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Characterization and evaluation of soils of Trans Yamuna area in Etawah district, Uttar Pradesh for Sustainable land use

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Abstract : Nine typical pedons representing four major landforms (old alluvial plain, recent alluvial plain, ravinous land and active flood plain) were studied in Badhpura block of Etawah district, Uttar Pradesh for their morphological, physical and chemical characteristics using IRS -IB geo-coded satetllite data and Survey of India toposheets (1:50,000 scale).The soils were developed from the alluvia of Yamuna and Chambal rivers and were slightly to strongly alkaline. The texture varied from sand to sandy clay loam and had low organic carbon (<0.40 g kg^{-1}) and CEC of 2.0 to 16.3 cmol(p+)kg^{-1}. Soils were low in available nitrogen and low to medium in available phosphorous and potassium content. Majority of the soils were low in DTPA-extractable Zn, Fe, Cu but sufficient in Mn. Soils of the old alluvial plain are represented by Typic Haplustepts and Typic Haplustalfs, and recent alluvial plains by Typic Haplustepts and Typic Calciustepts. Ravinous plains prone to moderate to severe erosion are dominated by Typic Calciustepts and Typic Ustifluvents and active flood plain by Typic Ustipsamments. The soils of the study area are cultivated and/or under forest/degraded lands with land capability classes ranging from II to VI. Soils of the plains are suitable for rice, wheat, maize, wheat, pearlmillet, mustard and chickpea whereas soils of ravinous areas are unsuitable for crops and better suited for agro-forestry, silvi-pastoral and silvi-horticulture systems under proper soil and water conservation measures.

Additional key words : *Geo-coded satellite data, cambic horizon, calcic horizon, argillic horizon, land use plan, silvi-pastoral*

Introduction

Soils differ in their morphology, physico-chemical characteristics, inherent productivity and fertility and their responses to management practices differ accordingly. Thus, it is imperative to study the soils of a particular area for genesis, classification and to evaluate the soils of a particular area for their sustainable land use. Keeping these objectives in mind, the present study was undertaken by conducting semi-reconnaissance soil survey in Trans-Yamuna areas of Badhpura block in Etawah district of Uttar Pradesh.

Materials and Methods

The study areas lies between 27°34'20" to 26°43'15" N latitudes and 78° 56'30" to 79° 20' E longitudes. The area is semi-arid, subtropical monsoonic type climate with LGP 250-300 days. The annual precipitation is 639 mm of which 85% is received during July to September. The mean annual soil temperature is more than 22°C with mean summer and winter temperature of 34°C and 15°C, respectively. The area is under '*Ustic*' soil moisture regime and '*Hyperthermic*' soil temperature regime. The natural

vegetation of the study area are vilayati babul (*Prosopis juliflora*), babul (*Acacia species*), ber (*Ziziphus jujuba*), neem (*Azadirachta indica*), shisham (*Dalbergia sissoo*), kaitha (*Artocarpus integrifolia*) and grasses like munj (*Saccharum munja*), kans (*Saccharum spontaneum*) and dub (*Cynodon dactylon*). The soils were developed on the alluvium of the Indo-Gangetic plains.

A semi-reconnaissance soil survey was conducted during January to March 1997 as per procedure outlined by AIS&LUS (1970) on 1:50,000 scale using IRS IB satellite data and survey of India Toposheets. Four major landform units were delineated *viz.*, old alluvial plain, recent alluvial plain, ravinous land and active flood plain. Mini pits and soil profiles were studied for their morphological characteristics following the methods described in Soil Survey Manual (Soil Survey Division Staff 20000). Soils of old alluvial plains (Baghaipur-P1, Shekhupur-P2, Makhanpur-P3 and Rahtauli-P4), recent alluvial plains (Akbarpur-P5), active flood plains (Bijhalpur-P9) are cultivated lands whereas soils of ravinous land (Ayana-P6, Paigamberpur-P7 and Dhakra-P8) are under forest and at places under cultivation.

