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Effect of Organic Nutrient Solutions on Growth and Yield Performances of Green Bean (*Phaseolus vulgaris* L.) in Red Yellow Podzolic Soil in Sri Lanka

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ABSTRACT

Purpose: *Liquid Organic Fertilizer (LOF) is one of the essential ways to add extra quantities of minor and major nutrients, plant hormones, stimulants, and other useful ingredients for soil cultivation.*

Research Method: *The experiment was set up using a Randomized Complete Block Design (RCBD) with seven treatments and four replicates. The treatments were recommended basal and topdressing (Control T1), 5t/ha poultry manure as basal with foliar spray of 0.5% (T2), 1% (T3), 1.5% (T4) of Vermiwash, 0.5% (T5), 1% (T6), 1.5% of vegetable waste solution (T7). Vermiwash and vegetable waste solution were applied at 1^{st}, 3^{rd}, 5^{th}, and 7^{th} week after planting.*

Findings: *The study showed that leaves per plant and number of branches per plant, plant height, number of flowers per plant, dry weight of leaves, and dry weight of stem and roots were significantly ($P<0.05$) increased in T2 at the 8^{th} week after planting. The total pick yield achieved in T2 was higher than in tested treatments.*

Originality/ Value: *This study suggests that the application of 5t/ha poultry manure with 0.5% vermiwash (T2) would be preferable for growing green beans in red-yellow podzolic soil.*

Keywords: *Green bean, Liquid organic fertilizer, Red-yellow podzolic soil, Vegetable waste solution, Vermiwash*

INTRODUCTION

The main aim of most nations and international development agendas is to improve food security through increased productivity. This, together with the rising global population, is boosting global food demand, placing upward pressure on agricultural production (Malik *et al*., 2018). On the other hand, to increase the production widespread excessive use of inorganic fertilizers in crop production has prompted concerns about the environment's health. Using chemical fertilizer on crops is not a long-term strategy for improving crop yields to fulfill global demand. Also, consumer demand for organically produced foods is growing as a result of potential human health risks associated with the overuse of inorganic fertilizers and environmental deterioration. As a result of this growing awareness, organic fertilizers are receiving greater attention these days (Ilahi *et al*., 2020).

A large number of raw materials are available (Maeda *et al*., 2014) which are suit for the preparation of organic manures. Not only organic waste can be composted or turned into solid fertilizer, but also into liquid fertilizer, which has several advantages and can be used as a compost activator (Soeparjono, 2016).

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Since Liquid Organic Fertilizer (LOF) is more readily available than solid organic fertilizer, it is crucial to provide additional nutrients (Fahrurrozi *et al.*, 2016). In comparison to traditional organic fertilizers, the LOF's abundant organic matter and soluble nutrients may maintain the sustainability of the soil and the health of the plants (Hou *et al.*, 2017). Also, it contains nutrients like N, P, and K, all of which encourage plant growth throughout the vegetative and generative phases (Colla *et al.*, 2014) and plants can absorb it more quickly. Because its elements contain decomposing bacteria that can provide nutrients needed by plants (Bahua and Gubali, 2020). Therefore, most of the developed countries are widely using this system and it must be extended among developing countries.

