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An evaluation of mango cultivation soils and identification of potentially suitable lands upon conversion of agricultural crop land to mango plantations in semi-arid land of south Telangana plateau, Andhra Pradesh

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ABSTRACT

In the south Telangana plateau, Andhra Pradesh, due to low rainfall and high temperature which is limiting the agriculture crop production as the semi-arid climatic condition. Hence, the crop land is being converted to mango plantation/orchards in most of the areas. The soils of mango cultivation were assessed for their physic-chemical properties as well as soil fertility status by studying two representative pedons from mango cultivated areas. Through a detailed soil survey, land capability classification was done and determined the suitability of land for mango production using GIS and RS. Results revealed that 53.57% area is moderately good cultivable (class III) land followed by class IV which is fairly good cultivable land (16.90%). Out of total geographical area (23240.7 ha), mango is marginally suitable (S3) in 42.71% area which is potential for mango production and 29.45% area is not suitable for mango cultivation. Gravelliness, soil fertility, drainage, root restriction, soil texture are the limiting factors for mango production in the region. Organic carbon (OC) content is low (0.32-0.40%), slightly acidic to neutral in reaction (pH: 6-6.83), non-saline, high base saturation (>50%), low CEC (3.1-6.1 cmol (p+) kg^{-1}) and available water content is 4.47 to 7.86%, reddish-brown (5YR4/4) to dark brown (7.5YR4/3) in surface and 35-60% coarse fragments. However, two mango cultivating series are identified. The study helps to increase the area under mango plantations in potential areas and to adopt mango cultivation by addressing limitations in problematic soils.

1. INTRODUCTION

Land resources management particularly non-agricultural crop lands for their potentially suitable crop production / plantation / forest will keep pace with the country's food needs, sustain the environment, blunting impacts of climate change, conserving and protecting natural resources, and supporting the livelihood of farmers in the country. Mango (*Mangifera indica* L.) being the king of fruits, is a major fruit crop of the tropics and subtropics of Asian countries believed to have originated from north-western Myanmar, Bangladesh, and north-eastern India and is a national fruit of India. The most expensive mango in the world is Taiyo no Tamago (Egg of the sun) grown in the Miyazaki province of Japan and then sold throughout the country at a rate of ₹ 300,000 kg (Shankar, 2021). In 2019, the production of mangoes was led by India with 46% (26 Mt) of the world's total (56 Mt), around half of the world's mangoes are being cultivated in India alone. Uttar Pradesh and Andhra Pradesh are having the largest area under mango each with around 23% of the total area followed by Karnataka, Bihar, Gujarat and Tamil Nadu (Anon., 2022). In Andhra Pradesh, mango is grown in an area of 2.85 lakh ha with a production of 20.95 lakh tonne and productivity of 7419 kg ha^{-1}. In the south Telangana plateau, the mango cultivation area is expanded due to its climatic condition. The mean annual precipitation is 638 mm and mean annual temperatures varies from 23°C to 34°C. Due to non-availability of irrigation facility and high temperature around the year

limits the agricultural crop production in the semi-arid region hence, the small and marginal farmers of the semi-arid region particularly in south Telangana plateau agricultural land is being converted into the mango fruit crop production. Soils are highly heterogeneous and differ in their morphological, physical, chemical and biological properties (Chandrakala *et al*., 2022a) which respond differently to management practices as well as their resilience to disturbance and vulnerability to degradation (FAO, 2017). Through characterization of soils, it's possible to classify the soils based on their properties which enable best management practices to specific land units (Chandrakala *et al*., 2018). Mango productivity is hampered due to imbalanced use of fertilizer and pesticides (Sultana *et al.,* 2018). Nutrient imbalance in different agroecology of commercial fruit crops is of very important concern, as their sustainability for the long term is becoming a serious question (Adak *et al.,* 2019). This imbalance poses a serious threat to the quality of the fruit as it's a serious matter as people get enriched through nutritive fruit sources (Rao and Swaminathan, 2017). The estimated total nutrient uptake (N, P_2O_5 and K_2O) by mango was 280 Mt with a nutrient wise uptake of 124 Mt N, 31 Mt P_2O_5 and 124 Mt of K_2O ha^{-1} (Adak *et al*., 2019). Nutritional security is the need of the hour apart from productivity. The nutrient content of fruits highly depending on the soil available nutrients status hence judicious use of fertilizers and manures is a must to maintain soil nutrient balance to sustain the fruit quality. With these above facts, the detailed soil survey was conducted on a 1:10000 scale using GIS and RS to study the soils of mango cultivation for their potential and their limitations in Rayachoty Mandal, YSR Kadapa district, Andhra Pradesh. Soils were characterised for available nutrients status and based on initial soil test values nutrients were recommended and mapped. The objectives of the study are i) to characterise and classification of mango production lands, ii) to identify the potential mango production lands and their limitations upon conversion of agricultural land to mango plantation iii) to map the organic carbon and initial soil phosphorus and potassium status of Rayachoty Mandal and iv) recommendation of nutrients to mango plants based soil fertility ratings and management of soils.

2. MATERIALS AND METHODS

A detailed soil survey was carried out at a selected Mandal *i.e.,* Rayachoty (TGA 23,240.7 ha (cultivated land is 16768.55 ha) belongs to YSR Kadapa district, Andhra Pradesh, south Telangana plateau, falls on north latitudes 13°59'45.28" and 14°7'12.263" and east longitudes 78°35' 24.85" and 78°54'5.608" (Fig. 1). South Telangana plateau is a hot, dry semi-arid eco-sub region (AESR 7.1). Rayachoty has a dry climate with tropical wet and high temperature around the year. Mean annual rainfall is 638 mm making the soil Ustic moisture condition and the mean annual temperature ranges from 23°C to 34°C with iso-hyperthermic soil temperature condition. LGP is 145 days. Hills and ridges, isolated hillocks, gently sloping uplands, very gently sloping uplands, nearly level uplands and nearly level lowland / valleys are the six major landforms delineated in the Mandal.

