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Physical and Chemical Properties of Soybean-growing Soils in Different Agro-ecological Zones of Marathwada Region

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Abstract: Horizon-wise soil samples (9 profiles) from Osmanabad, Latur, Beed (Drought prone zone) and Nanded, Parbhani (assured rainfall zone) from Marathwada region were collected and analyzed. The sand, silt and clay content ranged from 10.20 to 34.30, 17.90 to 32.20 and 43.70 to 59.30% respectively. The soils were slightly to moderately alkaline in reaction. The saturated hydraulic conductivity (sHC) ranged from 0.20 to 5.30 cm hr^{1} and CEC of soils varied from 33.30 to 67.10 cmol (p+) kg^{-1}. Majority of surface and sub-surface layers had relatively higher soil organic carbon than underlying ones. The available N, P and K content ranged from 37.60 to 334.80, 1.0 to 27.10 and 224.90 to 583.80 kg ha^{-1} in soils, respectively. The DTPA-Zn found deficient in all the soils.

Key words: *Physical and chemical properties, agro-ecological zone, soybean*

Introduction

Soybean (*Glycine max* L.) is one of the most important legume cum oilseed crop of the world and cheapest source of protein. The drought prone zone and assured rainfall zone of agro-ecological zone-6 in Marathwada region of Maharashtra is arid and semi-arid part under rainfed farming with erratic rainfall distribution resulting in low productivity of soybean. However, higher productivity of crop could be managed by suitable agro-managements (Hajare *et al.* 1995) and by illuviating the constraints (Jagdish Prasad and Bradely 1997) and in particular fertility (Karthikeyan *et al.* 2014). In view of the above, an attempt has been made to characterize the soybean-growing soils to know the soil characteristics and its related constraints so that action plan can be formulated.

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Materials and Methods

Study area

Marathwada region (74°40' to 70 15' E, 17°35 to 20°40' N) with an elevation ranging from 347 to 638 m above mean sea level (MSL). Osmanabad, Latur and Beed (Drought prone zone) and Nanded, Parbhani (assured rainfall zone) nine profile *viz.,* P_1 (Kej), P_2 (Ahmadpur), P_3 (Ausa), P_4 (Beed), P_5 (Govindpur), P_6 (Wadgaon), P_7 (Dhasadi), P_8 (Lohgaon) and P_9 (Bharaswada), from Osmanabad, Latur and Beed (Drought prone zone) and Nanded, Parbhani (Assured rainfall zone) were studied and horizon-wise collected for laboratory analysis were selected from Marathwada region. The soil temperature regime was hyperthermic and moisture regime is Ustic.

Sample collection and analysis

Particle-size distribution was determined as per the international pipette method, bulk density by clod coating method and hydraulic conductivity by constant head method. The pH and EC were measured in 1:2.5 soil-water suspension. Available N was determined by permanganate method (Subbiah and Asija 1956), available phosphorus by Olsen *et al.* (1954) and available potassium by ammonium acetate extractant (Jackson 1973). Cation exchange capacity (CEC) was determined by 1 *N* NaOAc at pH 8.2. Exchangeable Ca^{2+} was determined by KCI-triethanolamine method followed by EDTA titration and organic carbon by Walkley and Black (1934) method and total carbon by sum of soil inorganic carbon and organic carbon (Anonymous 2001). Calcium carbonate equivalent was determined by acid neutralization method of Black *et al.* (1965). Available zinc, copper, iron and manganese were extracted by 0.005 *M* DTPA solution (Lindsay and Norvell 1978) and estimated on Atomic absorption spectrophotometer.

Results and Discussion

Physical and chemical properties of soil

The partial-size distribution and sand/silt ratio showed inflection in sand, silt and clay content with depth. The sand, silt and clay content ranged from 10.2 to 34.3 and 17.9 to 33.1 per cent and 43.7 to 59.7 in different horizons. The higher bulk density (1.53 Mg m-3) was recorded in pedon P_4 and lowest (1.27 Mg m^{-3}) in pedon of P_6 and increased with soil depth. The hydraulic conductivity ranged from 0.20 to 5.30 cm hr^{-1} being lowest in last horizon of P4 owing to higher exchangeable Mg.

Soil pH varied from 7.40 to 8.60 and increase in pH with depth might be due to leaching of bases from surface layer. Electrical conductivity varied from 0.17 to 2.0 d Sm^{-1} (Table 2) in different horizons of pedons. Cation Exchange Capacity ranged from 33.30 to 67.10 cmol (p^+) kg^{-1} and it showed close relationship with clay and in particular smectitic clay. (Pal and Deshpande 1987; Gaikwad *et al.* 2020). The calcium carbonate content varied from 3.5 to 19.0 per cent. Higher calcium carbonate affects the physico-chemical characteristics of soil and may prevent root penetration (Sys 1985). Soil organic carbon and total carbon content ranged from 1.95 to 9.94 and 10.05 to 26.89 g kg^{-1}, respectively in different horizons of pedons and in general, soil organic carbon decreased with depth but total carbon content increased with depth.

