IJTA © Serials Publications
National Academy of Agricultural Science (NAAS) Rating : 3. 03

Studies on Water Repellent Behaviour of Soils Under Sweet Orange Cultivation

R.A. Jadhav[1], V.D. Patil[1] and H.K. Kausadikar[1]

Abstract: *Present investigation entitled "studies on water repellent behaviour of soils under sweet orange cultivation" was carried out during 2014-15 at Department of Soil Science and Agricultural Chemistry, VNMKV, Parbhani. It was aimed to study the soil properties in relation to water retension/repellent behaviour and to find out relation between soil properties and sweet orange of project consist of a survey of healthy and declined sweet orange orchards was carried out in sweet orange growing soils of Marathwada region. Soils samples from healthy and unhealthy sweet orange orchards, underneath acacia and lawn were collected from 0-10, 10-20 and 20-30 cm depth. The soil properties like pH, EC, bulk density, porosity, organic carbon and aggregate stability were studied. Soil properties were studied under healthy sweet orange trees and declined sweet orange trees. These results revealed that, the soil properties under declined sweet orange trees were degraded. These results showed that gradual degradation of favourable soil properties. (This was mainly because of addition of wax and organic substances which form of wax coat and clod/soil separates). This in turn blocks the macro and micro pores. In respect of soils in sweet orange growing orchard, water repellent behaviour was more in declined sweet orange orchards, as compared to normal sweet orange orchard soils. Infiltration rate and hydraulic conductivity was also badly affected in declined orchard soil. Lawn soil had highest water repellent properties followed by acacia tree species soils.*

Keywords: *Water repellent soils, aggregate stability and porosity.*

INTRODUCTION

Sweet Orange (*Citrus sinensis*) is the fruit crop belongs to *Rutaceae* family. It is most important fruit crop in the world after mango, banana and grapes. In India, Maharashtra is a leading producer of sweet orange and Marathwada region is a leading producer of sweet orange in MS. In India, area under sweet orange is 344.9 million ha and production is 3886.2 million MT with Productivity of 11.6 MT/ha. While, in Maharashtra area under sweet orange cultivation is 95 million ha with production of 712.5 million MT and productivity of 7.5 MT/ha. The low productivity of sweet orange in Maharashtra is due to decline of sweet orange fruit trees from the inception of fruiting age, which is a major constraint in sweet orange production in Marathwada region. Amongst many factors responsible for citrus decline are high calcium carbonate and low organic carbon content in soil (Patil, 1997). In addition to this, the citrus decline is getting aggregated to water repellent behaviour of citrus growing soils. In Marathwada region, poor growth of citrus orchards is due presence of high clay, $CaCO_3$ in sub-soil, low organic carbon, available nitrogen, phosphorus, in the surface of citrus orchard.

Water repellency in soils was first described by Schreiner and Shorey (1910), who found that some soils in California could not be wetted and thereby were not suitable for agriculture use. Waxy organic substances were responsible for the water repellency. Many workers have reported that water repellence of soils is caused by the organic matter

1 Department of Soil Science and Agricultural Chemistry, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani - 431402, Maharashtra.

fraction, but the origin of the active components of the total organic matter may differ from soil to soil. Soils which have hydrophobic properties (also called water repellent soils) can resist or retard surface water infiltration (Brandt, 1969). Soil water repellence can be defined as the phenomenon that a soil does not wet spontaneously when water is applied on the surface. Soil water repellency affects infiltration, evaporation, erosion and the hydrologic balance of soils (Leelamanie *et.al*. 2008). Besides the retardation resistance of surface water infiltration, water repellent soils have been associated with preferential flow (Jamison, 1942). Preferential flow paths create spatial variability in soil moisture affecting plant growth (Dekker and Ritsema, 1994). It is important to predict water distribution and flow processes in water repellent soils and to understand how porous media theory developed for hydrophilic soils applies to hydrophobic soils.

