Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(4): 874-881
Received: 07-05-2020
Accepted: 09-06-2020

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Land suitability evaluation for crops in Warangal district of Telangana under Raghunathapally division

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Abstract
Seven typical Pedon's from central and eastern parts of Warangal district, Telangana State were evaluated for their suitability to major crops Viz, rice, maize, cotton, chilly and red gram. The suitability classes ranged from highly suitable to these crops. Pedon's 1,4 were moderately suitable for maize, chilly and red gram marginal suitable for cotton and temporarily not suitable for rice. Pedon 4 marginally suitable for maize chilly and permanently not suitable for rice and cotton. Pedon 1,3,5,6 were is grouped under different type of Inceptisols like typic gaplustelts calcic haplustepts, verticeshaplustepts, which are moderately suitable for maize, chilly and red gram marginal suitable for cotton and temporarily not suitable for rice. Pedon 3 is highly suitable for red gram moderately suitable for maize, chilly and marginally suitable for rice and cotton. Pedon 5 is highly suitable for maize, chilly and marginally suitable for rice, cotton.Pedon 6 is highly suitable for rice, cotton, chilly and red gram moderately suitable for maize.Pedon 2 is grouped under typic haplusterts which is highly suitable for rice and cotton moderately suitable for maize, chilly and red gram. The major limitations are medium texture soil, slight variation. Depth of Pedon amount of clay, presence or absence ofcoarse fragments are medium texture. Crop suitability, shallow depth excessive drainage. (Wetness) soil physical characteristics and soul fertility characteristics are P^H& O.C.

Keywords: Soil – site suitability, Warangal district, soil taxonomy, limitation levels, potential lad suitability

Introduction
Soil characterization determines the soil's individual inherent potentials and constraints for crop production besides giving detailed information about the different soil properties. Characterization and systematic classification of dominant soil groups is an essential tool and a pre-requisite for soil fertility evaluation and efficient soilfertilizer-water management practices and, thus, crop management.

Each plant species require specific soil-site condition for its optimum growth. (B Vidyadhar *et al*. 2007) [2] For rationalizing land use, the soil site suitability for different crops needs to be determined. These suitability models provide guidelines to decide the policy of growing most suitable crops depending on the capacities of each soil unit (Sehgal, 1986) [27].

Further, in the Telangana region generally red and black soils occur in adjacent and the pedogenesis of the associated red and black soils are due to the difference in the mineralogical make up of the parent material, pedogenesis, conditioned by the drainage and relief (Rudra Murthy and Dasog, 2001) [23]. These soils are different in their quality characteristics, and each characteristic feature is important, in understanding the behaviour, nutrient supplying capacities, fertilizer responses, management strategies to be adopted for crop production and potential capability of soils.

The soil and land resources of central Telangana regions are supporting a variety of crops in the changing of scenario of cropping systems and management practices. Soil and land sources of the area are not surveyed and systematic reports on the characteristics, nutrient status, potential capabilities are not available, for the scale of implementation of recommended package of practices. The study area in unexplored and unreported and the farmers are following the recommendations in blanket without considering the suitability and use potential of the soil, land resources and shifting crop patterns and following cropping systems on their own.

Materials and Methods

Description of the study area

Warangal, Location of the study area Telangana State. The area selected for the present study, Warangal district, lies in central Telangana Zone in Telangana State has a total geographical area of 12846 Km^2 which lies between 17^o 19^1< 18^0 36^1 or latitude and 78^0 49^1& 80^0 43^1 East longitude. The climate is semi – arid monsoon with district summer, winter and rainy seasons. The mean annual rain fall is 803.2 mm of which 90.11% received during south west monsoon, 4.80% during summer season. (May to November) and JAN to Feb respectively.

The mean annual Temperature is maximum and minimum temperature of the district are 32.44 ^{0}C and 23.31^{oc} respectively. The maximum and minimum mean monthly temperature ranges from 17 ^{0}C to 40.8 ^{0}C. The mean minimum temperature is recorded during December 17.0 ^{0}C and maximum in may 40.8 ^{0}C. The mean annual air temperature of the district is 27.78 ^{0}C. The soil moisture regime is ustic, and soil temperature regime is iso hyper thermic. The natural vegetation comprises of species like fiscus, tamarind, mean prosopis, ber are predominated trees in the study area.

Fiscusbergatenesis, tamarind usIndica, *Azadiracta indica*, *Zizyphus jujube*.

