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Microwatershed in Chhotanagpur Plateau, West Bengal, India – Evaluation of Sabai grass as alternate farming option

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Abstract
Six representative soil sites, two on pediments (Series 1 and Series 2) and four on uplands (Series 3, Series 4, Series 5 and Series 6) of Dwarkeshwar microwatershed in Chotanagpur plateau region were characterized, classified and evaluated for Sabai grass, which can be opted for alternate farming. Soils of pediment were moderately deep to deep and sandy loam in texture, while soils of upland were shallow to deep with sandy loam and sandy clay loam texture. Soils of series 1, series 5 and series 6 were classified under coarse loamy; Typic Haplustepts and Fluventic Haplustepts. Soils of series 2 and series 3 were classified under loamy skeletal; Typic Ustorthents and Lithic Ustorthents. Soils of series 4 were classified under loam; Lithic Ustorthents. Soils were marginally suitable for Sabai grass with major limitations of soil fertility, which can be enhanced to moderate suitability by improving soil fertility conditions with moderate dose of fertilizer application. Economic evaluation shows that under present rate of Rs. 5.0 kg^{-1} of Sabai grass rope net income of growers will be Rs. 3500 $acre^{-1}$ $year^{-1}$.

Key words: Chhotanagpur plateau region, Sabai grass, Soil characteristics, Suitability evaluation.

Introduction

Sabai grass (*Eulaliopsis binata* (Retz.) C.E.Hubb), a perennial grass, belonging to the family Poaceae, is extensively grown in the upland soils of eastern states of India. It's thin and long leaves posses high quality fibre and used as a major raw material for paper industries. For flexibility and strength properties, leaves are utilized for making ropes and rope based utility items, which have a potential market demand because value added products like mats, carpets, wall hangings and other fashionable articles are produced. The grass also helps for conservation of soils especially in the marginal lands with medium to coarse textured soils. This grass is having a life span of 12 years and serves as a source of income to the poor people in the risk prone farming systems.

Several experiments were conducted on the performance evaluation of intercropping and nutrient uptake of Sabai grass (Barik, 1998; Mahapatra *et al*., 1985; Basu *et al*., 2006) in the eastern states. Experiment result shows that Sabai grass grows well on upland sandy loam, well drained soils at a depth of 79 mm with pH of 5.3 to 5.4, low organic carbon content (0.14%), low available P (2.0 kg ha^{-1}) and medium low available K (83.2 kg ha^{-1}); subhumid climate that receives 1200 to 1500 mm of rainfall during June to September. Combined application of lime (in case of low pH), organic matter and moderate dose of chemical fertilizer was much effective in increasing the yield to an optimum level as compared to no fertilizer or higher dose of only chemical fertilizer (Basu *et al*., 2006). It has also been observed that the growth of Sabai grass is quite slow during initial years of establishment and sufficient space remains vacant in between two rows for this period. This space can be utilized for growing short duration, quick growing high yielding varieties of forage or grain legumes without having any competitive effect on Sabai grass. Performance evaluation shows that intercropping of legumes in Sabai grass produce better yield compared with sole cropping mainly due to availability of extra nitrogen from intercropped legumes (Piper, 1994).

Although performance evaluation is done for nutrient uptake and intercropping, however information on soil-site suitability for Sabai grass is virtually lacking and hence, an attempt has been made to evaluate soil-site suitability for Sabai grass in the upland soils of Chhotanagpur plateau region in Puruliya district, West Bengal. Presently farmers of this area cultivate paddy for their livelihood with low return. But these areas are

either marginally suitable or unsuitable for paddy cultivation and are deteriorating soil health. In order to arrest soil degradation Sabai grass can be an option for alternate farming with good return in this marginal land of Chhotanagpur plateau region.

Material and Methods

The study was conducted in Dwarkeshwar micro watershed extending from 23°24' 31.4" to 23°26' 00.46" north latitude and 86°32' 35.3" to 86°34' 53.5" east longitude in Hura block of Puruliya district. The climate is sub humid dry with mean annual rainfall 1394.6 mm of which 77 *percent* is received from south-west monsoon (June to September) and 14 *percent* from north-east monsoon (October to December). Mean maximum and mean minimum temperatures recorded were 31.9°C and 20.9°C, respectively. Although amount of rainfall is quite high in this area, but its erratic nature along with high temperature leads to poor farming.