Water movement in soils is often markedly affected by the development of properties of wetting resistant. This property common with colloidal materials such as clays and soil organic matter and bears an important relationship to the behavior of soils moisture in sandy soil carrying plant residues as compared with subsurface soils low in organic matter content. The vary nature of organic matter seems to change in soils beneath older citrus trees, especially those affiliated with a peculiar kind of spreading decline and large bodies of dry soils are found beneath citrus trees even at the end of the rainy season. (The ordinary kind of wetting resistant due to drying will return with through drying and these kinds will not). Other factors than desiccations seems to contribute to the development of wettable soil under the citrus trees. Infiltration into a water repellent soil is slower and more variable than into a wettable soil. If the surface of a soil is water repellent, water will not infiltrate into the soil immediately in raining. It will first pond on the soil surface and, if there are any micro topographical or macro topographical contours, then flow to the lower depressions. Instead of flattening out by lateral diffusion the wetting front in a water repellent soil might lead to the formation of ''fingers'' or ''preferential flow paths'' (Ritsema and Dekker, 1994). In uncultivated, acid, sandy soils receiving no lime or magnesium application, water repellence may be due to other materials that accumulating insoluble soaps. It was suggested that application of sawdust mulch or any organic dressing may induce water repellence in soil. For example, the application of redwood mulch to citrus orchards in the riverside area induced a water repellent condition which hindered the rejuvenation of orchards. Many workers have reported that water repellence of soils is caused by organic matter fraction, but the origin of the active components of total organic matter may differ from soil to soil. The techniques used to assess the water repellence have varied considerably and this may have contributed to some of the apparent differences in the properties of soils (Bond and Harris, 1964). The suggestion that essential oils from the plant cover were deposited on the soil surface was logical and found some support, especially as the area of leaf- drip was often more water repellent than soil outside the canopies. The importance of the type of plant cover is well recognized, but whether this is a direct or an indirect effect needs clarification.

In Marathwada region, citrus is grown in south-east part along the railway track passing through Nanded, Parbhani, Jalna and Aurangabad. The citrus decline in these districts is induced by many factors; the formation of water repellent soil is one of these factors. Very few workers have focused this aspect; hence, this investigation is an initial step towards opening of new era of water repellence.

MATERIAL AND METHODS

Soil Sampling and Analyses

A survey comprising of healthy and declined sweet orange orchards was carried out in sweet orange growing soils of Marathwada region. Simultaneously, soil sample underneath the healthy and unhealthy (declined) sweet orange trees were collected separately from the depth of 0-10, 10-20 and 20-30 cm and was processed for further analysis.

Five healthy and five unhealthy fruit plants of sweet orange were selected (Avg. Age 15-20 yrs) and the soils of the selected sites were analyzed for various soil properties. Soils underneath the Acacia trees (3 Samples) and the lawns (3 Samples) of depth

0-10, 10-20 and 20-30 cm were also studied against sweet orange growing soils for various properties. The soil samples (depth wise) underneath the sweet orange trees was taken from the sweet orange orchard of department of water management, V.N.M.K.V., Parbhani.

The soil was air-dried, passed through 2-mm sieve, and analyzed for particle size distribution (International Pipette Method, (USDA Triangle Method); pH, electrical conductivity (EC); organic carbon (Walkly and Black 1934); bulk density (Clod Coating Method).

Statistical Analysis

The data of various observations were compiled, tabulated and analyzed by adopting CRD (Completely Randomized Design) suggested by Panse and Sukhatme 1985.

Facilities Required and their Availability

All the laboratory facilities and research needs were available at Department of Soil Science and Agril. Chemistry, V.N.M.K.V., Parbhani.

Place of Research Work

An experiment was conducted at sweet orange orchard of Department of water management, V.N.M.K.V, Parbhani.

RESULTS AND DISCUSSIONS

Soil water repellence can adversely affect general and hydrological soil properties. It reduces infiltration capacity and induces preferential flow, surface runoff as erosion. The research work in this area is mainly centralized in USA and European countries. There are very few references in respect of Indian continent. (Although primarily described from alluvial soil supporting lawn and sweet orange orchards almost no research work was carried out on black soils of Maharashtra and particularly sweet orange growing belts of Marathwada). The review supports that soil water repellence behaviour is one of the cause of citrus decline. Therefore to initiate the research work on this topic a project on "Studies on water repellent behaviour of soils under sweet orange cultivation" was planned and executed.