Methodology

After traversing the Raghunadpally division of Waranagal district, seven typical pedons were selected on two land forms (plains and uplands) in central and eastern parts of the division. The morphological characteristics of these typical pedons were described in the field by following the procedure outlined by Soil Survey Staff. Horizonwise soil samples were collected from these typical pedons and analyzed for their physical, physico-chemical and chemical properties following the standard procedures and were classified according to Soil Taxonomy (Soil Survey Staff, 1999) [9]. These pedons were evaluated for their suitability using limitation method regarding number and intensity of limitations. The landscape and soil requirements for the selected crops were matched with generated data at different limitation levels: no (0), slight (1), moderate (2), severe (3) and very severe (4). The number and degree of limitations suggested the suitability class of pedons for a particular crop. The potential land suitability (table 3) subclasses were determined after considering the improvement measures to correct these limitations

After traversing the Waranagal district, six typical pedons were selected on two land forms (plains and uplands) in central and eastern parts of Warangal district. The morphological characteristics of these typical pedons were described in the field by following the procedure outlined by Soil Survey Staff (2000) [9]. Horizonwise soil samples were collected from these typifying pedons and analyzed for their physical, physico-chemical and chemical properties following the standard procedures and were classified according to Soil Taxonomy (Soil Survey Staff, 1999) [9]. These pedons were evaluated for their suitability using limitation method regarding number and intensity of limitations (Sys *et al*. 1991) [10]. The landscape and soil requirements for the selected crops were matched with generated data at different limitation levels: no (0), slight (1), moderate (2), severe (3) and very severe (4). The number and degree of limitations suggested the suitability class of pedons for a particular crop (Sys *et al*. 1991) [10]. The potential land suitability (table 3) subclasses were determined after considering the improvement measures to correct these limitations (Sys *et al*. 1991) [10].

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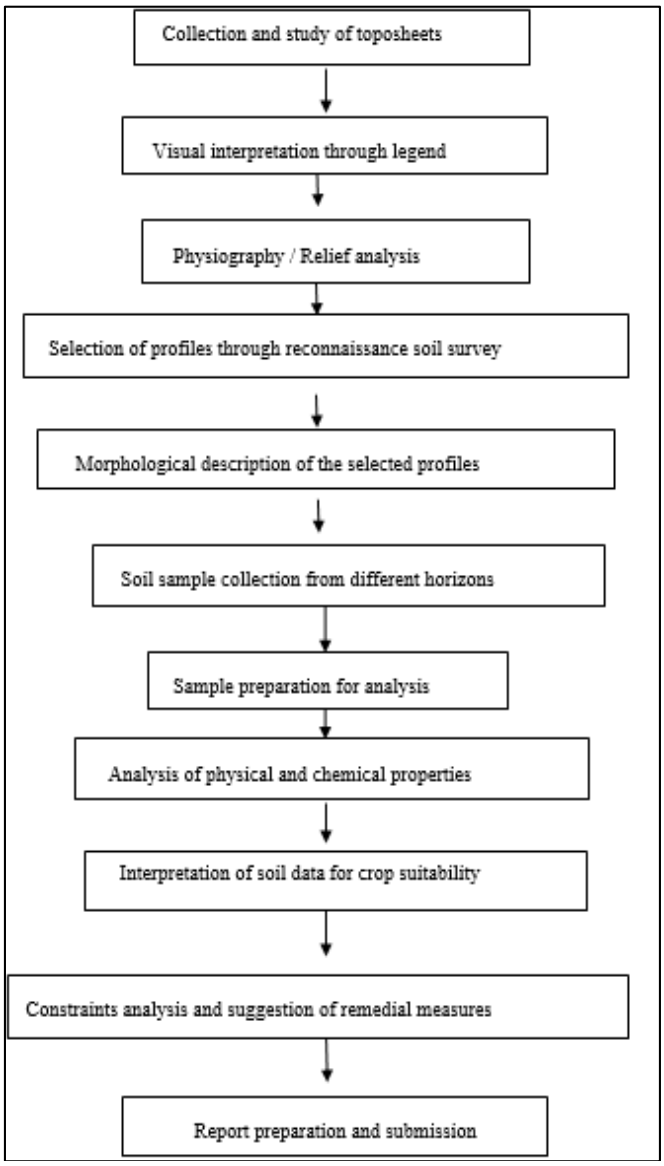
Soil suitability for major crop growing was evaluated based on FAO (1976) [13] frame work for land evaluation. It involved formulation of climatic and soil requirements of crop and ratings of these parameters viz., highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and unsuitable (N) for agriculture. Soil-site suitability for some of the major crops was evaluated based on the criteria suggested by Sehgal (1996) [14] and Sys *et al.* (1991) [10]. Soil-site suitability characteristics for crops are presented in table 1 to 3.