Detailed soil survey was carried out for the micro watershed using cadastral map (1:3,960 scales) to prepare plot wise database for the micro watershed. Sixteen soil series were identified in the whole micro watershed developed on ten identified landforms. Six representative soil series were selected; two from pediment and four from uplands for characterisation of morphological, physical and chemical properties vis-à-vis for suitability analysis. Horizon-wise soil samples were collected and analysed for physical and chemical properties following standard procedures (Black, 1965; Jackson, 1973). Available phosphorous was determined by Oleson method (Oleson *et al*., 1954) and available potassium was estimated by flame photometer. Soils were classified as per Soil Taxonomy (Soil Survey Staff 2003). The land suitability for growing Sabai grass was evaluated by using criteria developed by Sys *et al*., (1991) and Naidu *et al*., (2006) and the soils were grouped into S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable) and N (not suitable) considering the soil site limitations.

Results and Discussion

Morphological characteristics: Pediment of the microwatershed was gentle to moderately sloping with drainage condition of moderately well to well drained. The depth of soil varied from moderately deep (80 cm) to deep (128 cm) with sandy loam texture (Table1). Uplands are gentle to very gently sloping with moderately well to somewhat excessively drained. Soil depth in uplands varies from very shallow (12 cm) to deep (135 cm). Texture is sandy loam to sandy clay loam and loam. Soil colour is mainly yellowish brown indicating well drained condition both in the pediment and uplands.

Soil classification: The study area falls under Ustic moisture and hyperthermic temperature regime with mixed mineralogy. Soils in the pediment were deep to moderately deep, coarse loamy in texture with occurrence of 30-35% surface and subsurface gravel in some places.

The soils of series 1 were classified under coarse loamy, Typic Haplustepts, while the soils of series 2 show little evidence of horizonation and were classified under loamy skeletal, Typic Ustorthents. Among the upland soils, the series 3 and series 4 were shallow, gravelly soils, excessively well drained and were classified as Lithic Ustorthents. The soils of series 5 and series 6 were deep, moderately well drained to well drained and were classified under coarse loamy, Fluventic/ Typic Haplustepts.

Physical and chemical properties: Soils of pediment were moderately acidic (pH 4.8 to 5.5), while organic carbon content was medium (0.58 to 0.72%) in the surface layer and low (0.06 to 0.21) in the sub surface layer (Table 2). Soils were less fertile [(CEC 7.3 to 11.3 cmol (p+) kg^{-1} soil)]. Soils of upland were moderately acidic to neutral (pH 4.5 to 6.7) with medium to high (0.50 to 1.24%) organic carbon content in the surface layer and low (0.16 to 0.37%) in the sub surface layer. Unlike pediment soil this upland soil was less fertile [(CEC 6.7 to 19.5 cmol (p+) kg^{-1} soil)].

Suitability evaluation for Sabai grass: The six soil series analysed from Pediment and uplands were evaluated for Sabai grass suitability. Soils with moderate or severe limitations were grouped under moderately suitable class (S2) and marginally suitable (S3) class; the soils with very severe limitations, which can be corrected under N1 (currently not suitable); the soils with very severe limitations, which cannot be corrected were grouped under unsuitable class N2 (Sys *et al*., 1991). This method also identifies the dominant limitations that restrict the crop growth in the sub class symbol such as topography (t), wetness (w), physical soil characteristics (s) and soil fertility (f). The suitability classes and subclasses were decided by the most limiting soil characteristics.

Suitability evaluation of pediment soil: Soil series1 was marginally suitable for Sabai grass (Table 3). The major limitation was soil pH (5.0–5.4). However the pH status can be improved by applying lime. Series 2 was marginally suitable for Sabai grass because of soil pH (4.8-4.9) and cation exchange capacity (8.7-10.2) and topographic constraints.

