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Effect of media on growth and yield of lettuce under different hydroponic system

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Abstract
The study was contemplated to compare the performance of lettuce grown in hydroponic systems using the Nutrient Film Technique (NFT) (S_1) and the Dutch Bucket System (S_2), as well as three different media (M_1-Coco peat, M_2-LECA ball, and M_3-Rocl wool). Using a Factorial Completely Randomized Design (FCRD), the experiment was set up with two replications at the Department of Vegetable Science, Horticultural College and Research Institute for Women, Tiruchirappalli. The observations *viz*., Plant height (cm), root length (cm), shoot length (cm), number of leaves per plant, leaf area index (LAI), leaf Area Ratio (LAR), leaf chlorophyll content (LCC-SPAD Value), yield (g/plant) were determined. During the course of the trial, a constant pH between 6.5 and 6.8 and an EC of about 1.8 dS m^{-1} were maintained. The results of the study revealed that (S_1M_1) NFT system with coco peat media recorded the highest yield and growth parameters when compared to other treatments. The treatment S_2M_2 dutch bucket system using LECA ball medium exhibited the lowest yield and other growth characteristics.

Keywords: Growth, yield, lettuce under, hydroponic system

1. Introduction
In a place where the ecosystem is under threat and there are more people than ever before, innovative solutions are needed to sustainably meet the demands of agriculture. Soilless culture methods stand out among these options as a shining example of effectiveness, productivity, and environmental responsibility. This cutting-edge method is transforming how to grow crops and foster a greener tomorrow by dismantling the conventional idea of soil-bound farming.

Soilless culture, which encompasses both liquid culture and growing media/substrate cultivation, is a broad term for any plant production technique that doesn't employ mineral soil as the growing medium (Raviv *et al*., 2019) [13]. High-value vegetable crops can also be cultivated in greenhouse soilless systems as an alternative to field cultivation (Chu and Brown, 2021; Rodriguez *et al*., 2006) [4, 17]. Under soilless culture system there are many classifications and one such is “Hydroponics”. Plants are cultivated hydroponically using an inert medium, such as rock wool and fertilizer solutions. Greek influences can be seen in the phrases "hydro" and "ponos" which denote water and labour respectively (Douglas, 1975) [5]. In this study we have evaluated two soilless culture systems such as Nutrient Film Technique (NFT) and Dutch bucket system.

Due to its low initial cost, quick turn around between crops and perfect nutrient control, NFT is currently quite popular among producers (Rabiya, 2012). NFT is a recirculated design used to continually spray highly oxygenated dissolved nutrients over the roots of plants. Plants are normally grown in baskets suspended in PVC pipes. Through irrigators at the top of each sloping pipe, the solution is fed from a holding tank and the runoff from the bottom of the channels is pumped back into the tank. The nutrition solution is subsequently continually recycled (El-Kazzaz and Kaei-Kazzaz, 2017) [6].

Dutch and Belgian producers originally introduced the Dutch bucket technique, a soilless growing system, to the US in the early 1980s (Roberto, 2003). Tomatoes (*Solanum lycopersicum*), cucumbers (*Cucumis sativus*), peppers (*Capsicum annum*), eggplants (*Solanum melongena*), and other vine crops work well with it. A reservoir at the bottom of the Dutch bucket system's container-like design allows for more water and nutrient retention.

Hydroponic lettuce cultivation is a well-liked and effective method of growing leafy green food crops. With higher levels of the provitamin A complex beta-carotene, lettuce is a great source of vitamins K and A. 15 calories are found in 100 g of lettuce.

With only 13 percent of the world's total lettuce growing area, the United States produces the most lettuce as a salad crop, accounting for 22% of global lettuce production (Ryder, 1999). Additionally, significant regions of Turkey, Mexico, India and Japan are devoted to growing lettuce.

2. Materials and Methods

The trial was carried out in Factorial Completely Randomized Design (FCRD) with two replications at college orchard Department of Vegetable Science, Horticultural College and Research Institute for Women, Tiruchirappalli during 2022-2023.The site is located at a latitude of 10°45'20.6" N and longitude of 78º35'59.4" E. Seeds of lettuce were sown in protrays filled with cocopeat media. After 20 days the seedlings were transplanted into hydroponic system *viz*., NFT system and dutch bucket system.

