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Short Communication

Waterlogging as a soil related constraint in orchards of Nagpur mandarin

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Waterlogging in soils developed on basalt occurs at lower elevation in Vidarbha region of Maharashtra and these soils cultivated for Nagpur mandarin (*Citrus reticulata* Blanco). Tamgadge *et al.*(1996) reported five such extensively occurring soil series. Out of these series the Linga and Jambha are classified as very fine, smectitic, Typic/Udic Haplusterts and are under mandarin cultivation. Shyam Singh (1999) reported poor drainage as one of the major factors for decline in citrus yield in this region. At present large areas have been brought under mandarin cultivation irrespective of suitable topography causing waterlogging and also ponding at places due to canal irrigation (upper Wardha irrigation project). Earlier workers observed better performance of mandarin orchards on well drained soils as compared to poorly drained soils (Kalbande *et al.*,1983; Pathak, 1934). However, the data on changes in soil characteristics leading to waterlogging and orchard performance is lacking. The present investigation was undertaken to study the effect of waterlogging on soil characteristics and orchard performance.

The soil profiles from Nagpur mandarin orchard having 'impeded' as well as 'well drained' soils were studied. Depthwise soil samples were collected and analysed for their physical (Singh, 1989) and chemical (Black, 1965) characteristics following the standard procedures. Data on tree spread (E-W x N-S) expressed as canopy volume and fruit yield were recorded for three consecutive years during 1996-98 and discussed on an average basis by comparing properties of normal and waterlogged orchard. The data on characterisation of soils and performance of orchard from normal and waterlogged sites are presented in tables 1 and 2.

The soils under study are very clayey. The clay content ranges from 57.0 to 70.1 and 58.6 to 80.6% in the normal and waterlogged soils, respectively. The higher clay content soils is a result of there formation in basaltic alluvium and depositon of fine material from the upper reaches of topography. The clay content increases substantially in the sub-surface horizons of waterlogged soils. The fine to total clay ratio ranged from 51.8 to 67.9 and 57.1 to 75.5%. The higher content of fine clay caused the increase (1.56-1.84 Mg m^{-3}) bulk density of these layers, decreased porosity (Painuli and Pagliai 1996) and deteriorated the soil structure. Khan et al. (1998) also observed, higher clay accumulation in subsurface layers of seasonally flooded soils. High clay content mainly in subsurface layers appeared responsible for poor growth (Nilangekar and Patil 1982) and irregular flowering.(Dass *et al.* 1998), of the mandarin orchards.

Table 1. Physical and chemical properties of waterlogged and normal soils under Nagpur mandarin.

Depth (cm)	$CaCO_3$ (%)	pH	EC (dSm^{-1})	Bulk density ($Mg\ m^{-3}$)	Water retention (%)			Hydraulic conductivity ($mm\ h^{-1}$)	COLE cm cm^{-1}	Sand (%)	Silt (%)	Clay (%)	% of total clay		Coarse fragments (%
					33 kPa	1500 kPa	AWC						Coarse clay	Fine clay	
Normal Soils															
0-15	8.52	8.26	0.24	1.42	34.9	15.5	19.4	10.6	0.24	9.1	31.8	59.1	48.2	51.8	6.0
15-30	6.72	8.18	0.15	1.52	36.6	23.1	13.5	5.3	0.24	7.5	32.5	57.0	41.1	58.9	8.2
30-60	6.60	8.09	0.24	1.50	38.3	21.3	17.0	3.8	0.25	4.5	29.0	66.5	39.9	60.1	5.7
60-90	6.24	8.20	0.15	1.55	39.0	20.1	18.9	3.0	0.26	5.9	27.0	67.1	32.1	67.9	6.1
90-120	5.04	8.20	0.18	1.74	37.0	21.4	15.6	3.1	0.26	5.9	24.0	70.1	38.0	62.0	5.2
120-150	8.40	8.20	0.24	1.63	36.4	22.1	14.3	3.3	0.26	6.8	27.2	66.0	37.3	61.7	5.7
150-180	5.88	8.28	0.22	1.57	36.5	23.0	13.5	3.8	0.24	7.9	29.1	63.0	41.1	58.9	6.9
Waterlogged soils															
0-15	7.20	8.19	0.20	1.56	35.4	22.4	13.0	3.6	0.26	8.4	33.0	58.6	40.9	59.1	6.9
15-30	5.64	8.10	0.28	1.60	37.5	22.1	15.4	3.8	0.26	6.2	35.5	63.3	42.9	57.1	7.9
30.60	5.40	8.24	0.26	1.68	39.6	22.7	16.9	3.3	0.26	5.4	14.1	80.6	42.1	57.9	6.3
60-90	6.36	8.24	0.26	1.63	38.3	22.9	15.4	2.5	0.26	3.6	22.7	73.7	24.5	75.5	5.7
90-120	4.56	8.26	0.14	1.77	37.8	22.6	15.2	2.8	0.26	6.2	21.5	72.3	28.0	73.0	4.6
120-150	5.28	8.14	0.14	1.84	37.1	21.7	15.4	3.2	0.25	7.2	26.8	66.0	41.0	59.0	6.2
150-180	4.56	8.20	0.24	1.61	36.2	23.0	13.2	3.9	0.25	6.7	28.4	64.9	38.0	62.0	7.2

