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Studies on impact of organic amendments with fertilizers on growth, yield of watermelon (*Citrullus lanatus* thunb.) and soil properties of *Theri* land (red sand dune) in southern Tamil Nadu

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Abstract
The present investigation was carried out at Thirumaraiyur village, Sattankulam taluk, Thoothukudi district to study the effect of organic amendments with recommended dose of fertilizers on growth and yield of watermelon and soil properties in *Theri* soil (red sand dunes) during the year 2017 and 2018. The experiment was laid out in Randomized Block Design with Factorial concept (FRBD). In all there were three factors as organic amendments with 6 treatment combinations for each factor, which were assigned at random in each plots with three replications. The recommended dose of fertilizers in treatments was two levels as 75 and 100 per cent. Among the three factors, the tank silt application @ 100 t ha^{-1} with 100 per cent recommended fertilizer as 200:100:100 kg of NPK ha^{-1} through fertigation at 7 days interval (T_5) produced maximum number of branches (10.7), longest vine (362 cm), number of fruits $plant^{-1}$ (2.56), weight of fruit (5.3 kg), fruit yield (68.22 t ha^{-1}), gross return (₹4,09,320/ha), B:C ratio (2.45), minimum fine and course sand (68.3 and 2.8%, respectively)), highest clay and silt (20.2 and 8.7%, respectively), lowest values of bulk and particle density (1.32 and 2.32 Mg m^{-3}, respectively), maximum soil pore space (54.3%). The soil pH (6.56), electrical conductivity (0.26 dSm^{-1}) and the highest organic carbon (0.66%) were registered with the application of tank silt application @ 100 t ha^{-1} with 100 per cent recommended fertilizer as 200:100:100 kg of NPK ha^{-1} through fertigation at 7 days interval.

Keywords: Watermelon, *Theri* land, organic amendments, inorganic fertilizers, growth, yield and soil properties

Introduction
Watermelon (*Citrullus lanatus* Thunb.) is one of the important vegetable crops grown extensively in India. It is a major tropical crop in south Indian states of Karnataka, Andhra Pradesh and Tamil Nadu. India is the second largest producer of watermelon fruit among the Asian countries accounting 2.48 million tonnes from 1.01 lakh hectare with the productivity of 24.58 t ha^{-1} (HSD, 2017) [9]. In Tamil Nadu, the production is 1.63 lakh tonnes from an area of 6930 ha with the average productivity of 23.52 t ha (DES, 2017) [6].

The *Theri* lands (red sand dunes) are one of the major wastelands in Tirunelveli and Thoothukudi districts of Tamil Nadu. These *Theries* are located (77º 49' 44" to 78º 28' 22" E and from 8º 15'13" to 9º 11' 0" N) to an extent of 20,171 ha (Jawahar *et al*., 1999) [11]. The soils have low nutrient status, low water holding capacity, low organic carbon content and are susceptible to high wind erosion (Manikandan and Subramanian, 2010) [14]. The mean annual rainfall of the study area is between 610 to 700mm.

In *Theri* soils (red sand dune) organic amendments like tank silt, FYM, composted coir pith (CCP) *etc.* improve the physic-chemical properties of soil. Many organic amendments contain plant nutrients and act as organic fertilizers. Monitoring soil and plant nutrient status is an essential safeguard to ensure maximum crop productivity. It is well known that organic amendments and inorganic fertilizers are essential to increase the productivity of crops and fertility of soils.

The fertigation technology is the possible way to improve the crop production and soil productivity for profitable farming in constrained *Theri* soil. Fertigation within the rhizosphere matches with the physiological needs of the crop *viz.* root development, vegetative growth, flower and fruit development. Scientific information on fertigation in *Theri* land (red sand dune), especially in watermelon, is very scanty. Hence, the present field experiment was set up to determine influence of organic amendments combined with inorganic fertilizers through fertigation on growth, fruit yield of watermelon and soil property of *Theri* land.