Criteria for the determination of the land suitability classes

Land Classes	Criteria
S1 : Very suitable	Land units with no, or only 4 slight limitations.
S2: Moderately suitable	Land units with more than 4 slight limitations, and / or not more than 3 moderate limitations.
S3 : Marginally suitable	Land units with more than 3 moderate limitations, and / or one or more severe limitation(s).
N1 : Actually unsuitable and potentially suitable	Land units with very severe limitations which can be corrected.



Results and Discussion

Details of Pedon's and relevant soil characteristics are given in table 1 and site characteristics and weighted means of soil characteristics are given in table 2. These soils are developed from granite – gneiss, alluvial deposits and sand stones.

The land capability classification is grouping of a land unit (s) in to defined class (es) based on its capability. It is a broad grouping of soils based on their limitations and is designed to emphasize the hazards in different kinds of soils. It serves as a guide to assess suitability of the land for arable crops, grazing and forestry. The land capability classification consists of three categories namely i) capability classes' ii) capability sub-classes and iii) capability units. In all eight capability classes, class I, II, III and IV were suitable for cultivation and class- V, VI, VII were unsuitable for cultivation but suitable for permanent vegetation (grazing). The capability sub classes are based on kind of dominant limitation such as wetness or excess water (w), climate (c), soil(s), erosion (e) and topography (t). The capability unit includes soils which are sufficiently uniform in their characteristics. Potential and limitations and require fairly uniform conservation treatments and management practices. Dipak sarkar *et al*. (2002) [4] reported based on morphology and soil properties, soils have been classified in to the order Inceptisols (pedon1) and Ultisols (pedons 2, 3, 4, 5 & 6). The high hill soils (p1 and p2) are mostly classified in to capability class VI. The medium hill soils (p3and p4) are classified into capability class IV the foot hill soils (p5) are classified in to capability class III.

Esther Shekinah *et al*. (2004) [5] classified the soils of Sahaspur block in Uttaranchal in to six land capability classes viz., II, III, IV, VI, VII and VIII. The soils Chandragiri mandal in Chittoor district of Andhra Pradesh have been classified in to three land capability sub-classes i.e., IIS, IIIW, IIIes, IIIse, and IVs (Bhaskar *et al*., 2005). The soils resources in Sivagiiri micro-watershed of Chittoor district in Andhra Pradesh were classified in to three land capability sub-classes i.e. IIS, IIIes, IIIW and IVS (Thangasamy *et al*., 2005) [32]. The soils of Mirjan village of coastal agro-ecosystem of Karnataka, was studied and find out the potential and constraints of these soils through land capability classification and soil suitability evaluation. The mapped soils from the study area were matched with criteria for land capability classification and soil site suitability evaluation. In the land capability map, three classes have been differentiated viz., IIIS, IVS and VS (Mini *et al*., 2007) [15]. Soil resource information of South Tripura district of North-eastern India was utilized for land evaluation in terms of land capability classification (LCC) (Gangopadhyay *et al*., 2008) [8].

Riquier *et al*. (1978) were of the opinion that theoretically it was possible to have a maximum potential index of 100for all the soils, if all possible improvements were made. According to them, soil productivity could be altered completely by modern management practices. Sys *et al*. (1991) [10] provided practical guidelines for parametric method of land evaluation. Sehgal (1991) [26] reported that the critical limit of AWC is 100 mm, below which the cotton yields are uneconomical. Rainfed cotton gives best yields on deep, fine textured soils with a good structure. The very fine (> 60 percent clay) soils are considered to be critical.Walia and Chamuah (1991) [33] evaluated soils of two adjoining hilly districts of Assam for their suitability for fruit crop cultivation, and it was concluded that soils occupying piedmont plains and classified as Inceptisols or Alfisols are suitable for banana plantation. Gaikawad *et al*. (1998) [7] observed the productivity potential of soils of Maharashtra in the descending order i.e. Typic Haplusterts (48.92) > Udic Haplusterts (42.52) Udic Ustochrepts (40.64) > Typic Ustochrepts (38.26) > Udic Haplustalfs (37.29) > Vertic Ustochrepts (37.27) > Typic Haplustalfs (32.53) > Lithic Ustochrepts (33.42) > Typic Haplustolls (32.65) > Typic Ustorthents (28.62) > Lithic Ustrothents (21.38) under defined set of climatic conditions and management practices. Ranganathan (1998) [21] reported that the native fertility of tea-growing red and lateritic soils are strongly acid and have a high exchangeable Al3+, very poor fertility but crop respond well to good management and cultural practices. The land use study of the soils in Aurangabad district indicates that the soils of the district are suitable for growing most annual crops in shallow soil and perennials in the deeper soils (Maji *et al*., 1998) [13]. Sarkar and Sahoo (2000) [24] characterized, classified and evaluated the suitability of the Aquepts occurring in Indo-Gangetic plain of Bihar for crop production. Soil-site suitability evaluation revealed that these soils were moderately to marginally suitable for cultivation of rice and wheat and unsuitable for sugarcane. Tamgadge.

