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Evaluation of mature coconut water on soil nutrient availability and stimulation plant growth and yield of Greengram

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Abstract
The pot culture study was conducted in completely randomized design (CRD) with nine treatments replicated three times. The surface soil (0-15 cm) collected from the field no 37, Eastern block, TNAU farm was utilised for the study. The recommended dose of fertilizers adopted was 25:50:25 N: P2O5:K2O kg per ha-1 and the test crop was greengram (Var. Co8). The mature coconut water (MCW) was added in the soil at the time of 0, 15, 30 and 45thdays after sowing. The highest soil available nitrogen (170.8 kg ha-1), phosphorus (33.2 kg ha-1)and potassium (1098 kg ha-1) was noticed in treatment T9 receiving MCW 2000 l ha-1.The application of mature coconut water resulted in increased number of pods per pot, grain yield and stover yield of Greengram. The number of pods per pot was observed to be highest (16.33) in T9 receiving MCW 2000L ha-1 and remained on par with T8 (16.33), T7 (16.33), T6 (16.00), and T5 (16.00) and T4 (15.67) receiving MCW 1750, 1500, 1250, 1000 and 750 L ha-1 respectively.

Keywords: Matured coconut water (MCW), greengram, soil nutrient availability, yield

1. Introduction
Sustainable production in food grains, pulses, and oilseeds could be achieved through supplying adequate quantity of essential nutrients which are major constraints in crop production. The deficiency of nutritive elements in plants may be provoked by two causes *viz*., the availability of the element in the soil and the inability of the crops to absorb it. Once the nutritional deficiency is identified, these nutrients should be applied for increased availability to the crops. The nutrient source may be organic or inorganic fertilizers sources. The primary nutrient elements such as N, P and K are more important for the crop growth (White and Brown, 2010) [29]. They may be organic or Inorganic sources or waste products of bio systems which are in their ready plant availability and water solubility or it may increase the availability soil nutrients for crop growth. Micronutrients are also very important for their efficient plant growth and to complete its life cycle (Tripathi *et al.*, 2015) [28].
Because of the recent increase in fertilizer prices and environmental concerns, the need for efficient use of fertilizer has increased. Organic fertilizers or organic waste fertilizer sources have been utilized in conjunction with fertilizers to increase fertilizer use efficiency. Use of wastes as organic sources of nutrients will reduce the cost of cultivation, which means growers can use less priced product of high quantity to achieve the same results as compared to inorganic fertilizers (Baghdadi *et al.*, 2018) [4]. Here comes the possibility of utilization of waste mature coconut water which can be collected during the breaking of mature coconuts for copra making. The mature coconut water contains organic nutrients, which can meet the nutrient requirement of soil microbes. These materials are available more in recent days due to more consumption and cultivation of coconut (CDB, 2019) [8]. The mature coconut water was found to be suitable medium for multiplying number of beneficial microorganisms. The mature coconut water which is rich source of sugars, electrolytes and growth regulators such as auxins, gibberellins and cytokinins (Mamaril *et al.*, 1988) [17] was not evaluated for use as liquid organic manure. The panchakavya widely recommended as foliar spray for crop growth promotion contains tender coconut water as a component. The mature coconut water contains most of constituents present in tender coconut water though in different proportion (Yong *et al.*, 2009) [30] needs to be explored for boosting the crop growth. The positive influence of coconut water derived growth hormones on growth, development and yield of sweet pepper was observed, when applied in soil and sprayed (Mamaril and Lopez, 1997) [16]. The foliar

