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Impact of organic liquid fertilizers on growth and yield performance of Green Bean (*Phaseolus vulgaris* L.) in non-circulating hydroponic system

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Abstract

Non-circulating hydroponic systems are a type of soilless production system that has been found to be extremely productive, low-cost, water, land efficient, and well-suited to avoid fertilizer leaching and groundwater contamination. The experiment was conducted to study the effect of liquid organic nutrient solutions on Green Bean (Phaseolus vulgaris L.) cultivation in non-circulating hydroponic system. The experiment was laid out in a Completely Randomized Design (CRD) with seven treatments having fifteen replicates. The treatments were recommended inorganic fertilizer application (T1), ½ doses of Albert's solution with 0.5% vermiwash (T2), 1% vermiwash (T3), 1.5% vermiwash (T4), 0.5% vegetable waste solution (T5), 1% vegetable waste solution (T6), 1.5% vegetable waste solution (T7) was used as media. The results revealed that plant height, number of leaves and branches per plant, leaf area, dry weight of leaves and length of pods were significantly ($P<0.05$) varied at 6th week after planting and it was high in T5. However, number of pods per plant, girth of pods, fresh and dry weight of pods and yield were high in T2 at 3rd picking while yield at 1st and 2nd picking were high in T5. This result suggests that ½ doses of Albert's solution with 0.5% vegetable waste solution (T5) and ½ doses of Albert's solution with 0.5% vermiwash (T2) would be the potential source of plant nutrients for sustainable crop production of bean in Non-circulating Hydroponic system.

Keywords: *Green bean, Liquid organic fertilizer, non-circulating hydroponic, vegetable waste solution, vermiwash*

Introduction

Plant cultivation on soil has been devised and practiced since the beginning of civilization. However, because nutrients in many soil types are unpredictable and may be inaccessible to some plants, this traditional agricultural practice can cause problems with plant growth (Resh, 2012). Therefore, protected horticulture has recently transitioned away from soil-based system and toward soilless system. Hydroponics is a technique used to grow a wide range of crops in water-based closed systems without soil and using nutrient solutions, water, and other soilless media (Jan *et al.,* 2020). Hydroponic agriculture produces higher yields, better quality, and more efficient water use, and it can be tailored to support production throughout the year. This is a valuable technology in places where land areas are limited, or climatic problem exist.

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Hydroponic methods generally employ circulating systems, which rely on pumps to aerate the system for optimal oxygen and nutrient uptake (Arancon *et al.,* 2015). Non-circulating hydroponic systems are a type of soilless production system that has been found to be extremely productive, low-cost, water or land efficient, and well-suited to reduce fertilizer loss and groundwater contamination (Mahlangu, 2016). Non-circulating hydroponic solutions minimize the added expenses and difficulties of mechanical aeration and circulation of the nutrient solution, as well as the use of electricity and pumps. In compared to traditional soil-based setups, non-circulating hydroponic systems provide better hygienic quality and are free of soil particles (Kratky, 1993).

Chemical fertilizers are a key component of hydroponic systems However, due to the accumulation of hazardous compounds in vegetables, employing large concentrations of chemical fertilizer may represent a risk to consumers (Garland *et al.*, 1993). As a result, using Liquid Organic Fertilizer (LOF) as an alternative or complement to chemical fertilizer for hydroponic planting is a viable option (Phibunwatthanawong and Riddech, 2019). The advantages of liquid organic fertilizer include providing nutrients to plants, improving soil structure, suppressing harmful bacteria, and improving the physical, chemical, and biological activities over time and safe for the environment (Soeparjono, 2016). When compared to compact organic fertilizer, LOF application results in faster nutrients supply (Sopha and Uhan, 2013).

In todays society, use vermin technology to actively manage organic waste disposal crises and also using products of vermin technology as a nutrient source for modern agricultural technique (Ansari, and Sukhraj, 2010). Vermicompost improves the physical, chemical and biological properties of soil (Ansari, 2008). Vegetable waste is produced in great numbers in markets around the world; to make use of this waste and to prevent pollution, biofertilizers can be made. These wastes still have a lot of water in them and are full of organic components including carbohydrates, proteins, and lipids (Singh *et al.,* 2012). This liquor would generate leachate which contain organic matters, contaminating underground and surface water. It is critical to treat vegetable waste in order to reduce greenhouse gas emissions (Monisha and Rameshaiah, 2016). Vegetable waste provides a significant amount of nutrients to occupy microorganisms; they are neither a pathogen nor a threat to human health (Cioabla *et al.*, 2012).