The infiltration rate of waterlogged and normal soils was determined on an average basis and shown in figures 1(a) and 1(b) respectively. The basic infiltration rate of waterlogged soils was 7 mm hr^{-1} whereas for normal soils it was 15 mm hr^{-1}. Water infiltrates rapidly into the soil during wetting carries with it detached soil materials which clog macro and micro pore spaces and creates a condition of low conductivity near the surface. Therefore, initial intake of water appeared fairly good but on wetting, the swelled soil reduced intake. The hydraulic conductivity of the soils of 0-15 cm and 15-30 cm layers in the well drained soils was 3 and 1.5 times higher, respectively than the waterlogged soils. Considerable decrease in hydraulic conductivity in the 60-90 and 90-120 cm layer of waterlogged soils was observed, when compared with normal soils and was mainly because of high clay accumulation and for other layers the difference were not appreciable. The high clay accumulation in subsurface horizons increased water retention and allowed considerable more water to be stored in the perched water table restricting root growth of citrus as stated by Boman (1987).

The depthwise analysis showed high COLE values due to the dominance of smectitic clay. The values appeared slightly higher in waterlogged soils. No appreciable effect of waterlogging was observed on pH and EC values of the soil indicative of moderate salinity and absence of alkalinity. The $CaCO_3$ was observed to be low in waterlogged soils than normal soils which could be attributed to continuous wetting in the waterlogged soils. The mean values were 5.57 and 6.87%, respectively. The moisture retention data indicate no significant differences in soil water held at 33 kpa and 1500 kpa from normal and waterlogged sites, however the available water capacity of normal soils was slightly more than that of waterlogged soils.

A vast difference in vegetative growth and yield of Nagpur mandarin orchards was observed between waterlogged and normal soils (Table 2). The stock girth, scion girth, plant height and canopy volume were 51 cm, 44 cm, 3.70 m and 8.1 m^3 under waterlogged soils as compared to 85 cm, 74 cm, 4.45 m and 34.9 m^3 in normal soils. The waterlogging condition acts as a predisposing factor for pests and diseases. Under waterlogged condition the disease and pest infestation was high with 35.0 % mortality of trees as compared to 8.0 % in normal land. In Nagpur mandarin, root damage was observed within 3 to 10 days after flooding (Ford 1956; Hunzikar 1959) and the new root regeneration stopped completely . This rapid destruction of feeder roots on poorly drained sites subjected to flooding have been associated with the production of sulphides and bacterial metabolism (Ford, 1969) greatly affecting plant growth of orange orchards. Kalbande *et al.,* (1983) observed early maturity, improper growth, infestation of diseases, and root rot in oranges grown in 'Karla soils' of Central India due to water stagnation in subsoil layers. All these factors apperar to contribute for very poor yield from the waterlogged soils (13 fruits/plant/year) when compared with 240 fruits/plant/year from normal land. Inability to provide stress to the plant for inducing flowering is also one of the reason for poor yield as there is a continuous supply of water to the plants in waterlogged soils.

Table 2. Effect of waterlogging on Nagpur Mandarin orchard performance

Orchard type	Stock girth (cm)	Scion girth (cm)	Height (m)	Canopy volume (m^3)	Yield (no. of fruits/ tree/year)	Mortality of trees (%)
Normal orchard	85	74	4.45	34.9	240	8
Waterlogged orchard	51	44	3.70	8.1	13	35

Thus it has been observed that, deep clayey soils of very high shrink-swell characteristics and subsoil massiveness and compaction affect root and water distribution, thereby decreasing the reservior of water available to the plant use. Compaction in the sub-soil reduces infiltration rate and hydraulic conductivity, restricts root penetration and causes their destruction. Further it acts as a throttle to water entry and flow resulting waterlogging in wet periods. The declining productivity of Nagpur mandarin is largely a consequence of inability to overcome inherent structural problem and the development of subsurface compaction and waterlogging. Therefore, the areas subjected to temporary phase of waterlogging due to hydrological, topographical and/or soil related constraints (viz. poor drainage) should not be recommended to establish new plantation of Nagpur mandarin.

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