The horizon-wise soil samples were collected and characterized for important physical and chemical properties (Black 1965; Jackson 1973). Samples of upper genetic horizons were analyzed for available nitrogen, phosphorous and potassium (Jackson 1973) and micro nutrients (Lindsay and Norvell 1978) by standard procedures. Soils were classified as per Soil Taxonomy (Soil Survey staff 2006). Soil suitability evaluation based on soil-site characteristics and crop requirement for major *kharif* crops (rice, maize and pearlmillet) and *rabi* crops (wheat, mustard and chickpea) have been done using suitability criteria (Sys 1991; Sehgal 2005). Considering the limitations and potentials of the soils, a land use plan has been suggested.

Results and Discussion

Soil Morphology

The soils with very deep solum were moderate to excessively drained. The soil on very gently to moderately steep sloping lands (3-15%) were yellowish brown to dark yellowish brown (10YR 5/4 to 4/4M) and on nearly level slopes (0-1%) light yellowish brown to olive brown (10YR 5/4 to 2.5Y 4/4M) with fine to medium, distinct to prominent yellowish brown mottles (10YR 6/8) (Table 1). The soil colour appears to be a function of chemical and mineralogical composition as well as textural makeup of the soils (Walia and Rao 1997). The structure of the soil is sub-angular blocky to single grain. Pedon (P3) had thin and continuous clay cutans which signify argillic (Bt) horizon. P1 and P2 had cambic (Bw) P4, P5, P7 and P8 had cambic and calcic sub-surface diagnostic horizons.

Physical and chemical characteristics of soils

Sand and silt constituted major portion in these soils (Table 2) and clay varied from 2.50 to 45.5%. Silt and sand were irregularly distributed with depth which may be due to lithological discontinuity (Bhaskar *et al.* 2004). The ratio of clay to clay plus silt showed an increase with depth, suggesting an increased weathering and clay translocation from the upper layers. A decrease in clay content with depth was observed in pedons P8 and P9, which may be due to irregular deposition of alluvium.

The P2 was slightly alkaline (pH 7.5 to 7.6), P3, P4 and P5 slightly to moderately alkaline (pH 7.8 to 8.5), P6, P7, P9 moderately alkaline (pH 7.7 to 8.1) and P8 was moderately to strongly alkaline (pH 8.3 to 8.9). The organic carbon was low and generally decreased with depth barring in P6 (Table 3). The calcium carbonate (equivalent) ranged from 0.40 to 34.4%. The $CaCO_3$ in P4, P7, P9 increased with depth may be due to illuviation along with clay. The CEC of soil of P1, P2 and P4 varied from 11.3 to 18.70 cmol(p^+)kg^{-1} and higher than the other soils. Exchangeable bases decreased in the order of $Ca^{2+}>Mg^{2+}>Na^{+}>K^{+}$ and base saturation varied from 64.0 to 99.1%.

