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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(9): 08-12

www.thepharmajournal.com
Received: 16-06-2022
Accepted: 20-07-2022

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Assessment of physico-chemical properties in major tapioca growing blocks of Namakkal district, Tamil Nadu

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Abstract
Tapioca (*Manihot esculenta* Crantz) is an important food security crop (Karlstrom *et al*., 2016). It is very tolerant of drought and heat stress and produces well on marginal soils. This tuber crop is largely cultivated in Tamil Nadu (64%), Kerala (32%) parts of Andhra Pradesh (1.5%), Nagaland (1.2%) and Assam (0.5%). In Tamil Nadu, Namakkal (21%), Dharmapuri (19%), Salem (15%), Villupuram (14%), Trichy (9%), Erode (5%) and Thiruvannamalai (5%) in an area of 1.21 lakh hectare (Chennakrishnan and Thenmozhi, 2020)**.** In Namakkal the major tapioca growing blocks are Paramathy, Mohanur and Namagiripettai. The cost of cultivation of tapioca is very low but it is considered as high revenue crop. Even though the area under cultivation increased from 1,99,000 ha to 2,10,000 ha, there was no hike in yield and this might be due to improper soil and crop management. Soil test was the only criteria to delineate the fertility status of different regions and sampling was done by random method. The present study was undertaken to delineate, the physicochemical properties in major tapioca growing blocks (Mohanur, Paramathy and Namagiripettai) of Namakkal district. Totally 540 geo-referenced soil samples (Both surface (270) and subsurface (270) covering the entire three blocks of tapioca growing tracts of Namakkal district were collected by along with latitude and longitude. The results showed that the pH value of Paramathy block ranged between 5.83 to 9.85 with a mean of 9.48, the EC values ranged between 0.02 - 1.31 dS m^{-1} with a mean of 0.54 dS m^{-1}. In Mohanur block, the pH values found to be ranged from 7.00 – 10.78 with a mean of 10.31 and the EC values ranged from 0.02 – 0.85 dS m^{-1} with a mean value of 0.39 dS m^{-1}. In Namagiripettai block, the pH values ranged from 7.03 to 8.84 with a mean of 8.57, the EC values ranged between 0.11 - 0.17 with a mean value of 0.15 dS m^{-1}. Based on the results, we concluded that either we use application of lime for acid soil; gypsum for alkaline soil can be recommended as a source of nutrient under north western agro climatic conditions under study.

Keywords: Survey, soil sample, tapioca and blocks

Introduction
Tapioca (*Manihot esculenta* Crantz) is an important food security crop (Karlstrom *et al*., 2016) [5]. It is very tolerant of drought and heat stress and produces well on marginal soils. It is an important dietary staple in many countries within the tropical regions of the world (Perez and Villamayor, 1984) [7], where it provides food for more than 800 million people (FAO, 2007). As a subsistence crop, tapioca is the third most important carbohydrate food source in the tropics after rice and maize, providing more than 60% of the daily calorific needs of the populations in tropical Africa and Central America (Nartey, 1978) [6]. The edible leaves are relatively rich in protein. It is also the most important tropical root crop. It can be stored in the ground for several seasons, and thereby serve as a reserve food when other crops fail. Tapioca is a perennial woody shrub with an edible root, which grows in tropical and subtropical areas of the world like Asia and southern Africa. It grows to about 8 feet in height, has broad, shiny leaves roughly the shape of a human hand and attractive white and pink flowers. Many varieties of this species - divided into two groups: sweet and bitter tapioca - are cultivated in the tropics for their starchy, tuberous roots. These can be processed into tapioca, ground to produce manioc or tapioca meal (Brazilian arrowroot), used as animal fodder or cooked and eaten as a vegetable. Tapioca is also increasingly used for animal feed and in different industrial processes and products. Tapioca is used for preparation of macroni, papad, instant noodles, flour, rava, noodles, vermicelli etc., highly economical starch is extensively used in textile processes, confectioneries, foam strengthening and mainly as filler in manufacturing of compounded animal feeds.

