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Research Paper

Soil analogy for making varietal and fertilizer recommendations for rice (*Oryza sativa*) cultivars in Brahmaputra valley of Asom

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ABSTRACT

On farm experimental trials were conducted in 4 dominant soil series, namely *Lahangaon* series (Aeric Fluvaquents), *Bhogdai* series (Fluvaquentic Endoaquepts), *Matikhola* series (Typic Endoaquepts) and *Teok* series (Typic Endoaquepts), of Jorhat district with an objective of evaluating the performance of rice (*Oryza sativa* L.) cultivars, viz. 'Basundhara' and 'Satyaranjan' under recommended package of practices (RPP) as well as farmer's practice (FP) during 2005–07. The results showed major soils constraints are such as coarse texture coupled with poor water management and suboptimal available phosphorus (P), exchangeable potassium (K), cation-exchange capacity (CEC) and excessive iron (Fe^{2+}) uptake or (bronzing or yellowing symptoms). The rice cultivar 'Basundhara' performed better than 'Satyarajan' under RPP as well as under farmer's practices in all the 4 analogous soil series of Brahmaputra valley of Asom. Similarly, application of NPK in RPP recorded a good response of rice in all the four series and left significantly more available NPK in soil after the rice harvest.

Key words : *Analogous soil series, Asom, Brahmaputra valley, Hydric soils, Rice cultivars*

India produces 89 million tonnes (mt) of rice from 42.3 million ha, 57% of which is rainfed and the rest 43% is irrigated. Rice in Asom is cultivated in 1.74 m/ha with a production of 2.47 mt and an average yield of 1.44 t/ha (Agricultural Statistics, 2010). Floodplain alluvial soils, which are moderately to slightly acidic with poor base saturation, low exchange capacity, occupy 4.9 m ha, accounting 62% of the total geographical area (Sen *et al.,* 1999). Adequate information is lacking on site-specific characterization of land and water resources and climatic parameters, which is crucial for efficient land-use planning and resource deployment. Soil series identification is a crucial step in the decision-aid for nutrient management and simple observations of soil color, soil texture, calcareous concretions, soil pH, and soil depth can greatly help Bhaskar and Sarkar (2013). A reconnaissance soil survey was carried out in developing soil map of Kakadanga-Gelabil watershed covering 1,20,000 ha under National Agricultural Technology Project during 2002–04 for developing soil site suitability for rice based cropping systems Vadivelu *et al.* (2005).

The nutrient consumption in Asom is the lowest in the country (18.1 to 36.5 kg/ha). The rice productivity showed a significant increase of 5.15 t/ha under recommended practices over farmers practice 2.46 t/ha (Baishya *et al.,* 2009). Six rice-based cropping sequences in medium land situations of Asom were tested and it was found that rice (IP)–wheat was the best sequence from productivity point, whereas from the economic point of view, rice (IP)–*toria* was more beneficial (Das *et al.,* 2007). On contrary to this, the rice equivalent yield (REY) of rice–potato cropping system in *Lahangaon* series with RPP (15.66 t/ha) was found to be the highest, followed by *Bhogdai* (13.84 t/ha) and *Matikhola* (11.11 t/ha), whereas, rice–pea (10.1 t/ha) performed best and found economically viable in *Teok* series under flooded situation (Singh *et al.,* 2013). Rice–potato cropping system gave the highest gross returns in *Aeric Fluvaquents* (₹1,03,097/ha) followed by *Fluvaquentic Endoaquepts* (₹91,168/ha) and in *Typic Endoaquepts* with RPP (₹72,975/ha), whereas rice–pea gave the highest gross return (₹95,108/ha) in *Aeric Fluvaquents* (Singh *et al.,* 2013).

The information on relative performance of rice varieties on well-defined soil series is scanty and this necessi-

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tated evaluation of prominent rice cultivators based on soil analogy for agro-technology transfer. The present study was therefore taken up for comparing performance of 2 extensively grown rice cultivars 'Basundhara' and 'Satyaranjan' in 4 dominant series identified, viz. *Lahangaon*, *Bhogdai*, *Matikhola* and *Teok,* series of Jorhat district, Asom under recommended practices as well as under farmer's practices.