Table 1. Morphological characteristics of the soils*

Horizon	Depth (cm)	Boundary	Colour (moist)	Structure	Concre-tions	Consistency
P1: Baghaipur (Fine-silty, mixed, hyperthermic Typic Haplustepts)						
Ap	0-16	cs	10YR5/4	m1sbk	-	sh,fr,ssps
AB	16-38	cs	10YR5/4	m1sbk	-	sh,fi,sps
Bw1	38-70	cs	10YR4/4	m2sbk	-	fi,vsvp
Bw2	70-110	gs	10YR4/4	m2sbk	c c lime	fi,vsvp
Bw3	110-140	gs	10YR4/4	m2sbk	c m lime	fi,vsvp
BC	140-160	-	2.5Y 5/4	m2sbk	c m lime	fi,vsvp
P2 : Shekhupur (Fine-loamy, mixed, hyperthermic Typic Haplustepts)						
Ap	0-15	gs	10YR5/4	m1sbk	-	sh,fr,ssps
Bw1	15-38	gs	10YR4/4	m2sbk	-	fi,sp
Bw2	38-60	gs	10YR4/4	m2sbk	-	fi,sp
Bw3	60-84	gs	10YR4/4	m2sbk	-	fi,sp
Bw4	84-116	gs	10YR4/4	m2sbk	f c Fe/Mn	fi,sp
Bw5	161-140	gs	10YR4/4	m2sbk	f c Fe/Mn	fi,ssp
BC	140-160	-	10YR4/4	m3sbk	c Fe/Mn	fr,ss
P3: Makhanpur (Fine-silty over fine, mixed, hyperthermic Typic Haplustalfs)						
Ap	0-18	cs	10YR5/4	m1sbk	-	sh,fr,sp
Bw1	18-41	cs	10YR4/4	m2sbk	-	fi,sp
Bw2	41-76	cs	10YR4/3	m2sbk	-	fi,vsvp
Bt1	76-101	gs	10YR4/4	m2sbk	-	fi,vsvp
Bt2	101-130	gs	10YR4/4	m2sbk	f f Fe/Mn	fi,vsvp
BCk	130-155	-	10YR5/4	m2sbk	f f Fe/Mn	fi,vsvp
P4: Rahtauli (Fine-loamy over fine-silty, mixed, hyperthermic Typic Calciustepts)						
Ap	0-17	cs	10YR5/4	massive	-	sh,fr,sssp
AB	17-32	gs	10YR4/4	m1sbk	-	h,fi,ssp
Bw1	32-56	gs	10YR4/4	m2sbk	m c lime	fi,sp
Bw2	56-70	gs	10YR4/4	m1sbk	m c lime	fi,sp
Bk1	70-91	gs	10YR4/4	m2sbk	m m lime	fi,sp
Bk2	91-110	gs	10YR4/4	m2sbk	m m lime	fi,sp
Ck	110-150	-	10YR4/4	massive	m c lime	fi,sp
P5 : Akbarpur (Coarse-loamy, mixed, hyperthermic Typic Calciustepts)						
Ap	0-16	cs	2.5Y5/4	f1sbk	m c lime	sh,fr,ssps
Bk1	16-50	gs	2.5Y4/4	f1sbk	m c lime	fr,sssp
Bk2	50-75	gs	2.5Y4/4	f1sbk	m c lime	fr,sssp
BCk	75-102	gs	2.5Y4/4	f1sbk	m m lime	fr,sps
Ck1	102-137	gs	2.5Y4/4	massive	c m lime	fr,ssp
Ck2	137-165	-	2.5Y4/4	massive	c m lime	fr,ssp
P6 : Ayana (Coarse-loamy over sandy, mixed, hyperthermic Typic Ustifluvents)						
Ap	0-15	cs	10YR5/4	m	f f lime	soft,vfr,sspo
A2	15-38	gs	10YR4/4	m	f f lime	soft,vfr,sspo
C1	38-61	gs	10YR5/4	sg	m f lime	loose,vfr,sopo
2C2	61-97	gs	10YR5/4	m	m f lime	soft, vfr,sspo
3C3	97-126	gs	10YR5/4	sg	m c lime	soose,vfr,sopo
4C4	12-165	-	10YR5/4	sg	c c lime	loose,vfr,sopo