Green bean is cultivated all over the world due to their nutritional and medicinal values (Adeyemi *et al.,* 2012) and its adoptability. Beans provide dietary protein minerals such as ion, phosphorus, magnesium, manganese, and in lesser degree, Zinc, copper and calcium and important vitamins (Quintana *et al.,* 1999) that plays an essential role in human nutrition. Several crops have been studied in hydroponics by several scientists, but there is no sufficient information on green bean cultivation in hydroponic with liquid organic fertilizers in Sri Lanka. Therefore, this study was aimed to study the impact of Organic liquid fertilizer on growth and yield of green bean in non-circulating hydroponic system.

Materials and Methods

The experiment was conducted in Bandarawela, Sri Lanka which is located at an elevation of 1300 m above mean sea level in the Uva province. Experimental site geographical coordinates are 6º 50´ N latitude and 80º 59´E longitudes and comes under the Agro Ecological Zone of Up-Country Intermediate Zone (UCIZ). The mean annual rainfall of this area varies from 1100 mm to

1400 mm. The annual mean temperature varies from 12^0C to 32^0C and Humidity level is 79%. The soil of experimental site is Red podzolic soil. This study was carried out using Completely Randomized Design (CRD) with seven treatments having fifteen replicates. Treatments are Recommended Albert's Solution as control (T1), ½ doses of Albert' Solution with 0.5% (T2), 1% (T3), 1.5% (T4) of vermiwash, 0.5% (T5), 1% (T6), 1.5% (T7) of vegetable waste solution. Green Beans, variety *Sri Lankan Capri* was used in this study. Two Liquid Organic Fertilizers such as vermiwash (VW) and vegetable waste solution (VS) were tested on Green Beans cultivation separately.

Preparation of vermiwash

Red earthworms, coarse sand, loam soil, broken bricks, and cow manure were gathered from the home garden. A vermiwash unit was set up in an open, empty barrel with a tap on one side. The tap was left open, and a 25 cm layer of broken bricks was laid at the bottom. After that, a 25 cm layer of coarse sand was added, followed by a layer of loam soil that was 30-45 cm thick and lightly wet. A barrel was filled with red earthworms. The barrel was then gently moistened after being filled with waste materials, including cow manure. Water was added every day to keep the unit moist. The tap remained open for a full week. After a week, the eighth day tap was shut, and the liquid was then poured into the barrel. Once more, on the ninth day, the tap was opened, and the gathered liquid was dumped into the barrel. This repeated for the remaining two weeks. Vermiwash was then collected through the tap after two weeks (Ansari, 2012 and Ismail).

Preparation of Vegetable waste solution

Effective Microorganisms (EM) solution was made utilizing natural ingredients as a first stage. A bottle with lid was taken. Two cups of water were combined with one cup of brown rice. Then it was properly shaken. An empty bottle was filled with the liquid solution, which was then covered with paper. After that, it was kept in a dark area for seven days. It was mixed with milk after seven days (1:100). Then, it was covered and stored in a dark area for seven days. Lactic Acid Bacteria (LAB) solution was collected after 7 days.

Vegetable waste solution was created after preparing the EM solution. Brown sugar, coconut water, brown rice, and fresh milk were gathered from home to make a vegetable waste solution. A bucket with a lid was properly cleaned and laundered. The leftover vegetables were then chopped up to a weight of 2 kg. 100 ml of EM and 5 liters of water were then added to the bucket. The bucket was filled with 1 liter of coconut water, 1/2 kg of brown sugar, and 100 ml of sugar solution. The liquid was then thoroughly mixed by swirling it. After that, 2 kg of chopped vegetable waste was added to the bucket and stirred until everything was combined. Following that, the bucket was covered for up to 15 days. The Liquid Organic Fertilizer (LOF) was ready to usage after 15 days of daily stirring for only 5 rounds of LOF (Faruq *et al.,* 2021).