Reddy *et al*. (2005) [32] reported that in Medak district about 1.4% of total area was rated as highly suitable (S1) 41.66% area as moderately suitable (S2) and 50.82 percent as unsuitable (N2) for rice. Highly suitable lands are mainly distributed in Zaheerabad and Sadasipet. In case of sugarcane, highly suitable (S1), lands are distributed in Siddipet,

Dubbaka, Ramayampet, Gajwel, Narsapur, Medak, Andole Jonipet, Sangareddy, Shankarampet, Sadasipet and to a limited extent in Narayankher and Zaheerabad.

Rajeshwar and Mani (2014) [20] evaluated the soils for their suitability to different crops and reported that the red soils were marginally suitable to highly suitable for cultivation of maize, greengram, blackgram, sorghum, redgram, greengram and blackgram, black soils were moderately suitable to highly suitable for cultivation of cotton, sorghum, soybean, greengram, blackgram, redgram, sunflower, sesamum, maize, and pearlmillet. The red laterite soils were marginally suitable to moderately suitable for cultivation of groundnut, greengram, blackgram, redgram, horsegram and pearlmillet.

Management practices suggested based on the constraints

- Heavy texture in soils caused low infiltrartion, poor drainage, leading to runoff and erosion. It can be improved by cultivation with precautions against permanent damage like bunding / adoption of broad bed and furrow method of irrigation. Following agronomic measures like crop rotation / mixed cropping / growing leguminous crops in rotation or application of organic manures or organic mulches add organic matter to the soil which not only improve the drainage condition but also reduce runoff and erosion. Similar observations were also made by Leelavathi *et al.* (2010b) [15] and Geetha Sireesha and Naidu (2013b) [2] in Yerpedu mandal of Chittoor district and Banaganapalle mandal of Kurnool district in Andhra Pradesh, respectively.
- Light textured soils which also had low water holding capacity, can be improved by addition of tank silt (pond mud) along with careful soil and water management practices like mulching or addition of bulky organic manures / green leaf manuring. Similar observations were made and recommendations were suggested by Selvaraj and Naidu (2012) [20] and Niranjana *et al.* (2013) [17] in Renigunta mandal and Pulivendula region of Andhra Pradesh, respectively.
- Shallow depth of soils can be improved by deepening of soil by ridging, deep ploughing / breaking up of soil crust or contour bunding and contour farming or adoption of very careful soil and water management practices. Similar observations and recommendations were earlier made by Geetha Sireesha and Naidu (2013b) [2] and Patil *et al.* (2013) [21] in Banaganapalle mandal of Kurnool district in Andhra Pradesh and in Osmanabad tehsil of Maharashtra, respectively.
- The organic carbon content in these soils can be improved by incorporation of crop residues or application of farm yard manure / compost / press mud or green manuring with legumes or inclusion of legumes in crop rotation. These measures along with judicious water and soil management reduce the adverse affects of high $CaCO_3$ content in soils. Rahate *et al.* (2014) and Garhwal *et al.* (2013) [1] reported similar observations and recommendations in soils of Telangkhedi garden in Nagpur of Maharashtra and in Sirohi district of Rajasthan, respectively.
- The pH can be reduced by application of organic manures and soil amendments like sulphur / press mud / spent wash. Similar findings were noticed by Patil *et al.* (2010) [6] and Niranjana *et al.* (2013) [17] in Chandrapur district of Maharashtra and in Pulivendula region of Andhra Pradesh, respectively.
- Addition of gypsum and green manuring with dhaincha can reduce the alkalinity problem. Similar findings and recommendations were given by Likhar and Prasad (2011) and Nasre *et al.* (2013) [16] in Nagpur district of Maharashtra and in Karanji watershed of Yavatmal district in Maharashtra, respectively.
- Soil test based fertilizer recommendation should be followed to avoid nutrient imbalance and to supply the right nutrients at right time.
- Judicious use of organic manures and biofertilizers in combination with inorganic fertilizers not only improves the supply of major nutrients but also increases the availability of micronutrients for better crop production in these soils.
- Micronutrients can be directly applied to soil or by foliar application for their better management. Soil application of $ZnSO_4$ @ 25 kg ha^{-1} once in two seasons and / or foiliar application of $ZnSO_4$ @ 0.2 per cent for 2-3 times in a week helps in alleviating zinc deficiency. Foliar application of $FeSO_4$ @ 2 per cent for 2-3 times in a week controls iron deficiency.
- The organic carbon in these soils can be improved by incorporation of crop residues or application of farm yard manure / compost / press mud or green manuring with legumes or inclusion of legumes in crop rotation.
- The pH can be reduced by application of organic manures and soil amendments like sulphur / press mud / spent wash thereby increasing the availability of nutrients.
- High calcium carbonate content leads to greater fixation of P and Zn to limit crop production. Application of organic manures such as FYM or compost or vermicompost or green manuring with legumes or application of P and micro-nutrients by mixing with organics reduces the P and Zn fixation by formation of organo-Zn and organo-P complexes. Further, the acids produced during decomposition of organic manures causes solubilisation of $CaCO_3$ and decrease its content in the soil.
- Alkalinity (high ESP) in the soils can be reduced by addition of gypsum or green manuring with dhaincha not only reduces the alkalinity problem but also increases nutrient availability. Similar findings and recommendations were also reported by Likhar and Prasad (2011), Kuchanwar and Gabhane (2012) [3], Meena *et al.* (2012) and Niranjana *et al.* (2013) [17] in Nagpur district of Maharashtra, Ridhora watershed in Nagpur district of Maharashtra, Malwa plateau in Banswara district of Rajasthan and Pulivendula region of Andhra Pradesh, respectively.