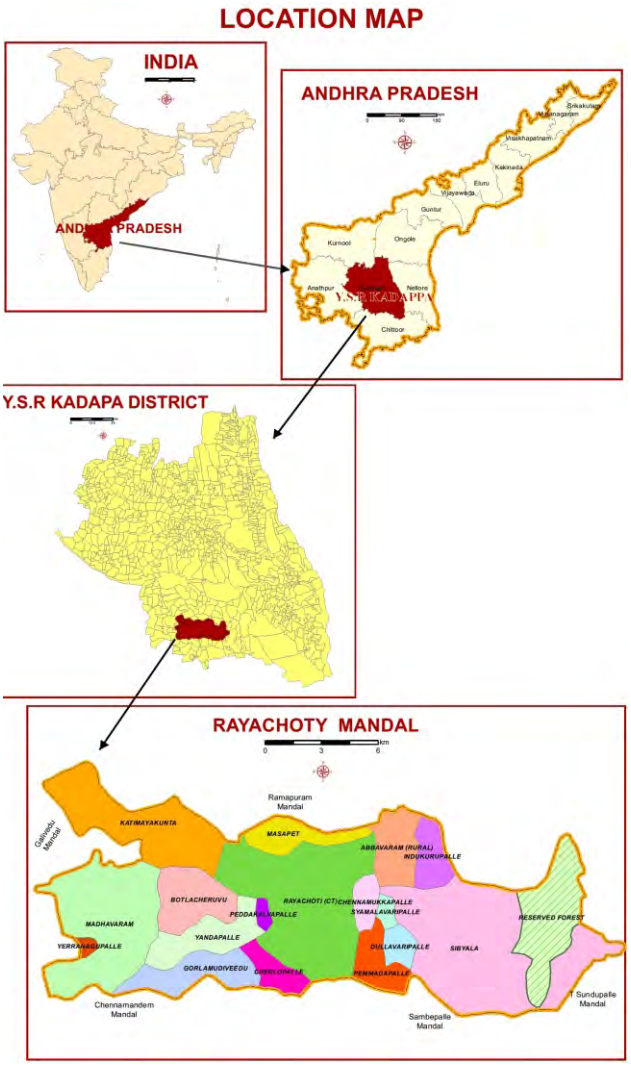
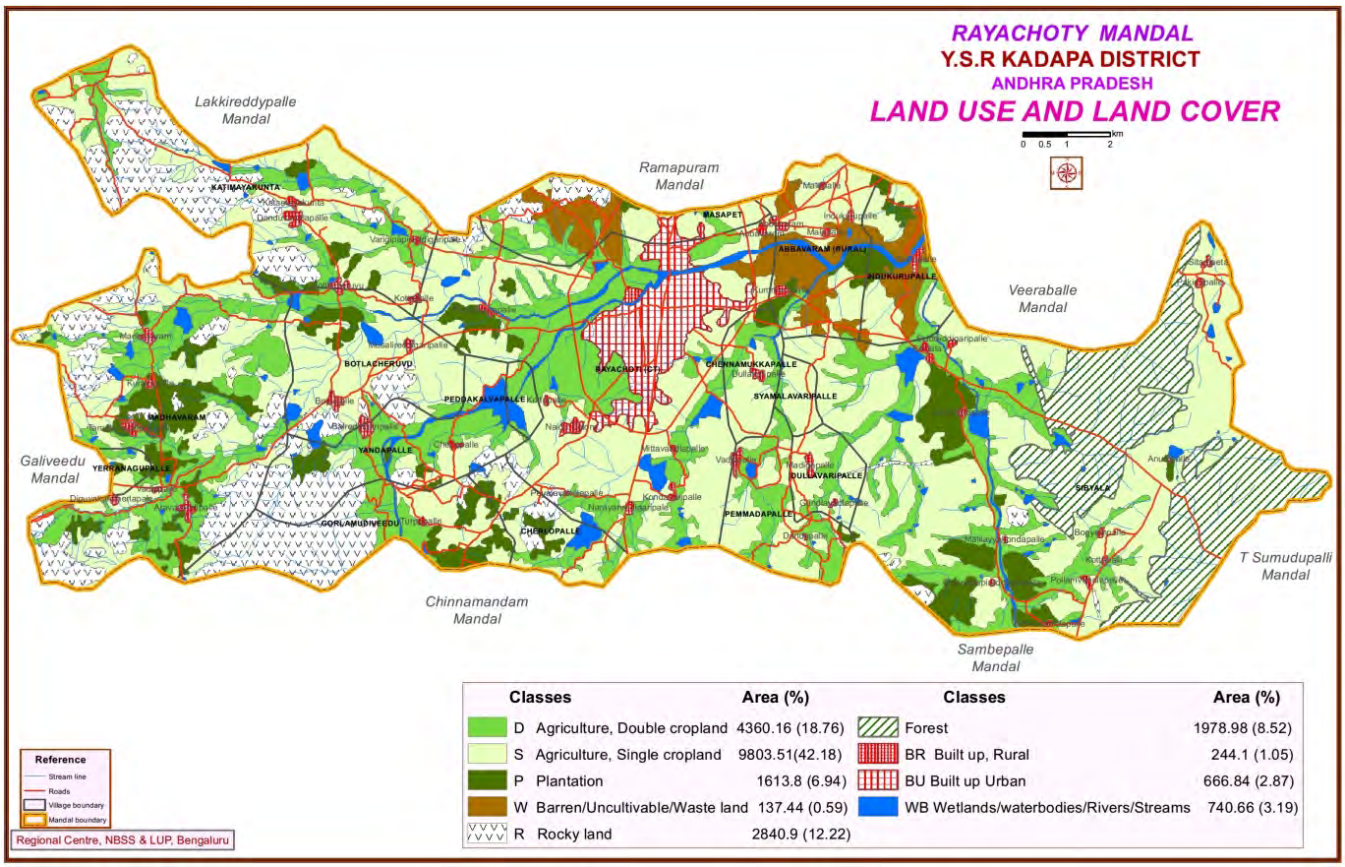


Fig. 1. Location map of Rayachoty Mandal, south Telangana plateau

Agriculture is the major livelihood activity of the small and marginal farmers in the region with major adopted crops are paddy, redgram, cowpea, groundnut, sunflower, sesamum, mulberry, and coconut and mango plantation (Chandrakala *et al*., 2019b).

Using the survey of India toposheet (1:50,000 scale), sentinel-2 and google imagery, land use / land cover (LU / LC) digitised and prepared the map in a GIS environment. The LU/LC shows how much area is under mango plantation presently in the Mandal alongwith agriculture and forest land (map 1), these maps was finalised upon ground



Map 1. Land use land cover map of Rayachoty Mandal, south Telangana plateau

truth checking during field survey work which shows mango is cultivating in 1613.8 ha (6.94% of TGA). Similarly, landform mapping was also done and six landforms were established in the Mandal as mentioned above. With the help of landforms, seven transects were selected along the slope and contour, a total of 103 soil profiles were studied. Two master representative soil profiles were brought from the mango plantations and 87 surface soil samples were brought to the laboratory, air-dried, ground and sieved through a 2-mm sieve which was analysed for physicchemical properties in the laboratory using the following procedure. International pipette method (Piper, 1966) was used for particle size analysis. Gravel content was determined by the Gravimetry method (Govindarajan and Koppar, 1975), Soil pH and electrical conductivity (EC) were measured with a 1:2.5 soil: water ratio available P_2O_5 (kg ha^{-1}) by Olsen's extractant for soils having pH < 6.5 and Bray's 1 extractant for soils pH was > 6.5 with colorimetry and available K_2O (kg ha^{-1}) by N NH_4OAC extractant and flame photometry (Jackson, 1973), organic carbon (OC) was determined by Walkley and Black (1934) method. Cation exchange capacity was determined by the NN ammonium acetate method (Schollenberger and Dreibelbis, 1930), calcium carbonate ($CaCO_3$) equivalent (%) was determined by the Piper method (1966).