Non-circulating Hydroponic Installation

Fifteen Styrofoam boxes (46 x 40 x 35 cm) were prepared, and black polythene sheets were used as a coating material for the inner side of the boxes. Then five holes were made on the lid of the box. Then, the Nutrient solutions were added to each box according to the treatments. After that the coir dust was mixed with some amount of water and prepared a moistened mixture. Then the net pots were filled with above mixture as a medium. Two Bean seeds were planted in one pot. Later, the net pots with seeds were transferred into the holes of Styrofoam boxes with nutrient media. Poles were placed when,

support is required. Readings were collected at 2nd, 4th, 6th and 8th weeks after planting by using destructive method in three plants. Plant height, number of leaves, branches and nodules per plant, leaf area, root length, number of flowers per plant, fresh and dry weight of plant, leaves, stem and root were measured at 2nd, 4th, 6th, and 8th weeks after planting. Picking was done at harvesting stage. Number of pods per plant, pod length and girth, fresh and dry weigh of pods, number of seeds per pod and weigh of 100 seeds were taken during harvesting. Total yield was calculated by the accumulation of yield per each picking. Statistical software such as SAS and Minitab were used to analyze the data.

Results and Discussion

Plant Height

The effect of Liquid Organic Fertilizer (LOF) and Albert's solution as a nutrient solution on average plant height of green bean from 2nd WAP to 8th WAP in hydroponic system is given in Table 1.

Table 1: Plant height (cm) of green bean with respect to treatment during the experiment period

Treatments	2nd WAP	4th WAP	6th WAP	8th WAP
T1	50.00±1.12a	128.85±1.17	160.70±1.38bcd	216.85±1.17
T2	40.10±0.98ab	126.80±1.19	207.85±1.78ab	210.45±1.28
T3	40.10±0.99ab	108.60±1.13	193.45±1.66ab	199.8±2.73
T4	42.05±0.97ab	121.20±1.28	190.75±1.68abc	193.15±1.49
T5	53.10±1.14a	110.30±1.67	229.00±1.78a	233.05±1.46
T6	49.00±1.13a	75.10±0.98	135.20±1.48cd	183.50±1.58
T7	27.35±0.98b	80.10±0.99	105.75±0.99d	151.40±1.38
F test	*	ns	*	ns

Value represent means ± standard error of three replicates. F test: - ns: not significant; *: P<0.05. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

There was no significant difference (P>0.05) in plant height at 4th and 8th WAP. However, significant difference (P<0.05) was observed in 2nd and 6th WAP. At 2nd WAP and 6th WAP, the tallest plants were recorded in T5. It may be due to provision of LOF contains nutrients that are ideal for the growth of plants, and it provides N, P, and K nutrients in the hydroponic system and also the activation of plant growth. Koesriharti and Istiqomah (2016) stated that addition of nutrient solution is complete and available for plants to absorb for pakcoy (*Brassica rapa* L. *Chinensis*) in hydroponic.

Number of leaves per plant

Effect of nutrient solution on number of leaves per plant is shown in Figure 1. At 2nd the highest number of leaves was observed in T2, T3 and T4. It may suggest that concentration of vermiwash in LOF not affect the green bean leaves per plant. It agreed with Andrian *et al*. (2019) the dosage of LOF in *Ipomoea reptans* did not affect the leaf number. Koesriharti and Istiqmah (2016) stated that the nutrient solution treatment was not significantly affect the number of leaves, stem diameter, root length, chlorophyll content, total fresh weight per plant and consumption of fresh weight per plant in Pakcoy (*Brassica rapa* L . *Chinensis*).

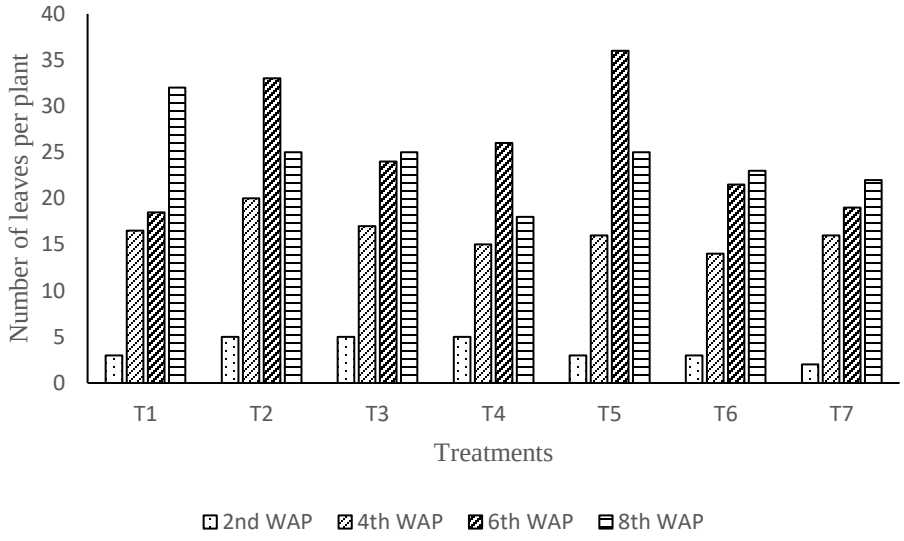

Figure 1: Number of leaves per plant with respect to treatment during the experiment period

