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A Study On the Physical and Hydraulic Properties of Soils of Nambor Forest

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Abstract: Water transmission and retention characteristics, water stable aggregates and some basic soil properties of soils of Nambor forest from three uniform soil depths *viz* 0-15, 15-30 and 30-45 cm were collected from 10 locations of Nambor forest were collected and analysed.. Their inter relationships with basic soil properties and constituents were drawn and finally the hydraulic functions were predicted using appropriate models.

The finer fractions of the soils reduced the water transmission *vis –a –vis* retention which was improved in combination with soil organic carbon content of the soils.

Key words: Water transmission, soil water characteristics

Introduction :

Scheduling of irrigation is an important aspect of water economy in crop production. As such for judicious management of water in agriculture, an integrated look at the dynamics of water in soil-plant-atmosphere continuum is essential. But water is practically manageable only in the soil system.

The differential equation describing the dynamics of water in unsaturated soils may be written by a combination of Darcy's law and conservation of mass principle as follows :

C(h) (dh/dt) = [□□□h□□Komos *et al* 1978

where, h is pressure head, t is time, □□is an operator, □H is the hydraulic gradient, K(h) is the hydraulic conductivity function and water capacity C(h) is the change in change in water content of the soil per unit pressure head change.

Solutions of the equation (I) numerically under varying boundary and initial conditions necessasitates the evaluation of soil, water functional relationships with special reference to K (□□□□ h□□□□and□D□□□□□

Materials and method:

For all laboratory purposes sieved soils < 2mm were used except in case of determining saturated hydraulic conductivity (K_s), bulk density and water stable aggregates.Details of the soils taken are presented in Table 1.

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Table 1. Methodologies used

Parameter	Method used
Mechanical analysis of soil	International Pipette Method
pH	Glass electrode Beckman pH meter
Organic carbon	Walkey and Black
Cation exchange capacity	Ammonia distillation method
Saturated hydraulic conductivity	Core Method
Soil water diffusivity	Bruce and Klute method
Weighted mean diffusivity	Bruce and Klute method

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Penetrability	Bruce and Klute method
Sorptivity	Bruce and Klute method
Infiltration rate and cumulative infiltration	Bruce and Klute method
Capillary conductivity	Bruce and Klute method
Soil water retention	Pressure plate and membrane apparatus
Bulk density	ParaffinClod
Water stable aggregates	Yoder's Method

Saturated hydraulic conductivity was calculated as follows:

K_s = (QL/At□□□ □□□□

where, ' K_s' is saturated hydraulic conductivity, 'Q' is the volume of water collected (cm^3), 'A' is the cross sectional area of the core (cm^2), 't' is time in minutes, 'L is the length of the soil column in the core(cm) and '□□' is head difference (cm).

Soil water diffusivity was calculated by the equation given by Bruce and Klute as follows :

□

Di(□□□= -0.5(dx/d□□□□□xd□ (III)

□□□□□□□□□□□□□□□□□□□□□□□□□i□□

where, 'D(□□' is the soil water diffusivity in $cm^2.min^{-1}$ at a volumetric water content (cm^3. cm^{-3}), 't' is the time required by the wetting frint to reach a distance 'x'(cm), 'i' is the initial volumetric water content.

Weighted mean diffusivity (D_{bar}) was calculated as follows :

□

D_{bar} = 5/3 {1/(□s□□□i□□□□ D(□□□□□□□□□□□□d□ (IV)

□□□i

where, 'D_{bar}' is weighted mean diffusivity ($cm^2.min^{-1}$), □s is the saturation water content and other terms are same as equation II

Penetrability (□□□ is calculated as follows:

x=□t□□□□□□□a (V)

where , 'x' is the distance moved by wetting front (cm),'t' is the time (min), '□' is penetrability and is the slope of the plot of 'x' ~~Vs~~ 't' and 'a' is the intercept.

Sorptivity (**S**) is calculated as follows:

$Q=St^{1/2} + b$ (VI)

where, 'Q' is the amount of water entering the diffusivity column,'t' is the time (min),'S' is sorptivity and is got from the plot of 'Q' ~~Vs~~ 't' and 'b' is the intercept.

Infiltration rate and cumulative infiltration were calculated using the equations given by Philip (1957) as follows:

i = (□s□□□i□□□D_{bar}□□t□ (VII)

□□□□□(□s□□□i□□□D_{bar}□□t□ (VIII)

where , 'i' is infiltration rate, 'I' is cumulative infiltration, others same as other equations.