The land suitability evaluation for mango is done in the four hierarchies *i.e.,* orders, classes, sub-classes and units. Suitable or not suitable for cultivation of mango can be done at an order level, based on kinds of suitability for the identified land use and mapping unit. Orders are subdivided into classes based on degrees of suitability followed by classes are classified into sub-classes based on the kinds of limitations, based on the type of management required, sub-classes are again categorised into land suitability units. Class S1, S2 and S3 represent highly suitable, moderately suitable, marginally suitable, respectively and class N1 and N2 represents currently not suitable and permanently not suitable, respectively. Classes S2 and S3 were further categorised into subclasses as per specific soil / climate limitations in the Mandal. Highly suitable land units have no subclasses. The limitations occurring in the Mandal for mango production area are Climate: temperature, rainfall total and distribution, dry months and growing period (c), topography (l), soil depth or rooting condition (r), soil texture (sandy or heavy clay) (t), coarse fragments (g), soil fertility (calcareousness) (n), drainage (w). Specific limitations are represented by lower case letters alongwith the class symbol (Chandrakala *et al*., 2019a).

The soils were classified according to soil taxonomy (Soil Survey Staff, 1999, 2003, 2014 and 2017) using

morphological, physical and chemical properties. Based on identified landforms, LU/LC, GPS profiles location points soil boundaries were drawn and the identified mapping unit boundary were also drawn. By using soil and mapping unit boundaries the land capability map was prepared as per the guidelines of Klingebiel and Montgomery (1966). Using the soil site suitability criteria (NBSS&LUP, 1994 and Naidu *et al.,* 2006), land resources of the Rayachoty Mandal was assessed for the suitability of mango, then, using mapping units with assigned mango suitability class details, suitability map has been prepared and by krigging and interpolation method fertility maps have been prepared in the Arc-GIS environment.

3. RESULTS AND DISCUSSION

Assessment of Soils of Mango Plantations and Their Classification

The soils of mango cultivation (Table's 1 and 2) are having depth 0-43 and 0-72 cm *i.e.,* shallow and moderately shallow, respectively whereas moderately deep and deep soils are occupied by other agricultural crops (Chandrakala *et al*., 2019b, 2022b and 2022c), fairly good soils are put under mango cultivation which restricts mango roots to penetrate deeper thereby affects nutrients uptake results in low production and productivity. Soil colour is reddish brown (5YR4/4) to dark brown (7.5YR4/3) in surface to dark reddish brown to brown sub-surface which imparted by parent materials containing iron is oxidised more readily due to the higher oxygen content as the semi-arid climatic condition with low rainfall. Soil structure is weak to moderate and fine to medium subangular blocky. This structure of soils holds low content of water during the cropping period as the water holding capacity varies between 4.47 to 7.86% and the consistency of soil is loose to very friable and friable and non-sticky, non-plastic to slightly sticky and slightly plastic. To improve soil structure and consistency organic matter addition is recommended. Soils are gravelly *i.e.,* coarse fragments are >35 to 60% hence tank silt application is recommended (Chandrakala *et al*., 2021). Soils are well-drained and moderate erosion as the slope of the land is nearly level (1-3%). Sand fraction (77.13 to 81.44% on the surface) is the dominant followed by clay content (5.77 to 10.52% on surface) which makes the soil loamy sand to sandy loam. However, sand content decreased whereas clay content increased in the subsurface which results in sandy clay to sandy clay loam subsurface texture showing that clay illuviation took place and also the presence of clay cutans developed the argillic (Bt) subsurface horizon which is good for mango cultivation as subsurface also recorded more water holding capacity compared to surface soils. OC content is low *i.e.,* <0.5% in surface (0.32 to 0.40%). Slightly acidic to neutral in soil reaction (ph: 6.00 to 6.83 in surface) and non-saline soils (EC is <2.00 dS m^{-1}). The exchangeable Ca > Mg > K > Na contents are quite a good amount resulting in

Table: 1
Morphological properties of mango cultivated soils, Rayachoty Mandal, south Telangana plateau

Pedons	Series name	Depth (cm)	Colour (moist)	Texture (USDA)	Structure	Consistence	Coarse fragments	Special	Drainage features	Erosion
Pedon 1	Sibyala	0-16	5 YR4/4	Loamy sand	f1sbk	l, so, po	40	-	Well	Moderate
		16-43	2.5 YR3/4	Sandy clay	m2sbk	vfr, s, p	60	T Tn P		
Pedon 2	Anumpalli	0-16	7.5 YR4/3	Sandy loam	f1sbk	vfr, so, po	40	-	Well	Moderate
		16-36	7.5 YR4/4	Sandy clay loam	m2sbk	fr, ss, sp	40	T Tn P		
		36-55	7.5 YR3/4	Sandy clay loam	m2sbk	fr, ss, sp	50	T Tn P		
		55-72	7.5 YR4/8	Sandy clay loam	m2sbk	fr, ss, sp	50	-		

Table: 2
Physical and chemical properties of mango soils of Rayachoty Mandal, south Telangana plateau

Depth (cm)	Horizon	Particle size distribution (% of <2 mm)			OC (%)	pH	EC (dS m^{-1})	Exchangeable bases (cmol (p+) kg^{-1})				CEC (cmol (p+) kg^{-1})	BS (%)	CCE (%)	AWC
		Sand	Silt	Clay				Ca	Mg	K	Na				
Pedon 1: *Clayey skeletal isohyperthermic Lithic Rhodustalfs*															
0-16	Ap	81.44	12.79	5.77	0.32	6.00	0.065	1.32	0.70	0.40	0.02	3.10	79	-	7.86
16-43	Bt	51.92	12.85	35.23	0.44	5.66	0.066	7.38	5.06	0.54	0.07	15.10	86	-	12.43
Pedon 2: *Loamy-skeletal mixed isohyperthermic Typic Haplustalfs*															
0-16	Ap	77.13	12.35	10.52	0.40	6.83	0.107	3.49	1.84	0.58	0.03	6.10	97	-	4.47
16-36	Bt1	67.55	11.85	20.60	0.36	7.10	0.058	6.25	3.16	0.43	0.16	10.10	99	-	5.41
36-55	Bt2	65.20	10.76	24.03	0.22	7.81	0.149	16.21	3.14	0.50	0.53	20.40	100	0.94	6.75
55-72	Bt3	67.46	9.90	22.64	0.24	8.11	0.132	-	-	0.51	0.21	18.50	100	6.46	7.14

more than 79 to 100% base saturation. The sub-surface has got more cation exchange capacity (10.10 to 20.40 cmol (p+) kg^{-1}) due to more clay content in the subsurface. Parts of the south Telangana plateau haves subsurface calcium carbonate accumulation (0.94 to 6.46%) presence of carbonates of Ca or Mg in the parent material or a layer of secondary accumulation of carbonates. The surface soils of pedons (Table 3) have low to medium available phosphorus (6.87 to 34.35 kg ha^{-1}) and potassium (142.8 to 156 kg ha^{-1} content, low in sulphur (2.50 to 5.00 ppm) and boron (0.06-0.09 ppm), sufficient in iron (5.38-12.60 ppm), manganese (6.28-16.86 ppm) and Cu (0.60 to 0.74 ppm) and deficient in zinc (0.28-0.58 ppm) content.

