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Study of vertical mulching on physico chemical characters of tender nut water in coconut (*Cocos nucifera* L.) *cv*. COD

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Abstract
A study was conducted to find out the physico-chemical characters of tender nut water in coconut (*Cocos nucifera* L.) *cv.* COD. In the present study, the tender nut water samples were collected from 7 months old tender nuts and were subjected to quality analysis *viz*., pH, acidity, TSS, Total sugars, Vitamin C and minerals like calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), iron (Fe), phosphorus (P), zinc (Zn). Among the different treatment combinations, pH (5.45), acidity (0.093%), TSS (6.19 oBrix), Vitamin – C (2.42 mg/100 ml), total sugars (5.62%) and minerals like calcium (42 mg%), potassium (296 mg%), magnesium (17.26 mg%), sodium (39.3 mg%), iron (4.23 mg%), phosphorus (8.53 mg%), zinc (0.85 mg%) was high in the treatment combination, D1N6 (D1 - vertical mulching at 30 cm depth; N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g).

Keywords: Coconut, COD, tender nut water, quality

Introduction
Coconut (*Cocos nucifera* L.) popularly known as “Tree of life”, is one of the most useful trees in the world. Globally, Indonesia is the largest coconut producer followed by Philippines and India. Indonesia generated approximately 18.55 million metric tons of coconut in 2018. While, India was the world’s third largest producer of coconut, contributing for almost 11.71 million metric tons of global demand. In India, Coconut is cultivated in an area of 2178.74 hectares with annual production of 21384.33 million nuts and productivity of 9815 nuts ha-1 (Indiastat, 2018-19). Chowghat Orange a dwarf cultivar of coconut also known as, “Gowrigathram” or “Chenthangu” and “Kenthali” in Kerala and Karnataka respectively is highly preferred for its tender nut water.

Coconut water contains plenty of minerals such as potassium, calcium, magnesium, iron, sodium, phosphorus, zinc, manganese, copper, sulphur, aluminium, boron, selenium and chlorine. Potassium is the major mineral in coconut water and sodium being the next (Jean *et al*. 2009). Coconut water is composed of many amino acids, nitrogenous compounds, inorganic elements, organic acids, sugars and their alcohols, vitamins, growth substances (Cytokines and auxins) and many other unknown components (George, 1993).

In coconut, the endosperm is a liquid containing free nuclei generated by a process, in which the primary endosperm nucleus undergoes several cycles of division without cytokinesis (the process in which the cytoplasm of a single eukaryotic cell is divided to form two daughter cells). Cytokinesis then occurs, progressing from the periphery end towards the center, thus forming the cellular endosperm layer.

At first, the cellular endosperm is jelly-like and translucent, but it later hardens at maturity to become white flesh (coconut meat). Unlike the endosperms of other plants (e.g., wheat and corn), the cellularization process in a coconut fruit does not fill up the entire embryo sac cavity, but instead leaves the cavity solution-filled. This solution is commonly known as coconut water and it is of cytoplasmic origin.

Accordingly, the present investigation was undertaken to evaluate the effect of vertical mulching on the quality of tender nut water in coconut (*Cocos nucifera* L.) cv. Cod.

Materials and Methodology
The present study was conducted at Coconut Nursery, Department of Spices and Plantation Crops, Horticultural College and Research Institute, Coimbatore. In this study, vertical mulching was done for 10 years old trees of coconut cv. COD planted at a spacing of 7.5 m x 7.5 m.

The soil type of the experimental plot was sandy clay loam and non-saline.

Design of experiment

The experiment was laid out in Factorial Randomized Block Design replicated thrice with two factors. There were three levels of Factor 1 i.e. vertical mulching at different depth *viz*., D1 - 30 cm, D2 - 45 cm & D3 - 60 cm and seven levels of Factor 2 i.e. nutrient combinations *viz*., N1 - Well decomposed FYM 10 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each; N2 - Poultry manure 10 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each; N3- Vermicompost 10 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each; N4 - Well decomposed FYM 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g; N5 - Poultry manure 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g; N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g; N0- Recommened dose of NPK.