In India, tapioca is cultivated in both irrigated and rainfed conditions. In India, Tamil Nadu ranks first in tapioca production followed by Kerala. Around 72% of tapioca production in Tamil Nadu is carried out by Salem, Namakkal, Erode, Cuddalore, Villupuram, Dharmapuri and Kanyakumari districts of Tamil Nadu. In that Namakkal stands first in production and productivity of tapioca hares about 20.15 percent of total production in the state. The higher productivity of tapioca in Namakkal was due to the most suitable soil condition and even distributed rainfall over the years. As Indian soils were higher in the availability of potassium there was much scope for tapioca cultivation in places of drought areas under rainfed condition. This tuber crop is largely cultivated in Tamil Nadu (64%), Kerala (32%) parts of Andhra Pradesh (1.5%), Nagaland (1.2%) and Assam (0.5%). India exports several forms of tapioca products like raw tapioca tuber, starch, sago, and other modified starches like Dextrins. Tapioca is being cultivated in major 14 districts: Namakkal (21%), Dharmapuri (19%), Salem (15%), Villupuram (14%), Trichy (9%), Erode (5%) and Thiruvannamalai (5%) in an area of 1.21 lakh hectare (Chennakrishnan and Thenmozhi, 2020) [2].

In Namakkal the major tapioca growing blocks are Paramathy, Mohanur and Namagiripettai. The cost of cultivation of tapioca is very low but it is considered as high revenue crop. Even though the area under cultivation increased from 1,99,000 ha to 2,10,000 ha, there was no hike in yield and this might be due to improper soil and crop management. For the past 5 decades, a considerable research work has been done in the country on various aspects such as varieties, irrigation, and macronutrients fertilization; weed management, spacing, post - harvest, etc. to increase the yield and quality of Tapioca. Soil physical properties related constraints (clay gradient in soil profile, drainage/ irrigation/ waterlogging) and soil fertility constraints induced by soil pH, salinity (specific ion-and cumulative osmotic pressure effect), calcareousness (pedogenic or non-pedogenic $CaCO_3$), besides increasing menace of nutrient mining, are the important pedological factors contributing to tapioca decline. In the past, soil tests were the only criteria to delineate the fertility status of different regions and sampling was done by random method. In the context of a changing scenario, there is an immense need to generate a spatial distribution of pH and EC using the Global Positioning System (GPS). In Namakkal district, there is a lack of information on soil physico chemical status at tapioca growing tracts in the village, block and taluk level. Hence, it seems necessary to survey the soil physico chemical status of tapioca growing blocks of Namakkal district. The study helps in understanding the future scope of tapioca growth in that region.

Materials and Methods

The geo-referenced soil samples were collected from the Tapioca growing tracts of Namakkal district to assess the physico chemical properties. The particulars of study area, the method of soil sample collection and the standard analytical procedures followed are presented in this chapter.

Description of study area

Namakkal district is the southern district of the state of Tamil Nadu. Namakkal district was bifurcated from Salem district with Namakkal town as headquarters on 25 July 1996 and started to function independently from 1January 1997 by the Government of Tamil Nadu. Namakkal is located at “11013’8.N to 78011’.2E”. It has an average elevation of 218 meters (715 ft). Namakkal district has an area of 3368.21 Sq Kms and it is separated into two revenue divisions as Tiruchengode and Namakkal.

Collection and processing of geo-referenced surface and subsurface soil Samples

Totally 540 geo-referenced soil samples (surface (270) and subsurface (270)) covering the entire three blocks of tapioca growing tracts of Namakkal district were collected by adopting the standard procedures of soil sample collection. The GPS data (8.97ºN and 77.3 ºE) were collected from each sampling sites distributed over the entire tapioca growing tracts by using Garmin GPS 76CS model. The collected soil samples were dried, sieved (2 mm sieve) and preserved in polythene bags for further analysis.

Table 1: Major tapioca blocks and villages

Blocks	Villages
Mohanur	Andipalayam Ariyanthuthur Ellai Medu Ganapathipalayam Iyampalayam Kamachi Nagar Kambathurpatti Manapalli Muthur Aniyapuram Ariyur Kumarapalayam Oruvandur Rasipalayam Sengapalli
Paramathy	Manicanatham Koodacheri Veeranampalayam Maravarpalayam Sirapalli Villipalayam Keezhakadai Kottanapalayam Nalliyampalayam Sooriyampalayam Kupuchipalayam Arthanaripalayam Padamudipalayam Pillur Devipalayam Sunkaranpatty Mavureddy Sungakaranpalayam Merkupudhur Oviyampalayam Pillaikalathur Unjampalayam Velur Punjai Edayar Melmugam
Namagiripettai	Easwaramurthipalayam Mangalapuram Moolakurichi Mullukurichi Naraikinaru Oyilpatti Perappansolai T Jedarpalayam Thoppapatti Vaduga Muniappampalayam Karkoodalpatti Mathuruttu Moolapallipatti Navalpatti Pachudaiyampalayam

Soil analysis
The soil samples were analyzed for various soil properties by adopting standard procedures. The methods employed are described below.