Table 1: Morphological characteristics of soils

Horizon	Depth (cm)	Colour (moist)**	Texture#	Coarse fragments (%)	Structure##	Consistency$
Soils of Pediment						
Series 1 : Coarse loamy, Typic Haplustepts						
Ap	0-12	10YR4/4	sl	-	2msbk	h fr ss ps
Bw1	12-28	10YR4/6	sl	-	3msbk	fr ss ps
BC	28-62	10YR4/6	sl	10-15	2msbk	fr ss po
C1	62-91	10YR4/6	sl	20-25	2msbk	fr ss po
C2	91-128	10YR2/2	sl	25-35	massive	l ss po
Series 2: Loamy skeletal, Typic Ustorthents						
Ap	0-13	10YR4/2	ls	5-10	2msbk	sh vfr so po
C1	13-28	10YR4/4	sl	10-15	2msbk	vfr ss po
C2	28-46	10YR4/2	sl	20-25	2msbk	vfr ss po
C3	46-80	10YR4/2	sl	30-35	3msbk	vfr ss po
Cr	80+		**weathered granite gneiss**			
Soils of Upland						
Series 3: Loamy skeletal, Lithic Ustorthents						
Ap	0-12	10YR5/4	l	25-30	2msbk	h fr ss po
Cr	12-31	10YR4/6	sl	50-60	massive	fr so po
Series 4: Loamy, Lithic Ustorthents						
Ap	0-12	10YR5/4	sl	5-10	2fsbk	
Cr	12+		**weathered granite gneiss**			
Series 5 : Coarse loamy, Fluventic Haplustepts						
Ap	0-18	10YR4/4	sl	-	2msbk	h fr ss ps
Bw1	18-40	10YR4/4	scl	-	3msbk	fr ss ps
Bw2	40-63	10YR4/6	sl	-	3msbk	fr s po
C1	63-92	10YR3/6	sl	-	massive	vfr so po
C2	92-135	10YR3/6	ls	-	massive	vfr so po
Series 6 : Coarse loamy, Typic Haplustepts						
Ap	0-15	10YR4/4	l	-	2msbk	h fr ss ps
Bw1	15-51	10YR4/4	sl	-	2msbk	fr ss ps
Bw2	51-75	10YR3/2	sl	-	2fsbk	fr ss po
Bw3	75-103	10YR3/2	sl	15-20	massive	fr ss po
Cr	103-120	10YR3/2	sl	70-80	massive	fr ss po

***Ap:** A horizon(plough layer); **Bw** (B horizon with weak colour/structure); **Cr** (C horizon with weak bedrock) **10YR**(hue),4(value),4(croma); **# l** (loam), **ls** (loamy sand), **scl** (sandy clay loam); **sl** (sandy loam); **##2,3** (moderate and strong grade), **f(**fine), **m** (medium size),**sbk** (sub angular blocky type); **$ sh** (slightly hard), **h** (hard dry), **fr** (moist friable), **so** (non sticky), **ss** (slightly sticky), **po** (non plastic), **ps** (slightly plastic)*

Suitability evaluation of upland soil: Series 3, 5 and 6 were marginally suitable for Sabai grass (Table 3). The major limitation was soil pH (5.3-6.5). Series 4 was currently not suitable for Sabai grass because soil pH (4.5). The pH status can be improved by applying lime and also basic cation content can be improved by the application of farmyard manure, green manuring and of growing of legumes in rotation.

Economic evaluation of Sabai grass: Economic evaluation was done for a period of ten years which showed average production of 0.8 t acre^{-1} year^{-1} with gross income of Rs. 4000.00 and net income of Rs. 3500.00 acre^{-1} year^{-1}. Further production of leguminous crops as intercrops of Sabai grass can also generate additional income to the farmers.