Table 1: Site and soil characteristics of studied profiles for crop suitability classification (Weighted average)

Pedon No	Soil	Drainage	Physical characteristics (s)			$CaCO_3$ (%)	Soil fertility characteristics (f)					Salinity and alkalinity (n)	
			Texture	Coarse fragments Volume (%)	Soildepth (cm)		CEC [cmol (p+) kg^{-1} soil]	Sum of basic cations [cmol (p+) kg^{-1} soil]	BS (%)	pH (1:2.5)	OC (%)	Ece (dSm^{-1})	ESP (%)
19	TypicRhodustalfs	Well drained	cl	22.36	0-110	-	10.97	7.24	59.29	5.95	0.38	0.06	1.97
20	TypicHaplusterts	Moderately well drained	c	30.18	0-135	7.44	40.39	40.39	100	8.72	0.39	0.42	5.51
21	TypicHaplustalfs	Well drained	cl	19.52	0-62	-	18.56	14.82	78.99	7.33	0.27	0.09	0.41
22	TypicHaplustalfs	Well drained	scl	16.75	0-46	-	14.56	10.78	73.66	7.2	0.59	0.1	2.66
23	Calcic Haplustepts	Imperfectly drained	cl	28.53	0-112	8.87	21.15	21.15	100	8.6	0.39	0.2	0.21
24	TypicHaplustepts	Moderately well drained	cl	21.8	0-72	-	15.1	15.11	100	7.3	0.6	0.32	0.38
25	VerticHaplustepts	Imperfectly drained	c	26	0-100	8.09	37.68	37.67	100	8.47	0.42	1.24	2.2

Table 2: Depth wise Soil characteristics used for assessing crop suitability evaluation