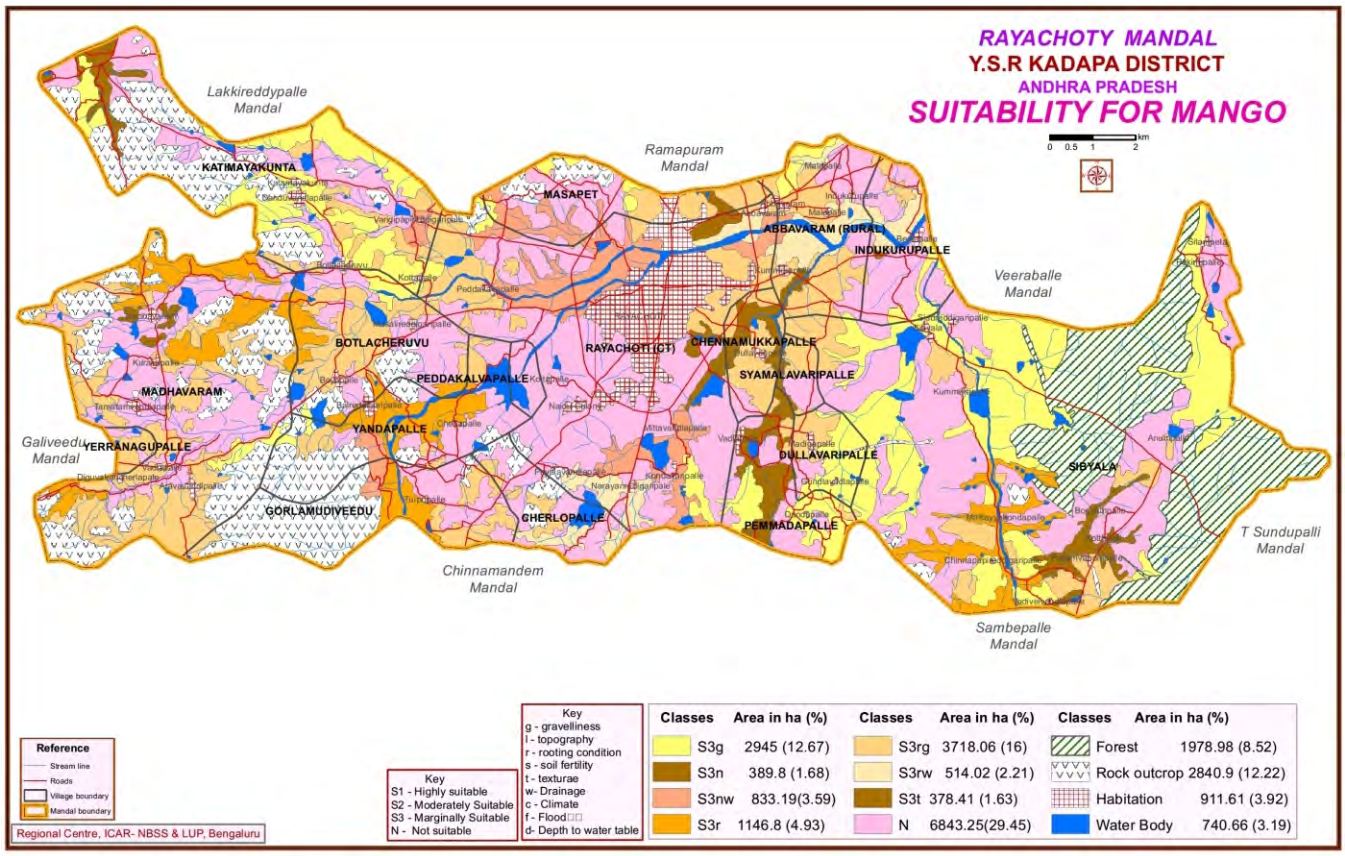
Based on these properties in soils of mango plantations, two soil series were established which are called Sibyala and Anumpalli series. Sibyala series is classified as clayey skeletal isohyperthermic *Lithic Rhodustalfs* whereas *Anumpalli* series is classified as loamy-skeletal mixed isohyperthermic *Typic Haplustalfs* as these series both have argillic horizon with >35% base saturation hence classified under the order Alfisols. Both the series are having moisture regimes intermediate between the aridic and udic regime hence classified as Ustalf. Since Sibyala series has 2.5 YR3/4 subsurface soil colour with shallow depth qualified under *Lithic Rhodustalfs* whereas *Anumpalli* series does not qualify under any suborder level hence classified under *Haplustalfs*. The difference between mean winter and mean summer temperature is >6^{o}C and the mean annual soil temperature is more than 22^{o}C hence both the series have been grouped under isohyperthermic temperature regime. Balakrishna *et al.* (2021) reported similar soil properties in mango plantations in the YSR Kadapa district including Rayachoty Mandal. Salunkhe *et al.* (2021) also studied the soil properties in mango orchards of the Ratnagiri district of the Konkan region.

Identification of Potential Mango Cultivation Lands

Agriculture land suitability assessment is a process of evaluation of land performance when used for alternative kinds of landuse / agriculture for specific crop cultivation (He *et al.,* 2011).The study area Rayachoty Mandal is having TGA of 23,240.70 ha with cultivated land of 16768.55 ha, out of which mango plantation is under 1613.8 ha (6.94% of TGA-map 1). In the Mandal, 53 mapping units (mapping units with a number given in Table 4) were identified based on morphological, physical and chemical properties of soils. Out of 53 mapping units, the mapping units number 29 to 53 are potential lands for mango cultivation which comes under marginally suitable *i.e.,* class S3 which accounts for 42.71% of total geographical area (map 2). These units are class S3 due to the slight limitation of gravelliness, root restriction, soil texture, soil fertility and drainage (limitations are provided along with a class in Table 5). However, mapping units 1 to 28 which

Table: 3
Soil available nutrients status of Mango soils, Rayachoty Mandal, south Telangana plateau

Pedons	Depth (cm)	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	S (ppm)	B (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Pedon 1	0-16	34.35	142.80	2.50	0.06	0.60	12.60	16.86	0.28
	16-43	2.29	169.20	2.50	0.25	2.10	13.10	23.12	0.12
Pedon 2	0-16	6.87	156.00	5.00	0.09	0.74	5.38	6.28	0.58
	16-36	2.29	109.20	2.50	0.70	1.44	3.06	3.58	0.12
	36-55	2.29	116.40	5.00	0.42	1.08	1.64	1.90	0.04
	55-72	11.45	138.00	14.16	0.08	0.18	1.26	1.22	0.14