Production systems:	Media:
• S_1- Hydroponic NFT-Horizontal type • S_2- Dutch bucket system	• M_1- Coco peat • M_2- LECA balls • M_3- Rock wool

Table 1: List of parameters measured with units

Index	Description	Formula	Units
	Plant height	-	cm
	Root length	-	cm
	Shoot length	-	cm
	Number of leaves per plant	-	Number
	Yield per plant	-	g/plant
LCC	Leaf Chlorophyll Content	-	SPAD value
LAI	Leaf area index	LA/P	-
LAR	Leaf area ratio	LA/TPDM	Cm^2 /g
LA-leaf area; P-spacing; TPDM-total plant dry matter			

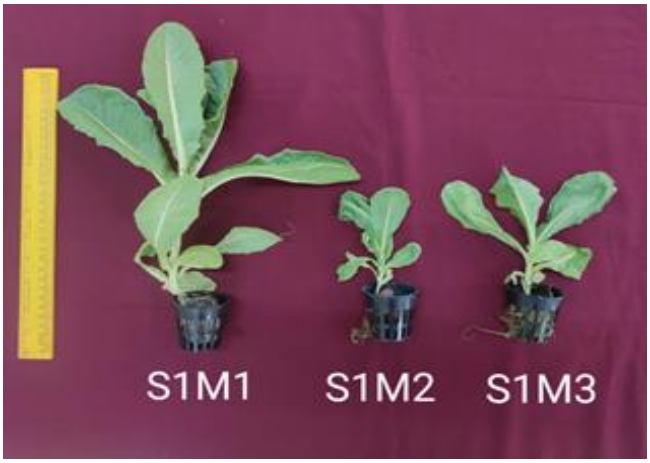

Fig 1: Comparative performance of 30 days lettuce on NFT system (S_1) in with three media viz., M_1-Cocopeat, M_2- LECA balls, M_3- Rock Wool

Fig 3: Comparative performance of 30 days lettuce on Dutch bucket system (S_2) in with three media viz., M_1-Cocopeat, M_2- LECA balls, M_3- Rock Wool

Fig 2: Comparative performance of 45 days lettuce on NFT system (S_1) in with three media viz., M_1-Cocopeat, M_2- LECA balls, M_3- Rock Wool

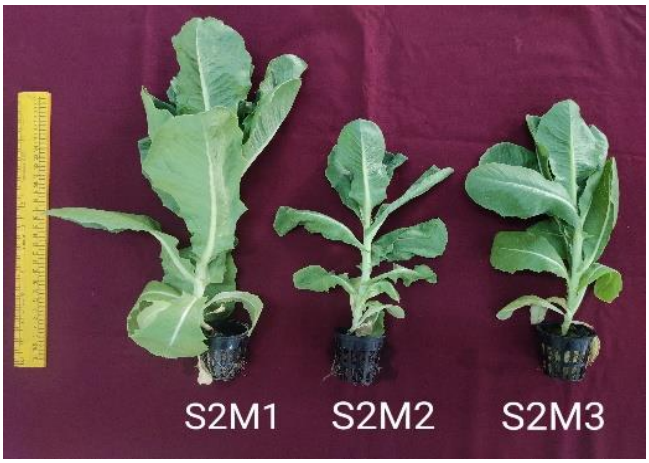

Fig 4: Comparative performance of 45 days lettuce on Dutch bucket system (S_2) in with three media viz., M_1-Cocopeat, M_2- LECA balls, M_3- Rock Wool