Table 2: Physical and chemical properties of soils

Horizon	Depth (cm)	pH (1:2.5)	O.C (%)	Sand	Silt	Clay	CEC [cmol (p+) kg-1	Base Saturation (%)	Sum of cations
A. Soils of Pediment									
Series 1. ***Coarse loamy, Typic Haplustepts***									
Ap	0-12	5.3	0.58	52.10	34.80	13.10	10.1	65	6.61
Bw1	12-28	5.2	0.12	62.70	23.10	14.20	9.2	69	6.32
BC	28-62	5.2	0.10	68.40	15.20	16.40	11.3	71	8.09
C1	62-91	5.4	0.06	71.40	15.30	13.30	8.4	74	6.24
C2	91-128	5.0	0.21	72.90	15.00	12.10	7.3	67	4.94
Series 2. *Loamy skeletal, Typic Ustorthents*									
Ap	0-13	4.9	0.72	77.80	13.90	8.30	10.2	57	5.87
Bw1	13-28	4.9	0.18	75.30	13.00	11.70	8.1	59	4.76
Bw2	28-46	4.8	0.18	76.40	11.20	12.40	9.3	61	5.70
Bw3	46-80	4.9	0.06	75.30	10.40	14.30	8.7	50	5.73
Cr	80+	Weathered granite							
B. Soils of Upland									
Series 3. ***Loamy skeletal, Lithic Haplustepts***									
Ap	0-12	5.7	1.13	49.40	31.90	18.70	12.5	70	8.80
Cr	12-31	5.9	0.37	57.40	26.00	16.60	10.3	74	7.67
Series 4. *Loamy, Lithic Ustorthents*									
Ap	0-12	4.5	0.80	54.30	31.20	14.50	10.2	59	6.00
Cr	12+	Weathered granite							
Series 5. *Coarse loamy, Typic/Fluventic Haplustepts*									
Ap	0-18	5.3	0.50	64.70	20.50	14.80	19.5	63	5.98
Bw1	18-40	5.3	0.26	58.60	20.70	20.70	11.3	61	6.90
Bw2	40-63	5.4	0.16	61.70	21.40	16.90	10.2	65	6.60
C1	63-92	5.4	0.20	71.90	12.40	15.70	11.5	67	7.80
C2	92-135	5.5	0.16	81.70	7.50	10.80	6.7	68	4.50
Series 6. *Coarse loamy, Typic Haplustepts*									
Ap	0-15	5.2	1.24	45.40	30.50	24.10	11.4	68	7.80
Bw1	15-51	6.2	0.19	61.30	19.40	19.30	10.5	78	8.21
Bw2	51-75	6.5	0.17	56.40	25.20	18.40	9.4	80	7.58
Bw3	75-103	6.5	0.21	65.80	19.00	15.20	10.2	64	6.62
Cr	103-120	6.7	0.22	75.50	12.10	12.40	7.8	84	6.53

Table 3: Suitability evaluation for Sabai grass

Soil series	Topography (t)	Wetness (w)	Soil physical characteristics (s)		Soil fertility (f)		Suitability	
	Slope	Drainage	Texture	Depth	CEC	pH	Actual suitability	Potential suitability
Pediment soil								
1	S2	S2	S1	S1	S2	S3	S3f	S2f
2	S3	S1	S1	S1	S3	S3	S3twf	S3tw
Upland soil								
3	S1	S1	S1	S2	S2	S3	S3f	S2f
4	S1	S1	S1	S3	S2	N	N_1f	S3f
5	S1	S1	S1	S1	S2	S3	S3f	S2f
6	S1	S2	S1	S1	S2	S3	S3f	S2wf

N.B. Criteria for soil suitability classes - S1 (Slope: 1-5%, Drainage: Well drained, Soil depth: >75 cm); S2 (Slope: 5-10%, Drainage: Moderate, Soil depth: 50-75 cm, CEC:10-15 cmol (p+) kg^{-1}); S3 (Slope: 10-20%, Soil depth: 25-50 cm, CEC:<10 cmol (p+) kg^{-1},pH:5.0-5.9); N (pH:<5.0).

Conclusion

The entire uplands of Chotanagpur plateau region was affected by sheet, rill and gully erosion. Therefore action plan for growing of crops should be carefully executed with proper attention towards restoration of these soils. The substratum should be developed for growing of crops in this group of land situation. Instead of upland paddy, Sabai grass can be a viable option and can be grown with moderate dosage of fertilizer application.

Due to slow growth rate during initial years of establishment of Sabai grass, sufficient spaces remain vacant in between rows, which can be utilized for growing short duration, quick growing high yielding varieties of forage or grain legumes without having any competitive effect. These intercrops hardly need any extra care which on the other hand will generate extra income to the poor farmers from same piece of land.

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