Sample collection

The tender coconuts of cv. Chowghat Orange Dwarf obtained from the coconut nursery, TNAU, Coimbatore. On arrival at the laboratory, the husk was removed and tender nut water was collected into a new and clean polythene bottle through an eye of middle hard shell. The water was the filtered through glass wool, placed into a polythene bottle and kept cool in a refrigerator at (4 °C) for investigation.

Physico-chemical analysis of tender nut water

Total soluble solids (TSS) and pH were estimated by using hand refractrometer and digital pH meter, respectively. The determination of sodium, potassium and calcium were carried out by using flame photometer (Vogel, 1961) [9]. The phosphorus and iron were assessed by spectrophotometer (Giridharan *et al*., 2007) [3]. The magnesium was determined by atomic absorption spectrometry (Vogel, 1961) [9]. Total acidity (Campos *et al*. 1996) [1], total sugars (Dubios *et al*. 1956) [2] method and Vitamin C (total ascorbic acid) were determined spectrophotometrically by the dinitropenylhydrazine method (Omaye *et al*., 1979) [6] respectively.

Results and Discussion

Effect of treatments on the physical and biochemical characters of tender nut water.

The effect of vertical mulching on pH and total acidity was seen in Table 1. Among the different treatments, highest pH (5.45) was recorded in the treatment D1N6 (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each at 30 cm depth), followed by (5.39) D1N4 (N4 - Well decomposed FYM 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g at 30 cm depth). The lowest pH was observed in the treatment (4.24) D3N0 (N0 - Recommened dose of NPK at 30 cm depth).

Table 1: pH and total acidity of tender coconut water

Treatment	pH				Total acidity (%)			
	D1	D2	D3	Mean	D1	D2	D3	Mean
N0	4.54	4.36	4.24	4.38	0.033	0.028	0.024	0.028
N1	5.14	4.94	4.75	4.94	0.063	0.052	0.045	0.053
N2	5.14	4.94	4.74	4.94	0.061	0.051	0.042	0.051
N3	5.24	5.14	4.84	5.07	0.064	0.054	0.049	0.056
N4	5.39	5.26	5.16	5.27	0.083	0.076	0.067	0.075
N5	5.36	5.25	5.15	5.25	0.079	0.071	0.062	0.071
N6	5.45	5.36	5.26	5.36	0.093	0.083	0.072	0.083
Mean	5.18	5.04	4.88	5.03	0.068	0.059	0.052	0.059
	N	D	N x D		N	D	N x D	
SE (d)	0.062	0.041	0.107		0.001	0.000	0.001	
CD (*p*=0.05)	0.126**	0.082**	0.218**		0.001**	0.001**	0.002**	

Both the parameters are highly significant (**)

This type of result was in accordance with Campos *et al*. (1996) [1]. For total acidity content the highest value was observed in D1N6 (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each at 30 cm depth) with the values of acidity (0.093%). The next highest acidity content of 0.083% was observed in D1N4 (N4 - Well decomposed FYM 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g at 30 cm depth) and D2N6 (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g at 45 cm depth).

Table 2: TSS and total sugar content of tender coconut water

Treatment	Total soluble solids (TSS) (0 Brix)				Total sugars (%)			
	D1	D2	D3	Mean	D1	D2	D3	Mean
N0	4.53	4.44	4.34	4.44	4.37	4.24	4.15	4.25
N1	5.28	5.10	4.60	4.99	4.84	4.73	4.64	4.74
N2	5.09	4.80	4.90	4.93	4.80	4.62	4.53	4.65
N3	5.35	5.25	4.73	5.11	5.15	4.99	4.85	4.99

N4	5.65	5.43	5.34	5.47	5.20	4.85	4.73	4.93
N5	5.30	5.24	5.07	5.20	5.15	4.71	4.62	4.83
N6	6.19	5.85	5.69	5.91	5.62	5.32	5.29	5.41
Mean	5.34	5.16	4.95	5.15	5.02	4.78	4.69	4.83
	N	D		N x D	N		D	N x D
SE (d)	0.048	0.032		0.084	0.060		0.040	0.105
CD (*p*=0.05)	0.098**	0.064**		0.170**	0.123**		0.080**	0.212**

Both the parameters are highly significant (**)