Pedon No	Location	Horizons	Depth (cm)	Physical characteristics (s)% of < 2 mm soil			$CaCO_3$ (%)	Physico-Chemical characteristics				Salinity and alkalinity (n)	
				Texture				CEC[cmol(p+) kg^{-1} soil]	BS (%)	pH (1:2.5 H_2O)	OC (%)	EC (dSm^{-1})	ESP
				Sand	Silt	Clay							
19	Wardhannapet	Ap	0-14	89.3	7.8	2.9	-	1.7	56.47	6.8	0.41	0.09	5.88
		Bt1	14-29	76.7	6.9	16.4	-	7.82	59.97	6.3	0.58	0.08	2.56
		Bt2	39-75	61.8	7.9	30.3	-	14.1	66.67	6.5	0.55	0.07	1.42
		BC	75-110+	56.7	8.8	34.5	-	15.4	69.48	6.6	0.28	0.05	1.3
20	Dharmasagar	Ap	0-14	24.3	25.7	50	4.2	36.2	100	8.3	0.48	0.28	1.1
		BA	14-33	26.7	19.8	53.5	6.2	37.2	100	8.5	0.44	0.31	2.42
		Bss1	33-65	27.9	17.8	54.3	7.8	38.6	100	8.8	0.39	0.39	3.11
		Bss2	65-102	25.6	17.7	56.7	7.8	41.5	100	8.5	0.41	0.52	6.75
		Bss3	102-135+	21.8	18.9	59.3	9	44.5	100	9.2	0.29	0.5	10.11
21	Palakurthi	Ap	0-10	82.9	7.9	9.2	-	4.8	75	6.8	0.41	0.14	0
		Bt1	10-26	65.7	7.5	26.8	-	14.5	77.93	7.3	0.55	0.09	0.69
		Bt2	26-62	45.8	15.4	38.8	-	24.2	80.58	7.5	0.65	0.1	0.41
		Cr	62+	Weathered Parent Material									
22	Raghunadhapally	Ap	0-8	63.5	11.5	26	-	7.2	70.83	6.7	0.43	0.15	2.78
		Bt1	8-22	62.9	12.9	24.2	-	11.5	73.91	7	0.58	0.11	2.61
		Bt2	22-46	46.6	16.5	36.9	-	18.8	74.47	7.5	0.66	0.09	2.66
		Cr	46+	Weathered Parent Material									
23	Lingalaghanpur	Ap	0-19	61.5	15.5	23	2.4	17.2	100	8	0.5	0.25	0
		Bw	19-44	59.7	14.9	25.4	4.1	19.6	100	8.2	0.49	0.2	0
		Bw2	44-82	57.9	15.5	26.6	11.6	21.5	100	8.6	0.39	0.18	0
		BCk	82-112	54.8	15.3	29.9	13.5	24.5	100	9.1	0.36	0.2	0.82
		Crk	112+	Weathered Parent Material									
24	Bachannapet	Ap	0-22	70.7	14.8	14.5	-	11.2	100	7.2	0.45	0.29	0
		Bw1	22-48	65.8	13.3	20.9	-	16.2	100	7.4	0.25	0.35	0
		Bw2	48-72	64.7	13.5	21.8	-	17.5	100	7.5	0.17	0.32	1.14
		Cr	72+	Weathered Parent Material									
25	Cheryal	Ap	0-15	33.5	27.3	39.2	1.2	28.2	100	8.3	0.8	0.03	1.42
		Bw1	15-45	18.9	29.5	54.6	6.9	38.2	100	8.6	0.43	0.05	1.57
		Bw2	45-75	15.7	28.3	56	9.8	40.1	100	8.5	0.37	2	2.24
		Bw3	75-100	13.9	30.7	55.4	11.6	39.8	100	8.4	0.24	2.5	3.52

Table 3: Limitation levels of the land characteristics and land suitability classes for major crops

Pedon No	Soil	Crop	Wetness (w) drainage	Physical soil characteristics (s)			$CaCO_3$ (%)	Soil fertility characteristics (f)				Alkalinity (n)	Actual land suitability sub-class	Potential land suitability sub-class
				Texture	Coarse fragments (Vol. %)	Soil depth (cm)		CEC	Sum of basic cations	pH 1:2.5	OC (%)	Esp		
19	Typic Rhodustalfs	Rice	3	3	0	0	0	3	0	0	0	0	N1wsf	S3sf
		Maize	0	1	0	0	0	2	0	0	0	2	S2sfn	S1s
		Cotton	2	3	0	0	0	3	0	0	0	0	S3wsf	S3s
		Chillies	0	1	0	0	0	2	0	0	0	0	S2sf	S1s
		Redgram	0	1	0	0	0	1	0	0	0	2	S2sfn	S1s
20	Typic Haplusterts	Rice	0	0	0	0	0	0	0	1	0	0	S1	S1
		Maize	1	1	0	0	1	0	0	2	0	0	S2sf	S1s
		Cotton	0	0	0	0	0	0	0	1	0	0	S1f	S1