Number of branches

LOF application on nutrient medium was not significantly influenced (P>0.05) the number of branches per plant at 4th, 6th and 8th WAP were confirmed with *P* values of 0.174, 0.238, 0.238 and chi square values of 9.00, 8.00, 8.00 (Figure 2).

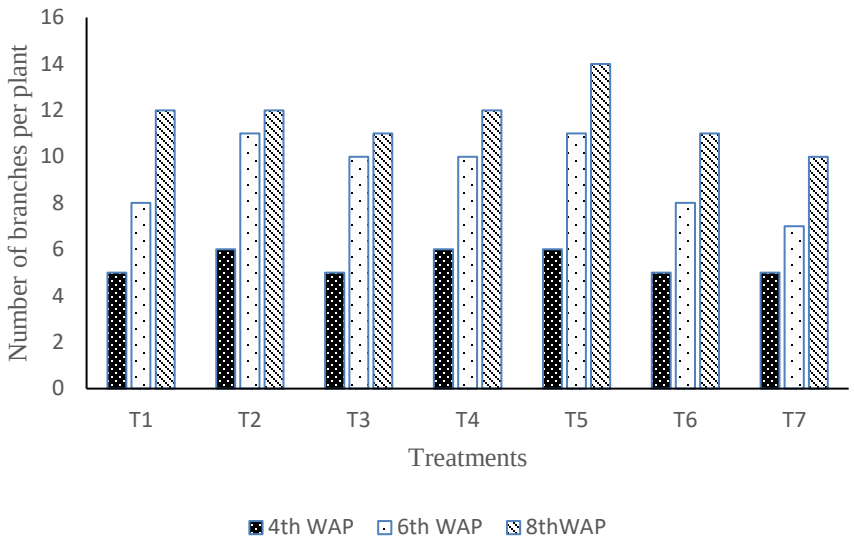

Figure 2. Number of branches per plant with respect to treatment during the experiment period

Number of flowers per plant

Number of flowers per plant of green bean present in Figure 3. The LOF application on nutrient medium was significantly influenced ($P<0.05$) the number of flowers per plant at 6th was confirmed with *P* value of 0.016 and chi square value of 15.65.

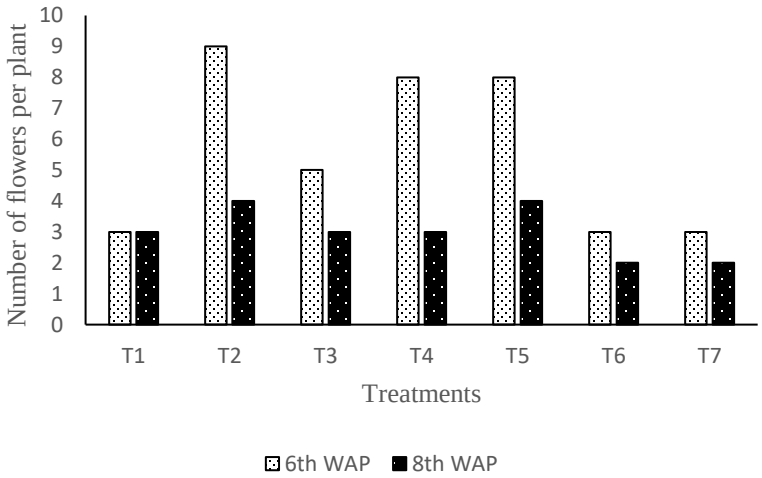

Figure 3: Number of flowers per plant with respect to treatment during the experiment period

The highest number of flowers per plant was observed in T2 while low in T1, T6 and T7. These results are agreed with Sopha and Murtiningsih (2021) stated that an application rate of 25 mL L^{-1} of liquid organic boron fertilizer increased the number of flower clusters by 22% in tomato plant. Furthermore, Edgar *et al*. (2017) indicates that tomato

plants grown under conventional hydroponic nutrient solution and under manure nutrient solution produced more flowers compared to those grown under tap water.