spray of mature coconut water was found to increase the growth parameters in fenugreek (Amrut Gaddamwar and Rajput, 2013) [2] and rice (Jayachandran *et al.,* 2001) [13]. The other uses of mature coconut water attempted were blending with lemon juice (Chauhan *et al.,* 2012) [6], Substitution for milk @ 25% in Yoghurt (Pandiyan *et al.,* 2011) [21], microbial medium for multiplication of Bacillus Thuringiensis (Chilcott and Pillai, 1985) [7], Trichoderma harzianum and Pseudomonas fluorescens (Mathew *et al.,* 2010) [18], Trichoderma viride (Kumar *et al.,* 2000) [15], Metarhiziumanisopliae (TNAU., 2016) [27], PGPR-Pseudomonas sp. and Bacillus pumilus (Anith, 2009) [3], manufacturing of Vinegar (CDB, 2016) [9], Biopolymer production (Thirumavalavan *et al.,* 2009 and Seesuriyachan *et al.,* 2011) [26, 23], preparation of Fermented spirit (Jayatissa *et al.,* 1972) [14] cut flower vase life enhancement (Agambodi and Jayawardena, 2007) [1], enhancing nodulation in legumes (Schaffer and Alexander, 1967) [22] and preparation of Al_2O_3 nanoparticles (Soares *et al.,* 2013) [24].

The experiments are pertaining to the liquid organic manure and the effect of applying as nutrient source through soil application. Hence, keeping these points in view, the present study on pot culture was carried out with the objective of studying the influence of mature coconut water on soil nutrient availability, nutrient uptake of greengram, yield and yield parameters of greengram crop under pot culture.

2. Materials and Methods

The detailed information about pot culture study, methods of soil and plant sample collected, and analysis of collected samples are presented in this investigation.

2.1 Pot culture experiment

A pot culture experiment was conducted in glass house to examine the effect of mature coconut water on growth and yield of greengram. The pot culture study was conducted in completely randomized design with nine treatments replicated three times. The recommended dose of fertilizers (25:50:25 N: P_2O_5:K_2O kg per ha) were mixed with soil and sowing was done with greengram (Var. Co8).

Application of fertilizers and Biofertilizers

2.2 Treatments

Application of mature coconut water (MCW) was done as per the treatments in four equal splits at the time of 0, 15, 30 and 45th day after sowing. The treatment details are as follows,

Treatments	Levels
T1	MCW Control
T2	MCW 250 L ha^{-1}
T3	MCW 250 L ha^{-1}
T4	MCW 750 L ha^{-1}
T5	MCW 1000 L ha^{-1}
T6	MCW 1250 L ha^{-1}
T7	MCW 1500 L ha^{-1}
T8	MCW 1750 L ha^{-1}
T9	MCW 2000 L ha^{-1}

Fig 1: Application of mature coconut water (MCW) at the time of sowing (0), 15, 30 and 45th day after sowing.

2.1.1 Soil and plant samples

Plant samples were collected at harvest (70th day after sowing) of greengram. The soil samples were taken after harvest. These samples were analysed to obtain the utilization of nutrients through various methods and the analysed methods were given below.

2.1.2 Statistical analysis

The data obtained from the investigation were subjected to statistical scrutiny to determine the influence of various treatments and the same is depicted below Table 1.

Table 1: Methods employed for analysis of soil and plant samples

Nutrient	Method	Reference
Soil samples		
Soil reaction (pH)	Potentiometry (1:2.5 Soil: Water)	Chang and Jackson.1957 [5]
Electrical conductivity (EC)	Conductometry (1:2.5 Soil: Water)	Chang and Jackson.1957 [5]
Available nitrogen	Alkaline $KMnO_4$	Subbiah and Asija (1956)
Available phosphorus	Olsen's method	Olsen *et al.,* (1954)
Available Potassium	Neutral normal Ammonium acetate	Stanford and English (1949)
Plant samples		
Nitrogen	Microkjeldahl method	Humphries (1956) [11]
Phosphorus	Vanadomolybdophosphoric yellow colour method	Chang and Jackson. 1957 [5]
Potassium	Flame photometry	Chang and Jackson. 1957 [5]

3. Result and Discussion

The soil used for conducting pot culture study was alkaline in reaction (pH-8.6), medium in salinity (EC-0.46 dSm^{-1}), sandy clay loam in texture, low in soil available nitrogen (160 kg ha^{-1}), high in available phosphorus (26.8 kg ha^{-1}) and high in available potassium (1050 kg ha^{-1}).