Physico-Chemical properties
Soil reaction (pH)
The pH of soil was estimated by employing potentiometry method using soil water suspension in the ratio of 1: 2.5 (Jackson, 1973) [4].

Electrical Conductivity (EC)
The electrical conductivity of soil was estimated by employing conductometry method in the soil water suspension of 1: 2.5 ratio (Jackson, 1973) [4].

Statistical analysis
The data obtained from the above experiments were subjected to statistical scrutiny (Snedecor and Cochran, 1967) [10] and the analyses were carried out in Agress statistical software using excel programme in Micro Soft office 2007.

Result and Discussion
Soil Reaction (pH) (Table 2, 3, 4)
The pH of investigated surface soils ranged from 5.83 to 9.85 with a mean of 9.48, whereas, in subsurface soils it varied from 5.14 to 9.53 with a mean of 9.34 in Paramathy block, the. In Mohanur block, the pH of the surface soils ranged from 7.00 to 10.78 with a mean of 10.31, Whereas in subsurface soils it varied from 7.29 to 10.77 with a mean of 10.43. In Namagiripettai block, the pH of surface soils ranged from 7.03 to 8.84 with a mean of 8.57, whereas in subsurface soils it varied from 7.49 to 8.83 with a mean of 8.93. In general, subsurface soil pH was found to be high as compared to that of surface soil.
The variation in pH from acidic to alkali range may be attributed to the variation in the parent materials and different compounds and ions present in the soil. Besides, variation in management practices may also contributed to slight extent in accordance with the variation in pH. Similar results were reported by Sharma *et al.* (2008) [8]. The mild to strongly alkalinity in some pockets of study area could be due to accumulation of exchangeable sodium and calcium carbonate. These results were in consonance with the findings of Singh *et al.* (2014) [9].

Electrical Conductivity (EC) (Table 2, 3, 4)
The EC of investigated in Paramathy block, the surface soils ranged from 0.02 to 1.31 with a mean of 0.54, whereas in subsurface soils it varied from 0.02 to 0.95 with a mean of 0.59. In Mohanur block, the EC of surface soils ranged from 0.02 to 0.85 with a mean of 0.39, whereas in subsurface soils it varied from 0.01 to 0.19 with a mean of 0.11. In Namagiripettai block, the EC of surface soils ranged from 0.11 to 0.17 with a mean of 0.15, whereas in subsurface soils it varied from 0.20 to 0.48 with a mean of 0.41.
The electrical conductivity of soil gives an indication about salt concentration. Soils having EC less than 0.80 dS m^{-1} are rated as non-saline (Bali *et al.*, 2010) [1]. The EC of majority of the soils was normal. The modest EC values of the soil samples could be ascribed to leaching of salts to lower horizon as frequent copious irrigations are very common in tapioca cultivation. Salt concentration observed in the study area gives an idea that by and large salinity is not a problem in tapioca growing tracts of Namakkal district.

Table 2: Range and mean values of physico-chemical properties (pH, EC) of surface and subsurface soils of Mohanur block of Namakkal district

S. No	Village name	Depth (cm)	pH			EC (dS m^{-1})		
			Min.	Max.	Mean	Min.	Max.	Mean
1	Andipalayam	0-15	9.00	9.50	9.28	0.02	0.03	0.02
		15-30	9.01	9.98	9.97	0.01	0.05	0.03
2	Ariyanthuthur	0-15	8.23	9.67	8.76	0.02	0.04	0.03
		15-30	8.26	9.68	8.78	0.03	0.09	0.06
3	Ellai Medu	0-15	9.24	9.89	9.56	0.04	0.08	0.07
		15-30	9.30	10.01	9.60	0.06	0.14	0.09
4	Ganapathipalayam	0-15	7.23	7.89	7.68	0.03	0.08	0.04
		15-30	7.29	7.93	7.72	0.03	0.11	0.08
5	Iyampalayam	0-15	9.23	9.94	9.51`	0.03	0.10	0.09
		15-30	9.26	9.99	9.55	0.06	0.13	0.10
6	Kamachinagar	0-15	9.35	10.78	10.29	0.08	0.85	0.39
		15-30	9.36	10.77	10.32	0.07	0.15	0.10
7	Kambathurpatti	0-15	9.45	9.98	9.77	0.05	0.09	0.06
		15-30	9.55	10.02	9.84	0.03	0.11	0.06
8	Manapalli	0-15	10.00	10.56	10.31	0.03	0.05	0.03
		15-30	10.23	10.65	10.43	0.03	0.14	0.07
9	Muthur	0-15	8.45	8.79	8.62	0.03	0.04	0.03
		15-30	8.55	8.87	8.71	0.05	0.15	0.08
10	Aniyapuram	0-15	7.56	7.90	7.82	0.03	0.04	0.03
		15-30	7.78	8.00	7.92	0.06	0.10	0.07
11	Ariyur	0-15	8.45	8.89	8.67	0.03	0.06	0.05
		15-30	8.49	9.00	8.73	0.05	0.09	0.07
12	Kumarapalayam	0-15	7.56	7.90	7.76	0.05	0.13	0.10
		15-30	7.60	7.93	7.78	0.06	0.11	0.08
13	Oruvandur	0-15	8.16	8.89	8.59	0.05	0.13	0.09
		15-30	8.15	8.90	8.62	0.14	0.17	0.15
14	Rasipalayam	0-15	7.00	7.90	7.60	0.05	0.13	0.10
		15-30	7.30	8.02	7.75	0.06	0.19	0.11