Materials and Methods

The experiment was conducted during *kharif*- winter seasons of 2016-2017 and 2017-2018 at Thirumaraiyur village, Sattankulam taluk, Thoothukudi district, Tamil Nadu. The sand dune ecosystem formed in *isomegathermic* and *ustic* regime from geogenic sand deposit under a semi-arid climate. The initial soil samples were collected and the physico-chemical properties were analyzed. The texture of the soil was fine sandy with fractions *viz.*, fine sand, course sand, clay and silt, (86.3, 3.5, 4.6 and 5.5%, respectively). The bulk density (1.58 Mg m^{-3}), particle density (2.63 Mg m^{-3}) and per cent pore space (36.38 per cent) were found in the experimental soil. Soil at the experimental site was fine sandy, with organic carbon 0.12%, slightly acidic pH (6.36) electrical conductivity (0.13 dS/m^{-1}) and cation exchange capacity (11.3 cmol (p^{+}) kg^{-1}). Seeds of watermelon F1 hybrid Suprit were sown in rows of 2m width, with 60 cm plant-to-plant spacing, during the first week of November in both years. The experiment was laid out in Factorial Randomized Block Design (FRBD) with six treatments and three replications. Factor as three organic amendments *viz.*, tank silt @ 100 t ha^{-1}, composted coir pith @ 12.5 t ha^{-1} and farm yard manure @ 20 t ha^{-1} were applied as uniform basal doses before sowing. The treatments were T_1- 75% recommended dose of fertilizers (RDF) (150:75:75 kg of NPK ha^{-1}) through soil application; T_2-100% recommended dose of fertilizers (RDF) (200:100:100 kg of NPK ha^{-1}) through soil application; T_3- 75% recommended dose of fertilizers (RDF) (150:75:75 kg of NPK ha^{-1}) through fertigation at 7 days interval; T_4- 75% recommended dose of fertilizers (RDF) (150:75:75 kg of NPK ha^{-1}) through fertigation at 15 days interval; T_5- 100% recommended dose of fertilizers (RDF) (200:100:100 kg of NPK ha^{-1}) through fertigation at 7 days interval; T_6- 100% recommended dose of fertilizers (RDF) (200:100:100 kg of NPK ha^{-1}) through fertigation at 15 days interval.

Conventional fertilizers used in the experiment were urea, single super phosphate, di-ammonium phosphate and muriate of potash; whereas, 19 each of N, P_2O_5, K_2O, KNO_3 and Ca $(NO_3)_2$ formed the source of water soluble fertilizer. Recommended dose of fertilizer in the present study comprised 200 kg N, 100 kg P_2O_5 and 100 kg K_2O per hectare. Fertilizer was applied at 7 and 15 days intervals through fertigation treatments. Soil treatments received the entire P_2O_5 and K_2O at sowing and N in two splits-one at sowing and the other 30 days later. Irrigation was given through drippers to all the treatments. Growth observations were taken 60 days after sowing. All agronomic and plant protection measures were adopted as per the guide lines of crop production guide for Tamil Nadu (CPG, TNAU, 2015) [5]. The crop was harvested at 90 to 100 days after sowing, at fruit maturity. Soil samples were analysed for physic-chemical properties following standard procedure. The organic carbon following Walkley and Black (1934), Soil texture following Robinson's International pipette method by Piper (1966), pH and EC following 1:2 of Soil water suspension by Jackson (1973) [10] were analysed. Observations on crop growth, yield and yield parameters were recorded and statistically analyzed as per Gomez and Gomez (1984) [7]. Economics of water melon cultivation as influenced by chemical fertilizer, drip fertigation and management practices were calculated by considering the prevailing market price of fruit and inputs used.

