Production potential appraisal of soils of for part of Palamaner division in Chittoor district, Andhra Pradesh, India

Abstract

The soil profile samples that are present in upper slopes of the Palamaner agricultural division are evaluated to know the production potential of the study area. The soils have moderate slope and are affected by erosion. Besides, soils have excessive drainage limitation. Geologically, soils are developed on the quartz-migmatite gneiss complex. All the soils are studied for morphological, physico-chemical and chemical properties. The results shown that, soils are slightly acidic to neutral in soil reaction (pH), non saline (EC), moderately deep to deep (90-135 cm) in depth. The texture of soils varied from moderately well drained with no erosion to severe erosion. The soils are placed under IVes land capability class. The actual productivity and the potential productivity are calculated; the maximum potential productivity was 81.23 and the crop improvement factor was 1.59.

Key words: Gneiss, Land capability, Productivity, Crop Improvement.

Introduction

The sustainable productivity of soil mainly depends upon its ability to supply essential nutrients to the crop. However, the capacity of soil to produce crops is limited and the limits to production are set by the intrinsic characteristics, agro-ecological settings, climate, land form conditions and landuse and management (FAO, 1993). Since the available land resources are scarce, there is an urgent need to protect soil while conserving natural resources. These resources should be managed in a sustainable manner so that changes proposed should meet the needs of the development which are brought out without diminishing the potential for their future use (Kanwar, 1994). There is a risk of increasing land degradation which of global concern now, especially in the regions prone to erosion due to slopes; therefore, soil resources should be properly conserved to reduce the loss of soil while improving the productivity of the region. The present study mainly focuses on investigating the fertility aspects of soils and comparing them with actual production of

the regional systems and suggesting the crop proper management practices to know a possible improvement factor and to improve the productivity of soils.

Material and Methods

Description of the study area

The study area located between 77° 54' and 79° 10' N lattitudes to 13° 41' and 12° 36' E longitudes at an elevation ranging from 690-760 m (msl). It is confined to the semi-arid monsoon type of climate with distinct summer (April to June), rainy (July to November) and winter (December to March) seasons. The mean annual rainfall of the study area is 973 mm of which 95 % was received during May to December. The mean annual temperature is 28.50 °C with a mean annual summer temperature of 32.19 °C and mean annual winter temperature of 24.08 °C. The maximum temperature for the last 30 years is 43.8°C, recorded in the month of April whereas the minimum temperature is 14.5°C, noticed in the month of January. The study area qualifies for ustic soil moisture regime and iso-hyperthermic soil temperature regime (Sujatha et al., 2021).

The survey was taken up in the upper slopes of the Palamaner division using the topgraphic map of 1:50,000 scale as per the procedure outlined by AIS & LUS (1970). Around 12 pedons are located including road cuts, mini pits of which six were studied in detail. The detailed description of the pedons were evaluated as per the procedure outlined in Soil Survey Manual (Soil Survey Division Staff 2000). Later, the horizon-wise samples were collected and all the profiles were characterized for important physical, physico-chemical and chemical **(Table 1)** properties using standard procedures (Bower *et al.* 1952; Piper, 1966 Jackson 1973; Chopra and Kanwar, 1991). The soils were classified taxonomically following the existence guidance (Soil Survey Staff 2010). Considering the limitations and potentials of the soils, land capability classification was evaluated up to the sub-class level (Klingebiel and Montgomery 1966). Based on that a suitable land use plan has also been suggested. Actual Productivity (P) was calculated with the parametric model developed by Riquier *et al.*, 1970. The nine parameters that were employed for assessment of soil productivity are given below in the equation (1).

$$P = H \times D \times P \times T \times N/S \times O \times A \times M \ldots (1)$$

Where, P = Production potential, H = Soil moisture content, D = Drainage, P = Effective soil depth, T = Texture/structure, N = Base saturation, S = Soluble salts, O = Organic matter, A = Mineral

exchange capacity and M = Mineral reserves. After employing all the possible improvement factors, the potential productivity rating was worked out by assigning different grades (Riquier *et al.*, 1970).