Nutrient status of soils

The available N, P and K ranged from 37.6 to 334.8, 1.0 to 27.1 and 224.9 to 583.8 kg ha^{-1}, respectively in different horizons of pedons and in general, their content decreased with the soil depth (Table 2). The variation in available N content in soil could be attributed to the differences in landforms intensity of cropping and agro-managements, losses through leaching denitrification *etc.* The results are in agreement with the findings of Malewar *et al.* (1998). The available N was optimum in Ap horizons of P_1, P_4 and P_6, low in P_9 and deficient in other pedons P_2, P_3, P_5, P_7 and P_8. Available P was optimum in surface horizon of P_6 and low to deficient in other pedons while K was above to optimum in P_6 and P_8, P_4, P_5; optimum in P_7 and low in P_1.

The DTPA-Zn in different soils varied from 0.26 to 1.39 mg kg^{-1} against the critical level of Zn 0.6 mg kg^{-1} which, was also reported by Malode and Patil (2014). DTPA-Fe range from 2.20 to 7.11 mg kg^{-1} (Table 3) and found medium to higher, wherein DTPA-Mn varied from 2.34 to 21.89 mg kg^{-1} in all the soils. DTPA-Cu of the soil ranged from 1.57 to 4.51 mg kg^{-1} and decreased with depth. Soil pH is the most important factor regulating the Zn supply in calcareous soils.

Conclusion

The soils were slightly to moderately alkaline, low to moderate in organic carbon content and calcareous in nature. The soils were deficient in DTPA-Zn while $CaCO_3$ induced chlorosis in calcareous soils may be

Table 1. Physical properties of soybean-growing soils

Agro-ecological Zone	Pedon	Depth (cm)	sHC ($cm\ hr^{-1}$)	Bulk density ($Mg\ m^{-3}$)	Particle-size distribution (%)		
					Sand	Silt	Clay
Drought Prone zone	P_1 (Kej)	0-15	1.1	1.39	19.2	24.7	56.1
		15-27	2.5	1.41	19.7	21.6	58.1
	P_2 (Amhadpur)	0-15	1.0	1.27	26.1	32.2	43.7
		15-25	2.1	1.28	25.6	27.6	46.8
	P_3 (Ausa)	0-15	2.5	1.39	21.8	26.9	51.3
		15-30	2.3	1.48	23.3	23.9	53.1
		30-75	1.9	1.43	34.3	17.9	47.8
	P_4 (Beed)	0-15	2.3	1.48	16.8	30.1	53.1
		15-27	2.8	1.51	14.6	29.8	55.6
		27-60	1.1	1.53	20.6	27.6	51.8
		60-100	0.2	1.53	16.1	25.1	58.9
	P_5 (Govindpur)	0-15	4.7	1.36	17.2	31.6	51.2
		15-30	5.3	1.41	16.1	31.1	52.7
		30-60	1.9	1.39	15.8	29.1	55.1
		60-105	0.9	1.29	14.2	27	58.8
	P_6 (Wadgaon)	0-15	2.5	1.29	19.8	28.1	52.2
		15-33	2.7	1.32	17.9	28.4	53.7
		33-65	0.9	1.36	16.2	28.2	55.6
		65-100	0.4	1.27	14.9	27.8	57.3
Assured Rainfall zone	P_7 (Dhasadi)	0-15	3.5	1.39	19.8	30.3	49.9
		15-26	4.2	1.38	20.5	27.7	51.8
	P_8 (Lohagaon)	0-15	2.1	1.35	24.6	23.8	51.6
		15-45	2.5	1.38	18.4	28.6	53.2
		45-75	1.1	1.48	17.1	33.1	48.4
	P_9 (Bharaswada)	0-15	1.3	1.37	19.9	23.4	56.7
		15-35	2.0	1.48	15.6	26.8	57.8
		35-65	0.9	1.47	18.2	27.1	54.7
		65-102	0.4	1.32	10.2	30.7	59.3