3.1 Soil nutrient availability

The soil nitrogen availability at post-harvest stage was significantly influenced by application of mature coconut water (Table 2). The highest soil available nitrogen (170.8 kg ha^{-1}) was noticed in treatment T9 receiving MCW 2000 l ha^{-1};however it remain on part T8 (169.9 kg ha^{-1}), T7 (168.0 kg ha^{-1}) and T6 (167.1 kg ha^{-1}) receiving MCW at the rate of 1750,1500 and 1250 L ha^{-1} respectively. The lowest soil available nitrogen was recorded in T1 (159.6 kg ha^{-1}); however it remained on part with

T2 (162.4 kg ha^{-1}) and T3 (163.3 kg ha^{-1}) which received no MCW, MCW 250 L ha^{-1} and MCW 500 L ha^{-1} respectively. The addition of MCW having organic sources of nutrients such sugars might have increased soil microbial activity and resulted in increased soil available nitrogen.

The highest soil available P (33.2 kg ha$^{-1)}$ was recorded in treatment receiving MCW 2000 L ha^{-1} (T9) followed by T8 receiving MCW 1750 L ha^{-1} (32.3 kg ha^{-1}). The lowest soil available P (26.5 kg ha^{-1}) was recorded in T1 receiving no MCW and it remained on par with T2 receiving MCW 250 L ha^{-1} (26.8 kg ha^{-1}). The application of MCW, which is a good source of nutrients for soil microbes might have increased P solublising microbes and there by soil available P.

The soil available K was significantly influenced by the soil application of mature coconut water. The highest soil available K (1098 kg ha^{-1}) was registered in T9 receiving MCW 2000 L ha^{-1}; however it remained on par with T8 (1089 kg ha^{-1}), T7 (1087 kg ha^{-1}), T6 (1078 kg ha^{-1}) and T5 (1069 kg ha^{-1}) which received MCW @ 1750, 1500, 1250 and 1000 L ha^{-1} respectively. The lowest soil available potassium was recorded in the T1 (1012 kg ha^{-1}) which remained on par with T2 (1040 kg ha^{-1}), T3 (1049 kg ha^{-1}) and T4 (1052 kg ha^{-1}) receiving MCW @ 250, 500 and 750 L ha^{-1} respectively. The MCW supporting soil microbial growth and production of organic acids in the soil might have brought into more of soil available K.

Table 2: Effect of matured coconut water on soil nutrient availability at post-harvest stage of Greengram under pot culture. (Mean of three replications)

Treatment	Available Nitrogen	Available phosphorus	Available potassium
T1- MCW Control	159.6	26.5	1012
T2- MCW 250 L ha^{-1}	162.4	26.8	1040
T3- MCW 500 L ha^{-1}	163.3	28.4	1049
T4- MCW 750 L ha^{-1}	165.2	29.2	1052
T5- MCW 1000 L ha^{-1}	165.2	30.1	1069
T6- MCW 1250 L ha^{-1}	167.1	30.9	1078
T7- MCW 1500 L ha^{-1}	168.0	31.4	1087
T8- MCW 1750 L ha^{-1}	169.9	32.3	1089
T9- MCW 2000 L ha^{-1}	170.8	33.2	1098
SED	2.0	0.3	20
CD (P=0.05)	4.2	0.6	41

3.2 Total nutrient uptake

The total N, P and K uptake of greengram was positively influenced by soil application of matured coconut water (Table 3). The highest N uptake (145.8 mg/pot) was observed in T9 receiving MCW 2000 L/ha and it remained on par with T8 (143.8 mg/pot), T7 (144.5mg/pot), T6 (141.7mg/pot), and T5 (139.2mg/pot) receiving MCW @ 1750, 1500 1250 and 1000 L ha^{-1} respectively. Similarly, highest P uptake (18.28 mg/pot) was observed in T9 receiving MCW 2000 L ha^{-1} however it remained on par with T8 (17.99 mg/pot) receiving MCW 1750 L ha^{-1}. The general trend in K uptake was similar to that of P uptake. The highest K uptake (154.8 mg/pot) was observed in T9 receiving MCW 2000 L ha^{-1}, which remained on par with T8 (152.4 mg/pot), T7 (151.4 mg/pot) receiving MCW 1750 and 1500 L ha^{-1} respectively.