Root Length

There was significant variation (P<0.01) on average root length at 2nd, 6th and 8th WAP due to application of LOF with different concentrations on Nutrient medium is shown in Table 2. At 2nd WAP, the highest root length was recorded in T2 and T3 (19.45 cm) while low in T7 (15.25 cm). At 6th WAP, the longest root was noted in T5 (27.05 cm) and shortest in T6 (20.40 cm). It may be due to the plant can better absorb water and nutrients directly from nutrient solution by capillary action and hydroponic systems that used liquid organic fertilizer were a suitable medium for observing interactions between rhizobacteria and roots. Guntara *et al*. (2021) stated that treatment of LOF concentration had a significant effect on root length of Pagoda (*Brassica narinosa* L.) in hydroponic system.

Table 2: Root length with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	17.60±1.14 abc	19.90±1.57	20.90±1.08d	28.50±1.12a
T2	19.45±1.47a	23.70±1.47	26.10±1.11bc	27.95±1.11b
T3	19.45±1.34a	23.15±1.51	24.05±1.09c	27.45± 1.14b
T4	18.45±1.35a	23.35±1.27	24.45±1.34c	25.35±1.17c
T5	15.85±1.37bc	18.65±1.27	27.05±1.05a	27.60±1.13b
T6	15.60±1.34 bc	19.40±1.48	20.40±1.17d	27.30±1.11b
T7	15.25±1.48c	21.10±1.57	26.70±1.11b	26.65±1.18bc
F test	**	ns	**	**

Value represent means ± standard error of three replicates. F test: - ns: not significant; **: P<0.01. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

However, at 8th WAP, the highest value of root length was observed in T1 (28.50 cm) while low value in T4 (25.35 cm). The reason may be absorption of inorganic fertilizer increase the root length in T1 at 8th WAP. Latique *et al*. (2013) studied the importance of different seaweed extracts on the growth of bean plants (*Phaseolus vulgaris* L.) was investigated using different concentrations of two species of macroalgae: *Ulva rigida* and *Fucus spiralis*. shows diverse results obtained with seaweed liquid extracts (SLE) on shoot and root length of bean plant.

Leaf Area

Plant photosynthesis determines by the rate of photosynthesis per unit leaf area, leaf area index, and leaf angle. The effect of LOF and Albert's solution on average leaf area of green bean from 2nd WAP to 8th WAP is given in Table 3. It was found that there was significant difference (P<0.05) at 2nd, 6th and 8th WAP on average leaf area. At 2nd WAP, the maximum value of 61.9 cm^2 was recorded in T2, while minimum value of 34.18 cm was recorded in T5. At 6th and 8th WAP, the highest leaf area value in T5 while low in T7. It is due to the leaf area value depending on the genetic ability of the plant and the provision of nutrients.

Table 3: Leaf Area with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	55.72±1.12ab	43.22±1.47	47.70±1.27b	46.88±1.56ab
T2	61.90±1.14a	37.98±1.23	72.98±2.24a	56.88±1.43a
T3	50.04±1.25abc	78.68±1.67	39.80±1.47bc	52.44±1.47ab
T4	42.98±1.16bcd	41.58±1.98	36.32±1.37c	44.62±1.37ab
T5	34.18±1.13d	24.54±1.46	78.52±2.27a	57.74±1.43a
T6	44.20±1.48bcd	41.16±1.38	33.54±1.49c	47.80±1.87ab
T7	38.30±1.36cd	25.94±1.57	32.22±1.37c	36.20±1.27b
F test	**	ns	*	*

Value represent means ± standard error of three replicates. F test: - ns: not significant; *: P<0.05; **: P<0.01. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Dry weight of leaves

There was significant difference (P<0.05) on average dry weight of leaves among the tested treatments due to nutrient medium with different concentration of LOF and Albert's solution (Table 4). At 2nd and 4th WAP, the highest dry weight of leaves was noted in T1 while lowest dry weight of leaves was noted in T7. At 6th WAP, T5 (2.68 g) high value while low in T1 (0.52 g) and at 8th WAP, the maximum value of dry leaf weight was recorded in T2 (6.43 g) and minimum value of dry leaf weight was noted in T7 (1.35 g).It may be due to the trend of plant height growth and number of leaves also caused an increase in the rate of dry weight accumulation, which was reflected in the relative growth rate variables. Arshad *et al*. (2018) reported that Lettuce plant produced leaves dry weight (LDW) as 15-25 g due to concentration of organic extracts in nutrient solution.