LOF made from agricultural waste and kitchen waste are gaining popularity. These fertilizers contain important plant nutrients, and improve soil structure (Chenyu *et al.*, 2018), reducing dangerous bacteria in the soil (Chew *et al.*, 2019), improving the physical, chemical, and biological soil, and being environmentally friendly (Soeparjono, 2016) as well as beneficial microorganisms that recycle organic debris (Phibunwatthanawong and Riddech 2019). Vegetable waste is a biodegradable material. These wastes still have a lot of water and are full of organic components including carbohydrates, protein, and lipids (Singh *et al.*, 2012). Therefore, one method of managing these wastes is to convert them into LOF known as a vegetable waste solution (Faruq *et al.*, 2021). Further, vermiwash also plays an important role in waste management. Vermiwash is an LOF produced from earthworms (Ansari *et al.*, 2019) and associated microorganisms (Edwards *et al.*, 2011). Numerous enzymes, plant growth hormones, vitamins, and micro- and macronutrients such as nitrogen, phosphorus, potassium, calcium, magnesium and zinc are all present in vermiwash and it improves the ability of crops to fend against numerous illnesses, as well as their development and productivity. It also improves soil fertility and lowers nitrogen losses (Gomiero *et al.*, 2008). By using LOF we can enhance the quality of products while sustainably maintaining an environment. In many nations, the green bean (*Phaseolus vulgaris*) is a significant crop since it offers a significant source of protein for human diets. Between 20 and 25 percent of protein can be found in bean seeds. Also, raw green beans contain 7 g carbohydrates, 1.83 g protein, 3.4 g dietary fiber, vitamins A, B6, C, and D and are rich in micro minerals (Quintana *et al.*, 1999). Further, beans are a polyphenol-rich food that has been shown to benefit human health by reducing obesity, diabetes, and inflammatory processes in the body (Ganesan and Xu, 2017). However, there is no sufficient evidence to use liquid organic fertilizers in green bean farming in Sri Lanka. The objective of this study is to assess the growth and yield of beans in the field using LOF and select the appropriate concentration of LOF for bean cultivation in red-yellow podzolic soil.

MATERIALS AND METHODS

The experiment was conducted in Bandarawela, Sri Lanka, which is located at an altitude of 1300 meters above mean sea level in the Uva province. The geographical coordinates of the experimental site are $6°50'$N and $80°59'$ E longitudes (Kankanamge *et al.*, 2019) and come under the Agro-Ecological Zone of the Up-Country Intermediate Zone. The region's average annual rainfall ranges from 1100 mm to 1400 mm (Nissanka *et al.*, 2011). The annual mean temperature varies from 12°C to 32°C and the Humidity level is 79%. The soil of the experimental site is yellow podzolic soil (ESDAC, 1988). The Randomized Complete Block Design (RCBD) was used in this investigation, and each of the seven treatments had four replicates. Treatments included Department of Agriculture, Sri Lanka recommended inorganic fertilizer (Urea 110 kg/ha Triple Super Phosphate 270 kg/ha and Muriate of potash 75 kg/ha) as basal and topdressing (Control T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as foliar spray at 1^{st}, 3^{rd}, 5^{th} and 7^{th} week after planting. Green Beans, a variety of Sri Lankan Capri were used in this study.

Preparation of Vermiwash

Cow dung, coarse sand, loam soil, broken bricks, fruit and vegetable waste, and red earthworms were collected from the home garden. The vermiwash unit was set up on one side open empty barrel with a tap. A 25 cm layer of broken bricks was placed while keeping the tap open. Then coarse sand layer of 25 cm was placed followed by a 30-45 cm layer of loam soil and gently moistened. Red earthworms were introduced into the barrel. Then cow dung and waste things were introduced into the barrel and gently moistened. Water was added every day to keep the unit moist. The tap was kept open for one week. After one week, the 8^{th} day tap was closed and the liquid was poured into the barrel. Again 9^{th} day tap was opened and the collected liquid was poured into the barrel and it was continued for two weeks. Then after two weeks, vermiwash was collected through the tap (Ansari and Ismail, 2012).

Preparation of Vegetable Waste Solution

As a first step Effective Microorganisms (EM) solution was prepared by using natural materials. A bottle with a lid was taken. One cup of brown rice and two cups of water were mixed. Then it was shaking well. The liquid solution was filtered into an empty bottle and it was covered with paper. Then it was stored in a dark place for seven days. After seven days, it was mixed with milk (100 ml: 1000 mL) (1:100). Again, it was covered and kept in a dark place for 7 days. Lactic Acid Bacteria (LAB) solution was collected after 7 days. After preparing the EM solution vegetable waste solution was prepared. For that vegetable waste, brown sugar, coconut water, brown rice, and fresh milk were collected from the house for the preparation of vegetable waste solution. A bucket with a lid was washed and cleaned properly. Following that, the vegetable waste such as cabbage, carrot, leeks, brinjal, chili, leafy vegetables, potato, tomato, and pumpkin were chopped up to a weight of 2 kg. 100 ml of EM and 5 liters of water were then added to the bucket. 100 mL of sugar solution, 1/2 kilogram of brown sugar, and 1 liter of coconut water were placed in a bucket. After that, the mixture was thoroughly mixed by swirling. After that, 2 kg of chopped vegetable waste was added to the bucket and stirred until everything was combined. For up to 15 days, the bucket was then covered. The Liquid Organic Fertilizer (LOF) was ready to use after 15 days of daily stirring for only 5 rounds of LOF (Faruq *et al.*, 2021).