Map 2. Soil suitability for mango in Rayachoty Mandal, south Telangana plateau

occupies 29.45% of total area is non-potential lands for mango cultivation which falls under unsuitable lands with class N for mango cultivation due to the limitation of soil depth which restricts the root growth and development thereby crop cannot withstand due to poor root anchorage as the depth of these units is less than 75 cm. The land capability classification (map 3) in the Mandal shows that these identified potential mango suitable lands belong to Class III *i.e.,* moderately good cultivable lands except mapping units 39, 49, 50, 52 and 53 which belongs to Class IV *i.e.,* fairly good cultivable lands due to soil and wetness limitation. A similar study of the identification of mango suitable land and their capability was reported by Abdel Rahman, *et al.* (2016). Naidu *et al.* (2009) also reported shorter growing periods, poor fertility status, poor drainage, presence of calcium carbonate and gravels in the sub-soils are identified as major constraints for mango production in Andhra Pradesh. Rathi *et al.* (2021) also reported similar studies on land capability and land suitability for different crops including soil fertility status in Khandala village of Nagpur district, Maharashtra.

Soil Fertility Status, Fertilizer Recommendation and Management

Delayed / unseasonal rainfall, temperature fluctuations, low soil fertility are the major constraints affecting mango production in Andhra Pradesh (Ganeshamurthy *et al.,* 2018) hence, available nutrients in the soil are important to be

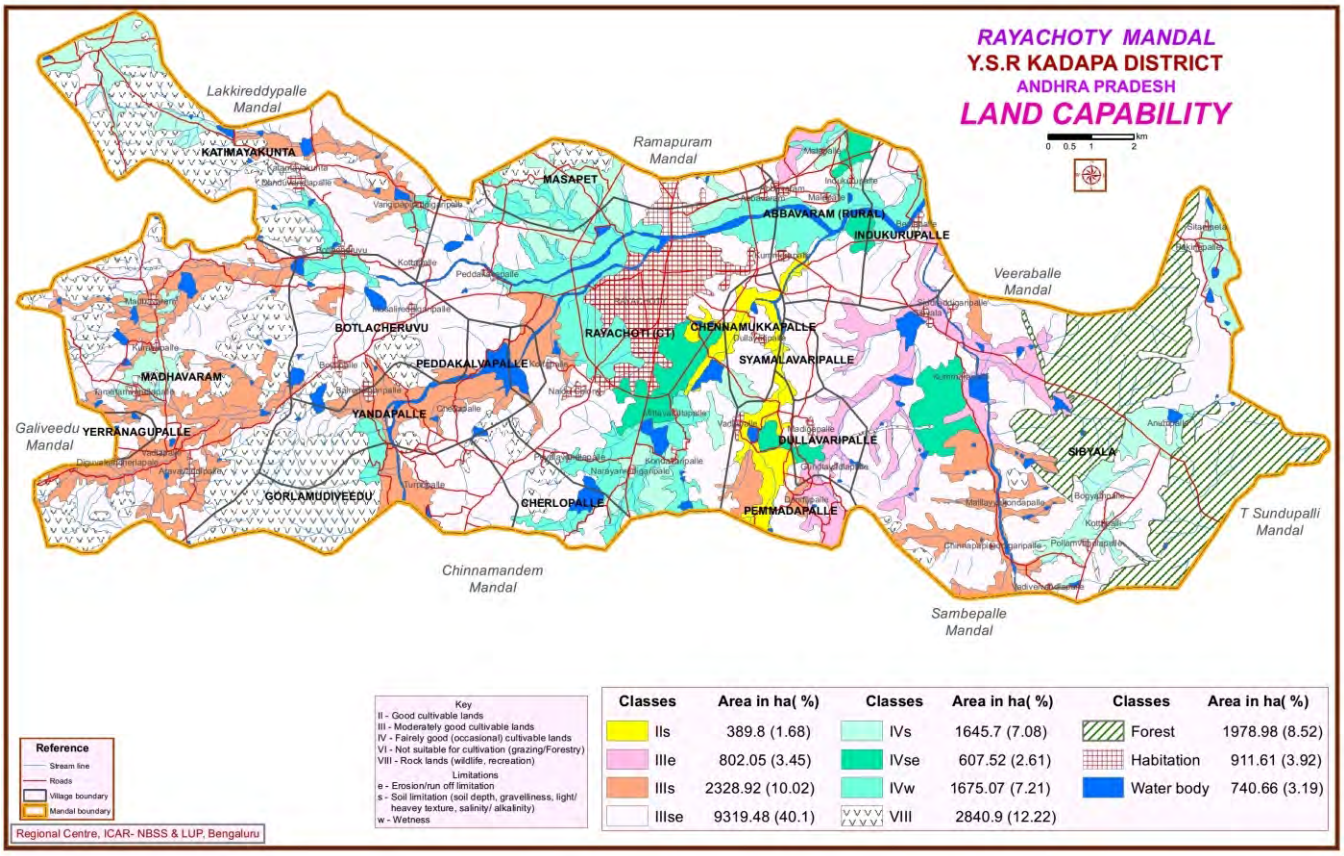
Table: 4
Mapping units with descriptive legend in Rayachoty Mandal, south Telangana plateau

