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Root pattern studies in acid lime in silt clay soils

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ABSTRACT

The slow decline in the acid lime (*Citrus aurantifolia swingle*) resulted in reduction in the area and production of the crop especially in Tamil Nadu. Though many theories were postulated for this decline, it still remains as a complex problem. Hence a study was undertaken to find out whether the orchards with silt clay soil type have any effect on the productivity of acid lime. The problem was approached from an angle *viz.*, studying the rooting pattern of acid lime trees in this soil. The results revealed that the fibrous root spread was restricted to 0 – 30 cm from the ground level.

Key words : Acidlime, Silt clay soil, Root studies.

Citrus is one of the important fruit crops grown in India. It is raised in 244,000 ha in tropical and warm humid tropics. Among different species of citrus, acidlime (*Citrus aurantifolia swingle*) is grown in large areas of Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu.

In recent years, a slow decline in productivity of acidlime trees was observed in Tamil Nadu and elsewhere. The slow decline was generally identified by symptoms like severe chlorosis and mottling in leaves and the roots become brittle. Many theories were put forward for the slow decline. Sahasrabuddhe (1927) observed the poor aeration in heavy soils to be the reason for the decline. Kanwar and Randhawa (1960) observed that quality of water and type of soil played a role in citrus decline. Molanaar (1962) reported that citrus grown in porous soils showed decline suddenly. Chapman (1952) and Marloth *et al.* (1965) indicated the difficulty of establishing citrus orchards on heavy soils because of the microflora and decomposable toxic substance. In Andhra Pradesh, the presence of hard pan due to the calcium carbonate was found to be the main reason for the citrus decline (Kanwar and Randhawa, 1960).

However, no definite cause for the same was indicated and citrus decline appeared to be a complex problem and as stated by Chadha (1970), it could be due to more than one factor.

To find out the causes for the citrus decline in Tamil Nadu and to evolve ways and means to improve the situations, a study was undertaken to find out the influence of silt clay of its role on rooting pattern and soil type on its growth and production of acid lime.

MATERIALS AND METHODS

The investigation was undertaken to study the role of siltyclay soil in cultivation of acid lime *viz.*, the rooting pattern of acid lime trees raised in siltyclay soils sampling orchards were selected in six different agro ecological situation with siltyclay soil type and were divided into healthy and declining based on the crop stand. The trees which exhibited deficiency and chlorotic leaves up to 25 per cent were grouped into vigorous and upto 50 per cent and above 50 per cent were grouped as declining-1 and declining-2, respectively. The boundary (border) line of the tree canopy on four sides was pegged. Then the soil within this boundary was excavated in a constant circular distance in stages 30 cm wide towards the tree trunk. Roots at earlier stage were collected both laterally and vertically downwards. The soil was excavated deep till the maximum length of the root has been located. Collected roots were dried and dry weight was recorded.

As suggested by Aiyappa *et al.* (1968), the roots were classified as follows: fibrous roots below 0.2 cm; thin 0.5 cm ; medium roots 0.5 cm to 1.5 cm ; and thick 1.5 cm and above in diameter. The number of roots found at constant lateral distance in a constant depth was computed as percentage of the total roots available in each type separately. The dry weight of roots was expressed in percentage by weight (laterally and vertically). The datum collected from the orchards of silt clay soil type was analyzed statistically through factorial completely blocked randomized design as suggested by Panse and Sukhatme (1961).

RESULTS AND DISCUSSION

The root system plays an essential role in plant growth and development. Roots are sensitive indicators of soil

properties. According to Kachinsky (1925), the soil dictates the plant root system and its development. Root spread depends on the soil types, availability of nutrients and water (Kolesnikov, 1962). The present study showed that the root penetration was even beyond 90 cm in silty clay (Table 1). Fibrous roots occupied more percentage among the different types of roots in all types of trees *i.e.*, 80.35 per cent in vigorous, 70.10 per cent in D_1 and 65.00 per cent in D_2 types of trees (Table 2). In vigorous trees, root extension was observed up to 120 cm away from the trunk whereas it was upto 150 cm in D_1 trees and beyond 150 cm in D_2 trees. Thick roots extended upto 120 cm in vigorous trees, 150 cm in D_1 trees and 60 cm in D_2 trees.

The better texture of the soil with less bulk density and high macro pore space would have enhanced early development of strong root system which would have resulted in a better aerial canopy and framework. This might have been a strong sink for further development of fibrous root system.

A decrease of 50 per cent in fibrous root content was recorded in 30-60 cm zone away from trunk when compared to 0-30 cm zone in vigorous and in D_1 trees. In D_2 trees, the decrease was not pronounced.