Results and discussion

Effect of tank silt

Growth attributes

The growth and yield attributes of watermelon *viz.*, number of branches, vine length, number of fruits and fruit weight were significantly influenced by different organic amendments with recommended dose of NPK as 200:100:100 kg ha^{-1} through fertigation (Table 1). Significantly maximum number of branches (10.7), longest vine (362 cm), maximum number of fruits per plant (2.56), maximum weight of fruit (5.3 kg) and maximum fruit yield (68.22 t/ha) were obtained in treatment applied with tank silt @ 100 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval (T_5) followed by tank silt @ 100 t ha^{-1} with 75 per cent NPK through fertigation at 7 days interval (T_3) with the number of fruit as 9.3, longer vine (351 cm), higher number of fruits per plant (2.40), weight of fruit (5.17 kg) and higher fruit yield (62.23 t ha^{-1}), however, among the two levels of NPK without fertigation the minimum number of branches (7.3), shortest vein length (274 cm), minimum number of fruits per plant (1.83), lowest fruit weight (4.43 kg) and minimum fruit yield (40.66 t ha^{-1}) were found in treatment applied with tank silt @ 100 t ha^{-1} with 75 per cent NPK ha^{-1} through soil application (T_1)**.** The present findings were supported by Kadam *et al.*, (2009) [12], Gonsalves *et al.*, (2011) [8] and Castellanos *et al.*, (2012) [4].

Effect of composted coir pith (CCP)

The composted coir pith (CCP) with 100 per cent NPK was showed the similar trend as that of tank silt amendment (Table 1). Significantly maximum number of branches (10.3), longest vine (351 cm), maximum number of fruits $plant^{-1}$ (2.33), weight of fruit (5.27 kg) and maximum fruit yield (61.59 t ha^{-1}) were obtained in treatment applied with composted coir pith @ 12.5 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval (T_5) followed by composted coir pith @ 12.5 t ha^{-1} with 75 per cent NPK through fertigation at 7 days interval (T_3) with the value of 9.0, longer vine (338 cm), higher number of fruits $plant^{-1}$ (2.27), weight of fruit (5.00 kg) and higher fruit yield (56.93 t ha^{-1}). The two levels of NPK without fertigation, the minimum number of branches (76.7), shortest vein length (270 cm), minimum number of fruits per plant (1.77), lowest fruit weight (4.17 kg) and minimum fruit yield (37.06 t ha^{-1}) were found in treatment applied with CCP @ 12.5 t ha^{-1} with 75 per cent NPK ha^{-1} through soil application (T_1)**.** The present finding was supported by Umamaheswarappa *et al.*, (2005) [19] and Kumar *et al.*, (2007) [13].

Table 1: Effect of organic amendment with inorganic fertilizers on growth, yield and economic of hybrid watermelon