Series name	Mapping unit No.	Mapping unit	Descriptive legend
Sibyala	1	SblbB2	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	2	SblbB2g2	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3% with surface very gravels of 35-60%
	3	SblcA1	Soils of sandy loam texture occurring on uplands with nearly level slope of 0-1%
	4	SblcB2	Soils of sandy loam texture occurring on uplands with very gentle slope of 1-3%
Variyapapireddypalli	5	VprbB1	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	6	VprbB2	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	7	VprcA1	Soils of sandy loam texture occurring on uplands with nearly level slope of 0-1%
	8	VprcC2	Soils of sandy loam texture occurring on uplands with gentle slope of 3-5%
Turpupalli	9	TppbB2	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	10	TppbC2	Soils of loamy sand texture occurring on uplands with gentle slope of 3-5%
	11	TppcA1	Soils of sandy loam texture occurring on uplands with nearly level slope of 0-1%
	12	TppcB2	Soils of sandy loam texture occurring on uplands with very gentle slope of 1-3%
	13	TppcB2g1	Soils of sandy loam texture occurring on uplands with very gentle slope of 1-3% with surface gravels of 15-35%
	14	TppcC2g1	Soils of sandy loam texture occurring on uplands with gentle slope of 3-5% with surface gravels of 15-35 %
	15	TpphB2g1	Soils of sandy clay loam texture occurring on uplands with very gentle slope of 1-3 % with surface gravels of 15-35%
	16	TppiC2	Soils of sandy clay texture occurring on uplands with gentle slope of 3-5%
Anumpalli	17	AnpbB1	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	18	AnpbB2	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	19	AnpbC2	Soils of loamy sand texture occurring on uplands with gentle slope of 3-5%
	20	AnpcB2	Soils of sandy loam texture occurring on uplands with very gentle slope of 1-3%
	21	AnpcB2g1	Soils of sandy loam texture occurring on uplands with very gentle slope of 1-3% with surface gravels of 15-35%
	22	AnphB1	Soils of sandy clay loam texture occurring on uplands with very gentle slope of 1-3%
	23	AnpiA1	Soils of sandy clay texture occurring on uplands with nearly level slope of 0-1%
Madhavaram	24	MdvbC2	Soils of loamy sand texture occurring on uplands with gentle slope of 3-5%
	25	MdvcA1	Soils of sandy loam texture occurring on uplands with nearly level slope of 0-1%
	26	MdvhA1	Soils of sandy clay loam texture occurring on uplands with nearly level slope of 0-1%
	27	MdvhB1	Soils of sandy clay loam texture occurring on uplands with very gentle slope of 1-3%
	28	MdviA1	Soils of sandy clay texture occurring on uplands with nearly level slope of 0-1%
Kumarapalli	29	KmpbB2	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	30	KmpbB2g1	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3% with surface gravels of 15-35%
	31	KmpbC2	Soils of loamy sand texture occurring on uplands with gentle slope of 3-5%
	32	KmpcB2	Soils of sandy loam texture occurring on uplands with very gentle slope of 1-3%
	33	KmpcC2g1	Soils of sandy loam texture occurring on uplands with gentle slope of 3-5% with surface gravels of 15-35%
	34	KmphB1	Soils of sandy clay loam texture occurring on uplands with very gentle slope of 1-3%
	35	KmphC2	Soils of sandy clay loam texture occurring on uplands with gentle slope of 3-5%
Balreddigaripalli	36	BrpbC2	Soils of loamy sand texture occurring on uplands with gentle slope of 3-5%
	37	BrphB1	Soils of sandy clay loam texture occurring on uplands with very gentle slope of 1-3%
	38	BrpfB1	Soils of clay loam texture occurring on uplands with very gentle slope of 1-3%
	39	BrpiA1	Soils of sandy clay texture occurring on uplands with nearly level slope of 0-1%
	40	BrpiB1	Soils of sandy clay texture occurring on uplands with very gentle slope of 1-3%
Kondavandlapalli	41	KvpbB1	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	42	KvpbB2	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3%
	43	KvpbB2g2	Soils of loamy sand texture occurring on uplands with very gentle slope of 1-3% with surface very gravels of 35-60%
	44	KvpcA2g1	Soils of sandy loam texture occurring on uplands with nearly level slope of 0-1% with surface gravels of 15-35%
	45	KvpcB2	Soils of sandy loam texture occurring on uplands with very gentle slope of 1-3%
	46	KvpcB2g1	Soils of sandy loam texture occurring on uplands with very gentle slope of 1-3% with surface gravels of 15-35%
	47	KvphB1	Soils of sandy clay loam texture occurring on uplands with very gentle slope of 1-3%
	48	KvphB2	Soils of sandy clay loam texture occurring on uplands with very gentle slope of 1-3%
Nayanurpalli	49	NyphA1	Soils of sandy clay loam texture occurring on lowlands with nearly level slope of 0-1%
	50	NypiA1	Soils of sandy clay texture occurring on lowlands with nearly level slope of 0-1%
Duganvandlapalli	51	DvpcA1	Soils of sandy loam texture occurring on lowlands with nearly level slope of 0-1%
	52	DvphA1	Soils of sandy clay loam texture occurring on lowlands with nearly level slope of 0-1%
	53	DvpiA1	Soils of sandy clay texture occurring on lowlands with nearly level slope of 0-1%

Table: 5
Soil suitability for mango in Rayachoty Mandal, south Telangana plateau

Mapping unit no.	Suitability classes	Description	Area ha	Area %
41, 42, 43, 44, 45, 46, 47, 48	S3g	Marginally suitable land with slight limitation of gravelliness	2945	12.67
51	S3n	Marginally suitable land with slight limitation of soil fertility	389.8	1.68
52, 53	S3nw	Marginally suitable land with slight limitation of soil fertility and drainage	833.19	3.59
36, 37, 40	S3r	Marginally suitable land with slight limitation of root restriction	1146.8	4.93
29, 30, 31, 32, 33, 34, 35	S3rg	Marginally suitable land with slight limitation of root restriction and gravelliness	3718.06	16
39	S3rw	Marginally suitable land with slight limitation root restriction and drainage	514.02	2.21
49, 50	S3t	Marginally suitable land with slight limitation of soil texture	378.41	1.63
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28	N	Currently not suitable land	6843.25	29.45
Soil total			**16768.55**	**72.15**
Rock outcrops			2840.9	12.22
Forest			1978.98	8.52
Habitation			911.61	3.92
Waterbody			740.66	3.19
Total geographical area			23240.7	100

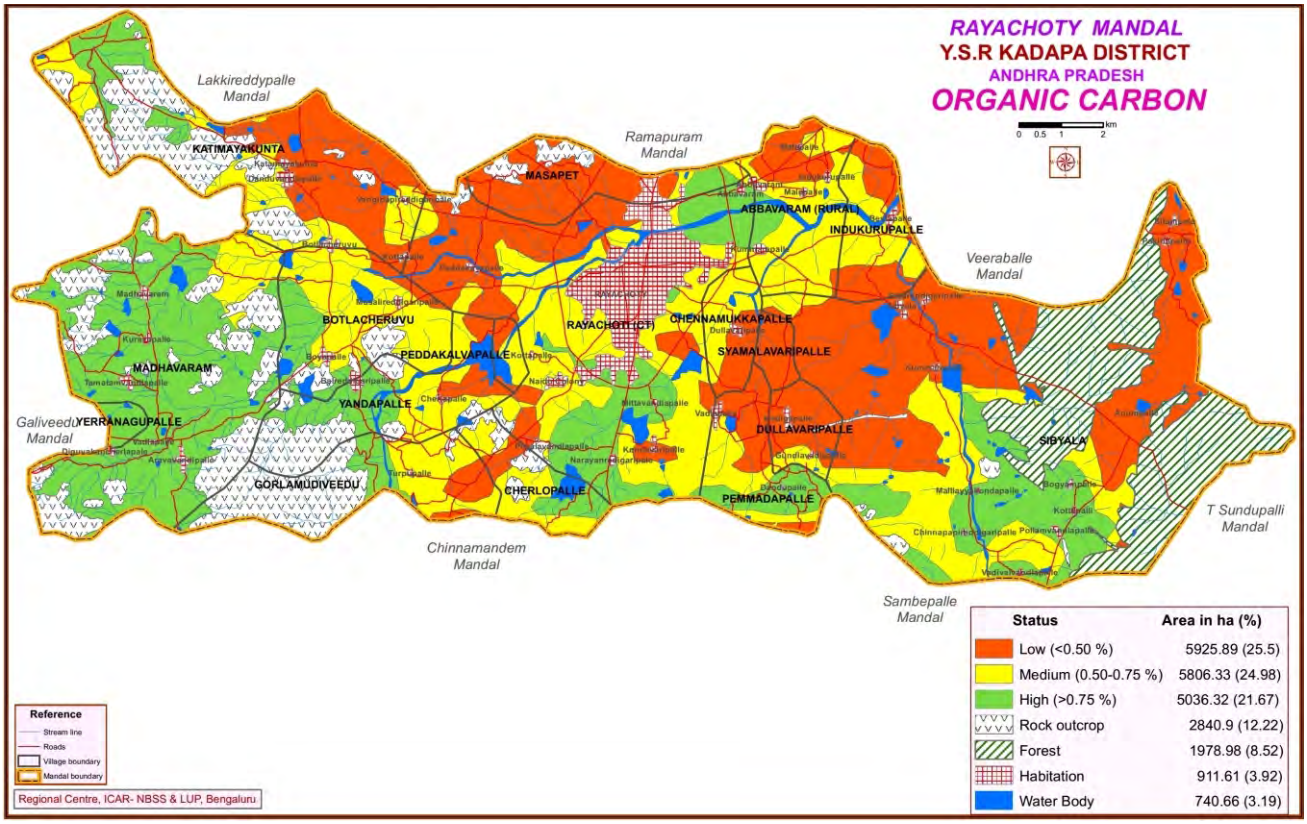
Note: Climatic limitation is commonly present in Rayachoty Mandal