Agronomic Practices

All agronomic procedures were carried out by Sri Lanka's Department of Agriculture except Treatments. Readings such as number of leaves, plant height (from the base of the stem to the highest part of the plant), number of branches, flowers per plant and nodules per plant, root length, leaf area, fresh and dry weight of plant, leaves, stems and roots were measured at two weeks interval from 2nd to 8th weeks after planting by using the destructive method. The number of pods per plant, pod length and girth, fresh and air dry weight of pods, number of seeds per pod, and weight of 100 seeds were taken during harvesting. A portable leaf area meter was used to measure leaf area. Plant height, root length, and pod length were measured with the help of a measuring scale. Vernier was used to measure pod girth. Collected data was analyzed using statistical software both SAS and Minitab. Duncan's Multiple Range Test was used to compare means while the mood median test was employed to analyze the count data.

RESULTS AND DISCUSSION

Plant Height

The effect of LOF on the average plant height of green beans from the 2nd Week After Planting (WAP) to the 8th WAP is shown in Table 1. The average plant height at the 2nd WAP and the 8th WAP varied significantly ($P<0.05$) among the studied treatments. At the 2nd WAP, the highest plant height was recorded in T3, followed by T5. At 8th WAP, it was high in T2. However, there was no significant difference ($P>0.05$) between T2 and T4 in an increase in plant height. This may be because the given nutrient composition of LOF can provide enough nutrients especially N for the vegetative growth of plants. However, Febriyanti *et al.*, (2021) stated that the plant height was increased with LOF produced from rice washing wastewater concentration of 100% than control in Chili. According to Frahdian *et al.* (2018), plant height is influenced by availability of nutrients and nutrient uptake by roots. Therefore, the Provision of LOF could contain nutrients that are ideal for the growth of plants and provide N, P, and K nutrients in the soil. An increase in height is a response and indicator of the nutrient status of a plant. Plants grown at T2 and T4 would have received the required amount of nutrients compared to plants exposed to other treatments at 8th WAP.

Number of Branches per Plant

The number of branches per plant at the 2nd, 4th, 6th, and 8th WAP was substantially influenced by LOF application ($P<0.05$), as shown in Table 2 with P values of 0.005, 0.046, 0.050, and 0.005 and chi-square values of 18.33, 12.83, 12.52, and 18.33. When use low concentration of LOF, it may affect the growth of plants may be the reason for high branches in T2 and T5 at 8th WAP.

Number of Leaves per Plant

Leaves are one of the vegetative organs that contribute to the process of photosynthesis. LOF application was significantly impacted ($P<0.05$) the number of leaves per plant at the 2nd, 6th and 8th WAP was confirmed with P values of 0.016, 0.005, 0.016 and chi-square values of 15.65, 18.33 and 15.56 respectively is shown in Table 3. The maximum number of leaves was found in T1, T5, and T7 in 2nd week while the lowest numbers were found in T4 and T6.