Soil water retention and its parameters are calculated as given below:

Available water (AW) = (Water retained at 30 kPa) – (Water retained at 1500 kPa)
Readily available water(RAW) = Water retained at 10 kPa) – (Water retained at 100 kPa)
Available water holding capacity (AWHC) = AW [(Apparent specific gravity X depth)/100]
Total AWHC = □ (AWHC)/Depth of soil

Water stable aggregates were calculated from the equation given by Van Bavel as follows:

$$MWD = \sum_{i=1}^{n} \bar{x}_i d_i$$

where, $\bar{x}_i$ is the mean weight diameter or fraction and 'd_i' is the proportion by weight of a given size fraction.

Summation of all the fractions > 0.25 mm and summation of all the fractions < 0.25 mm in wet sieving gave per cent macro and micro aggregates.

Results and discussion

The pH of the soils are acidic in nature and ranged from 4.91 to a low of 4.30 in the soils of Garampani, wheras in case of the soils of Nambor forest the pH ranged from 6.00 to 6.24 .Organic carbon ranged from a high of 1.42 to 0.14 in Garampani, on the otherhand it ranged from 0.53 to 1.62 % in Nambor forest soils.. Garampani soils are loamy sand wheras Nambor forest soils are Sandy loam in texture (Table 2). The correlation between different soil physical properties and transmission are presented in Table 4.

Table 2. Basic soil properties between physical properties and transmission

Soil no	Location	Depth (cm)	pH (1:2.5) soil water ratio	Organic carbon (%)	CEC (c.mole.kg^{-1})	Mechanical analysis (%)			Texture
						Sand	Silt	Clay	
001	Garampani	0-15	4.80	1.32	5.40	85.60	8.00	5.00	Loamy sand
002	Garampani	15-30	4.30	0.56	6.80	82.80	9.10	7.15	Loamy sand
003	Garampani	30-45	4.60	0.14	7.00	81.50	7.80	8.35	Loamy sand
004	Garampani	0-15	4.78	1.29	5.64	86.80	7.80	3.00	Loamy sand
005	Garampani	15-30	4.65	0.64	6.45	82.80	9.20	6.70	Loamy sand
006	Garampani	30-45	4.51	0.61	7.12	80.25	7.70	9.85	Loamy sand
007	Garampani	0-15	4.83	1.29	5.60	86.40	8.20	4.61	Loamy sand
008	Garampani	15-30	4.79	0.89	6.45	82.50	9.20	7.20	Loamy sand
009	Garampani	30-45	4.65	0.78	7.21	80.25	6.90	10.45	Loamy sand
010	Garampani	0-15	4.89	1.41	5.64	85.60	8.40	4.80	Loamy sand
011	Garampani	15-30	4.84	0.94	5.98	84.20	9.20	4.20	Loamy sand
012	Garampani	30-45	4.60	0.95	7.23	80.20	7.90	10.60	Loamy sand
013	Garampani	0-15	4.91	1.42	5.62	86.70	8.50	4.20	Loamy sand
014	Garampani	15-30	4.82	0.99	6.99	84.50	9.20	3.80	Loamy sand
015	Garampani	30-45	4.65	0.89	7.23	82.00	6.80	8.70	Loamy sand
016	Nambor forest	0-15	6.20	1.62	6.58	59.70	24.60	13.20	Sandy loam
017	Nambor forest	15-30	6.00	1.03	6.86	57.70	25.80	14.1	Sandy loam
018	Nambor forest	30-45	6.00	0.53	7.21	50.40	31.00	16.7	Sandy loam
019	Nambor forest	0-15	6.24	1.54	6.49	58.90	25.60	13.4	Sandy loam
020	Nambor forest	15-30	6.12	1.23	6.45	57.80	32.50	8.00	Sandy loam
021	Nambor forest	30-45	6.23	0.69	7.56	59.40	27.60	10.60	Sandy loam
022	Nambor forest	0-15	6.24	1.45	6.97	57.70	26.90	13.00	Sandy loam
023	Nambor forest	15-30	6.20	1.23	6.42	56.60	32.50	8.10	Sandy loam
024	Nambor forest	30-45	6.00	0.98	.7.23	54.50	27.00	16.10	Sandy loam
025	Nambor forest	0-15	6.01	1.43	6.99	58.30	26.45	12.75	Sandy loam
026	Nambor forest	15-30	6.02	1.02	6.45	57.80	26.50	12.70	Sandy loam
027	Nambor forest	30-45	6.00	0.78	7.91	56.60	30.00	10.60	Sandy

									loam
028	Nambor forest	0-15	6.00	1.49	6.78	59.80	26.00	11.80	Sandy loam
029	Nambor forest	15-30	6.00	1.24	6.21	57.60	25.40	14.20	Sandy loam
030	Nambor forest	30-45	6.01	0.64	7.00	56.60	24.60	16.40	Sandy loam