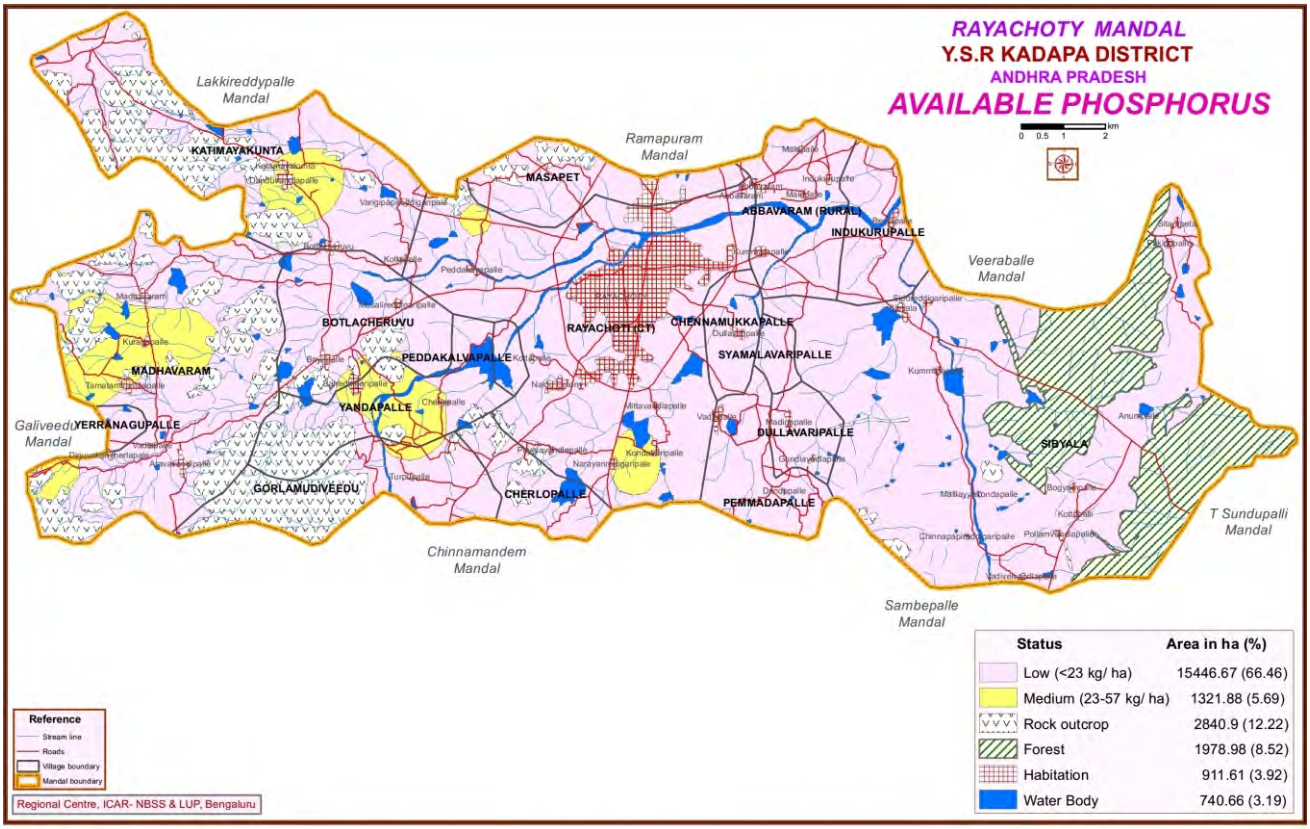
Map 3. Land capability classification in Rayachoty Mandal, south Telangana plateau

mapped to investigate the state of nutrients present in specific site / soil. Randomly collected 87 surface soil samples were analysed for OC (map 4), available phosphorus (map 5) and potassium status (map 6) of Rayachoty Mandal and fertility status was mapped in Arc-GIS. Results show that the OC content of soils of Rayachoty Mandal ranged from 0.20 to 2.11%. However, 25.5% of the area is low in OC content followed by 24.98% of area is medium and 21.67% area is high. High OC in some areas might be due to the addition of a sufficient quantity of organic manure for cultivating crops. A similar result of low soil organic matter was reported in mango orchards of western Uttar Pradesh (Kumar *et al*., 2015). In soils of low OC status (map 4) it is recommended to apply organic manures such as FYM, vermicompost, liquid organic manures such as panchagavya and jeevamruth to enrich the soil organic nutrient source for elevated mango production and productivity. Higher levels of OC not only provides part of nitrogen requirement of the mango plants but also enhance the nutrient and water retention capacity of soils and create a favourable environment as it is semiarid lands (Rajasekharan *et al.*, 2013).