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P7 : Paigamberpur (Coarse-silty over fine-loamy, mixed, hyperthermic Typic Calciustepts)						
A	0-17	cs	10YR5/4	m1sbk	m f lime	sh,fr,ss
AB	17-34-	gs	10YR4/4	m1sbk	m c lime	sh,fr,ss
Bk1	34-50	gs	10YR4/4	m1sbk	m c lime	fi,sssp
Bk2	50-74	gs	10YR4/4	m1sbk	m c lime	fi,sssp
Bk3	74-102	gs	10YR4/4	m1sbk	m c lime	fi,sssp
Bk4	102-125	gs	10YR4/4	m2sbk	m c lime	fi,sp
Bk5	125-150	-	10YR4/4	m1sbk	m f lime	fr,sssp
P8 : Dhakra(Fine over coarse-loamy, mixed, hyperthermic Typic Calciustepts)						
A	0-16	cs	10YR5/4	massive	m c lime	h,fi,vsp
Bw	16-37	gs	10YR5/4	m1sbk	c c lime	h,fi,vsvp
Bk1	37-70	gs	10YR5/4	m2sbk	c c lime	fi,vsvp
2Bk2	70-100	gs	10YR5/4	m2sbk	m f lime	fi,vsvp
3BC	100-142	gs	10YR5/4	m2sbk	c f lime	fr,ssps
4C	142-169	-	10YR5/4	sg	c f lime	vfr,sopo
P9 : Bijhalpur (Calcareous, mixed, hyperthermic Typic Ustipsamments)						
Ap	0-15	cs	10YR5/4	sg	-	loose,so
AC	15-25	cs	10YR5/4	sg	-	loose,so
C1	25-65	gs	10YR5/6	sg	-	loose,so
C2	65-112	gs	10YR5/6	sg	-	loose,so
C3	112-160	-	10YR5/6	sg	-	loose,so

**Abbreviations are as per Soil Survey Staff (1995) and Sehgal et al. (1987)*

Table 2. Physical characteristics of the soils

Horizon	Sand (%)	Silt (%)	Clay (%)	Clay/silt+clay
P1: Baghaipur (Fine-silty, mixed, hyperthermic Typic Haplustepts)				
Ap	48.5	35.2	16.3	0.32
AB	34.3	44.8	20.9	0.31
Bw1	13.2	58.0	28.8	0.33
Bw2	15.0	54.8	30.2	0.36
Bw3	18.2	49.5	32.3	0.40
BC	19.7	47.5	32.8	0.41
P2 : Shekhupur (Fine-loamy, mixed, hyperthermic Typic Haplustepts)				
Ap	67.3	15.00	17.7	0.53
Bw1	51.0	20.0	29.0	0.59
Bw2	53.5	17.0	29.5	0.63
Bw3	56.2	17.0	26.8	0.61
Bw4	55.2	19.0	25.8	0.64
Bw5	59.2	14.0	26.8	0.58
BC	69.7	12.5	17.8	0.59
P3: Makhanpur (Fine-silty over fine, mixed, hyperthermic Typic Haplustalfs)				
Ap	33.2	48.5	18.3	0.27
Bw1	19.2	53.5	27.3	0.34
Bw2	18.00	50.7	31.3	0.38
Bt1	15.8	42.7	41.5	0.49

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Bt2	17.7	39.0	43.3	0.53
BCk	17.0	37.5	45.5	0.55
P4: Rahtauli (Fine-loamy over fine-silty, mixed, hyperthermic Typic Calciustepts)				
Ap	37.7	50.6	11.7	0.19
AB	36.2	45.8	18.0	0.28
Bw1	33.2	42.3	24.5	0.37
Bw2	31.3	42.0	26.7	0.40
Bk1	28.3	45.2	26.5	0.37
Bk2	30.1	44.4	25.5	0.37
Ck	31.8	43.2	25.0	0.37
P5 : Akbarpur (Coarse-loamy, mixed, hyperthermic Typic Calciustepts)				
Ap	54.2	39.0	6.8	0.15
Bk1	53.6	40.9	5.5	0.12
Bk2	53.0	41.4	5.6	0.12
BCk	50.4	42.6	7.0	0.14
Ck1	58.0	51.5	10.5	0.17
Ck2	33.4	53.1	13.5	0.20
P6 : Ayana (Coarse-loamy over sandy, mixed, hyperthermic Typic Ustifluvents)				
Ap	74.1	15.2	10.7	0.42
A2	73.4	16.6	10.0	0.38
C1	82.5	12.5	5.0	0.29
2C2	75.4	10.8	13.8	0.56
3C3	89.4	0.9	9.7	0.91
4C4	87.4	1.8	10.8	0.86
P7 : Paigamberpur (Coarse-silty over fine-loamy, mixed, hyperthermic Typic Calciustepts)				
A	62.7	25.8	11.5	0.31
AB	61.5	26.0	12.5	0.33
Bk1	59.5	24.0	16.5	0.41
Bk2	59.0	24.0	17.0	0.55
Bk3	58.5	23.7	17.8	0.43
Bk4	53.5	25.7	20.8	0.45
Bk5	52.7	29.0	18.3	0.49
P8:Dhakra (Fine over coarse-loamy, mixed, hyperthermic Typic Calciustepts)				
A	28.5	31.5	40.0	0.56
Bw	15.7	40.3	44.0	0.52
Bk1	18.7	46.3	35.0	0.43
2Bk2	51.0	25.7	23.3	0.47
3BC	77.5	11.0	11.5	0.51
4C	83.2	9.0	7.8	0.46
P9 : Bijhalpur (Calcareous, mixed, hyperthermic Typic Ustipsamments)				
Ap	95.5	2.0	2.5	0.55
AC	88.8	6.7	4.5	0.40
C1	95.6	2.4	2.0	0.45
C2	89.2	6.6	4.2	0.40
C3	91.8	4.4	3.8	0.46