The characters TSS and total sugars, highest TSS of 6.19 (oBrix) was observed in D1N6 (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each at 30 cm depth) followed by D2N6 (5.85) in Table 2. The total mean value observed in the character TSS is 5.15 (o Brix). The character total sugar content D1N6 (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each at 30 cm depth) observed highest value of 5.62% followed by D2N6 (5.32%) this result was in accordance with Chattopadhyay *et al*. (2013) nut water becomes acidic because of the presence of organic acids, free amino acids due to dissolved carbon dioxide evolved during respiration. Coconut water is reported to be under hydrostatic pressure which facilitate the absorption of CO2 in water.

Table 3: Vitamin C and calcium content of tender coconut water

Treatment	Vitamin – C (mg/100 ml)				Calcium (mg%)			
	D1	D2	D3	Mean	D1	D2	D3	Mean
N0	1.34	1.26	1.22	1.27	27.5	25.8	23.6	25.63
N1	1.95	1.93	1.70	1.86	33.3	32.3	31.0	32.20
N2	1.92	1.84	1.50	1.75	30.3	29.4	28.8	29.50
N3	1.96	2.07	1.94	1.99	35.8	34.3	33.3	34.46
N4	2.36	2.20	2.00	2.19	39.0	35.0	32.5	35.50
N5	2.20	2.03	1.83	2.02	36.0	33.0	29.8	32.93
N6	2.42	2.33	2.20	2.32	42.0	38.7	36.3	39.00
Mean	2.02	1.95	1.77	1.91	34.84	32.64	30.76	32.75
	N	D	N x D		N	D	N x D	
SE (d)	0.020	0.013	0.035		0.457	0.299	0.792	
CD (*p*=0.05)	0.041**	0.027**	0.071**		0.928**	0.607**	1.607**	

Both the parameters are highly significant (**)

The vitamin C and calcium content were recorded highest in D1N6 (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each at 30 cm depth) with the values of vitamin C (2.42 mg/100 ml) and 42 (mg%) calcium followed by D1N4 (N4 - Well decomposed FYM 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g at 30 cm depth) with the values of (2.36 mg/100 ml) vitamin C and 39 (mg%) calcium, respectively.

Vermicompost application at 7.5 t/ha in strawberry plants, showed increase in the total soluble solids (TSS), ascorbic acid (Vitamin-C) content and gives attractive colour in strawberry fruits (Singh *et al*. 2008) [8]. Worm castings contain up to 5 times the plant available nutrients found in average potting soil mixes. Chemical analysis of the castings was conducted (Ruz J. *et al*, 1992) [7] and found that it contains 5 times the available nitrogen, 7 times the available potassium and 1.5 times more calcium than that found in 15 cm of good top soil.

Table 4: Potassium and sodium content of tender coconut water

Treatment	Potassium (mg%)				Sodium (mg%)			
	D1	D2	D3	Mean	D1	D2	D3	Mean
N0	233.64	229.72	226.55	229.97	31.5	30.7	29.8	30.66
N1	292.69	286.55	279.57	286.27	35.5	33.5	34.5	34.50
N2	291.68	285.48	277.67	284.94	34.3	32.5	33.6	33.47
N3	293.68	287.75	280.58	287.34	36.5	35.5	32.4	34.80
N4	295.72	289.69	283.59	289.66	37.4	36.6	35.4	36.46
N5	293.54	288.16	281.67	287.79	35.6	34.3	35.8	35.23
N6	296.60	291.68	285.56	291.28	39.3	37.6	36.4	37.76
Mean	285.36	279.86	273.59	279.61	35.73	34.39	33.99	34.70
	N	D	N x D		N	D	N x D	
SE (d)	3.208	2.100	5.556		0.400	0.262	0.693	
CD (*p*=0.05)	6.507**	4.260**	11.271**		0.812**	0.531**	1.406**	

Both the parameters are highly significant (**)

Potassium and Sodium concentration increased with increased addition of vermicompost. The increased potassium (296.6 mg%) and sodium (39.3 mg%) was observed in D1N6 treatment (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each at

30 cm depth) Table 4. The grand mean value observed was 279.6 (mg%) potassium and 34.7 (mg%) sodium, respectively.