In vigorous trees, 78.78 per cent of the roots were fibrous roots. The weight of fibrous roots was more at 0 - 30 cm away from the tree at 0 - 30 cm depth. The weight of thin and medium roots was almost equal at 30 - 60 cm depth, but at 60-90 cm depth, equal weight of fibrous roots and thin roots was observed. However, beyond 90 cm depth, the fibrous and thin roots differed significantly (95 g and 80 g, respectively).

Table 1 : Root spread (per cent) in lateral distance in silty clay soil

Tree type	Root type	Lateral distance						
		0-30 cm	30-60 cm	60-90 cm	90-120 cm	120-150 cm	150 cm	Total
Vigorous	Fibrous	46.20	26.40	4.50	3.25	-	-	80.35
	Thin	4.31	4.20	1.25	1.74	-	-	11.50
	Medium	1.05	4.00	1.00	1.00	-	-	7.05
	Thick	0.30	0.40	0.20	0.20	-	-	1.10
	Total	51.85	35.00	6.95	6.19	-	-	100.00
D_1	Fibrous	34.20	15.10	10.80	6.00	4.00	-	70.10
	Thin	7.10	3.10	2.00	2.00	1.00	-	15.20
	Medium	4.00	2.00	3.35	3.65	1.00	-	14.00
	Thick	0.35	0.25	0.05	0.05	-	-	0.70
	Total	45.65	20.45	16.20	11.70	6.00	-	100.00
D_2	Fibrous	29.10	20.00	5.70	5.10	3.10	2.00	65.00
	Thin	9.10	3.15	2.10	3.15	2.70	-	20.20
	Medium	4.60	5.10	4.30	-	-	-	14.0
	Thick	0.50	0.30	-	-	-	-	0.80
	Total	43.30	28.55	11.10	8.25	5.80	2.00	100.00

Table 2 : Root penetration (per cent) in different depth in silty clay soil

Tree type	Depth cm	Fibrous	Thin	Medium	Thick	Total
Vigorous	0.30	40.25	5.10	2.00	0.50	47.85
	30-60	20.10	3.40	3.05	0.30	26.85
	60-90	15.00	2.00	1.00	0.20	18.20
	> 90	5.00	1.00	1.00	0.10	7.10
	Total	80.35	11.50	7.05	1.10	100.00
D_1	0-30	35.00	5.80	4.60	0.30	45.70
	30-60	20.00	5.20	3.20	0.20	28.60
	60-90	10.00	3.20	5.00	0.20	18.40
	> 90	5.10	1.00	1.20	-	7.30
	Total	70.10	15.20	14.00	0.70	100.00
D_2	0-30	41.00	15.20	14.00	0.70	100.00
	30-60	20.00	6.00	7.00	0.30	59.60
	60-90	20.00	6.00	7.00	0.30	33.30
	> 90	-	-	-	-	-

In D_1 trees, 66.66 per cent of the roots were fibrous roots (600 gm). A gradual decrease of fibrous roots was observed with increase in depth. The decreasing percentage of roots with increase in the lateral distance and depth is similar to the findings of Irizarry *et al.* (1981).

In D_2 trees, the roots penetration was observed up to 90 cm. Sixty per cent of the roots were fibrous roots in all depths. A decrease in dry weight of fibrous roots was observed with the increase in lateral distance. A gradual decrease of fibrous roots was observed with the increase

Table 3 : Dry weight of roots (g) in various depths at different lateral distance in silty clay soil