MATERIALS AND METHODS

On-farm field experiments for evaluating the performance of 2 rice cultivars, viz. 'Basundhara' and 'Satyaranjan' were conducted during the rainy seasons (*kharif*) of 2005 and 2006 at 4 representative soil series in Jorhat district of Asom having distinct soil series, namely *Lahangaon*-coarse loamy 'Aeric Fluvaquents' (26º37'21" N and 94°20'43" E) *Bhogdai*, fine silty 'Fluvaquentic Endoaquepts', (26º40'45" N and 94°12'34" E), *Matikhola*, fine loamy 'Typic Endoaquepts' (26°49'06" N and 94°22'56" E) and *Teok*- fine loamy over sandy, 'Typic Fluvaquents' (26º49'00" N and 94°14'00" E). During reconnaissance soil survey (1:50000 scale) of Jorhat district, the 4 soil series under this study were identified and reported in Soil Resource Atlas of Jorhat district by Vadivelu *et al.* (2004) and land-use plan was suggested based on soil-site suitability for rice based cropping systems Vadivelu *et al.* (2003). Brief description of soil series analogy under study was given below:

1. *Lahangaon* series (Coarse loamy, mixed, hyperthermic family of 'Aeric Fluvaquents': This soil has grey (10YR6/1), or yellowish brown (10YR 5/4), very strongly acid, sandy loam Ap horizon and greyish brown (10YR5/2) to light olive brown (2.5Y5/6), neutral to slightly acid sandy or sandy loam Cg horizons.

2. *Bhogdai* series (Fine silty mixed, hyperthermic family of Fluvaquentic Endoaquepts): This soil has light brownish grey (10YR6/2), strongly acid, silt loam A horizons and light grey (10YR7/1) to brownish grey (10YR6/2), moderately acid silt loam to clay loam, brownish yellow mottled (7.5YR5/8) B horizon. Lower part of B horizon is yellowish brown, silt loam and grey (10YR6/1) mottled.

3. *Matikhola* series: (Fine loamy, mixed, hyperthermic *Typic Endoaquepts*): These soils have grey, very strongly acid, loam Ap horizon and grey, yellowish brown or brown, moderately to slightly acid silt loam to clay loam Bw horizon with high chroma mottles.

4. *Teok* series (Fine loamy over sandy, mixed, hyperthermic, family of *Typic Fluvaquents*): This soil has grey (10YR5/1) to greyish brown (10YR5/2), slightly to very strongly acidic, sandy loam to clay loam A horizons over light grey (10YR6/1) to grey (10YR5/1), slightly acidic to neutral, sand to loam Cg horizons.

These soils are strongly acid and poor with variation in clay 16% in *Lahangaon* series to 33.8% in *Bhogdai* and 20 to 22% clay in *Matkhola* and *Teok* series. These soils are medium in available nitrogen but low in available phosphorus and potassium in case of *Matikhola* and *Teok* series but medium in *Bhogdai* and *Lahangaon* series. The analysis for soil series revealed that these soils have 0.80 to 1.26% organic carbon, 180.50 to 264.5 and 423.36 kg/ha available nitrogen, 1.33 to 1.58 kg/ha available phosphorus, 75.2 to 121.1 kg/ha available potassium and pH of 5.0 to 5.5 (Table 1).

The climate is humid subtropical with mean annual precipitation of 1,950 mm. The mean annual air temperature is 23.5°C. The mean winter (December to February) and summer (June to August) air temperatures are 17°C and 28.7°C, respectively. The calculated mean annual soil temperatures is 24.5°C with a difference between mean summer (26.3°C) and mean winter temperature (19.05°C) of more than 5°C to qualify as hyperthermic soil temperature regime. The rainfall distribution is well throughout the year though a major portion (266.3 mm) is received during March (71.5 mm) to September but more than 200 mm is received in June, July and August to define soil moisture regime as Udic. The low-lying areas in the region are subjected to seasonal floods and qualify for aquic soil moisture regime Vadivelu *et al.* (2005).