15	Sengapalli	0-15	8.23	8.56	8.40	0.13	0.14	0.13
		15-30	8.29	8.60	8.46	0.13	0.19	0.16
	Mean	(0-15)	8.47	9.14	8.79	0.04	0.13	0.08
		(15-30)	8.54	9.23	8.94	0.05	0.12	0.09
		SD			0.63			0.63
		CV (%)			8.10			42.68

Min.- Minimum; Max.- Maximum. *Mean – Average of five locations.

Table 3: Range and mean values of physico-chemical properties (pH, EC) of surface soils and subsurface soils of Paramathy block of Namakkal district

S .No	Village name	Depth (cm)	pH			EC (dS m^{-1})		
			Min.	Max.	Mean	Min.	Max.	Mean
1	Kupuchipalayam	0-15	9.13	9.85	9.44	0.02	0.08	0.05
		15-30	8.19	9.50	9.24	0.02	0.10	0.06
2	Arthanaripalayam	0-15	7.74	7.92	7.80	0.13	0.19	0.16
		15-30	7.24	7.91	7.49	0.17	0.26	0.21
3	Kudacheri	0-15	8.16	8.37	8.28	0.02	0.09	0.05
		15-30	7.89	8.98	8.43	0.27	0.43	0.35
4	Padamudipalayam	0-15	9.14	9.27	9.19	0.10	0.19	0.14
		15-30	8.89	9.72	9.29	0.11	0.20	0.16
5	Pillur	0-15	7.37	7.44	7.40	0.12	0.19	0.15
		15-30	6.69	7.29	7.10	0.13	0.21	0.17
6	Devipalayam	0-15	9.15	9.27	9.20	0.02	0.09	0.05
		15-30	9.01	9.45	9.20	0.02	0.14	0.07
7	Sunkaranpatty	0-15	6.30	6.43	6.36	0.02	0.09	0.06
		15-30	6.20	6.49	6.36	0.03	0.09	0.06
8	Mavureddy	0-15	8.62	8.77	8.71	0.10	0.19	0.14
		15-30	8.16	8.81	8.54	0.12	0.19	0.15
9	Kottanapalayam	0-15	9.14	9.27	9.21	0.20	0.27	0.24
		15-30	9.16	9.72	9.48	0.20	0.31	0.25
10	Villipalayam	0-15	8.45	8.56	8.49	0.13	0.19	0.16
		15-30	7.21	7.93	7.57	0.11	0.18	0.15
11	Sungakaranpalayam	0-15	6.06	6.15	6.11	0.12	0.18	0.15
		15-30	6.02	6.29	6.11	0.16	0.27	0.20
12	Merkupudhur	0-15	8.50	8.61	8.54	0.10	0.28	0.15
		15-30	8.48	8.56	8.51	0.11	0.19	0.15
13	Oviyampalayam	0-15	8.49	8.58	8.53	0.20	0.26	0.23
		15-30	7.14	7.53	7.33	0.22	0.29	0.25
14	Pillaikalathur	0-15	6.79	6.88	6.83	0.16	0.21	0.18
		15-30	6.17	6.59	6.35	0.11	0.20	0.16
15	Unjampalayam	0-15	7.91	8.10	7.99	0.10	0.19	0.15
		15-30	7.29	7.81	7.49	0.12	0.19	0.16
16	Velur	0-15	6.75	6.84	6.78	0.03	0.08	0.06
		15-30	6.14	6.47	6.31	0.21	0.25	0.23
17	Maravarpalayam	0-15	5.83	5.89	5.86	0.02	0.09	0.05
		15-30	5.14	5.90	5.50	0.12	0.19	0.15
18	Keezhakadai	0-15	8.72	8.79	8.75	0.21	0.30	0.26
		15-30	8.14	8.42	8.29	0.13	0.18	0.15
19	Punjai Idaiyar Melmugam	0-15	9.41	9.49	9.44	0.08	0.19	0.14
		15-30	9.13	9.53	9.34	0.12	0.19	0.15
20	Nallipalayam	0-15	9.50	9.57	9.53	0.23	0.28	0.25
		15-30	8.54	8.98	8.80	0.18	0.15	0.16
21	Manikanatham	0-15	8.15	8.25	8.20	0.21	0.60	0.42
		15-30	8.10	8.15	8.13	0.31	0.58	0.43
22	Seerapalli	0-15	8.39	8.15	8.45	0.11	1.31	0.54
		15-30	8.15	8.45	8.32	0.26	0.95	0.59
23	Veeranampalayam	0-15	8.10	8.15	8.13	0.17	1.09	0.39
		15-30	8.12	8.69	8.33	0.24	0.29	0.26
24	Sooriyampalayam	0-15	8.62	8.70	8.66	0.18	0.41	0.26
		15-30	8.35	8.95	8.67	0.13	0.38	0.22
	Mean	(0-15)	8.10	8.22	8.16	0.12	0.29	0.18
		(15-30)	7.65	8.17	7.92	0.15	0.26	0.20
		SD			0.65			0.65
		CV (%)			8.50			71.19