Treatments	No. of branches plant^{-1}	Vine length (cm)	No. of fruits plant^{-1}	Average fruit wt. (kg)	Fruit yield (t ha^{-1})	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Benefit: cost ratio
Tank silt @ 100 t ha^{-1}									
T_1- 75% RDF (Soil application)	7.3	274	1.83	4.43	40.66	72,820	1,62,640	89,820	1.23
T_2 -100% RDF (Soil application)	8.0	305	2.03	4.63	47.14	83,750	1,88,560	1,04,810	1.25
T_3 -75% RDE at 7 days interval (Fertigation)	9.3	351	2.40	5.17	62.23	1,12,820	3,73,380	2,60,560	2.31
T_4 -75% RDF at 15 days interval (Fertigation)	8.4	319	2.20	4.87	53.74	1,07,820	3,22,440	2,14,620	1.99
T_5-100% RDF at 7 days interval (Fertigation)	10.7	362	2.56	5.30	68.22	1,18,750	4,09,320	2,90,570	2.45
T_6 -100% RDF at 15 days interval (Fertigation)	8.7	327	2.30	5.00	57.68	1,13,750	3,46,080	2,32,330	2.04
SEd	3.35	0.08	0.032	0.084	1.68	-	-	-	-
CD (P=0.05)	7.46	0.19	0.071	0.187	3.74	-	-	-	-
Composted coir pith (CCP) @12.5 t ha^{-1}									
T_1- 75% RDF (Soil application)	6.7	270	1.77	4.17	37.06	92,820	1,48,200	55,380	1.60
T_2 -100% RDF (Soil application)	7.3	298	2.03	4.40	44.80	1,03,750	1,79,200	75,450	1.73
T_3 -75% RDE at 7 days interval (Fertigation)	9.0	338	2.27	5.00	56.93	1,32,820	3,41,580	2,08,760	2.57
T_4 -75% RDF at 15 days interval (Fertigation)	7.7	308	2.10	4.67	49.19	1,27,820	2,95,140	1,67,320	2.31
T_5-100% RDF at 7 days interval (Fertigation)	10.3	351	2.33	5.27	61.59	1,38,750	3,69,540	2,30,790	2.66
T_6 -100% RDF at 15 days interval (Fertigation)	8.3	318	2.17	4.83	52.03	1,33,750	3,12,180	1,78,430	2.33
SEd	0.09	3.17	0.03	0.09	1.15	-	-	-	-
CD (P=0.05)	0.21	7.05	0.06	0.20	2.56	-	-	-	-
Farm yard manure (FYM) @ 20 t ha^{-1}									
T_1- 75% RDF (Soil application)	6.2	259	1.67	4.27	35.76	82,820	1,43,040	60,220	1.73
T_2 -100% RDF (Soil application)	6.7	287	1.93	4.53	43.85	93,750	1,75,400	81,650	1.87
T_3 -75% RDE at 7 days interval (Fertigation)	8.6	328	2.20	5.00	55.18	1,22,820	3,31,080	2,08,260	2.69
T_4 -75% RDF at 15 days interval (Fertigation)	7.3	301	2.00	4.83	48.45	1,17,820	2,90,700	1,72,880	2.47
T_5-100% RDF at 7 days interval (Fertigation)	9.4	332	2.26	5.17	58.61	1,28,750	3,51,660	2,22,910	2.73
T_6 -100% RDF at 15 days interval (Fertigation)	8.3	308	2.06	4.93	51.66	1,23,750	3,09,960	1,86,210	2.50
SEd	0.15	2.99	0.04	0.06	0.79	-	-	-	-
CD (P=0.05)	0.34	6.66	0.09	0.12	1.78	-	-	-	-

Effect of farm yard manure (FYM)

Among the three amendments, the application of farm yard manure (FYM) @ 20 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval (T_5) also revealed similar trend growth and yield attributes with the maximum branches (9.4), longest vine (332cm), maximum number of fruits plant^{-1} (2.26), weight of fruit (5.17 kg) and maximum fruit yield (58.61 t ha^{-1}). These results are in agreement with the findings of Battilani and Solimando (2006) [3] Andrade Junior *et al.,* (2009) [2] and Shyamaa *et al*., (2009) [18].

Effect of organic amendment on soil properties

At the end of the experiment, the physic-chemical properties of the soil were significantly improved due to the application of aorganic amendments *viz* tank silt, composted coir pith and farm yard manure (Table 2). The texture of the soil is improved by the enhancing textural fractions of soil *viz,* fine sand, course sand, clay and silt (68.3, 2.8, 20.2 and 8.7 per cent, respectively) due to the application of tank silt @ 100 tonnes ha^{-1} with 100 per cent NPK through fertigation at 7 days interval (T_5). The bulk density, particle density and pore space also improved (1.32, 2.32 Mg m^{-3} and 54.3 per cent, respectively) for the same treatment. The chemical parameters *viz.*, soil reaction (pH), electrical conductivity (EC), cation exchange capacity (CEC) and organic carbon (OC) were also significantly influenced with the values of 6.56 and 0.26 dSm^{-1}, 23.3 cmol (p$^+$) kg^{-1} and 0.66 per cent, respectively for the same treatment. The improvement of physicochemical properties was due to the application of tank silt. Similar findings were given earlier by Sajitha *et al.,* (2013) [15] and Sharma *et al.,* (2016) [17].

