

Table 9: Soil-site suitability for Mango (*Mangifera indica* L.)

Soil-site characteristics		Rating with limitations				
		PN 1	PN 2	PN 3	PN 4	PN 5
Climate regime	Mean temp. in growing season	S1	S1	S1	S1	S1
	Mean min. temp. before flowering	S1	S1	S1	S1	S1
Moisture availability	Length of growing period	S1	S1	S1	S1	S1
Oxygen availability to roots	Soil drainage	S1	S2	S1	S1	S1
Nutrient availability	Texture	S1	S2	S1	S1	S1
	pH	S2	S1	S1	S2	S1
	OC (%)	S2	S2	S2	S2	S2
	Base saturation (%)	S1	S1	S1	S1	S1
Soil toxicity	Salinity (EC_e)	S1	S1	S1	S1	S1
	Sodicity (ESP)	S1	S1	S1	S1	S1
Erosion hazard	Slope (%)	S1	S1	S1	S1	S1
	Overall suitability	**S2**	**S2**	**S1**	**S2**	**S1**

4. CONCLUSION

The soil profiles of Ambach village fall under a range from dark brown to light yellowish brown along with textures from silty loam to heavy clay. Drainage varied from imperfect to excessively drained, influenced by elevation, depth of bed rock and high rainfall. Bulk densities were 1.25-1.46 g cc^{-1} and particle densities 2.09-2.58 g cc^{-1}. Moisture content ranged from 3.23 per cent to 16.57 per cent, and hydraulic conductivity varied widely. Soils were slightly alkaline with non-saline EC values and permissible ESP levels. CEC indicated good fertility, but organic carbon was medium to low. Nitrogen levels were generally low, phosphorus was high except in PN 3 and potassium was high. Fe and Mn were high except in PN 4, Zn was medium to high and Cu was high. The soil profiles were evaluated for various crops, showing high suitability (S1) for sorghum and moderate suitability (S2) for pearl millet and mango cultivation. For *kharif* rice, profiles 1 and 2 were highly suitable (S1), profiles 3 and 5 were moderately suitable (S2), and profile 4 was marginally suitable (S3). For sugarcane, profiles 1, 3 and 4 were highly suitable (S1), while profiles 2 and 5 were moderately suitable (S2).

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