Min.-Minimum; Max.-Maximum. *Mean – Average of five locations.

Table 4: Range and mean values of physico-chemical properties (pH, EC) of surface and subsurface soils of Namagiripettai block of Namakkal district

S. No	Village name	Depth (cm)	pH			EC (dS m^{-1})		
			Min.	Max.	Mean	Min.	Max.	Mean
1	Easwaramurthipalayam	0-15	7.18	7.53	7.33	0.11	0.14	0.13
		15-30	7.54	7.90	7.78	0.37	0.46	0.41
2	Mangalapuram	0-15	7.54	7.91	7.73	0.13	0.15	0.13
		15-30	7.95	8.27	8.12	0.27	0.38	0.33
3	Moolakurichi	0-15	7.83	8.26	8.27	0.13	0.14	0.14
		15-30	8.15	8.83	8.46	0.31	0.45	0.36
4	Mullukurichi	0-15	7.58	8.17	7.78	0.12	0.13	0.13
		15-30	7.99	8.38	8.17	0.33	0.46	0.37
5	Naraikinaru	0-15	7.03	7.42	7.26	0.13	0.17	0.14
		15-30	7.11	7.82	7.70	0.22	0.44	0.34
6	Oyilpatti	0-15	8.28	8.84	8.57	0.13	0.15	0.13
		15-30	8.77	9.01	8.89	0.24	0.45	0.31
7	Perappansolai	0-15	7.83	8.18	7.97	0.12	0.17	0.14
		15-30	8.17	8.33	8.25	0.21	0.48	0.33
8	T Jedarpalayam	0-15	7.41	7.93	7.64	0.14	0.16	0.14
		15-30	7.84	8.30	8.02	0.27	0.43	0.34
9	Thoppapatti	0-15	8.04	8.48	8.26	0.13	0.15	0.13
		15-30	8.30	8.93	8.77	0.33	0.47	0.38
10	Vaduga Muniappampalayam	0-15	7.49	8.06	7.75	0.13	0.14	0.13
		15-30	7.89	8.45	8.29	0.27	0.43	0.35
11	Karkoodalpatti	0-15	8.17	8.78	8.55	0.13	0.15	0.14
		15-30	8.67	9.07	8.93	0.26	0.56	0.47
12	Mathuruttu	0-15	7.26	7.56	7.49	0.13	0.14	0.13
		15-30	7.71	8.01	7.90	0.24	0.33	0.30
13	Moolapallipatti	0-15	7.09	7.40	7.22	0.14	0.15	0.15
		15-30	7.71	7.93	7.85	0.27	0.41	0.29
14	Navalpatti	0-15	7.95	8.32	8.15	0.13	0.14	0.13
		15-30	8.29	8.56	8.48	0.22	0.40	0.31
15	Pachudaiyampalayam	0-15	7.42	7.88	7.65	0.13	0.14	0.14
		15-30	7.88	8.07	7.98	0.20	0.34	0.27
	Mean	0-15	7.60	7.93	7.81	0.13	0.15	0.14
		15-30	7.98	8.20	8.05	0.25	0.38	0.31
		SD			0.62			0.53
		CV(%)			7.82			8.61

Min - Minimum; Max - Maximum. *Mean- Average of five locations

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