Table 3. Chemical characteristics of soils

Horizon	pH (1:2.5)	E.C. (1:2.5) dsm^{-1}	O.C. %	$CaCO_3$ %	CEC (cmol(p+) kg^{-1})	Exchangeable Cations (cmol(p+)kg^{-1})				Base Saturation (%)
						Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	
P1: Baghaipur (Fine-silty, mixed, hyperthermic Typic Haplustepts)										
Ap	8.3	0.50	0.44	2.25	10.87	3.78	1.24	1.26	0.64	63.7
AB	9.0	0.70	0.21	3.15	10.96	5.02	1.72	1.36	0.83	81.5
Bw1	9.3	1.50	0.16	1.80	14.44	6.02	1.89	1.54	1.65	76.9
Bw2	9.4	1.50	0.14	6.90	15.18	7.25	2.14	1.55	1.60	85.0
Bw3	9.3	1.60	0.14	6.30	16.30	7.62	2.21	1.48	1.65	79.5
BC	9.3	1.60	0.12	7.20	16.25	7.33	2.18	1.46	1.60	77.4
P2 : Shekhupur (Fine-loamy, mixed, hyperthermic Typic Haplustepts)										
Ap	7.5	0.12	0.42	Nil	9.81	4.68	2.17	0.35	0.29	76.4
Bw1	7.5	0.15	0.19	Nil	14.55	6.36	3.16	0.45	0.48	71.8
Bw2	7.6	0.10	0.18	Nil	14.20	6.63	3.59	0.54	0.36	78.3
Bw3	7.6	0.10	0.15	Nil	13.45	5.94	3.01	0.52	0.42	73.5
Bw4	7.6	0.10	0.08	Nil	12.70	5.34	2.97	0.50	0.36	72.2
Bw5	7.6	0.12	0.07	Nil	13.35	5.50	3.01	0.48	0.36	70.0
BC	7.6	0.10	0.06	Nil	9.80	5.61	2.10	0.52	0.18	85.8
P3: Makhanpur (Fine-silty over fine, mixed, hyperthermic Typic Haplustalfs)										
Ap	7.8	0.15	0.31	Nil	10.46	3.36	2.18	0.56	1.28	70.6
AB	7.9	0.15	0.15	Nil	15.35	6.81	2.95	0.57	1.28	75.6
Bw	8.1	0.14	0.12	Nil	15.45	7.76	2.83	0.69	1.15	80.5
Bt1	8.2	0.18	0.10	Nil	18.91	8.03	4.14	0.77	1.92	78.6
Bt2	8.2	0.25	0.06	0.36	19.78	8.43	4.19	0.91	1.86	77.8
BCk	8.2	0.25	0.02	8.10	19.56	7.88	4.14	0.93	1.86	75.7
P4: Rahtauli (Fine-loamy over fine silty, mixed, hyperthermic Typic Calciustepts)										
Ap	7.8	0.16	0.40	1.35	6.69	4.88	0.83	0.61	0.28	98.7
AB	8.1	0.11	0.28	1.98	8.91	7.52	0.79	0.43	0.10	99.2
Bw1	8.5	0.11	0.28	3.96	11.87	8.55	0.76	1.00	0.08	87.5
Bw2	8.4	0.12	0.25	12.42	12.61	9.35	0.50	0.91	0.08	86.0
Bk1	8.5	0.13	0.23	20.25	11.52	9.09	0.50	0.96	0.06	92.1
Bk2	8.4	0.15	0.21	20.70	11.30	9.78	0.51	0.78	0.05	98.4
Ck	8.3	0.15	0.08	25.20	11.83	9.11	0.86	0.65	0.05	90.2
P5 : Akbarpur (Coarse-loamy, mixed, hyperthermic Typic Calciustepts)										
Ap	7.6	0.12	0.28	26.10	3.13	1.65	0.66	0.56	0.15	96.5
Bk1	7.9	0.10	0.17	34.38	2.98	1.34	0.63	0.52	0.08	86.4
Bk2	8.0	0.10	0.13	18.45	3.08	1.58	0.64	0.48	0.08	90.3
BCk	7.9	0.11	0.11	24.75	3.39	1.62	0.82	0.48	0.06	87.9
Ck1	8.2	0.10	0.09	28.35	5.13	1.65	1.55	0.56	0.10	75.2
Ck2	8.3	0.19	0.07	32.40	6.78	1.87	1.78	0.61	0.15	65.0