Application of composted coir pith (CCP) @ 12.5t/ha with 100 per cent NPK through fertigation at 7 days interval (T_5) exhibited the superior performance on soil properties *viz,* fine sand, course sand, clay and silt (76.3, 3.4, 14.1 and 6.3 per cent, respectively). The bulk density, particle density and pore space also improved (1.23, 2.13 Mg m^{-3} and 45.6 per cent, respectively) for the same treatment. The chemical parameters *viz.*, soil reaction (pH), electrical conductivity (EC), cation exchange capacity (CEC) and organic carbon (OC) were significantly influenced with the values of 6.37 and 0.28 dSm^{-1}, 19.5 cmol (p$^+$) kg^{-1} and 0.57 per cent, respectively for the same treatment. Similar findings were also reported by Abad *et al.,* (2014) [1].

Application of FYM @ 20 t/ha with 100 per cent NPK through fertigation at 7 days interval (T_5) exhibited the better performance on soil properties *viz,* fine sand, course sand, clay and silt (79.3, 3.3, 11.6 and 5.8 per cent, respectively). The bulk density, particle density and pore space also improved (1.19, 2.18 Mg m^{-3}, 23.3 cmol (p$^+$) kg^{-1} and 48.5 per cent, respectively) for the same treatment. The chemical

parameters *viz.*, soil reaction (pH), electrical conductivity (EC), cation exchange capacity (CEC) and organic carbon (OC) were significantly influenced with the values of 6.38 and 0.29 dSm^{-1} 21.6 cmol (p^{+}) kg^{-1} and 0.52 per cent, respectively for the same treatment. The physicochemical properties were influenced due to the application farm yard manure Sharma *et al.*, (2016) [17].

Table 2: Effect of organic amendment with inorganic fertilizers on physic-chemical properties of *Theri* (Red sand dune) soil