The hydraulic properties soil (Transmission characteristics) are given in Table 3

Table 3.Hydraulic properties of soil

Soil No	Texture	Saturated hydraulic conductivity (x 10^{-3} cm.min^{-1})	Weighted mean diffusivity (cm^2.min^{-1})	Penetrability (cm.min$^{-1/2}$)	Sorptivity (ml.min$^{-1/2}$)	Infiltration rate (cm.min^{-1})	Cumulative infiltration (cm)
001	Loamy sand	22.20	0.75	2.00	10.00	20.40	2.86
002	Loamy sand	109.00	1.23	2.60	10.00	36.10	4.42
003	Loamy sand	123.00	1.14	2.20	7.14	33.20	3.38
004	Loamy sand	24.35	0.64	2.70	15.00	21.54	2.87
005	Loamy sand	110.50	1.25	2.65	14.50	34.50	4.65
006	Loamy sand	125.60	1.23	2.60	10.25	36.20	3.46
007	Loamy sand	25.60	0.78	2.80	11.00	25.60	2.78
008	Loamy sand	112.50	1.24	2.70	12.00	37.50	4.54
009	Loamy sand	132.00	1.64	2.60	7.90	34.60	3.36
010	Loamy sand	25.60	0.85	2.90	12.00	25.40	2.97
011	Loamy sand	102.30	1.50	2.50	13.00	26.60	4.41
012	Loamy sand	119.50	1.60	2.20	7.00	24.50	3.38
013	Loamy sand	21.30	0.95	2.85	11.00	28.50	2.84
014	Loamy sand	100.20	1.46	2.60	12.25	26.40	4.52
015	Loamy sand	110.00	1.23	2.20	8.50	24.50	3.62
016	Sandy loam	46.00	0.85	1.75	6.66	20.70	4.19
017	Sandy loam	0.25	1.09	2.14	6.00	23.60	3.63
018	Sandy loam	31.50	0.93	2.33	5.33	34.90	4.27
019	Sandy loam	15.00	0.95	1.85	6.89	22.40	4.25
020	Sandy loam	2.50	1.20	2.25	5.60	29.50	3.42
021	Sandy loam	25.60	1.30	2.30	5.20	32.50	4.56
022	Sandy loam	34.50	0.95	1.95	5.66	35.60	4.50
023	Sandy loam	10.25	1.20	2.40	6.00	28.90	4.20
024	Sandy loam	32.50	1.30	2.50	5.40	24.90	4.10
025	Sandy loam	29.50	1.00	2.00	6.70	25.60	3.72
026	Sandy loam	16.60	1.25	1.90	5.60	34.50	3.56
027	Sandy loam	24.50	1.35	2.50	6.20	36.50	3.60
028	Sandy loam	32.50	0.95	2.25	7.90	27.60	4.25
029	Sandy loam	19.90	1.00	2.50	6.60	35.60	3.60
030	Sandy loam	24.50	1.25	2.55	5.40	34.50	3.45

Table 4. Linear correlation coffecient between different soil physical properties and transmission

	Sand	Silt	Clay
Saturated hydraulic conductivity	0.61	-0.69	-0.27
Weighted mean diffusivity	0.04	-0.09	0.07
Penetrability	0.53	-0.48	-0.50
Sorptivity	0.84	-0.77	-0.81
Infiltration rate	-0.15	0.11	0.22
Cumulative infiltration	-0.33	0.32	0.27
pH	-0.95	0.97	0.69
CEC	-0.44	0.33	0.56
OC	-0.14	0.22	-0.07

The soil water characteristics data are presented in Table 5

Table 5. Soil Hydraulic properties (Retention)