3. Results and Discussion

Leaf chlorophyll content (LCC)

gives vital information on the potential of photosynthetic processes since leaf chlorophyll content is directly related to the capacity and effectiveness of the photosynthetic equipment. According to Lin *et al.* (2013) [11], leaves are highly important to calculate chlorophyll because when a leaf degrades, its colour shifts from a bright green to other colours (brown orange, yellow, and purple), and this change in colour denotes a reduction in the quality of the product. According to statistical analysis, the highest chlorophyll content (39.2 SPAD value) was found in the S_1M_1 NFT system using cocopeat media. According to Coronel *et al.* (2011) [19], plants with sufficient amounts of nutrients like N, Fe, Mg and Mn have increased chlorophyll content since this nutrient is directly associated to the effectiveness of photosynthetic rate. In the S_2M_2 dutch bucket with LECA ball media, the chlorophyll content was at its lowest (34.3 SPAD value). According to Castillo and Ligarreto (2010) [15], the amount of chlorophyll in plants is directly tied to the amount of nitrogen, hence a plant's low chlorophyll content may be an indication of a nutrient deficiency. There are differences across treatments and systems and their interactions (PXM) also revealed big differences. (Table 5 & Fig.6). Given that the majority of the nitrogen in leaves is incorporated with chlorophyll, it was also discovered that chlorophyll content is directly correlated with nitrogen status. The most often used diagnostic method in Soil Plant Analysis Development (SPAD) to measure plant chlorophyll content Barrios *et al* (2011) [2]. According to Richardson *et al.* (2002), nitrogen status cannot be directly determined by a measurement of chlorophyll content; nevertheless, the data gained can be used to modify the rate of nitrogen fertilization.

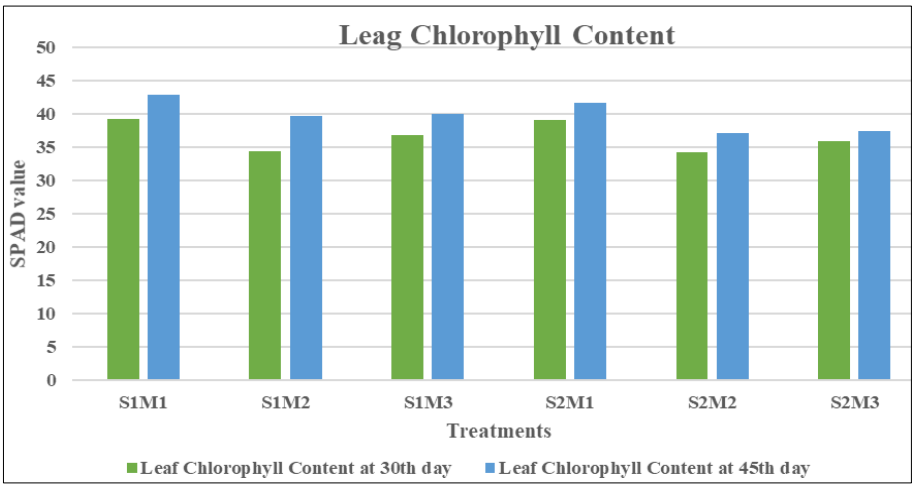

Fig 6: Influence of different systems and three media on Leaf Chlorophyll Content (LCC) of lettuce

Plant height

The height of the plant is a crucial growth factor. For this aspect, lettuce varied greatly between production systems and medium in the current study. In the tomato plant, Zekki *et al.* (1996) [20] reported similar outcomes, stating that an NFT system with frequent nutrient solution recycling led to an increase in plant height. The findings of Kulkarni *et al.* (2016) in spinach and coriander confirmed that plants produced in hydroponic conditions were found to be taller than plants grown in soil and these results are consistent with their findings. Plant height of lettuce on 30th day (35.30 cm) was the highest in S_1M_1-NFT (Fig.1) with cocopeat media and minimum (20.40 cm) in S_2M_2 dutch bucket system with LECA ball media (Table 2 & Fig.7). Where as in 45th day the plant height was maximum in S_1M_1-NFT system (Fig.2) with cocopeat media (47.3 cm) and minimum (33.85) in S_2M_2 dutch bucket system with LECA ball media.