The coefficient of improvement (CI) was defined based on the actual productivity and potential productivity ratings as given below:

$$\text{Coefficient of improvement } (\mathbf{Ci}) = \frac{\text{Potential productivity}}{\text{Actual productivity}}$$

Results and Discussion

Physical and chemical characteristics

All the pedons are slightly acidic to neutral in soil reaction. This variation might be due to the nature of parent material, leaching, erosion, calcium carbonate content and exchangeable sodium percentage. All the pedons were non-saline in nature and this low electrical conductivity might be due to the good drainage conditions which favoured leaching of bases from the soil profile. The organic carbon content was ranged from 0.04 to 0.70 % which is low to medium (Table 1). The organic carbon content exhibited a decrease in trend with depth in all the pedons, which is attributed to the addition of plant residues and farmyard manure to surface horizons than in the lower horizons. The low organic matter content in soils of study area might be attributed to the prevalence of tropical condition, where the degradation of organic matter occurs at a faster rate coupled with low vegetation cover, there by leaving less organic carbon in the soils (Nayak *et al.*, 2002).

The cation exchange capacity of the soils varied from 6.43 to 38.38 cmol (p+) kg^{-1} which corresponds to clay content in the horizons. The free calcium carbonate content in soils ranged from 0.5 to 8.5% and the pedons showed an irregular trend with depth. This may either be due to the variable nature of geological material that contributed to these soils or to rapid leaching of carbonates from the porous sandy soils (Singh and Agarwal 2005). The base saturation of soils ranged in between 43.81and 98.53 %. The base saturation mainly varied with the exchangeable cations.

Crop- suitability classification

The land capability classification of soils in the upper slopes of the Palamaner division is

given in **Table 2.** The land and soil characteristics like slope, erosion, drainage conditions, texture and CEC were studied while classifying land capability classes. All the soils in the study area comes under class IVes, which has limitations in slope, erosion and soil characteristics. However, many of them can be overcome with proper agronomic and soil-water management practices.