The highest number of leaves was found in T5 at the 6th WAP and T2 at the 8th WAP. It may be due to

Table 1: LOF application on average plant height (cm) of green bean bean

Treatments	2nd WAP	4th WAP	6th WAP	8th WAP
T1	19.20±0.89c	89.75±1.12	164.15±1.24	211.90±2.13bc
T2	21.00±0.97bc	99.80±1.35	201.30±2.03	355.65±3.54a
T3	35.30±0.76a	67.60±0.98	126.85±0.97	233.95±2.47bc
T4	17.90±0.68c	88.55±0.89	140.45±1.12	281.00±2.15ab
T5	31.80±0.55ab	65.65±0.87	190.80±1.87	205.80±2.09bc
T6	17.45±0.67c	53.30±0.59	159.60±1.67	231.25±2.45bc
T7	15.30±0.59c	50.00±0.25	161.05±1.69	194.85±1.68c
F test	*	ns	ns	*

Values represent the mean ± standard error of four replicates. F test :- ns: not significant; *: P<0.05. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at a 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 2: LOF application on branches per plant of green bean

Treatments	2nd WAP	4th WAP	6th WAP	8th WAP
T1	1	6	8	13
T2	2	6	7	20
T3	2	6	7	12
T4	1	6	6	17
T5	2	6	8	20
T6	1	5	9	12
T7	2	5	7	12
P value	0.005	0.046	0.050	0.005
Chi-Square value	18.33	12.83	12.52	18.33

Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 3: LOF application on leaves of green bean

Treatments	2nd WAP	4th WAP	6th WAP	8th WAP
T1	5	17	22	38
T2	3	17	19	51
T3	3	15	18	32
T4	2	15	15	46
T5	5	15	25	33
T6	2	11	24	33
T7	5	15	20	37
P value	0.016	0.286	0.005	0.016
Chi-Square value	15.65	7.39	18.33	15.56

Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

additional nutrients leading to producing more leaves and influencing vegetative growth in the plant. The number of leaves increased almost 3 times within 2 weeks in the treatments of T2 and T4. It may be the plant can better absorb nutrients directly from the soil by capillary action by roots and foliar application of leaves during the growing stage of the plant.

Leaf Area

Leaf area (LA) was found to differ significantly (P<0.05) at the 2nd and 6th WAP (Table 4). In this experiment, the highest leaf area of 59.14 cm^2 was noted in T1 at the 6th WAP. However, there was no significant difference between T1 and T5. But at 2nd WAP, it was high in T3. However, there was no significant difference between T3 and T1. T2,

Table 4: LOF application on average leaf area of the plant green bean

Treatments	2nd WAP	4th WAP	6th WAP	8th WAP
T1	41.22±1.12ab	43.56±1.14	59.14±1.74a	97.36±2.15
T2	43.60±1.17ab	42.78±1.58	45.50±1.56bc	79.00±2.14
T3	54.92±1.98a	43.14±1.46	45.66±0.98bc	51.02±2.48
T4	28.68±2.14b	36.42±1.68	43.34±0.87c	83.08±2.48
T5	41.20±1.85ab	41.40±1.78	52.24±1.74ab	96.38±2.38
T6	37.12±1.09ab	38.66±1.85	45.82±1.56bc	45.04±1.68
T7	39.88±1.13ab	40.80±1.62	45.24±1.24bc	48.76±1.78
F test	*	ns	*	ns

Values represent the mean ± standard error of four replicates. F test :- ns: not significant; *: $P<0.05$. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at a 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 5: LOF application on the median number of total nodules of the green bean

Treatments	2nd WAP	4th WAP	6th WAP
T1	12.0	7.0	3.0
T2	13.0	7.0	2.0
T3	13.0	6.0	2.0
T4	5.0	11.0	1.0
T5	22.0	13.0	2.0
T6	4.0	5.0	1.0
T7	10.0	14.0	1.0
P value	0.238	0.062	0.016
Chi-Square value	8	12	15.56

Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 6: LOF application on average number of flowers of green beans

Treatments	6th WAP	8th WAP
T1	12	5
T2	5	21
T3	4	2
T4	4	4
T5	15	3
T6	12	1
T7	7	3
P value	0.062	0.016
Chi-Square value	12	15.56

Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

T5, T6, T7. Plantlets would have received sub sub-optimum amount of nutrients. It could be the reason for the lowest increase in the plant LA. Maximum leaf area and total leaf biomass are elements that affect crop productivity, and the optimal rate of N boosts photosynthetic activity and leaf area generation, according to Massignam *et al.*, (2009). LOF studies conducted by Ginandjar *et al.*, (2019) reported that the application of LOF to vegetable waste increases the leaf area of strawberries and Peiris and Weerakkody (2015) reported that *Gliricidia* leaf extract is the most favorable LOF for best performance on LA of leaf lettuce.