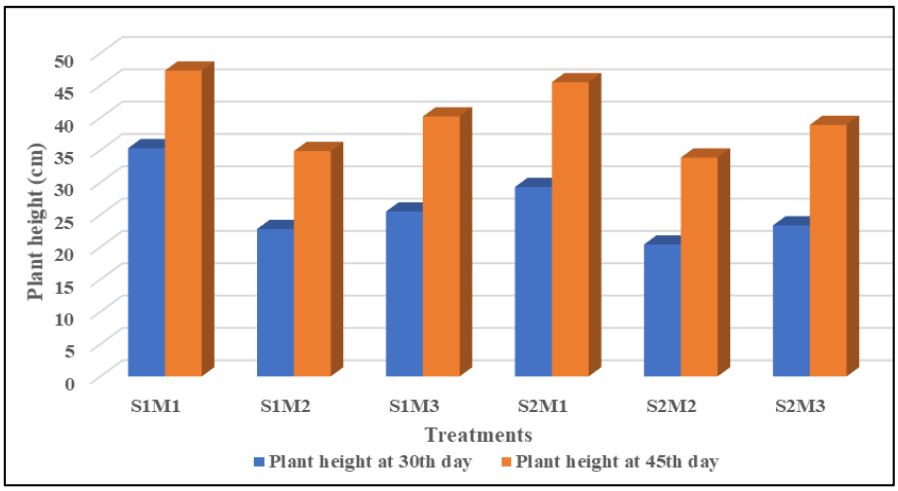

Fig 7: Influence of different systems and media on plant height of lettuce

Root length

Root length of lettuce on 30th day was highest in S_1M_1-NFT with cocopeat media (12.50 cm) followed by (12.05 cm) S_2M_1- dutch bucket with cocopeat media and minimum (9.40 cm) in S_2M_2 dutch bucket system with LECA media (Table 2). Similarly on 45th day root length was found to be maximum in S_1M_1-NFT with cocopeat media (17.05 cm) followed by S_2M_1- dutch bucket (14.65 cm) with cocopeat media and minimum in S_2M_2 dutch bucket system with LECA media (10.55 cm).

Shoot length

Shoot length of lettuce on 30th & 45th day was highest in S_1M_1-NFT with cocopeat media 23.85 cm & 43.35 cm respectively and minimum length was recorded in S_2M_2 dutch bucket system with LECA media for on 30th (7.89 cm) (Fig.3) & 45th (12.60 cm) day (Table 3 & Fig.4).

Number of leaves per plant

On the 30th day, the number of lettuce leaves per plant was maximum in the S_1M_1-NFT with cocopeat media (13) and lowest (5.25) in the S_2M_2-dutch bucket system with LECA medium (Table 3). Similarly on 45th day number of leaves per plant recorded maximum in S_1M_1-NFT with cocopeat media (18) followed by (16) S_2M_1- dutch bucket with cocopeat media and minimum (11.25) in S_2M_2 dutch bucket system with LECA media. These outcomes were very similar to those of Amit (2007) who studied leafy vegetables (spinach, fenugreek, coriander, amaranthus). In a protected setting, more number of leaves per plant, was recorded than under field cultivation. Similar findings in palak, coriander, lettuce, red and green amaranthus other plants were made by Kotadia *et al*. (2012) [9] and Isaac (2015) [8].

Yield

The findings of Omokhua *et al*. (2015) [12] in *Terminalia ivorensis* showed the intensive contact that roots have with growing media and the media's ability to hold nutrients and water, survival and growth are typically increased. Statistical analysis of the yield parameter (Table 4 and Fig. 8) revealed a substantial difference between the treatments and systems. S_1M_1 NFT with cocopeat media recorded the highest yield (35.56 g/plant). The plant yield was recorded lowest in S_2M_2 dutch bucket system with LECA ball media (8.45 g/plant).