The basic properties like soil pH, EC, organic carbon, bulk density, porosity, were determined from healthy and declined sweet orange orchards, underneath the acacia and lawn growing soils at a depth of 0-10, 10-20 and 20-30 cm respectively. The data were collected and analyzed in CRD. The results emerged out are presented in following tables under appropriate sub-heads.

Bulk Density and Porosity

The bulk density and porosity of various soils is prerated in Table 1 and Table 2. It is clear from the data presented in table 1 and table 2 that declined sweet orange orchards soil has minimum porosity as compared to other soil types, while lawn soil showed more porosity. This might be due to cushioning to the lawn provided while placing the lawn in garden.

Table 1
Bulk density of various soils

	Depth (cm)			
Treatments	*0-10*	*10-20*	*20-30*	*Mean*
SH (1-5)	1.04	1.04	1.04	1.04
SD (1-5)	1.15	1.09	1.11	1.12
A (1-3)	1.00	1.03	1.12	1.05
L (1-3)	1.01	1.06	1.10	1.06
SE (±)		0.034		
CD @ 5%		0.10		
GM		1.07		

Table 2
Porosity (%) of various soils

	Depth (cm)			
Treatments	*0-10*	*10-20*	*20-30*	*Mean*
SH (1-5)	48.6	48.1	47.5	48.07
SD (1-5)	47.9	47.2	47.1	47.40
A (1-3)	49.0	48.3	48.0	48.43
L (1-3)	49.9	49.3	48.8	49.33
SE (±)		0.420		
CD @ 5%		1.284		
GM		48.30		

Aggregate Stability

The aggregate stability of soil is governed by adhesion and cohesion forces between soil particles. The data presented in Table 3 indicated that soils from healthy sweet orange trees are more stable at soil depth and it was ranged from 0.54 to 0.55 while aggregate stability was at lower magnitude (0.51 to 0.52) in declined sweet orange trees. The soils under acacia and lawn recorded very low aggregate stability indicating low aggregation due to low content of cementing agents *viz.* clay, $CaCO_3$ and oxides of iron and manganese. The unstable aggregates in acacia and lawn soils found to be poor in water retention capacities which can be seen in the data presented in Table 3.

Table 3. Soil aggregate stability/Mean weight diameter (mm)

	Depth (cm)		
Treatments	*0-10*	*10-20*	*20-30*
SH (1-5)	0.54	0.54	0.55
SD (1-5)	0.51	0.51	0.52
A (1-3)	0.20	0.21	0.22
L (1-3)	0.18	0.20	0.21
SE (±)		0.0088	
CD @ 5%		0.0249	
GM		0.37	

Soil pH

The results did not show any significant effect in respect of pH. However the trend showed acacia soils had lower pH as compared to other might be because of soil site fells under rainfed condition. The lawn and declined sweet orange soil showed similar trend of soil pH. The high soil pH of lawn soil can be attributed to frequent irrigation and semi arid climate of the region. From above it can be inferred that high pH in lawn and healthy sweet orange soil was due to application of irrigation, and low pH in acacia might be due to rainfed condition.

Electrical Conductivity

Electrical conductivity represents the total soluble salt content of soil. The data on Electrical Conductivity were presented in Table 4. It was interesting to note here that in all soils the salt concentration was decreased at an appreciable rate in 10- 20 cm depth. Further there was increase in salt concentration to the depth of 20-30 cm. Among the various soils, Electrical Conductivity maximum was obtained / noticed under acacia soil followed by lawn soil and healthy sweet orange soil. The soil from declined sweet orange orchard showed lowest EC values at 10-20 and 20-30 cm soil depth.

Table 4
Electrical conductivity various soils

	Depth (cm)			
Treatments	*0-10*	*10-20*	*20-30*	*Mean*
SH (1-5)	0.42	0.33	0.32	0.36
SD (1-5)	0.45	0.28	0.30	0.34
A (1-3)	0.60	0.43	0.54	0.52
L (1-3)	0.53	0.48	0.56	0.52
SE (±)		0.058		
CD @ 5%		0.179		
GM		0.436		

Organic Carbon

The data on organic carbon content of soils are given in table 5. The maximum organic content was found at surface layer (0-10 cm) in all the treatments. There was nearly 50% drastic reduction in organic carbon content with increase in depth. Minimum organic carbon content was recorded at 20-30 cm depth.