The magnesium and iron content was higher in D1N6 treatment (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each at 30 cm depth) shows (17.26 mg%) magnesium and (4.23 mg%) iron, respectively, followed by D2N6 treatment (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g at 45 cm depth) shows (16.53 mg%) magnesium and (4.13 mg%) iron content, respectively, in Table 5.

Table 5: Magnesium and iron content of tender coconut water

Treatment	Magnesium (mg%)				Iron (mg%)			
	D1	D2	D3	Mean	D1	D2	D3	Mean
N0	8.62	8.55	8.45	8.54	2.33	2.14	1.98	2.15
N1	12.12	11.43	11.14	11.56	3.92	3.73	3.53	3.73
N2	11.14	10.60	10.48	10.74	3.70	3.55	3.34	3.53
N3	13.56	12.54	12.34	12.81	4.10	3.86	3.62	3.86
N4	12.53	12.14	12.31	12.33	4.10	3.86	3.73	3.89
N5	11.37	11.52	11.34	11.41	3.92	3.73	3.75	3.80
N6	17.26	16.53	15.57	16.45	4.23	4.13	3.90	4.09
Mean	12.37	11.90	11.66	11.98	3.76	3.57	3.41	3.58
	N	D	N x D		N	D	N x D	
SE (d)	0.128	0.084	0.221		0.047	0.031	0.081	
CD (p=0.05)	0.259**	0.169**	0.448**		0.095**	0.062**	0.165**	

Both the parameters are highly significant (**)

Maheswarappa *et al*. (1999) [4] reported increased amounts organic carbon, improvements in pH, decreased bulk density, improved soil porosities and water holding capacities, increased microbial populations and dehydrogenase activity of soils in response to vermicompost treatments. Vermicompost addition increases the macropore space ranging from 50-500 µm, resulting in improved air-water relationship in the soil, favourably affecting plant growth (Marinari *et al*. 2000) [5]. The phosphorus and zinc content highest value was observed in D1N6 treatment (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each at 30 cm depth) shows, (8.53 mg%) phosphorus and (0.85 mg%) zinc content in Table 6, followed by D1N4 treatment (N4 - Well decomposed FYM 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g at 30 cm depth) with the values of (8.45 mg%) phosphorus and (0.84 mg%) zinc concentration, respectively.

Table 6: Phosphorus and zinc content of tender coconut water

Treatment	Phosphorus (mg%)				Zinc (mg%)			
	D1	D2	D3	Mean	D1	D2	D3	Mean
N0	6.33	6.15	5.94	6.14	0.53	0.43	0.32	0.43
N1	8.25	8.17	7.86	8.09	0.83	0.79	0.75	0.79
N2	8.17	7.97	7.65	7.93	0.79	0.77	0.74	0.77
N3	8.34	8.27	7.96	8.19	0.82	0.81	0.78	0.80
N4	8.45	8.36	8.26	8.36	0.84	0.82	0.81	0.82
N5	8.27	8.24	8.14	8.22	0.82	0.81	0.79	0.81
N6	8.53	8.42	8.34	8.43	0.85	0.84	0.82	0.84
Mean	8.05	7.94	7.74	7.91	0.78	0.75	0.72	0.75
	N	D	N x D		N	D	N x D	
SE (d)	0.088	0.058	0.153		0.010	0.007	0.018	
CD (p=0.05)	0.179**	0.117**	0.311**		0.021**	0.013**	0.036**	

Both the parameters are highly significant (**)

Therefore vertical mulching of 30cm in combination with Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g increases the physic-chemical properties of tender nut water in cv. COD.

Conclusion

For tender nut purpose quality parameters play an important role for selection. The experimental results characterized specific features of physic-chemical properties of coconut water of different vertical mulching treatments. A significant difference (p<0.05) was observed in the treatment D1N6 (N6 - Vermicompost 20 kg + Urea 1.23 kg + SSP 2 kg + MOP 2 kg + Coconut micronutrient mixture 1 kg + Biofertilizers (Azospirillum & Phosphobacteria) 50 g each + VAM 200 g at 30 cm depth) deserve for enhancing the physico-chemical characters of tender coconut water.

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