Experimental area is the part of Brahmaputra river basin with general elevation of 80 to 120 m above mean sea-level. The field experiment was conducted as per the recommendation of Department of Agriculture (DOA) and Assam Agricultural University (AAU) in randomized block design (Cochran and Cox, 1957) with five replications at each site with 2 short-duration rice cultivars under two managements, namely farmer's practices (FP) and recommended package of practices (RPP). Plot size was 50 m^2 each. The crop was raised under rainfed conditions. Rice seedlings were prepared in nursery with 45 kg seeds for transplanting of 1 ha area as per standard recommendation of DOA and AAU, Asom. The field was prepared 3–4 times ploughing followed by laddering and application of farmyard manure @ 10 t/ha. Puddling was carried out in the field one day before transplanting.

Recommended dose of 40 N: 20 P_2O_5: 20 K_2O kg/ha was applied in RPP plots, whereas no fertilizer was applied in FP. Two intercultural operations were carried out, i.e. first at 30 and second at 50 days after transplanting of rice seedlings for RPP. The sources of fertilizers for N, P_2O_5 and K_2O were urea, single superphosphate (SSP) and muriate of potash (MOP) respectively. Half the quantity of recommended N and entire amount of P_2O_5 and K_2O were applied as basal. Rice was transplanted in the second week of July. Remaining N was applied in 2 split doses as top dressing, i.e., first at 45 and second at 60 days after transplanting of rice seedling.

Observations on plant height (cm), tillers/hill, number of panicles/plant and grains/panicles were recorded. Yield/plant in gram and 1 m^2 area were recorded at 5 places in a plot and average yield was computed in t/ha.

Plant samples collected at the time of harvesting and grain and straw were analysed for NPK uptake. Soil samples were collected from effective root zone depth (0–30 cm) before planting and after the harvest of rainy (kharif) rice from each plot and analysed for available nitrogen, phosphorus and potassium by standard laboratory procedure. ANOVA analysis was done using SPSS windows (PASW statistics 18). The critical difference was calculated using the formulae of

$$CD = t\sqrt{MSE\left(\frac{1}{n1}+\frac{1}{n2}\right)}$$

Where t is CD=Critical difference, T= t statistics, n1 and n2 = number of samples, MSE = mean square of error. The nutrient content was then multiplied with grain and straw yield to estimate nutrient uptake. The soil samples were air-dried and passed through a 2 mm sieve for fine earth fraction used in analysis. Agronomic N-use efficiency, Agronomic-use efficiency of N kg grain/kg N applied was worked out on the basis of yield using standard formula Prasad (2009).

RESULTS AND DISCUSSION

Plant height, yield attributes and grain and straw yields of rice

Varieties : Of the 2 varieties, 'Basundhara' had significantly dwarfer plants, more panicles/hill, longer and heavier panicles and higher 1,000-grain weight than 'Satyaranjan' (Table 2). Higher values of all yield attributes gave an advantage to 'Basundhara', which recorded significantly higher grain yield than 'Satyaranjan'. 'Basundhara' maintained its superiority in grain yield in all the four soil series (Table 3). These findings are in agreement with the findings of earlier workers (Singh and Chandra, 2011). On the other hand, 'Satyaranjan' rice had significantly taller plants and recorded significantly more straw than 'Basundhara'.

Management practices : The RPP produced taller plants and recorded higher values for grain and straw yield of rice. Both grain and straw yields of rice with RPP were nearly double of those obtained with FP. The major contributing factor was application of fertilizer (NPK) in RPP, while the FP had no fettilizer. Most farmers in this region of Asom do not apply fertilizer. Chaturvedi (2005) reported that the number of effective tillers/plant increased with application of NPK. Manzoor *et al.* (2006) also reported the advantage of nitrogen fertilization in rice.