P6 : Ayana (Coarse-loamy over sandy, mixed, hyperthermic Typic Ustifluvents)										
Ap	8.1	0.07	0.13	6.93	5.96	2.51	0.90	0.50	0.51	74.2
A2	8.1	0.12	0.11	12.33	5.30	2.41	0.89	0.52	0.64	84.2
C1	8.1	0.12	0.06	14.85	2.92	1.28	0.49	0.52	0.51	95.9
2C2	8.1	0.10	0.09	12.60	6.82	2.12	1.22	0.68	0.47	65.8
3C3	8.1	0.13	0.04	11.70	5.18	1.84	0.82	0.86	0.32	74.1
4C4	7.7	0.05	0.14	8.20	5.32	1.78	0.99	0.78	0.28	72.0
P7 : Paigamberpur (Course-silty over fine-loamy, mixed, hyperthermic, Typic Calciustepts)										
A	7.9	0.17	0.39	10.62	6.83	3.31	1.51	0.51	0.64	87.4
AB	7.9	0.14	0.21	13.95	6.53	3.03	1.48	0.52	0.70	87.7
Bk1	7.9	0.13	0.19	15.37	8.76	3.39	1.56	0.52	0.70	70.4
Bk2	7.9	0.15	0.18	17.73	8.90	3.61	1.67	0.54	0.77	74.1
Bk3	7.9	0.15	0.17	19.08	9.39	4.04	1.86	0.54	0.83	77.4
Bk4	8.1	0.19	0.15	20.88	10.50	5.46	2.44	0.56	0.77	85.3
Bk5	8.1	0.25	0.11	21.78	9.24	5.73	2.22	0.58	0.77	100+
P8 : Dhakra (Fine over coarse-loamy, mixed, hyperthermic Typic Calciustepts)										
A	8.3	0.12	0.24	26.64	19.34	9.05	4.16	0.84	1.66	81.2
Bw	8.4	0.17	0.18	21.60	21.08	9.99	5.11	0.88	1.02	80.7
Bk1	8.7	0.19	0.14	32.85	17.60	8.55	4.24	0.90	0.96	83.2
2Bk2	8.8	0.25	0.06	20.25	11.43	6.54	2.19	0.92	0.83	91.7
3BC	8.8	0.10	0.05	14.58	6.63	2.54	1.74	0.98	0.64	89.0
4C	8.9	0.20	0.05	14.58	4.56	1.73	1.02	1.02	0.38	91.0
P9 : Bijhalpur (Calcareous, mixed, hyperthermic Typic Ustipsamments)										
Ap	8.1	0.08	0.09	7.47	1.74	0.89	0.27	0.39	0.05	92.0
AC	8.0	0.10	0.06	7.38	2.00	0.81	0.53	0.48	0.06	94.0
C1	8.0	0.10	0.04	9.63	1.39	0.70	0.20	0.37	0.04	94.2
C2	8.0	0.08	0.04	10.35	2.04	1.04	0.69	0.41	0.06	99.1
C3	8.0	0.08	0.04	10.53	2.22	1.03	0.58	0.43	0.15	98.7