		Chillies	1	0	0	0	2	0	0	2	0	0	S2wsf	S1s
		Redgram	0	0	0	0	2	0	0	2	0	0	S2sf	S1s
21	Typic Haplustalfs	Rice	3	3	0	2	0	2	0	0	0	0	S3wsf	S2sf
		Maize	1	1	0	1	0	2	0	0	0	0	S2wsf	S2s
		Cotton	3	3	0	2	0	2	0	0	0	0	S3wsf	S2s
		Chillies	2	2	0	1	0	2	0	0	0	0	S2wsf	S2s
		Redgram	1	1	0	0	0	1	0	0	0	0	S1wsf	S1s
22	Typic Haplustalfs	Rice	3	4	2	4	0	3	0	0	0	0	N2wsf	N2wsf
		Maize	2	2	1	3	0	2	0	0	0	0	S3wsf	S2wsf
		Cotton	3	3	2	4	0	3	0	0	0	0	N2wsf	N2wsf
		Chillies	2	1	2	3	0	2	0	0	0	0	S3sf	S2sf
		Redgram	2	1	0	2	0	1	0	0	0	0	S2wsf	S1s
23	Calcic Haplustepts	Rice	0	2	0	0	0	0	0	0	0	0	S2s	S1s
		Maize	1	0	0	0	1	0	0	2	0	0	S1wf	S1f
		Cotton	0	2	0	0	1	0	0	0	0	0	S2sf	S1s
		Chillies	0	0	0	0	1	0	0	2	0	0	S2sf	S1s
		Redgram	1	0	0	0	2	0	0	1	0	0	S2wf	S1
24	Typic Haplustepts	Rice	1	3	3	1	0	2	0	0	0	0	S3sf	S2s
		Maize	0	1	2	0	0	0	0	0	0	0	S2s	S1s
		Cotton	0	3	3	2	0	2	0	0	0	0	S3sf	S2s
		Chillies	0	2	2	1	0	0	0	0	0	0	S2s	S2s
		Redgram	0	1	1	0	0	0	0	0	0	0	S1s	S1s
25	Vertic Haplustepts	Rice	0	0	0	0	0	0	0	1	0	0	S1f	S1
		Maize	2	1	0	0	1	0	0	2	0	0	S2wsf	S1sf
		Cotton	0	0	0	0	0	0	0	1	0	0	S1f	S1
		Chillies	1	0	0	0	1	0	0	2	0	0	S1sf	S1s
		Redgram	0	1	0	0	1	0	0	2	0	0	S1sf	S1s

Limitations: 0- No; 1- Slight; 2- Moderate; 3- Severe; 4- Very severe

Suitability classes: f- soil fertility limitations; s- Physical soil limitations; w- wetness limitations; n- Salinity (and /or alkalinity) limitations

Limitations are wetness (drainage), physical soil characteristics (soil depth and texture) and soil fertility characteristics (organic carbon and pH).The pedons 2, 3, 5 and 7 are marginally suitable and the pedons 1, 4 and 6 are permanently not suitable for rice. Leelavathi *et al* (2010) [5] and Selvaraj and Naidu (2013) [7] also reported that the soils of Yerpedu and Renigunta mandals in Chittoor district, respectively were marginally suitable for growing rice. The pedons 1 and 3 are moderately suitable while the pedons 2, 4, 5, 6 and 7 are marginally suitable for growing cotton crop. Patil *et al* (2010) [6] and Garhwal *et al* (2013) [1] also reported that soils in Lendi watershed of Chandrapur district in Maharashtra and Sirohi district in Rajasthan, respectively were moderately suitable (S2) for growing cotton. The pedons 1, 2, 3, 5, 6 and 7 are marginally suitable and the pedon 4 is temporarily not suitable for chickpea crop. Garhwal *et al*., (2013) [1] also reported that soils of Sirohi district of Rajasthan were marginally suitable (S3) for chickpea. Pedons 5 and 7 are marginally suitable and pedons 1, 2, 3, 4 and 6 are temporarily not suitable for growing tobacco. The pedon 3 is highly suitable, pedons 1, 5, 6 and 7 are moderately suitable, pedon 2 is marginally suitable whereas the pedon 4 is temporarily not suitable for growing sorghum. Geetha Sireesha and Naidu (2013) [2] reported that the soils of Banaganapalle mandal in Kurnool district of Andhra Pradesh were marginally suitable for growing sorghum. Wetness (drainage), soil depth, organic carbon content and pH are limitation in all the pedons. Poor drainage can be improved by soil conservation measures, growing leguminous crops in rotation and application of organic manures. Shallow depth of soils can be improved by deepening of soil by ridging, deep ploughing / breaking up of soil crust or contour bunding and contour farming or adoption of very careful soil and water management practices. Organic carbon content in these soils can be improved by incorporation of crop residues or application of farm yard manure / compost / press mud or green manuring with legumes or inclusion of legumes in crop rotation. The pH can be reduced by application of organic manures and soil amendments like sulphur / press mud / spent wash. Texture is a limitation in pedons 1, 2, 5, 6 and 7. Heavy textured soils can be improved by cultivation with precautions against permanent damage like bunding / adoption of broad bed and furrow method of irrigation. Following agronomic measures like crop rotation / mixed cropping / growing leguminous crops in rotation or application of organic manures or organic mulches add organic matter to the soil which not only improve the drainage condition but also reduce runoff and erosion. CaCO3 content is also a limiting factor in all the pedons except pedons 5 and 7. High calcium carbonate content leads to greater fixation of P and Zn to limit crop production. Application of organic manures such as FYM or compost or vermicompost or green manuring with legumes reduces the P and Zn fixation by formation of organo-Zn and organo-P complexes. Further, the acids produced during decomposition of organic manures causes solubilisation of CaCO3 and decrease its content in the soil. Alkalinity is a limiting factor in pedon 4. Alkalinity (high ESP) in the soils can be reduced by addition of gypsum or green manuring with dhaincha which not only reduce the alkalinity problem but also increase nutrient availability.The crop suitability of soils in the central and eastern parts of Prakasam district ranged from highly suitable (S1) to permanently not suitable (N2) for the major crops viz., rice, cotton, chickpea, tobacco and sorghum. The limitations observed in these soils were physical characteristics like soil depth, wetness and texture, high CaCO3 content and fertility characteristics like high pH, low organic carbon content and alkalinity. Remedial measures were suggested to achieve potential productivity of these soils without deteriorating the soil quality and to sustain crop yields.