Soil Series : The rice plants were the tallest in, *Lahangaon* series and shortest in *Teok* series. In respect of plant height the 4 soil series were in the following order: *Lahangaon* >

Table 1. Soil-site characteristics of on-farm experiments

Particular	*Lahangaon* series (Aeric fluvaquents)	*Bhogdai* series (Fluvaquentic endoaquepts)	*Matikhola* Series (Typic endoaquepts)	*Teok* series (Typic fluvaquents)
Slope (%)	Very gently 1–3	Nearly level 0–1	Nearly level 0–1	Nearly level 0–1
Elevation (m)	120	100	90	80
Physiography	Lower piedmont	Gently sloping upland	Very gently sloping plain	Lower flood plain
Sand	54.0	21.03	48.22	42.70
Silt	29.5	45.13	31.28	34.90
Clay	16.5	33.84	20.50	22.40
pH (H_2O 1:2.5)	5.5	5.2	5.1	5.0
OC (%)	1.06	0.80	1.26	1.26
CEC	6.0	10.7	12.82	5.28
Base saturation (%)	98.0	55.0	98.00	18.00
Drainage	Poor in rainy season and well drained in winter	Poor in rainy season and well drained in winter	Poor in rainy season and moderately well drained in winter	Poor in rainy season and moderately well drained in winter
Water depth (m)	3.5	3.0	1.5	1.00
Soil fertility status kg/ha				
N	264.5	352.8	352.8	423.36
P_2O_5	3.23	3.27	3.67	3.09
K_2O	145.86	165.43	91.37	90.6

OC, organic carbon; CEC, cation-exchange capacity

Bhogdai > *Matikhola* > *Teok*. Although the differences were not significant, the four soil series were in the same order as in the case of plant height. The panicles/hill were the maximum in *Lahangaon* series, while the longest panicles and the highest 1,000-grain weight of rice were obtained in *Matikhola* series. Thus soil properties in different series differently affected rice growth. The major advantage of *Lahangaon* series was its higher sand content, which provided better aeration and better plant growth in early stages. Bhaskar and Sarkar (2013) observed that major constraints identified in these pedons are poor soil texture, which translates to poor water management coupled with suboptimal available phosphorus (P), exchangeable potassium (K), and cation-exchange capacity (CEC), which may predispose rice plants to excessive iron (Fe^{2+}) uptake or (bronzing or yellowing symptoms). On the other hand, *Matikhola* series had the highest CEC, which permitted better storage and supply of applied plant nutrients.

Nutrient uptake and agronomic nitrogen-use efficiency

Varieties : As would be expected rice variety 'Basundhara', which gave nearly double the grain yield of 'Satyaranjan' recorded significantly higher NPK uptake and as a consequence left lesser amounts of available NPK in soil after the rice harvest. Due to higher grain yield, agronomic NUE was also higher in 'Basundhara' (Table 4).

Management practices : Recommended package of practices, which included NPK, recorded significantly more NPK uptake by rice as well as significantly more available NPK in soil after the rice. Bezbaruah *et al.* (2011) also reported a good response of rice to fertilizer application.

Soil Series : As regards N uptake the four soil series were in order of *Lahangaon* > *Bhogdai* > *Matikhola* > *Teok*. *Lahangaon* recording the highest and *Teok* the lowest N uptake. The P and K uptake was also the highest in *Lahangaon* series and the lowest in *Matikhola* series. *Bhogdai series* recorded lesser than *Lahangaon series*, but significantly more than other 2 series. This is difficult to explain, since all the four soil series had very low available phosphorus.