Soil No	IEC	SWC	FC	PWP	AW	RAW	AWHC	TAWHC
001	0.02	0.41	0.22	0.07	0.15	0.10	3.06	0.24
002	0.05	0.51	0.30	0.11	0.15	0.09	4.06	
003	0.04	0.49	0.31	0.12	0.19	0.16	3.90	
004	0.02	0.42	0.31	0.06	0.19	0.11	3.04	0.27
005	0.04	0.43	0.32	0.11	0.19	0.10	3.09	
006	0.06	0.49	0.30	0.12	0.18	0.12	4.20	
007	0.03	0.42	0.34	0.09	0.16	0.09	3.90	0.28
008	0.05	0.46	0.30	0.12	0.17	0.10	3.80	
009	0.06	0.48	0.32	0.13	0.19	0.11	3.40	
010	0.02	0.36	0.28	0.09	0.18	0.09	3.50	0.25
011	0.05	0.49	0.35	0.15	0.19	0.14	3.60	
012	0.06	0.42	0.34	0.13	0.18	0.12	3.40	
013	0.03	0.42	0.32	0.10	0.16	0.07	4.20	0.26
014	0.04	0.40	0.34	0.15	0.19	0.12	3.60	
015	0.06	0.43	0.32	0.13	0.14	0.14	3.90	
016	0.03	0.48	0.38	0.24	0.14	0.08	2.70	0.21
017	0.02	0.44	0.34	0.20	0.14	0.05	3.10	
018	0.06	0.52	0.37	0.18	0.19	0.10	3.80	
019	0.03	0.46	0.40	0.28	0.15	0.05	2.90	0.22
020	0.02	0.44	0.35	0.25	0.16	0.06	3.40	
021	0.05	0.43	0.38	0.26	0.18	0.04	3.10	
022	0.02	0.46	0.38	0.24	00.18	0.08	2.90	0.23
023	0.03	0.45	0.39	0.26	0.18	0.07	2.80	
024	0.04	0.48	0.42	0.21	0.16	0.06	2.90	
025	0.04	0.46	0.35	0.22	0.18	0.04	2.80	0.20
026	0.03	0.51	0.34	0.28	0.16	0.05	2.70	
027	0.02	0.50	0.36	0.21	0.14	0.06	2.60	
028	0.03	0.52	0.32	0.29	0.18	0.07	2.70	0.19
029	0.04	0.46	0.30	0.20	0.16	0.06	2.60	
030	0.03	0.46	0.28	0.19	0.12	0.03	2.50	

The data on soil water characteristics are presented in Table 6

Table 6. Experimental values of soil water content (□□ at different tensions

Soil No	10 kPa	30 kPa	100 kPa	300 kPa	1500 kPa
001	0.30	0.22	0.20	0.11	0.07
002	0.37	0.30	.027	0.16	0.10
003	0.38	0.30	0.22	0.17	0.12
004	0.31	0.28	0.26	0.18	0.11
005	0.32	0.27	0.24	0.17	0.10
006	0.33	0.30	0.26	0.20	0.15
007	0.30	0.28	0.22	0.19	0.12
008	0.34	0.30	0.25	0.20	0.18
009	0.31	0.29	0.27	0.23	0.16
010	0.32	0.30	0.28	0.24	0.15
011	0.30	0.27	0.24	0.20	0.15
012	0.33	0.30	0.25	0.22	0.19
013	0.31	0.27	0.21	0.20	0.14
014	0.30	0.31	0.25	0.23	0.18
015	0.32	0.28	0.24	0.20	0.18
016	0.42	0.38	0.34	0.28	0.24
017	0.43	0.37	0.32	0.29	0.27
018	0.40	0.36	0.33	0.28	0.21
019	0.40	0.35	0.30	0.24	0.20
020	0.42	0.32	0.30	0.25	0.21
021	0.45	0.35	0.34	0.30	0.25

022	0.43	0.38	0.36	0.24	0.24
023	0.42	0.37	0.34	0.31	0.25
024	0.42	0.36	0.33	0.28	0.24
025	0.40	0.38	0.30	0.28	0.24
026	0.42	0.35	0.30	0.28	0.15
027	0.40	0.36	0.30	0.28	0.24
028	0.45	0.38	0.34	0.32	0.30
029	0.40	0.34	0.28	0.24	0.14
030	0.43	0.36	0.26	0.20	0.12

Linear correlation between moisture held (Table 7) by soil at various tensions and soil separates revealed that the finer fraction helped in retaining more water as compared to the larger fractions. The data seems to be a bit citradictory when the relationship between moisture content nad larger fraction is observed closely, as more water is retained by the forest soils though the larger fraction per cent is high. This may be attributed to the fact that the forest soil are high in organic carbon as revealed from Table 1. Thus, the role of organic matter in enhancing the retention characteristics of coarse textured soils through the formation of organic complexes between the surfaces of quartz grains in particular and whatsoever little clay domains available for stabilization of macroaggregates to account for this effect, may be taken into account in these organic matter rich soils.