Tree type	Root type	Lateral distance						
		0-30 cm	30-60 cm	60-90 cm	90-120 cm	120-150 cm	150 cm	Total
Vigorous 0 - 30	Fibrous	650.00 (78.78)	250.00 (50.81)	62.00 (37.80)	38.00 (38.38)	-	-	1000.00 (63.29)
	Thin	120.00 (14.54)	120.00 (24.39)	70.00 (42.68)	40.00 (40.40)	-	-	350.00 (22.15)
	Medium	40.00 (4.84)	100.00 (20.32)	25.00 (15.24)	15.00 (15.15)	-	-	180.00 (11.39)
	Thick	15.00 (1.81)	22.00 (4.47)	7.00 (4.20)	6.00 (6.06)	-	-	50.00 (3.16)
	Total	825.00	492.00	164.00	99.00	-	-	1580.00
30 - 60	Fibrous	340.00 (66.66)	120.00 (63.15)	100.00 (58.82)	60.00 (60.00)	-	-	620.00 (63.91)
	Thin	75.00 (14.70)	30.00 (15.78)	30.00 (17.64)	15.00 (15.00)	-	-	150.00 (15.46)
	Medium	80.00 (15.68)	20.00 (10.52)	30.00 (17.64)	20.00 (20.00)	-	-	150.00 (15.46)
	Thick	15.00 (2.94)	20.00 (10.52)	10.00 (5.88)	5.00 (5.00)	-	-	50.00 (5.15)
	Total	510.00	190.00	170.00	100.00	-	-	970.00
60 - 90	Fibrous	90.00 (38.29)	50.00 (37.03)	25.00 (31.25)	10.00 (20.00)	-	-	175.00 (35.00)
	Thin	95.00 (40.42)	45.00 (33.33)	25.00 (31.25)	10.00 (20.00)	-	-	175.00 (35.00)
	Medium	30.00 (12.76)	20.00 (14.81)	15.00 (18.75)	15.00 (30.00)	-	-	80.00 (16.00)
	Thick	20.00 (8.51)	20.00 (14.81)	15.00 (18.75)	15.00 (30.00)	-	-	70.00 (14.00)
	Total	235.00	135.00	80.00	50.00	-	-	500.00
90	Fibrous	35.00 (31.81)	25.00 (23.43)	20.00 (44.44)	15.00 (48.33)	-	-	95.00 (47.50)
	Thin	40.00 (36.36)	15.00 (23.43)	15.00 (33.33)	10.00 (32.25)	-	-	80.00 (32.00)
	Medium	25.00 (22.72)	20.00 (31.25)	5.00 (11.11)	5.00 (16.12)	-	-	55.00 (22.00)
	Thick	10.00 (9.09)	4.00 (6.25)	5.00 (11.11)	1.00 (3.22)	-	-	20.00 (8.00)
	Total	110.00	64.00	45.00	31.00	-	-	250.00
D_1 Trees 0-30	Fibrous	300.00 (70.58)	100.00 (56.49)	100.00 (68.96)	60.00 (63.15)	40.00 (68.96)	-	600.00 (66.66)
	Thin	60.00 (14.11)	40.00 (22.59)	20.00 (13.79)	20.00 (21.05)	10.00 (17.24)	-	150.00 (16.66)
	Medium	40.00 (9.41)	22.00 (12.42)	20.00 (13.79)	10.00 (10.52)	8.00 (13.79)	-	100.00 (11.11)
	Thick	25.00 (5.88)	15.00 (8.47)	5.00 (3.44)	5.00 (5.26)	-	-	50.00 (5.55)
	Total	425.00	177.00	145.00	95.00	58.00	-	900.00

Table 3 contd…..

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	Fibrous	250.00 (72.46)	70.00 (66.03)	60.00 (68.96)	25.00 (65.78)	40.00 (68.96)	-	600.00 (66.66)
	Thin	60.00 (17.39)	15.00 (14.15)	15.00 (17.24)	6.00 (15.78)	10.00 (17.24)	-	150.00 (16.66)
30 -60	Medium	25.00 (7.24)	15.00 (14.15)	10.00 (11.49)	5.00 (13.15)	8.00 (13.79)	-	100.00 (11.11)
	Thick	10.00 (2.89)	6.00 (5.66)	2.00 (2.29)	2.00 (5.26)	-	-	50.00 (5.55)
	Total	345.00	106.00	87.00	38.00	58.00	-	900.00
	Fibrous	75.00 (52.18)	30.00 (51.72)	25.00 (47.16)	15.00 (46.87)	5.00 (31.25)	-	150.00 (49.83)
	Thin	25.00 (17.60)	10.00 (17.24)	10.00 (18.86)	10.00 (31.25)	6.00 (37.50)	-	61.00 (20.25)
60 - 90	Medium	35.00 (24.64)	15.00 (25.80)	15.00 (28.30)	5.00 (15.62)	5.00 (31.25)	-	75.00 (24.91)
	Thick	7.00 (4.92)	3.00 (5.17)	8.00 (5.66)	2.00 (0.25)	-	-	15.00 (4.98)
	Total	142.00	58.00	53.00	32.00	16.00	-	301.00
	Fibrous	35.00 (61.40)	15.00 (60.00)	15.00 (70.75)	5.00 (55.55)	5.00 (62.50)	-	75.00 (62.39)
	Thin	10.00 (17.54)	4.00 (16.00)	3.00 (16.15)	2.00 (22.22)	1.00 (12.50)	-	20.00 (16.63)
90	Medium	12.00 (21.05)	6.00 (24.00)	3.20 (15.09)	2.00 (22.22)	2.00 (2.50)	-	25.20 (20.96)
	Total	57.00	25.00	21.20	9.00	8.00	-	120.00
D_2	Fibrous	110.0	98.00	60.06	20.06	10.00	2.00	300.12
0 - 30		(56.41)	(64.05)	(66.68)	(44.51)	(66.66)	(100.00)	(60.00)
	Thin	50.00 (25.64)	20.00 (13.07)	20.00 (22.20)	25.00 (55.50)	51.00 (33.33)	-	166.00 (23.99)
0 - 30	Medium	20.00 (10.25)	30.00 (19.60)	10.00 (11.10)	-	-	-	60.00 (11.99)
	Thick	15.00 (7.69)	5.00 (3.26)	-	-	-	-	20.00 (3.99)
	Total	195.00	153.00	90.06	45.06	61.00	2.00	546.12
	Fibrous	98.00 (57.25)	40.00 (52.04)	20.00 (52.28)	10.00 (66.66)	10.00 (83.00)	2.00 (100.00)	180.00 (57.10)
	Thin	38.00 (22.20)	15.00 (19.51)	10.00 (26.14)	5.00 (33.33)	2.00 (16.60)	-	60.00 (22.20)
30 - 60	Medium	32.00 (18.69)	20.00 (26.02)	8.25 (21.56)	-	-	-	60.25 (19.11)
	Thick	3.15 (1.84)	1.85 (2.40)	-	-	-	-	5.00 (1.58)
	Total	171.15	76.85	38.25	15.00	12.00	2.00	315.20
	Fibrous	20.00 (58.33)	10.00 (44.44)	10.00 (58.82)	6.00 (61.53)	3.50 (73.68)	0.50 (100.00)	50.00 (54.34)
	Thin	12.00 (32.00)	8.00 (35.55)	5.00 (29.41)	3.75 (38.46)	1.25 (26.31)	-	30.00 (32.60)
60 - 90	Medium	4.00 (10.66)	4.00 (17.77)	2.00 (11.76)	-	-	-	10.00 (10.86)
	Thick	1.50 (4.00)	0.50 (2.22)	-	-	-	-	2.00 (2.17)
	Total	37.50	22.50	17.00	9.75	4.75	0.50	92.00