Results from on farm experiment in floodplain soils of *Brahmaputra valley* showed that the rice cultivar

Table 2. Rice yield and yield parameters of rice cultivars and levels of management in major soils of Jorhat (pooled data of 2 years)

Treatment	Plant height (cm)	Tillers/hill	panicles/ hill	Length of panicles (cm)	Grains/ panicle	1,000-grain wt (g)	Yield (t/ha)	
							Grain	Straw
Variety								
'Basundhara'	115.9	38.0	38.0	26.5	141	25.9	4.23	6.25
'Satyaranjan'	141.7	34.5	34.5	25.1	115	22.0	4.06	6.49
SEm±	0.09	0.04	0.04	0.06	0.1	0.05	0.031	0.048
CD (P=0.05)	0.19	0.09	0.09	0.13	0.2	0.11	0.064	0.096
Cultivation practices								
Farmer's practice	104.35	14.2	14.2	16.3	79	17.1	2.75	4.14
RPP	153.29	58.3	58.3	35.3	177	30.8	5.55	8.60
SEm±	0.09	0.04	0.04	0.06	0.1	0.05	0.031	0.048
CD (P=0.05)	0.19	0.09	0.09	0.13	0.2	0.11	0.064	0.096
Soil series								
Lahangaon series	136.05	38.7	38.7	24.5	134	23.8	4.46	6.90
Bhogdai series	134.8	36.9	37.5	24.6	130	23.7	4.09	6.39
Matikola series	125.4	34.2	34.2	32.	119	25.6	4.06	6.11
Teok series	118.9	35.3	35.3	22.0	128	22.8	3.98	6.08
SEm±	0.013	0.06	0.06	0.08	0.01	0.07	0.044	0.095
CD (P=0.05)	0.27	0.12	0.12	0.17	0.3	0.15	NS	NS

Table 3. Effect of soil series and packages practice on rice yield t/ha (pooled data over 2 years)

Variety/fertilizer and soils	'Basundhara'			'Satyaranjan'			Mean for soil series
	FP	RPP	Mean	FP	RPP	Mean	
Lahangaon soil series	2.96	6.21	4.59	2.79	5.90	4.34	4.46
Bhogdai soil series	2.83	5.48	4.16	2.71	5.34	4.03	4.09
Matikhola soil series	2.65	5.69	4.17	2.70	5.19	3.94	4.07
Teok soil series	2.70	5.34	4.02	2.64	5.23	3.93	3.98
Mean	2.78	5.68	4.23	2.71	5.41	4.06	4.15
SEm±			0.09			0.09	
CD (P=0.05)			NS			NS	

Table 4. Uptake and availability of nutrients as influenced by rice cultivars, levels of management

Particular	Uptake by rice kg/ha			Available nutrients after rice (kg/ha)			ANUE
	N	P	K	N	P	K	
Variety							
'Bashundhra'	98.9	36.2	130.4	341.9	33.9	69.8	74.7
'Satyaranjan'	82.6	28.5	114.4	330.8	25.4	61.2	73.7
SEm±	0.07	0.03	0.08	0.24	0.03	0.05	
CD (P=0.05)	0.15	0.07	0.17	0.49	0.07	0.11	
Cultivation practice							
Farmer's practice	51.10	11.30	52.10	244.50	17.80	48.60	0
RPP	130.3	53.5	192.8	428.3	41.5	82.5	74.2
SEm±	0.07	0.03	0.08	0.24	0.03	0.05	
CD (P=0.05)	0.15	0.07	0.17	0.49	0.07	0.11	
Soil series							
Lahangaon series	103.8	41.5	153.4	362.1	34.9	72.4	88.2
Bhogdai series	97.3	34.2	129.4	340.9	28.8	65.4	72.5
Matikola series	71.9	17.9	79.1	320.4	27.0	61.4	67.5
Teok series	89.9	32.5	127.9	322.1	27.9	62.9	72.7
SEm±	0.10	0.06	0.10	0.35	.04	0.07	
CD (P=0.05)	0.21	0.12	0.21	0.72	.09	0.15	

ANUE, agronomic nitrogen-use efficiency; RPP, recommended package of practices

'Basundhara' performed better than 'Satyarajan' under RPP as well as under FP in all the 4 analogous soil series of *Brahmaputra valley* of Asom. Similarly, application of NPK in RPP recorded a good response of rice in all the four series and left significantly more available NPK in soil after the rice harvest. These results show that agronomic recommendations on variety and NPK worked out on a soil series can be extended to other soils of analogous series.

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