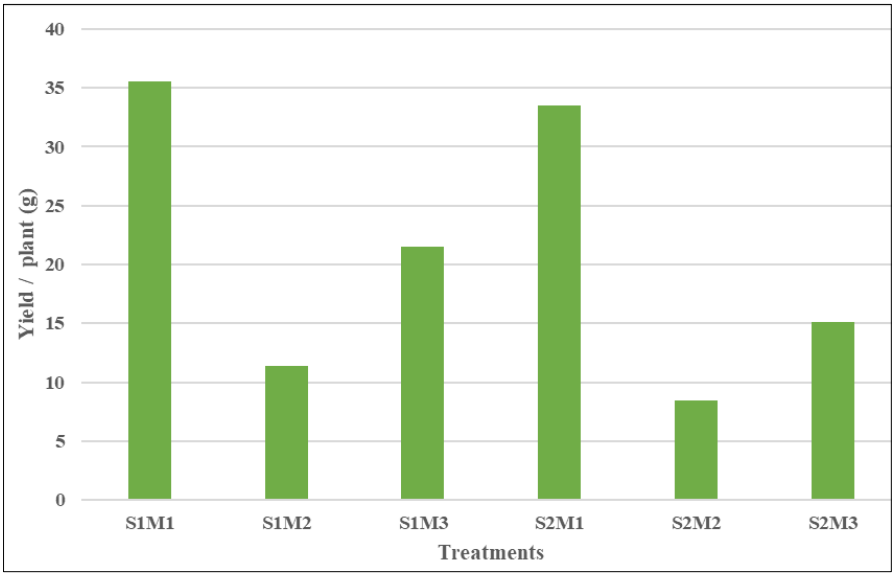

Fig 8: Influence of different systems and three media on Yield of lettuce

Leaf area index (LAI)

As a parameter in plant ecology, the leaf area index (LAI), which measures the photosynthetic active area, is crucial because it connects canopy structure and ecosystem performance. According to data on the leaf area index (Table 4), there is a substantial difference between the NXG effect and treatments. The S_1M_1 -NFT system with the cocopeat media showed highest value 4.2285 for LAI on 30th day. According to Hernandez and Soto (2012), an increase in the LAI is dependent on hydration, temperature, radiation absorption and nutrition. Lowest LAI (0.159) was observed in S_2M_2 dutch bucket system with LECA ball media. On 45th day maximum LAI (17.0081) in S_1M_1 -NFT system with cocopeat media and lowest LAI on 45th day (0.3547) was observed in dutch bucket system S_2M_2 with LECA ball media.

Leaf area ratio (LAR)

Statistical analysis revealed that the treatments for leaf area ratio differed significantly, with a substantial difference (Table 5). The S_1M_1 NFT system with cocopeat media produced the highest leaf area ratio on 30th day (29.0226 cm^{-2} g^{-1} day), while the S_2M_2 dutch bucket system with LECA ball media produced the lowest leaf area ratio (7.8774 cm^{-2} g-1day). The same pattern persisted on the 45th day with S_1M_1 (59.9934 cm^{-2} g^{-1} day) and S_2M_2 (13.127 cm^{-2} g^{-1} day) recording the highest and lowest leaf area ratio respectively.

Table 2: Influence of different systems and three different media on Plant height (cm) and root length (cm)

Treatments	Plant height (cm)						Root length (cm)					
	30 DAYS			45 DAYS			30 DAYS			45 DAYS		
S_1M_1	35.3			47.3			12.505			17.05		
S_1M_2	22.8			34.85			9.85			11.4		
S_1M_3	25.5			40.2			11.45			13.5		
S_2M_1	29.3			45.5			12.05			14.65		
S_2M_2	20.4			33.85			9.4			10.55		
S_2M_3	23.35			38.9			10.15			12.95		
Mean	26.10833			40.1			10.90083			13.35		
	P	M	PXM	P	M	PXM	P	M	PXM	P	M	PXM
S. Ed	0.186	0.228	0.322	0.067	0.082	0.116	0.034	0.042	0.059	0.06	0.074	0.105
CD (0.05)	0.075	0.091	0.129	0.167	0.24	0.289	0.085	0.104	0.147	0.151	0.185	0.261

P- Production systems, M-Media, PXM-Interaction effect, NS-Non significant Two systems *i.e*. Horizontal type (NFT)-S_1, Dutch bucket system –S_2 and with three media *viz*., M_1-Cocopeat, M_2- LECA balls, M_3- Rockwool.

Table 3: Influence of different systems and three different media on shoot length (cm), number of leaves per plant (No.)