Table 1. Depth wise soil characteristics used in assessing crop suitability

Pedon No.	Location	Horizon	Depth (m)	Physical characteristics (s)			$CaCO_3$ (%)	Fertility characteristics (f)					Salinity and alkalinity (n)	
				Sand	Silt	Clay		CEC	BS (%)	Sum of basic cations	pH (1:2.5 H_2O)	OC (%)	EC (Ds m^{-1})	ESP
				<2mm soil										
1	Kanalillu	**Ap**	0.00-0.21	64.83	14.50	20.67	6.0	16.91	88.17	14.91	6.91	0.62	0.20	1.48
		Bw1	0.21-0.44	24.25	45.54	30.21	5.0	27.10	50.11	13.58	6.48	0.41	0.18	0.96
		Bw2	0.44-0.69	19.62	50.84	29.54	7.0	28.60	73.77	21.10	6.98	0.37	0.13	1.36
		Bw3	0.69-0.91	17.53	46.17	36.30	7.5	33.34	65.84	21.95	6.94	0.16	0.12	1.89
		Bw4	0.91-1.20+	15.19	53.49	31.32	5.5	27.56	89.96	24.79	6.56	0.10	0.12	2.87
2	Kummaragunta	**Ap**	0.00-0.18	79.54	9.03	11.43	7.5	16.41	89.85	14.75	6.86	0.41	0.10	1.77
		Bt1	0.18-0.37	56.53	18.80	24.67	6.5	25.67	65.32	16.77	6.54	0.31	0.13	1.17
		Bt2	0.37-0.63	62.17	7.89	29.94	6.0	38.38	71.05	27.27	6.64	0.27	0.12	0.83
		Bt3	0.63-1.00+	60.62	18.10	21.28	8.5	20.07	90.09	18.08	6.53	0.10	0.15	2.14
	Atukurallapalli	**Ap**	0.00-0.15	62.82	13.46	23.72	5.5	11.29	95.53	10.79	6.47	0.51	0.35	2.39
3		**BA**	0.15-0.38	47.83	24.08	28.09	4.0	13.16	55.84	7.35	6.26	0.41	0.11	2.13
		Bt1	0.38-0.52	36.81	29.72	33.47	4.5	25.33	85.44	21.64	6.23	0.28	0.11	1.07
		Bt2	0.52-0.95	39.61	28.48	31.91	1.0	30.05	93.69	28.15	6.08	0.18	0.13	1.03
4	Samalagadda	**Ap**	0.00-0.26	65.36	13.20	21.44	5.0	16.34	48.61	7.95	6.80	0.70	0.25	4.10
		A/B	0.26-0.42	72.79	17.52	9.69	4.5	6.43	95.25	6.13	6.76	0.55	0.27	12.13
		B/A	0.42-0.65	59.13	22.18	18.69	4.1	10.24	98.53	10.09	6.90	0.18	0.30	8.89
		Bw1	0.65-0.87	20.19	41.20	38.61	5.5	31.12	91.97	28.62	6.75	0.10	0.24	3.53
		Bss1	0.87-1.20+	19.78	43.27	36.95	7.5	28.93	70.26	20.32	7.26	0.04	0.16	4.01
5	Zararipalli	**Ap**	0.00-0.23	76.47	10.59	12.94	5.5	8.52	82.73	7.05	6.52	0.39	0.08	2.23
		A/B	0.23-0.38	75.13	11.21	13.66	1.2	7.67	95.54	7.33	6.66	0.31	0.04	2.09
		Bt1	0.38-0.58	63.69	8.13	28.18	1.5	16.28	96.88	15.77	6.26	0.26	0.17	3.26
		Bt2	0.58-1.00	54.12	23.78	24.10	0.5	13.73	80.70	11.08	6.17	0.06	0.12	3.42
6	Kilapatla	**Ap**	0.00-0.24	80.24	5.09	14.67	4.5	18.92	50.37	9.53	6.22	0.31	0.07	1.85
		Bt1	0.24-0.46	53.12	24.54	22.34	4.0	15.74	96.59	15.20	6.44	0.26	0.08	1.72
		Bt2	0.46-0.77	69.33	7.57	23.10	2.5	21.53	59.34	12.77	6.23	0.20	0.05	2.09
		2Bt1	0.77-1.07	63.62	9.54	26.84	2.0	20.08	62.27	12.51	6.38	0.12	0.04	1.59
		2Bt2	1.07-1.30+	69.71	8.06	22.23	5.0	17.45	43.81	7.64	6.36	0.10	0.04	2.12

Table 2. Land capability classification of soils of the Palamaner division

Pedon No.	Soil characteristics												
	Slope (%)	Drainage	Erosion	Flooding	Texture	Surface coarse fragments	Rockyness (%)	Soil depth (m)	CEC [cmol (p^+)kg^{-1}]	BS (%)	OC (0-15 cm) (%)	Salinity and alkalinity	Land capability class with limitation
1	3-5	Moderately well drained	Moderate	Nil	scl	None	None	1.20	16.91	88.17	0.62	Nil	IVes
2	3-5	Well drained	Moderate	Nil	sl	None	None	1.00	16.41	89.85	0.41	Nil	IVes
3	3-5	Moderately well drained	Moderate	Nil	scl	None	None	0.95	11.29	95.53	0.51	Nil	IVes
4	3-5	Moderately well drained	Moderate	Nil	scl	None	None	1.20	16.34	48.61	0.70	Nil	IVes
5	5-10	Well drained	Nil	Nil	sl	None	None	1.00	8.52	82.73	0.39	Nil	IVes
6	5-10	Well drained	Severe	Nil	sl	None	None	1.30	18.92	50.37	0.31	Nil	IVes