Table 4: Dry weight of leaves per plant with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	0.26±0.01a	2.35±0.01a	0.52±0.01c	3.58 ±0.01ab
T2	0.22±0.01ab	1.82±0.01abc	1.89 ±0.01b	6.43±0.01a
T3	0.20±0.01ab	1.925 ±0.01ab	0.92±0.01c	1.92±0.01b
T4	0.16±0.01b	1.50±0.01bc	1.30±0.01bc	1.43±0.01b
T5	0.16±0.01b	1.57±0.01abc	2.68±0.01a	5.09±0.01a
T6	0.19±0.01ab	1.54±0.01bc	0.87±0.01c	2.14±0.01b
T7	0.14±0.01b	1.095 ±0.01c	0.57±0.01c	1.35±0.01b
F test	*	*	*	*

Value represent means ± standard error of three replicates. F test: - *: P<0.05. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Dry weight of stem

There was significant difference (P<0.05) on average dry stem weight among the tested treatments (Table 5). At 2nd and 4th WAP, the maximum value of dry stem weight was recorded in T1 while minimum value was recorded in T4 and T7 at 2nd WAP and T6 at 4th WAP. At 6th WAP, T2 highest value while low in T6. At 8th WAP, the highest value of 1.32 g was recorded in T5 and low value of 0.59 g in T7. This is due to the presence of different water content in the plant tissue. The fresh weight reported by Kowalczyk *et al.* (2016) in a nutrient solution of N, P, K of 140, 50, and 300 mg/L, respectively, was 245 g and 175 g for two other lettuce cultivars. Furthermore, the increasing N concentration on a hydroponic culture of lettuce from 0 to 60 mg/L increased shoot weight from 68.7 to 129.7 g.

Dry weight of roots

The dry weight of roots is shown in Table 6. There was no significant difference (P>0.05) in dry weight of roots at 2nd, 4th and 8th WAP.

However, there was significant difference (P<0.05) at 6th WAP. At 6th WAP, the highest value of 1.10 g was observed in T3 and T5 while low value of 0.16 g was observed in T6. It may be due to an increase in fresh production is accompanied by an increase in dry production.

Table 5: Dry weight of stem per plant with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	0.23±0.01a	1.67±0.01a	1.29±0.01ab	1.24±0.01ab
T2	0.21±0.01a	1.50±0.01ab	1.40±0.01a	1.21±0.01ab
T3	0.21±0.01a	1.34±0.01b	1.29±0.01ab	0.92±0.01ab
T4	0.10±0.01b	1.44±0.01b	1.25±0.01ab	0.92±0.01ab
T5	0.22±0.01a	1.39±0.01b	1.37±0.01ab	1.32±0.01a
T6	0.18±0.01ab	1.29±0.01b	1.21±0.01ab	1.07±0.01ab
T7	0.10±0.01b	1.30±0.0b	1.23±0.01ab	0.59±0.01b
F test	*	*	*	*

Value represent means ± standard error of three replicates. F test: - *: P<0.05. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Table 6: Dry weight of roots per plant with respect to treatment during the experiment period

Treatment	2nd WAP	4th WAP	6th WAP	8th WAP
T1	0.08±0.01	0.31±0.01	0.34±0.01ab	0.57±0.01
T2	0.10±0.01	0.25±0.01	0.48±0.01ab	0.97±0.01
T3	0.09±0.01	0.28±0.01	1.10±0.01a	1.19±0.01
T4	0.07±0.01	0.15±0.01	0.32±0.01ab	0.34±0.01
T5	0.06±0.01	0.15±0.01	1.10±0.01a	1.15±0.01
T6	0.08±0.01	0.19±0.01	0.16±0.01b	1.04±0.01
T7	0.08±0.01	0.33±0.01	0.795±0.01ab	0.86±0.01
F test	ns	ns	*	ns

Value represent means ± standard error of three replicates. F test: - ns: not significant; *: P<0.05. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Number of pods per plant

LOF application on nutrient medium was significantly influenced (P<0.05) the number of pods per plant at 1st, 2nd and 3rd picking were confirmed with *P* values of 18.00, 21.00, 21.00 and chi square values of 0.006, 0.002, 0.002 is shown in Table 7. The maximum number of pods per plant was observed in T2 while minimum value in T7 at 1st picking and T3, T6 at 2nd and 3rd picking. It might be due to its vigor and the higher number of leaves per plant. Ekanayake *et al*. (2020) stated that fish tonic treated plants produced the highest number of pods and the fresh weight while plants treated with compost tea produced the least number of pods and the fresh weight.