Treatments	Shoot length (cm)						Number of leaves per plant (No.)					
	30 DAYS			45 DAYS			30 DAYS			45 DAYS		
S_1M_1	23.85			43.35			13			18		
S_1M_2	12.95			18.45			7.25			12.25		
S_1M_3	8.45			22.05			9			14		
S_2M_1	19.9			23.45			10			16		
S_2M_2	7.895			12.6			5.25			11.25		
S_2M_3	13.2			19.2			8			13.25		
Mean	14.37417			23.18333			8.75			14.125		
	P	M	PXM	P	M	PXM	P	M	PXM	P	M	PXM
S. Ed	0.047	0.058	0.082	0.048	0.058	0.083	0.067	0.082	0.116	0.058	0.071	0.1
CD (0.05)	0.118	0.145	0.205	0.0119	0.146	0.206	0.167	0.204	0.289	0.145	0.177	0.251

P- Production systems, M-Media, PXM-Interaction effect, NS-Non significant Two systems *i.e*. Horizontal type (NFT)-S_1, Dutch bucket system –S_2 and with three media *viz*., M_1-Cocopeat, M_2- LECA balls, M_3- Rockwool.

Table 4: Influence of different systems and three different media on Yield/plant (g), Leaf area Index (LAI)

Treatments	Yield / plant (g)			Leaf Area Index (LAI)					
	45 DAYS			30 DAYS			30 DAYS		
S_1M_1	35.56			4.2285			17.0081		
S_1M_2	11.365			0.5875			1.7352		
S_1M_3	21.495			1.3098			4.5921		
S_2M_1	33.54			0.8979			5.7732		
S_2M_2	8.45			0.159			0.3547		
S_2M_3	15.115			0.3942			1.5524		
Mean	20.92083			1.262817			5.169283		
	P	M	PXM	P	M	PXM	P	M	PXM
S. Ed	0..07	0.009	0.012	0.00034	0.00042	0.00059	0.002	0.002	0.003
CD (0.05)	0.018	0.022	0.03	0.00084	0.00102	0.00145	0.005	0.006	0.008

P- Production systems, M-Media, PXM-Interaction effect, NS-Non significant Two systems *i.e*. Horizontal type (NFT)-S_1, Dutch bucket system –S_2 and with three media *viz*., M_1-Cocopeat, M_2- LECA balls, M_3- Rockwool.

Table 5: Influence of different systems and three different media on Leaf Area Ratio (LAR), Leaf chlorophyll content (LCC)

Treatments	Leaf Area Ratio (LAR)						Leaf Chlorophyll content (LCC)					
	30 DAYS			45 DAYS			30 DAYS			45 DAYS		
S_1M_1	29.0226			59.9934			39.2			42.9		
S_1M_2	8.3423			21.0082			34.4			39.7		
S_1M_3	12.6642			26.4446			36.8			40.1		
S_2M_1	19.6599			56.9304			39.1			41.7		
S_2M_2	7.8774			13.127			34.3			37.2		
S_2M_3	12.1813			24.1592			35.9			37.4		
Mean	14.95795			33.61047			36.61667			39.83333		
	P	M	PXM	P	M	PXM	P	M	PXM	P	M	PXM
S. Ed	0.001	0.001	0.002	0.002	0.003	0.004	0.081	0.1	0.141	0.082	0.1	0.142
CD (0.05)	0.003	0.003	0.005	0.006	0.007	0.01	0.203	0.249	0.352	0.204	0.25	0.354

P- Production systems, M-Media, PXM-Interaction effect, NS-Non significant Two systems *i.e*. Horizontal type (NFT)-S_1, Dutch bucket system –S_2 and with three media *viz*., M_1-Cocopeat, M_2- LECA balls, M_3- Rockwool.

4. Conclusion

It was determined that out of different systems and media studied, NFT system with cocopeat media, produced higher yield as well as higher levels of other growth parameters such as plant height, root length, shoot length, number of leaves per plant, LAI, and LAR. Therefore, it can be concluded from this experiment that the (S_1M_1) NFT system with cocopeat media is an alternative novel method for growing lettuce. This is because plants grown in soil expend a lot of energy searching for food whereas plants grown hydroponically are provided with everything they require allowing them to focus all of their energy on producing a higher yield.

5. Acknowledgement

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