

Original Research Article

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

Abstract

The soils profiles 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 effected by erosion and the soils have excessive drainage limitation. The soils are developed from quartz-migmatite gneiss complex. All the soils are studied for morphological, physico-chemical and chemical properties. The soils were slightly acidic to neutral in soil reaction (pH), non saline (EC), moderately deep to deep (90-135 cm) in depth. The texture of the 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 is calculated and 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 a soil mainly depends upon its ability to supply essential nutrients to the crop. However, the capacity of a soil to produce crops is limited and the limits to production are set by intrinsic characteristics, agro-ecological settings, soil, climate, land form conditions and their use and management (FAO, 1993). The available land resources are scant and there is an urgent need to protect the soil while conserving the natural resources. These resources should be managed in a sustainable manner so that the changes proposed should meet the needs of development are brought out without diminishing the potential for their future use (Kanwar, 1994). There is a risk of increasing land degradation which is global concern now, especially in the regions which are prone to erosion due to slopes, the soil resources should be properly conserved to reduce the loss of soil while improving the productivity of the region. The present study mainly focus on studying the fertility aspects of the soils and comparing them with actual production of the regions

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

Material and Methods

Description of the study area

The study area lies in between 77° 54' and 79° 10' North latitudes to 13° 41' and 12° 36' East longitudes at an elevation ranging from 690-760 m (msl). It confined to 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 per cent 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.

The survey was taken up in the upper slopes of Palamaner division using toposheet of 1:50,000 scale as per the procedure outlined by AIS & LUS (1970). Around 12 pedons are located including road cuts, mini pits and 6 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, 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; Chopra and Kanwar, 1991; Jackson 1973; Piper, 1966). The soils were classified taxonomically by following Soil Survey Staff 2010. Considering limitations and potentials of the soils, land capability classification was evaluated up to sub-class level (Klingebiel and Montgomery 1966) and 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 an equation.

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

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.

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

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

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 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 and this 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 the 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, thereby 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 of the soils ranged from 0.5 to 8.5% and the pedons showed an irregular trend with depth. This may either be due to 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 the soils ranged in between 43.81 and 98.53%. The base saturation mainly varied with exchangeable cations.

Crop- suitability classification

The land capability classification of the soils in upper slopes of 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 have 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 ₂ O)	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
3	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
		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
4	Samalagadda	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
		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
5	Zararipalli	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
		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
6	Kilapatla	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
		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 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 potential productivity of the 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 and after applying 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 and 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 conformation with the study reported by Sireesha and Naidu, 2020 in Banganapalle mandal of Kurnool district, Andhra Pradesh and the study made 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 following agronomic measures like 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 like FYM, green manuring and adding silt to improve the texture of the soils. As the soil comes under land capability sub class IVes, the

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

Future scope

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

References

AIS & LUS. Soil survey manual (1970). All India soil and land use survey organization, IARI, New Delhi, 1- 63.

Bower CA, Reitemeier RF & Fireman M (1952). Exchangeable cations analysis of saline and alkali soils. *Soil science*, 73:251-261.

Chopra SL & Kanwar JS (1991). Analytical agricultural chemistry. Kalyani Publishers, New Delhi, 279.

Food and agriculture organization (1993). Frame work for Land Evaluation. *Soil Bulletin*, 32, Rome.

Jackson ML. Soil chemical analysis (1973). Oxford IBH publishing house, Bombay, 38.

Kanwar, J. S., 1994, Characterization and classification of Chandapuri watershed in Rajasthan. *J. Indian Society of Soil Science*, 42:245-255.

Klingebiel, A.A. & Montgomery, P.H. (1966). Agricultural Hand Book No. 210, USDA, Washington.

Nayak, D. C., Sarkar, D & Das, K (2002). Forms and distribution of pedogenic iron, aluminum and manganese in some Benchmark soils of West Bengal. *Journal of the Indian Society of Soil Science*, 50, 89-93.

Piper CS (1966). Soil and plant analysis. Hans's publications, Bombay, 59.

Riquier, J., Bramo, D.L & Cornet, J.P (1970). A New System of Soil Appraisal in terms of Actual and Potential Productivity. FAO, Soil Resource Development and Conservation Service, Land and Water Development Division, FAO, Rome. 88-99.

Singh, I.S. & Agarwal, H.P (2005). Characterization, genesis and classification of rice soils of Eastern Region of Varanasi, Uttar Pradesh. *Agropedology* 15, 29-38.

Sashikala, G., Naidu, M.V.S., Ramana, K.V., Nagamadhuri, K.V., Pratap Kumar Reddy, A & Sudhakar, P. (2020). Land evaluation for alternate land use planning of soils of Tatrakallu village of Ananthapuramu district of Andhra Pradesh. *Agropedolog.* 30(2): 88-111.

Sireesha, P.V.G & Naidu, M.V.S (2020). Production potential appraisal: A case study in Banaganapalle mandal of Kurnool district in Andhra Pradesh, India. *International Journal of Current Microbiology and Applied Sciences.* 9(6): 787-798.

Soil Survey division staff (2000) Soil survey manual (Indian print), USDA hand book No.18, US govt. printing office, Washington, DC.

Soil Survey Staff (2010). Keys to Soil Taxonomy, 11th edition, USDA, Natural Resource Conservation Service, Washington, DC.