Macronutrients

The data (Table 4) indicated that the N content in these soils was low (44.8 to 277.6 kg ha^{-1}). The available P content varied from 3.8 to 30.46 kg ha^{-1}. Majority of soils were low in available P, except P1, P2, P4 and P5. Available K varied from 45.2 to 303.4 kg ha^{-1} and majority of soils were rich in available K. Pasricha (2002) reported high K content in these soils owing to the presence of mica in fine silt and clay fractions.

Micronutrients

Majority of the soils of the district were found to be low in Zn except P7 (Table 4). The DTPA-extractable Cu ranged from 0.15 to 1.80 mg kg^{-1} and hence adequate in available Cu, The available copper content is high in all the soils except in P9. DTPA-Fe in the soils ranged from 1.80 to 16.43 mg kg^{-1} with highest content in P1. The available manganese in these soils ranged from 3.24 mg kg^{-1} in P9 soils to 18.80 mg kg^{-1} in P4 soils. Rahtauli and Akbarpur soils are deficient in available Mn content which may be due to coarser texture (Randhawa and Singh 1997).

Suitability of crops

Baghaipur soils are moderately suitable for wheat, mustard and rice due to fine texture favourable for cultivation of these crops and marginally suitable

Table 4. Available nutrient in surface soils

Soils	Available macronutrients (kg ha^{-1})			Available micronutrients (mg kg^{-1})			
	N	P	K	Zn	Cu	Fe	Mn
Baghaipur (P1)	257.6 (170.2-277.6)	22.1 (12.7-25.1)	293.4 (134.2-303.4)	0.50 (0.45-0.70)	0.80 (0.64-0.95)	13.55 (13.9-16.43)	11.3((8.30-12
Shekhupur (P2)	246.4 (134.4-276.4)	22.4 (18.96-30.46)	138.9 (81.76-148.9)	0.58 (0.49-0.78)	0.66 (0.32-0.67)	3.96 (3.88-6.83)	14.2: (13.96-2(
Makhanpur (P3)	230 (110-260)	12.4 (8.9-14.6)	100.8 (90.0-125.8)	0.30 (0.28-0.40)	1.35 (1.14-1.40)	11.02 (9.84-12.02)	6.49 (5.91-6.
Rahtauli (P4)	245 (212.0-274.4)	12.65 (10.32-15.0)	216.16 (140.00-220.12)	0.52 (0.50-0.60)	1.29 (0.90-1.80)	3.81 (3.80-7.20)	18.6: (11.91-1(
Akbarpur (P5)	212.3 (90.0-232.8)	14.9 (4.2-16.1)	140.0 (118.2-190.5)	0.51 (0.35-0.55)	0.78 (0.58-0.85)	4.81 (4.10-4.95)	1.28 (1.20-1.
Ayana (P6)	80 (67.2-84.0)	8.06 (8.00-14.05)	100.80 (45.2-105.2)	0.20 (0.17-0.22)	0.51 (0.48-0.53)	2.06 (1.80-2.10)	7.14 (6.50-7
Paigham-barpur (P7)	230 (168.0-246.4)	12.4 (9.51-20.67)	200.5 (138.9-202.30)	0.71 (0.65-0.72)	0.59 (0.54-0.69)	2.69 (2.10-2.82)	8.94 (8.20-10
Dhakra (P8)	228 (78.5-258.4)	11.2 (3.8-20.2)	102.0 (98.0-130.0)	0.39(0.32-0.42)	0.77(0.72-0.83)	3.94 (3.85-4.61)	11.1((11.09-1
Bijhalpur (P9)	45 (44.8-134.4)	10.99 (8.46-12.9)	47.0 (45.60-96.30)	0.46 (0.38-0.48)	0.16 (0.15-0.47)	3.92 (3.52-4.97)	3.43 (3.24-7.