Productivity and productive potentials

The factors considered and the ratings given for the study area to calculate the potential productivity of soils are given in **Tables 3 and 4.** The actual productivity of pedons 1 (51.17), 2 (53.87) and 3 (48.48) were good. After applying the proper management practices to improve soil fertility characteristics the rating has improved from good to excellent class *i.e.* 81.23, 76.95 and 76.95, respectively, for pedons 1, 2 and 3. The crop improvement factor (Ci) was 1.59 for pedons 1 and 3, 1.43 for pedon 2. Pedons 4 and 6 showed average actual productivity of 29.09 and 32.75. However by the application of suitable soil and water conservation measures, the productivity was improved to 46.17 and 46.79, i.e class good. The crop improvement factor was 1.59 and 1.43. The actual productivity of pedon 5 was good (38.78) and it remained good (55.40) after implying suitable management practices. The crop improvement factor was 1.43. based on the Riquier's parametric approach. The soils of Palamaner division were classified as poor, average and good **(Table 5).** The results were in accordance with previous study reported by Sireesha and Naidu, (2020) in Banganapalle mandal of Kurnool district, Andhra Pradesh and the study by Sashikala *et al*, (2020) in Tatrakallu village of Ananthapuram district of Andhra Pradesh.

Table 3. Factors considered for potential productivity calculation of soils in Palamaner Division

Pedon No	Moisture (H)	Drainage (D)	Effective depth (P)	Texture/ Structure (T)	Base saturation (N)	Soluble salts (S)	Organic matter content (O)	Mineral exchange capacity (A)	Mineral reserve (M)
1	H4b	D4	P6	T7	N5	S1	O4	A2	M2b
2	H4b	D4	P5	T6	N5	S1	O4	A3	M2b
3	H4b	D4	P5	T7	N5	S1	O4	A1	M2b
4	H4b	D4	P6	T7	N3	S1	O4	A1	M2b
5	H4b	D4	P5	T6	N5	S1	O4	A1	M2b
6	H4b	D4	P6	T6	N4	S1	O4	A2	M2b

Table 4. Ratings for different factors to calculate potential productivity of soils in Palamaner Division

Pedon No	Moisture (H)	Drainage (D)	Effective depth (P)	Texture/ Structure (T)	Base saturation (N)	Soluble salts (S)	Organic matter content (O)	Mineral exchange capacity (A)	Mineral reserve (M)
1	90	100	100	100	100	100	100	95	95
2	90	100	100	90	100	100	100	100	95
3	90	100	100	100	100	100	100	90	95
4	90	100	100	100	60	100	100	90	95
5	90	80	100	90	100	100	100	90	95
6	90	80	100	90	80	100	100	95	95

Table 5. Productivity classes and coefficient of improvement of soils in Palamaner Division

Pedon No	Actual productivity (P)		Potential Productivity (P')		Crop improvement factor (Ci)
	Rating	Classes	Rating	Classes	
1	51.17	Good	81.23	Excellent	1.59
2	53.87	Good	76.95	Excellent	1.43
3	48.48	Good	76.95	Excellent	1.59
4	29.09	Average	46.17	Good	1.59
5	38.78	Good	55.40	Good	1.43
6	32.75	Average	46.79	Good	1.43

Conclusion

The soils of Palamaner division had major limitations like slope, erosion, texture and soil fertility characteristics like organic carbon content and poor nutrient status. Slope and erosion can be managed by the following agronomic measures; contour bunding, contour farming, growing of erosion resistant crops and by following soil-water management practices. Soil fertility can be enhanced by rotation with legumes, addition of amendments such as FYM, green manuring and adding silt to improve the texture of the soils. As the soil comes under the land capability sub class

IVes, the soils are more suitable for millets, pulses and oil seeds and they are also suitable for multipurpose tress and orchard crops. Thus, actual productivity of soils can be improved and coefficient of improvement (Ci) will be achieved without the deteriorating of the soil health.

Future scope

Integration of prime lands and land suitability for specific crops needed in conserving the land resources and to enhances the resource use efficiency and implementation of research requires the use of GIS and simulation modules for the development of the decision support systems as needed to guide practical action.

Conflict of intrests

Authors have declared that no competing interests exist.

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