Table 3: Effect of matured coconut water on total nutrient uptake (mg/pot) at harvest stage of greengram under pot culture (Mean of three replications)

Treatment	Nitrogen	Phosphorus	Potassium
T1- MCW Control	121.7	13.04	125.9
T2- MCW 250 L ha^{-1}	126.4	14.02	131.9
T3- MCW 500 L ha^{-1}	132.6	15.50	137.9
T4- MCW 750 L ha^{-1}	137.8	15.70	143.3
T5- MCW 1000 L ha^{-1}	139.2	15.85	145.2
T6- MCW 1250 L ha^{-1}	141.7	16.48	148.8
T7- MCW 1500 L ha^{-1}	144.5	16.88	151.6
T8- MCW 1750 L ha^{-1}	143.8	17.99	152.4
T9- MCW 2000 L ha^{-1}	145.8	18.28	154.8
SED	3.2	0.40	2.8
CD (P=0.05)	6.7	0.90	5.8

3.3 Yield and yield attributes

The number of pods per pot, pod weight per pot, gram weight per pot and stover weight per pot was found to be positively influenced by soil application of mature coconut water (Table 4). The number of pods per pot was observed to be highest (16.33) in T9 receiving MCW 2000L ha^{-1} and remained on par with T8 (16.33), T7 (16.33), T6 (16.00), and T5 (16.00) and T4 (15.67) receiving MCW 1750, 1500, 1250, 1000 and 750 L ha^{-1} respectively.

The similar pattern was observed in pod weight (g) per pot, grain weight (g/ pot) and stover weight (g/pot). The lowest values were observed in T1 (No MCW) and T2 (MCW 250 L ha^{-1}). This correlates well with the increased yield of cowpea due to soil application of jivamirtham @ 500 L ha^{-1} at 20 DAS along with 75% RDF and panchakavya @ 6 % at flowering (Desai *et al.*, 2014) [10]. Panchgavya application study by Naik *et al.*, 2013 [19] confirmed the results that, panchgavya (coconut water as one of the ingredients) applied both in foliar or media application on Cymbidium hybrid 'Sleeping Nymph' resulted in better growth and spike production. Panchgavya application which contains matured coconut water of 4% on some plants improved the plant growth in terms of plant height and chlorophyll content also macro and micronutrients (zinc, copper, and manganese), microbial activity had increased as compared to FYM, and vermicompost applied soils. Hence, Application of Panchgavya with matured coconut water could beneficially utilized as an alternative organic supplement in agriculture which boost the crop production significantly (Jain *et al.*, 2014) [12].

Table 4: Effect of matured coconut water on yield and yield attributes of greengram under pot culture (Mean of three replications)

Treatment	No of pods per pot	Pod weight (g) per pot	Grain weight (g) per pot	Stover weight (g) per pot
T1- MCW Control	13.67	3.00	1.74	3.59
T2- MCW 250 L ha^{-1}	14.00	3.20	1.79	3.71
T3- MCW 500 L ha^{-1}	15.00	3.40	1.86	3.85
T4- MCW 750 L ha^{-1}	15.67	3.43	1.92	3.97
T5- MCW 1000 L ha^{-1}	16.00	3.51	1.93	3.99
T6- MCW 1250 L ha^{-1}	16.00	3.55	1.95	4.03
T7- MCW 1500 L ha^{-1}	16.33	3.58	1.97	4.08
T8- MCW 1750 L ha^{-1}	16.33	3.60	1.96	4.06
T9- MCW 2000 L ha^{-1}	16.33	3.63	1.97	4.08
SED	0.59	0.10	0.04	0.07
CD (P=0.05)	1.23	0.21	0.08	0.16

* Data are on moisture free basis

4. Summary and Conclusion

The application of mature coconut water has enhanced the soil nutrient availability and uptake of nutrients (N, P and K), which resulted in increased number of pods per pot, grain yield and stover yield of greengram. The mature coconut water supporting the multiplication of microbes might have resulted in the buildup of soil organic nitrogen, solubilisation of soil phosphorus and potassium resulting in the increased nutrient uptake and yield. The pot culture study shows the potential of using mature coconut water up to a level of 750 L ha^{-1} for increasing the yield of greengram, which needs to be confirmed in the field trial involving fertigation of mature coconut water.

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