The sweet orange decline soil showed relatively high organic carbon content as compare to other soils, followed by lawn. The increase in organic carbon in declined sweet orange orchard soil might be due to intensive leaf fall observed in these orchards. It is well known that there is intensive shedding of leaves in declined sweet orange trees. Further lawn showed more organic carbon (0.56 %) content at a depth of 10-20 cm; this can be attributed to dense root system at 10-20 cm depth. Under acacia tree soil, the minimum organic carbon content was noted due to less litter fall of acacia tree.

Soil Properties and Sweet Orange Decline

The soil properties were studied in context of sweet orange decline. For this study soil properties from declined sweet orange trees and healthy sweet

Table 5
Organic carbon content of various soils (%)

	Depth (cm)			
Treatments	*0-10*	*10-20*	*20-30*	*Mean*
SH (1-5)	0.44	0.36	0.31	0.37
SD (1-5)	0.50	0.37	0.22	0.36
A (1-3)	0.28	0.17	0.15	0.20
L (1-3)	0.46	0.56	0.29	0.44
SE (±)		0.088		
CD @ 5%		0.271		
GM		0.34		

orange trees were determined and are presented in Table 6. Revealed that, the soil properties under declined sweet orange trees were declined. These results showed that gradual degradation of favourable soil properties. This degradation was mainly because of addition of wax and organic substances which form of wax coat and clod/soil separates. This in turn blocks the macro and micro pores.

Table 6
Soil properties under healthy and declined sweet orange trees.

		Sweet orange trees	
Soil properties	*Unit*	*Healthy*	*Declined*
1. Bulk density	g/cm^3	1.04	1.12
2. Porosity	%	48.07	47.40
3. Aggregate stability	(mm)	0.54	0.51
4. pH	–	7.92	7.86
5. EC	dsm^{-1}	0.36	0.34
6. Organic carbon	%	0.37	0.36

CONCLUSIONS

Among the soils *viz.* healthy sweet orange tree, declined sweet orange tree, acacia tree and lawn, soil from acacia tree species and from lawns showed inferior soil properties/parameters as compared to healthy and declined sweet orange orchards. The physical/hydrophobic properties like aggregate stability was reduced in acacia and lawn soil.

However between healthy and declined sweet orange tree species, soils under declined orchard showed decrease in most of the soil properties. These results showed that gradual erosion of favourable soil properties. This erosion was mainly because of addition of wax and organic substances which form of wax coat and clod/soil separates. This in turn blocks the macro and micro pores.

In respect of sweet orange growing orchard soils, water repellent behaviour was more under declined sweet orange orchards as compared to normal/ healthy sweet orange orchard was slightly affected in declined orchard soil. Lawn soil had highest water repellent properties followed by acacia tree species soils.

References

Bauters, Steenhois, Decarlo, Niaebear and Dekker, (2000), "Physics of water repellent soils." *Journal of Hydrology* 231: 233-243.

DeBano L.F., and J.S. Krammes., (1966), Water repellent soils and their relation to wildlife temperatures. Bull. Int. Assoc. Sci. Hydrol. 11(2): 14-19.

Dekkar L., Ritsema C. and Oostende K., (1994), Extent and significance of water repellency in dunes along the Dutch coast. *Journal of Hydrology*, 231-232 (2000), 112-125.

Dekker L.,Ritsema J.,Oostindie K.,Moore D.,and Wesseling J., (2009), Methods for determining soil water repellency on field-moist samples, Water Resour. Res., 45, W00D33, doi: 10.1029/2008WR007070.

Jamison V.C., (1942), The slow reversible drying of sandy surface soils beneath citrus trees in central Florida. *Soil Sci. Soc. Amer. Proc.* 7: 36-41.

Wander I.W., (1949), An Interpretation of the Cause of Water-Repellent Sandy Soils in Citrus Groves of Central Florida." *Science* 110 (2856): 299-300.