	Particle size distribution (%)				Bulk density ($Mg\ m^{-3}$)	Particle density ($Mg\ m^{-3}$)	Pore space (%)	pH	EC (dSm^{-1})	CEC (c mol (p^{+}) kg^{-1})	OC (%)
	Fine sand	Course sand	Clay	Silt							
Tank silt @ 100 t ha^{-1}											
T_1- 75% RDF (Soil application)	71.6	3.7	18.0	6.7	1.43	2.62	45.20	6.32	0.18	18.8	0.42
T_2 -100% RDF (Soil application)	71.0	3.8	18.1	7.1	1.38	2.53	48.50	6.38	0.21	19.7	0.47
T_3 -75% RDE at 7 days interval (Fertigation)	69.4	3.3	19.6	7.7	1.35	2.46	51.50	6.3.7	0.25	21.8	0.56
T_4 -75% RDF at 15 days interval (Fertigation)	70.5	3.7	18.5	7.3	1.39	2.52	46.70	6.46	0.24	20.4	0.49
T_5-100% RDF at 7 days interval (Fertigation)	68.3	2.8	20.2	8.7	1.32	2.32	54.30	6.56	0.26	23.3	0.66
T_6 -100% RDF at 15 days interval (Fertigation)	70.6	3.5	18.8	7.1	1.42	2.55	48.90	6.41	0.23	20.8	0.52
SEd	0.23	0.33	0.06	0.04	0.02	0.09	0.02	0.02	0.03	0.12	0.01
CD (P=0.05)	0.52	0.74	0.13	0.08	0.04	NS	0.04	0.05	NS	0.26	0.02
Composted coir pith (CCP) @12.5 t ha^{-1}											
T_1- 75% RDF (Soil application)	79.1	3.4	12.3	5.2	1.21	2.03	40.50	6.30	0.21	15.2	0.41
T_2 -100% RDF (Soil application)	78.4	4.1	12.3	5.2	1.21	2.08	41.90	6.27	0.21	16.4	0.44
T_3 -75% RDE at 7 days interval (Fertigation)	77.2	3.9	13.5	5.9	1.19	2.12	44.50	6.32	0.26	17.3	0.52
T_4 -75% RDF at 15 days interval (Fertigation)	78.3	3.6	12.5	5.6	1.21	2.05	41.04	6.27	0.24	16.7	0.45
T_5-100% RDF at 7 days interval (Fertigation)	76.3	3.4	14.1	6.3	1.20	2.13	45.60	6.37	0.28	19.5	0.57
T_6 -100% RDF at 15 days interval (Fertigation)	78.4	3.3	12.0	5.7	1.24	2.15	41.40	6.30	0.23	17.5	0.47
SEd	0.58	2.22	0.19	0.19	0.01	0.06	0.08	0.03	0.02	0.17	0.01
CD (P=0.05)	1.29	1.22	0.43	0.43	0.01	NS	0.18	0.05	NS	0.39	0.03
Farm yard manure (FYM) @ 20 t ha^{-1}											
T_1- 75% RDF (Soil application)	81.6	3.9	9.8	4.7	1.16	2.15	46.10	6.30	0.15	17.5	0.38
T_2 -100% RDF (Soil application)	80.6	3.7	10.5	5.2	1.16	2.17	46.60	6.34	0.21	18.3	0.41
T_3 -75% RDE at 7 days interval (Fertigation)	80.2	3.4	10.5	5.9	1.17	2.18	51.3	6.42	0.31	20.8	0.55
T_4 -75% RDF at 15 days interval (Fertigation)	82.1	3.6	9.5	4.8	1.18	2.15	45.20	6.28	0.22	18.7	0.44
T_5-100% RDF at 7 days interval (Fertigation)	79.3	3.3	11.6	5.8	1.19	2.18	48.50	6.38	0.29	21.6	0.52
T_6 -100% RDF at 15 days interval (Fertigation)	81.3	3.7	10.4	4.6	1.16	2.25	46.50	6.36	0.25	20.4	0.46
SEd	0.38	0.12	0.19	0.18	0.03	0.20	0.07	0.03	0.01	0.14	0.01
CD (P=0.05)	0.86	NS	0.43	0.41	NS	NS	0.17	0.07	0.03	0.32	0.03

Economic

Details on economics and benefit: cost ratio in watermelon F1 hybrid Suprit in relation to various organic amendments with inorganic fertilizers with and without fertigation treatments tested are presented in Table 1**.**

The application of tank silt @ 100 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval (T_5) fetched significantly the highest net returns (₹2,90,570 and benefit : cost ratio (2.45) over the rest of the treatments (Table 1). The better treatment was application of tank silt @ 100 t/ha with 75 per cent NPK as 150:75:75 kg ha^{-1} through fertigation at 15 days interval (T_3), which fetched a net return of ₹ 2,60, 560 and benefit: cost ratio of 2.31. The application of CCP @ 12.5 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7days interval recorded the net return of ₹ 2,30, 790 and benefit: cost ratio of 1.66 which was higher than the application of FYM @ 20 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval by fetching the net return of ₹ 2,22, 910 and benefit : cost ratio of 1.73. This might be due to increased higher productivity and lower cost of cultivation. The variation in the cost of cultivation under different treatments was recorded due to variable costs of fertilizers. Fruit yield was the major factor, which caused differences in net return. These results are in close conformity with the findings of Kumar *et al.*, (2007) [13], Vasanth Kumar et al., (2012) [20] and Sajitha (2013) [16].

Conclusion

It can be concluded that application of tank silt @ 100 t ha^{-1} with 100 per cent NPK as 200:100:100 kg ha^{-1} through fertigation at 7 days interval could be recommended for increasing the fruit yield of hybrid watermelon, better net return and sustaining soil fertility in *Theri* land (Red sand dune) of Thoothukudi district of Tamil Nadu.

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