* Figures in parenthesis are per cent by weight of root penetration and spread

D_1 - Declining Tree I stage D_2 - Declining Tree II stage

in depth. The weight and proportion of fibrous roots in silty clay depended much on the porosity, bulk density and compactness of soil. The studies of Atulchandra and Yamdagini (1984) and Komamura and Sekiya (1985) confirmed the above results.

In silty clay soil, the fibrous roots per cent by weight revealed the maximum zone of nutrient absorption (Table 3). Sixty five per cent spread of the fibrous roots was present at 0-30 cm lateral distance, followed by 25 per cent spread at 30 - 60 cm lateral distance. It was very low at 90 - 120 cm lateral distance *viz.,* 3.80 per cent.

A gradual decrease in percentage of fibrous roots was observed with an increase of distance. In 60 - 90 cm depth, the fibrous roots per cent at 0 - 30 cm lateral distance. When the fibrous root percentage was compared between depths, it was more in 0 - 30 cm depth in a radius of 0 - 30 cm from tree trunk. A decreasing trend of fibrous root per cent was observed in 60 - 90 cm and 90 - 120 cm distances.

In D_1 trees, 50 per cent by weight of fibrous root was present in 0 - 30 cm lateral distance under 0 - 30 cm depth and an equal distribution of fibrous roots 16.66 per cent each was observed at 30 - 60 cm and 60 - 90 cm lateral distance. The same trend was observed in all types of roots. An increase in fibrous roots in all types of trees was observed at 30 - 60 cm depth. Fibrous roots accounted for 59.52 per cent at 0 - 30 cm lateral distance. But a decrease in fibrous roots per cent was observed at 60 - 90 cm depth and more than 90 cm depth at 0 - 30 cm lateral distance. But an increasing trend was observed with the increase in depth at 60 - 90 cm and more than 90 cm depth at 30 - 60 cm and 60 - 90 cm lateral distance.

In D_2 trees, the fibrous root distribution was more or less equal in 0 - 30 cm and 30 - 60 cm distance (36. 65 per cent and 32.65 per cent, respectively). The fibrous root per cent was more in 30 - 60 cm depth at 0 - 30 cm lateral distance, *viz.,* 54.44 per cent. A sudden drop by nearly 50 per cent was observed at 30-60 cm depth at 30 - 60 cm lateral distance and it was 22.22 per cent by weight. At 60 - 90 cm depth, 40 per cent of roots were present in 0 - 30 cm lateral distance and it was 20 per cent in each at 30 - 60 cm and 60 - 90 cm distance, respectively. The availability of nitrogen and potassium was more in silt clay soil. This had helped in the stimulation of absorbing roots and aerial roots. Optimum level of nitrogen increased the weight of absorbing surface of roots. The increased total weight of roots at all depths in silty clay was more because of the presence of more number of absorbing roots present. The studies of ford *et al*. (1975) are also in confirmity with above results.

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