Table 7: Number of pods per plant of green bean with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking
T1	2	11	10
T2	4	15	12
T3	3	7	7
T4	2	8	8
T5	4	13	11
T6	2	7	7
T7	1	8	8
***P* value**	0.006	0.002	0.002
Chi square value	18.00	21.00	21.00

Length of pods

The effect of nutrient medium with LOF and Albert's solution on average length of pods per plant from 1st picking to 3rd picking is shown in Table 8. There was significant difference (P<0.01) at 3rd picking and also there was significant variation (P<0.05) at 2nd picking. However, there was no significant difference (P>0.01) at 1st picking. At 2nd and 3rd picking stage, the highest value of pod length was observed in T5 while low in T4. Jayawardana *et al*. (2016) stated that the terms of fruit parameters, simplified hydroponic system was better with significant increase in fruit length, fruit fresh weight and fruit firmness than that of non-circulating liquid hydroponic system supplied with either New Formula (NF) or Albert's nutrient solution.

Table 8: Average length of pods per plant with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking
T1	15.55±0.08	21.80±0.01a	20.10±0.08ab
T2	13.45±0.03	18.55±0.04ab	17.15±0.07bc
T3	10.55±0.04	17.20±0.03b	17.05±0.07bc
T4	13.70±0.07	16.20±0.07b	16.10±0.03c
T5	14.90±0.03	22.35±0.07a	22.05±0.03a
T6	14.10±0.07	19.20±0.04ab	18.40 ±0.07bc
T7	11.60±0.07	17.20±0.05b	17.15±0.08bc
F test	ns	*	**

Value represent means ± standard error of three replicates. F test: - ns: not significant; *: P<0.05; **: P<0.01. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Girth of pods

Girth of pod of green bean was significantly influenced by the nutrient medium with LOF and Albert's solution (Table 9). There was significant difference (P<0.05) among the tested treatments. At 1st picking, maximum girth of pods of 3.40 cm was observed in T5 followed by 2.9 cm in T6, 2.85 cm in T1, 2.75 cm T2 while low value of 1.85 cm in T3.

At 2nd and 3rd picking, the highest value was observed in T2 while low value was observed in T3. It may be due to the relatively better nutrient uptake in this condition compared to other treatments. Where nutrient uptake and good translocation rates cause the relative growth rate to be good for the whole plant as well as for other plant parts. Ekanayake *et al*. (2020) showed that the highest stem girth was recorded in Albert's solution applied plants at flowering. However, it was not significantly different from the stem girth recorded in fish tonic treated plants.

Fresh weights of pods

The effect of nutrient medium with LOF and Albert's solution on average fresh pods weight of green bean from 1st picking to 3rd picking is given in Table 10.

There was significant difference (P<0.01) at 2nd picking and at 3rd picking, significant difference (P<0.05) was observed. At 2nd and 3rd picking, the maximum value of fresh pod weight was observed in T2 while minimum value in T7 at 2nd picking and T3 at 3rd picking. These results are agreed with Ekanayake *et al*. (2020) stated that Fish tonic treated plants produced the highest number of pods and the fresh weight while plants treated with compost tea produced the least number of pods and the fresh weight.

Table 9: Girth of pods per plant with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking
T1	2.85±0.01ab	3.50±0.01ab	3.30±0.01ab
T2	2.75±0.01ab	3.80±0.01a	3.75±0.01a
T3	1.85±0.01b	2.95±0.01b	2.75±0.01b
T4	2.60±0.01ab	3.45±0.01ab	2.95±0.01b
T5	3.40±0.01a	3.60±0.01ab	3.35±0.01ab
T6	2.90±0.01ab	3.30±0.01ab	3.00±0.01b
T7	2.10±0.01b	3.20±0.01ab	2.80±0.01b
F test	*	*	*