A total of 140 surface soil samples were studied. Each pedon represent about 15 soil samples.

for pearl millet, maize and chick pea because of limitations of fine texture and imperfect drainage. The soils of Shekhupur are moderately suitable for all the major *kharif* and *rabi* crops except pearl millet which is highly suitable due to fine loamy texture and well drained soils favourable for its cultivation. Makhanpur soils are highly suitable to rice due to heavy texture and moderately suitable for other major *rabi* and *kharif* crops. Akbarpur soils are marginally suitable for rice and wheat due to limitation of coarser texture but were moderately suitable for maize, pearl millet, chickpea and mustard. Rahtauli soils are moderately suitable for all the major crops except rice due to medium textured and moderate erosion. Ayana soils are marginally suitable for majority of *rabi* and *kharif* crops due to coarser texture, severe erosion and excessively drained condition. These soils are better suited for agro-forestry and silvi-pasture. Paighambarpur soils are unsuitable for the almost all the crops due to coarser texture, droughtiness, severe erosion and moderate slope. These soils are better suited to silvi-pasture and silvi-horticulture. The soils of Dhakra series were unsuitable for crops due to very severe erosion, steep slopes and rapid run-off and droughtiness but suitable for silvipasture and silviculture.

Suitability of crops

Baghaipur soils are moderately suitable for wheat, mustard and rice due to fine texture favourable for cultivation of these crops and marginally suitable for pearl millet, maize and chick pea because of limitations of fine texture and imperfect drainage. The soils of Shekhupur are moderately suitable for all the major *kharif* and *rabi* crops except pearl millet which is highly suitable due to fine loamy texture and well drained soils favourable for its cultivation. Makhanpur soils are highly suitable to rice due to heavy texture and moderately suitable for other major *rabi* and *kharif* crops. Akbarpur soils are marginally suitable for rice and wheat due to limitation of coarser texture but were moderately suitable for maize, pearl millet, chickpea and mustard. Rahtauli soils are moderately suitable for

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References

AIS&LUS S (1970) Soil Survey Manual, All India Soil and Land Use Survey Organization, IARI, New Delhi, p1-63.

Bhaskar, B.P., Saxena, R.K., Vaidivelu, S., Baruah, U., Butte, P.S. and Dutta, D.P. (2004). Pedogenesis in high altitude soils of Meghalaya plateau. *Agropedology* **14**, 9-23.

Black, C.A. (1965) *Methods of Soil Analysis*, Part 2, *American Society of Agronomy*, Inc., Madison, Wisconsin, U.S.A.

Jackson, M.L. (1973). *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd., New Delhi, India.

Lindsay, W.L. and Norvell, W.A.(1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal* **42**,421-428.

Pasricha, N. S. (2002). Potassium dynamics in soils in relation to crop nutrition. *Journal of the Indian Society of Soil Science* **50**, 333-344.

Randhawa, H.S. and Singh, S.P. (1997). Distribution of manganese fractions in alluvium derived soils in different agro climatic zones of Punjab. *Journal of the Indian Society of Soil Science* **45**, 53-57.

Soil Survey Division staff (2000). *Soil Survey Manual*, Agric. 18, Indian reprint, Oxford & IBH Pub.Co., New Delhi.

Soil survey staff (2006). *Key to Soil Taxonomy*, Tenth Edition. (U.S.D.A.: Washngton, D.C.).

Sys, C., Van Ranst, E. and Debaveye, J. (1991). Land Evaluation Part 1 & 2, Agricultural Publication 7, Brussels, Belgium.

Walia, C.S. and Rao, Y.S. (1997). Characteristics and classification of some soils of Trans-Yamuna plains. *Journal of the Indian Society of Soil Science* **45**,156-162.

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