Table 7. Linear correlation between soil separates, organic carbon and moisture held in soil at different tensions

	10 kPa	30 kPa	100 kPa	300 kPa	1500 kPa
Sand	0.87	0.85	.076	0.78	0.69
Silt	0.89	0.85	0.68	0.78	0.69
Clay	0.76	0.77	0.52	0.56	0.50
Organic carbon	0.06	0.18	0.34	0.27	0.28

Data on soil physical analysis are presented in Table 8. The bulk density of the soils studied ranged from 1.35to 1.42 in soils of Garampani whereas in Nambor forest the data ranged from 1.31 to 1.42. Mean weight diameter had a maximum value of 1.48 to a minimum of 0.03 $Mg.m^{-3}$ in Garampani, on the otherhand in soils of Nambor forest had a maximum of 0.84 to a minimum of 0.24 (mm).Aggregates of size > 0.25 mm (%) ranged from a high of 52.31 to a low of 21.25 % in Nambor forest, whereas in Garampani it ranged from a minimum of 0.002 to a high of 69.69 % in Garampani. In case of aggregates < 0.25 mm the values ranged from 0.004 to 53.38 in Garampani soils and from 49.91 to 20.23 % in Nambor forest soils. The linear correlation between the physical parameters and mechanical analysis are presented in Table 9.

Table 8. Soil physical analysis

Soil No	Bulk density ($Mg.m^{-3}$)	Mean weight diameter (mm)	Aggregate >0.25 mm (% macroaggregate)	Aggregate <0.25 mm (% microaggregate)
001	1.36	0.78	68.61	31.39
002	1.41	1.48	46.62	53.38
003	1.40	0.03	0.002	0.004
004	1.35	0.76	67.61	30.24
005	1.42	0.98	46.62	52.46
006	1.40	0.04	0.004	0.009
007	1.36	0.81	69.64	35.64
008	1.42	1.42	56.61	46.65
009	1.40	0.07	0.007	0.009
010	1.36	1.62	69.21	34.64
011	1.40	1.23	54.51	46.95
012	1.41	0.08	0.005	0.008
013	1.35	094	69.69	36.91
014	1.40	0.94	54.64	43.56
015	1.42	0.08	0.009	0.008
016	1.31	0.64	49.43	48.75
017	1.42	0.37	29.03	27.65
018	1.35	0.24	22.02	21.24
019	1.41	0.64	52.23	49.51
020	1.35	0.40	29.45	24.69
021	1.36	0.25	21.25	20.25
022	1.41	0.70	51.25	45.64
023	1.36	0.64	56.31	46.37
024	1.32	0.29	21.25	20.23

025	1.45	0.68	49.56	46.97
026	1.40	0.50	29.05	24.69
027	1.35	0.06	21.54	20.56
028	1.40	0.84	52.31	49.89
029	1.35	0.46	42.12	45.56
030	1.30	0.28	26.35	23.35

Table 9 Linear correlation between soil separates and soil physical properties

	Sand	Silt	Clay
Bulk density	0.27	-0.29	- 0.15
Mean weight diameter	0.23	-0.18	- 0.27
Aggregates > 0.25 mm	0.19	-0.05	- 0.46
Aggregates < 0.25 mm	-0.10	0.21	- 0.14

Conclusion:

It can be concluded that the soils though belong to ligt texture group but are not supposed to suffer from moisture defecit due to the high organic carbon content of the soils, since their water retention properties are amplified to a higher level due to the presence of high organic carbon which is a common phenomenon of the forest soil.

References:

Bruce,R.R and Klute,A (1956). The measurement of soil moisture diffusivity. *Soil Sci. Soc.Am. Proc.*20:458-462

Fayez –al- komos, Oswal,M.C and Khanna,S.S (1978).Comparision of calculated and experimentally determined soil water diffusivity.*Jour. of hydrology*, Netherlands.39:105-111

Philip,J.R (1969). Theory of infiltration.*Adv. Hydrol. Sci* 5 : 216-291.