Pedon 1, which is grouped under typic haplustarts is highly suitable for cotton, moderately suitable for rice, maize and

chilly, marginally suitable for red gram. Temporarily not suitable and permanently not suitable for aby crop. The limitations are include wetness, (drainage), physical soil characteristics soil depth cotton, red gram, $CaCo_3$ content and soil fertility characteristics P^H and organic carbon due to alkaline P^H and high ESP. It can be improved by cultivation crop rotation, mixed cropping growing leguminous crops in rotation or application of organic manuves. Improve the drainage condition but also reduce the run off erosion. Similar observations are also made by Leelavathietal (2010b), and Geetha Siresha and Naidu, 2013b [2]. in Yerpedu Mandal of Kadapa district and Banaganapalle Mandal of Karnool district in AP respectively.

Pedon 2 is grouped under typic haplustepts is highly suitable for rice, maize, chilly, cotton, red gram the limitations include wetness (drainage), physical characteristics texture and soil depth $CaCo_3$content and soil fertility characteristics organic carbon and P^H similar findings were reported by Satyavathi and Reddy 2004 [8] in Telangana region.

Pedon 3 is classified under verticeshaplustepts is highly suitable for rice, cotton, chilly and red gram moderately suitable for maize owing to good drainage conditions finer texture of the soil absent of course fragments, very low $CaCo_3$high CEC and high base saturation and no other soil related problems the five texture of these soil, may cause some drainage problems for main especially during the seedling stage. Hence, these soils were categorized as moderately suitable for maize. Alkalinity in the soils can be reduced by addition of gypsum or green magnum with dhaincha not only reduces the alkalinity problems but also increases nutrient availability similar finding and recommendation were also reported likkar and Prasad (2011) Kuchanwar and Gabhane 2012 [3], Meena *et al* 2012 and Niranjan *et al* 2013 in Nagpur district of Maharashtra. Ridhora watershed in Nagpur district of Maharashtra, Malwa plateau in Banswara district of Rajastan and Pulivendula region of AP respectively.

Pedon 4 is grouped under typic Rhodustalts is moderately suitable for chilly, maize and red gram and marginally suitable for rice, cotton. However slight variations in soil properties. Depth of Pedon among of clay, presence or absence of course fragments, and relative locations of the Pedon on the land scape future the major factors due to the textual drainage related to limitations these soils were shallow depth excessive drainage.

Pedon 5 is grouped under typic haplustepts is highly suitable for maize, moderately suitable for chilly, marginally suitable for rice, cotton and red gram. In view of good drainage and clay loam texture and no other yield limiting constraints.

Pedon 6 is grouped under typic Rhodustalts is moderately suitable for chilly, maize and red gram marginally suitable for rice, cotton course surface, soil texture and medium sub---- soil texture made them classified as moderately suitable for maize, chilly and red gram crops. But due to the textural and drainage related limitation these soils were classified as marginally suitable for rice, cotton. Similar results were findings by Sathish Kumar and Naidu (2012b) reported that typic ustorthants were marginally suitable for growing rice crop in vadamalapeta Mandal of Chittore district in AP. Drin age, texture, soil depth., O.C & P^H.

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