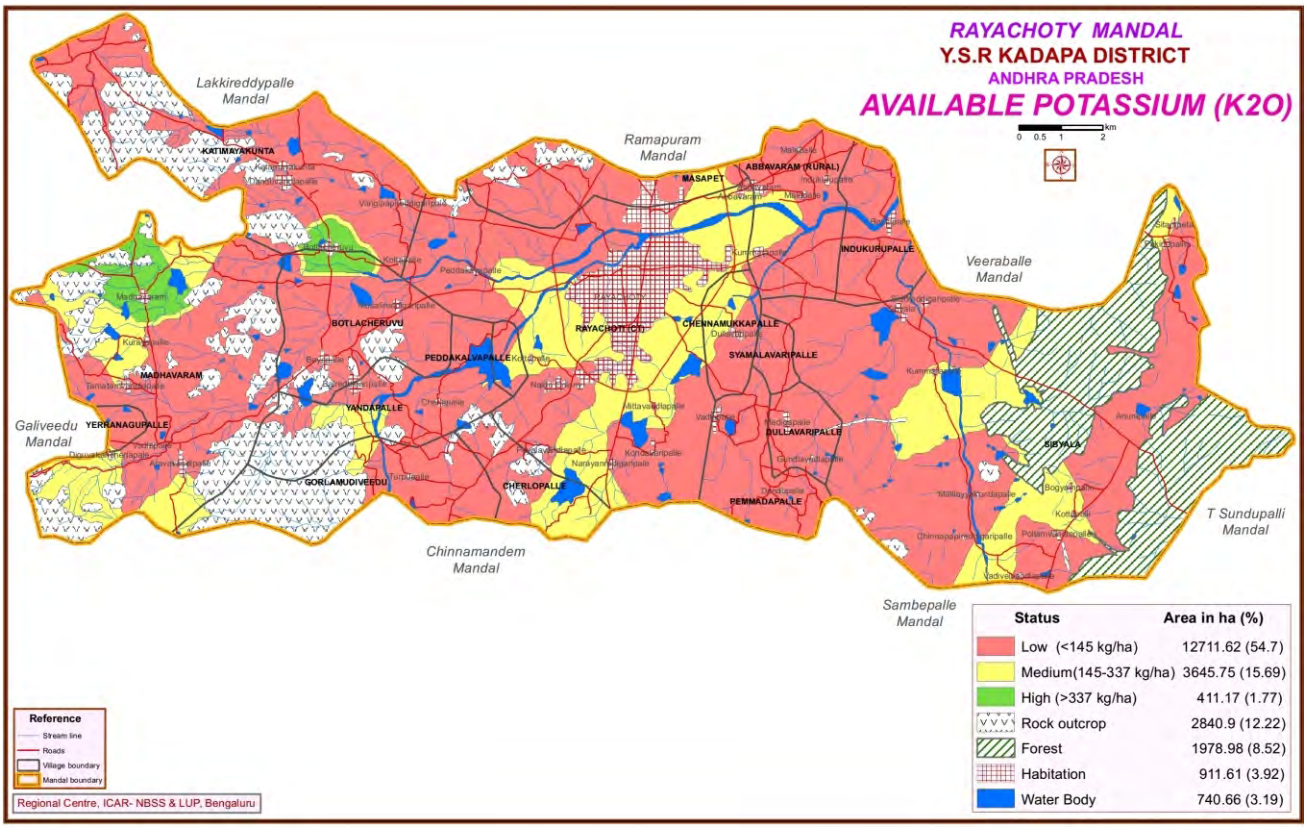
Phosphorus is described as the second limiting nutrient for crop production after nitrogen. The available phosphorus status (map 5) varied from 2.0 to 54.0 kg ha^{-1}. About 66.46% of the area is under low and 5.69% area under medium; hence it's very necessary to apply 125% of the recommended dose of phosphorus to mango plantations in the low phosphorus status soils and recommended dose of phosphorus to medium status soils. The available potassium status (map 6) in soils of Rayachoty Mandal varied from 36.0 to 442.0 kg ha^{-1}. About 54.70% of the area under low followed by 15.69% of the area under medium and 1.77% of the area under high. Similarly, to phosphorus, it is very necessary to apply 125% of the recommended dose of potassium in low potassium status soils and 75% of recommended dose in high status and recommended dose of potassium in medium status soils for better production and productivity of mango in order to maintain soil nutrient balance. Similar studies on soil fertility mapping have been done by Nalina *et al.* (2016) and Chandrakala (2020). Soil fertility / nutrient status is significantly varying due to natural factors like temperature, rainfall, soil erosion, weathering etc., and manmade factors such as land use, cultural operations, conservation practices and grazing etc. (Vishnoi *et al.,* 2020). Correction of soil nutrient deficiency is very necessary as the mango yield was correlated with the potassium contents, the sum of bases and pH as the low yield was resulted due to low K content associated with the presence of gravel (Siqueira *et al*., 2019). Major nutrients need an optimum application in order to sustain the productivity as well as soil health of mango orchards (Adak *et al.,* 2019). Application of soil test based nutrient recom-



Map 4. Soil organic carbon status of Rayachoty Mandal, south Telangana plateau



Map 5. Available phosphorus status of Rayachoty Mandal, south Telangana plateau



Map 6. Available potassium status of Rayachoty Mandal, south Telangana plateau

mendation is a must as the lower productivity of mango is linked to low to medium soil nutrients status hence, for ensuring better productivity, proper nutrition management systems should be adopted by the mango growers (Adak and Pandey, 2020).

Fertility capability classification of identified mango soils series is SCedhmr^{++} (1-3) and Ldhr^{++} (1-5) in Sibyala and Anumpalli series, respectively (Chandrakala *et al*., 2021). The Sibyala series has a sandy surface texture, it can be improved by the addition of mycorrhizae, cow dung, and biochar (Herawati *et al.,* 2021). Slope of the mango plantation is very gently (1-3%) to gently sloping (3-5%), hence, graded bunding and ploughing and cultivating across the slope (Chandrakala *et al,* 2019b) and also contour cropping, strip-cropping, inter cropping, mulch tillage, residue incorporation, vegetative barrier and contour barrier (Mandal *et al*., 2021) are recommended for managing the slope. Low cation exchange capacity (e) and low OC content (m) exist in Sibyala series hence, organic manures, FYM and compost is must be applied. Dry soil moisture regime (d) can be managed provided with artificial irrigation, however, the drip irrigation method saves water and increases water use efficiency in mango plantations which provides a consistent moisture regime in the soil hence, the root remains active throughout the season resulting in optimum availability of nutrient and proper translocation of food materials which accelerates the fruit growth and development in mango (Kumar *et al*., (2008); Bush (2020) and Taha, 2020). Acidity of soil (h) has to be managed by the application of burnt lime. Application of limestone enhanced the soil pH and base saturation status by adding Ca^{2+} and Mg^{2+} concentrations, in addition to decreasing H and Al thereby increasing the mango fruit yield in acid soils (Correia *et al*., 2018). Both the series have >35% gravel content (r^{++}) hence, the addition of tank silt or black clayey soils is recommended.

4. CONCLUSIONS

High temperature is not so injurious to mango, which can usually thrive well in the low rainfall and dry season. Hence, the identification of productive mango lands is urgently required in the semi-arid region for improving the socio-economical status, livelihood generation and creating employment for small and marginal farmers in the semi-arid region. Mango cultivation has the potential to provide food, nutrition, health security and livelihood opportunity in the south Telangana plateau. The present study identified the 42.71% area as potential for mango production with manageable soil and climatic limitations. Two soil series namely Sibyala and Anumpalli series were established in the mango plantations of Rayachoty Mandal, South Telangana plateau. Soils with low OC, available phosphorus and potassium status need to be applied with manures and fertilizers for elevated mango production and productivity apart from maintaining soil nutrient balance and soil health to obtain the mango fruit quality for achieving nutritional security in the country.

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