Value represent means ± standard error of three replicates. F test: - *: P<0.05. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Table 10: Fresh weight of pods per plant with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking
T1	12.00±0.01	138.55±0.01bc	126.00±0.01b
T2	13.64±0.01	171.70±0.01a	146.30±0.01a
T3	2.25±0.01	101.65±0.01d	81.45±0.01c
T4	5.97±0.01	133.40±0.01bc	97.45±0.01c
T5	21.44±0.01	163.15±0.01ab	131.25±0.01ab
T6	8.53±0.01	108.40±0.01cd	82.55±0.01c
T7	2.85±0.01	88.95±0.01d	81.05±0.01c
F test	ns	**	*

Value represent means ± standard error of three replicates. F test: - ns: not significant; *: P<0.05; **: P<0.01. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Dry weights of pods

The data on dry weight of pods per plant as influenced by nutrient medium with LOF and Albert's solution in Hydroponic system is presented in Table 11. There was significant difference ($P<0.01$) at 2nd and 3rd picking. It was significantly difference ($P<0.05$) at 1st picking. At 1st picking, T5 (3.38 g) high value while low in T3 (0.62 g). At 2nd picking, the highest value of dry pod weight of 15.1 g was observed in T1. At 3rd picking, the maximum value was observed in T2 (12.75 g) followed by T1, T5 (12.05 g) while minimum value was observed in T7 (6.05 g).

Table 11: Dry weight of pods per plant with respect to treatment during the experiment period

Treatment	1st picking	2nd picking	3rd picking
T1	2.05±0.001ab	15.10±0.001a	12.05±0.001b
T2	2.27±0.001ab	12.05 ±0.001b	12.75±0.001a
T3	0.62±0.001b	6.90±0.001d	5.75±0.001d
T4	1.41±0.001ab	10.20±0.001bc	8.85 ±0.001bc
T5	3.38±0.001a	10.95±0.001bc	12.05±0.001b
T6	1.68±0.001ab	7.50±0.001cd	8.90±0.001bc
T7	0.98±0.001b	6.10±0.001 d	6.05±0.001c
F test	*	**	**

Value represent means ± standard error of three replicates. F test: - *: $P<0.05$; **: $P<0.01$. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Total yield

The effect of nutrient medium with LOF and Albert's solution on total yield of green bean from 1st picking to 3rd picking is given in Table 12. There was significant difference ($P<0.01$) among the tested treatments on total yield. At 1st and 2nd picking, the highest value of yield was observed in T5 followed by T2, T1, T6, T4, T3 while low in T7. At 3rd picking, T2 high value while low in T4. Higher EC creates higher nutrient concentration of the solution which may lead to toxicities in plant nutrition. These results are agreed with Koesriharti and Istiqmah (2016) stated that the nutrient content also affects the growth and yield of pakcoy on hydroponic substrate, because the nutrient solution is one of the most important determining factors on the yield and quality in hydroponic system. Edgar *et al*. (2017) also noted increased growth and yield performance of tomato grown on goat manure.

Table 12: Total yield of green bean with respect to treatment during the experiment period

Treatments	1st picking	2nd picking	3rd picking
T1	4.76±0.001c	5.21±0.001c	4.23±0.001d
T2	5.28±0.001b	5.77±0.001b	5.89±0.001a
T3	3.22±0.001f	3.32±0.001f	4.23±0.001c
T4	3.88±0.001e	4.10±0.001e	2.20±0.001g
T5	5.50±0.001a	5.88±0.001a	4.85±0.001b
T6	3.92±0.001d	4.18±0.001d	3.08±0.001e
T7	1.96±0.001g	3.30±0.001g	2.27±0.001f
F test	**	**	**

Value represent means ± standard error of three replicates. F test: - **: P<0.01. Means followed by the same letter in each column are not significantly different according to the Duncan's Multiple Range Test at 5% level.

Conclusion

There were significant differences (P<0.05) on plant height, number of branches per plant, leaf area, dry weight of leaves, length of pods and root length and highest performance were obtained from 1/2 doses of Albert's solution with 0.5% vegetable waste solution (T5) at 6th WAP. Further, 1/2 doses of Albert's solution with 0.5% vermiwash (T2) increased number of pods per plant, girth of pods, fresh and dry weight of pods and yield at 3rd picking. Therefore, 1/2 doses of Albert's solution with 0.5% vegetable waste solution (T5) and 1/2 doses of Albert's solution with 0.5% vermiwash (T2) would be more suitable for cultivation of green bean in non-circulating hydroponic system. Further studies are needed to investigate vermiwash and vegetable waste solution without Albert's solution at hydroponic.

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