Table 2. Chemical properties of soybean-growing soils

Agro-ecological Zone	Pedon	Depth (cm)	pH	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	TC ($g\ kg^{-1}$)	$CaCO_3$ (%)	CEC $cmol\ (p+)\ kg^{-1}$
Drought Prone zone	P_1 (Kej)	0-15	7.4	0.170	7.61	16.61	7.5	67.1
		15-27	7.4	0.275	8.19	19.11	9.1	66.5
	P_2 (Amhadpur)	0-15	8.0	0.369	5.29	21.13	13.2	61.2
		15-25	8.3	0.363	4.29	24.45	16.8	62.8
	P_3 (Ausa)	0-15	8.1	1.020	9.55	22.15	10.5	52.1
		15-30	7.9	1.170	4.75	16.15	9.5	53.5
		30-75	8.0	0.398	2.92	19.96	14.2	51
	P_4 (Beed)	0-15	8.0	0.270	6.24	11.16	4.1	59.2
		15-27	7.8	0.286	5.85	10.05	3.5	62.1
		27-60	8.1	0.231	5.62	15.94	8.6	62
		60-100	7.9	0.261	3.31	16.75	11.2	59.1
	P_5 (Govindpur)	0-15	8.1	0.254	9.94	15.70	4.8	45.4
		15-30	8.5	0.288	6.24	15.36	7.6	47.1
		30-60	8.3	0.346	5.24	16.04	9.0	51.6
		60-105	8.4	0.560	2.92	16.12	11.0	41.3
	P_6 (Wadgaon)	0-15	8.0	0.233	9.75	21.15	9.5	48.9
		15-33	7.9	0.269	7.21	20.41	11.0	51.5
		33-65	7.9	0.204	5.46	24.42	15.8	56.3
		65-100	8.1	0.290	4.09	26.89	19.0	40.3
Assured Rainfall zone	P_7 (Dhasadi)	0-15	8.6	1.770	5.41	16.81	9.5	43.4
		15-26	8.6	1.130	4.28	22.04	14.8	47.1
	P_8 (Lohagaon)	0-15	8.2	1.120	6.28	19.16	6.3	52.1
		15-45	8.1	1.210	4.32	10.32	5.0	54.3
		45-75	8.2	2.000	3.11	12.47	7.8	33.3
	P_9 (Bharaswada)	0-15	8.1	0.255	7.41	14.37	5.8	51.2
		15-35	8.0	0.230	6.41	13.01	5.5	54.7
		35-65	8.1	0.237	2.92	16.72	11.5	61.1
		65-102	8.2	0.227	1.95	22.11	16.8	41.5

Table 3. Nutrient status of soybean-growing soils

Agro-ecological Zone	Pedon	Depth (cm)	Available macro nutrient (kg ha^{-1})			Available micronutrient (mg kg^{-1})			
			N	P	K	Fe	Mn	Zn	Cu
Drought Prone zone	P_1 (Kej)	0-15	244.0	12.60	276.5	4.81	10.13	0.65	2.10
		15-27	189.3	2.60	270.3	3.53	16.05	0.28	1.90
	P_2 (Amhadpur)	0-15	156.0	4.10	423.6	3.87	14.28	0.44	1.90
		15-25	125.4	1.80	435.9	3.50	18.23	0.27	1.83
	P_3 (Ausa)	0-15	97.2	10.8	317.2	3.64	11.11	0.69	1.82
		15-30	75.3	7.1	259.5	3.29	6.43	0.49	2.10
		30-75	37.6	4.8	224.9	2.34	5.16	0.28	1.57
	P_4 (Beed)	0-15	259.9	18.20	318.2	6.13	21.89	1.23	2.61
		15-27	125.4	2.80	404.7	4.20	14.39	0.92	3.11
		27-60	94.9	1.20	350.3	3.17	12.94	0.92	2.16
		60-100	74.4	1.00	272.6	3.00	8.39	0.49	1.67
	P_5 (Govindpur)	0-15	128.5	16.30	403.8	5.91	12.81	0.93	4.13
		15-30	134.8	8.90	427.1	4.76	13.80	1.11	4.12
		30-60	97.2	3.10	348.2	3.93	2.36	0.81	4.23
		60-105	87.8	2.00	382.5	3.51	3.09	0.61	2.22
	P_6 (Wadgaon)	0-15	206.9	27.10	583.8	6.20	15.42	1.39	3.90
		15-33	334.8	11.20	472.1	5.53	12.83	0.91	4.10
		33-65	128.5	1.60	461.2	4.18	6.40	0.61	2.56
		65-100	63.9	1.40	382.3	3.81	7.51	0.51	1.75
Assured Rainfall zone	P_7 (Dhasadi)	0-15	159.9	2.40	460.7	4.66	11.13	0.49	2.11
		15-26	131.7	1.80	369.8	3.18	5.14	0.26	1.80
	P_8 (Lohagaon)	0-15	166.2	11.8	583.6	4.54	12.81	0.67	3.17
		15-45	172.5	4.9	546.3	3.40	11.87	0.56	4.23
		45-75	80.2	2.6	382.9	2.20	6.33	0.41	2.60
	P_9 (Bharaswada)	0-15	219.1	10.20	523.4	7.11	16.80	1.32	4.51
		15-35	75.4	3.40	469.5	6.27	16.15	1.13	3.98
		35-65	69.0	1.80	373.2	4.14	13.04	0.82	1.77
		65-102	51.2	1.20	291.4	4.01	10.48	0.41	1.98

supplemented with Fe through foliar spray. Soil test based fertilizer application through inorganic / organic sources are advocated.

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