Root Length

It was discovered that there were no statistically significant variations (P>0.05) in the average root length across the studied treatments due to the administration of LOF at various concentrations along with poultry manure. Among the essential nutrients, some of the nutrients are antagonistic about root growth and some of the nutrients have a synergistic relation to the root growth and development. These substances will directly affect seed germination and plant root length if the fertilizer is poisonous (Wong *et al.*, 2001).

Number of Total Nodules

The total number of nodules per plant was significantly impacted by LOF application (P<0.05) at the 6th WAP. It was confirmed with a P value of 0.016 and a chi-square value of 15.56 as shown in Table 5. In contrast, Jajuk *et al.* (2017) reported that the application of LOF from organic sugarcane pulp waste and sugarcane skin with a concentration of 7.1% resulted in more root nodules per plant in Soybean. According to that, a high concentration of LOF also can affect the number of root nodules.

Number of Flowers per Plant

LOF application was significantly influenced (P<0.05) by the number of flowers per plant at the 8th WAP. It was confirmed with a P value of 0.016 and a chi-square value of 15.56 as shown in Table 6. At 8th WAP, the highest number of flowers per plant was noted in T2 while low in T6. It may be due to the application of nutrients especially LOF leads to the production more of flowers influences vegetative growth in plants and reduces fertilizer loss resulting in a higher number of flowers per plant. The presence of a higher number of potassium and growth regulators stimulated flowers per plant and enhanced plant yield (Jayasinghe *et al.*, 2016). These findings support Manyuchi *et al.*, (2013) that phosphorous present in vermiwash mainly stimulates the early flowering and flower development in the plants.

A foliar application of LOF had a notable impact on the average number of flowers produced by plants. In this experiment, the maximum value was reported in T2 at the 8th WAP. It may be due to the foliar application of vermiwash in low concentration with poultry manure is impacts the number of flowers per plant. However, Jayasinghe *et al.*, (2016) noted that Seaweed Liquid Fertilizer (SLF) extract prepared from Ulva lactuca applications increased the average maximum mean number of flowers in SLF by 75%. In that case, the concentration of LOF is very important based on their produced materials.

Dry Weight of Leaves

The effect of LOF on the average dry weight of leaves of green beans from the 2nd WAP to the 8th WAP is given in Table 7.

It was significantly varied (P<0.05) among the tested treatments on the average dry weight of leaves. At the 2nd WAP, the highest dry weight of leaves was noted in T1. However, there was no significant difference between T1 and T2, T3, T5. At the 4th WAP, T3 (1.76 g) recorded the highest dry weight of leaves. However, there was no significant difference between T3 and T1, T2, T4, T6. The highest value was noted in T1 at the 6th WAP. The concentration of foliar application and reduced fertilizer losses may be influenced by the dry weight of leaves. A similar pattern of result was recorded by Kiran *et al.*, (2016) that NPK showed the highest dry leaf weight of the radish plant, which statistically differed from all other treatments. Application of poultry manure as basal contains most of the nutrients, which affect the growth of plants. If plants absorb more nutrients and more water, it may impact on dry weight of leaves. Also, LOF application can increase the dry weight of plants by absorbing nutrients. The present study is in line with the results of Ginandjar *et al.* (2019) that the Liquid Organic Fertilizer of Vegetable Waste application greatly improved the fresh weight and dry weight of Strawberry (*Fragaria* spp.).

Dry Weight of Stems

The investigated treatments at the 2nd and 6th WAP did not significantly differ in terms of average dry stem weight (P>0.05) (Table 8). However, significant variation (P<0.05) was observed at 4th and 8th WAP.

At the 8th WAP, the highest dry weight of stems was observed in T2. However, there was no significant difference between T2 and T1, T4, and T5 in the increased dry weight of stems. It could be due to the optimum amount of nutrients received by these plantlets at the optimum frequency. The optimum amount of nutrients is important for the maximum dry weight of stems.

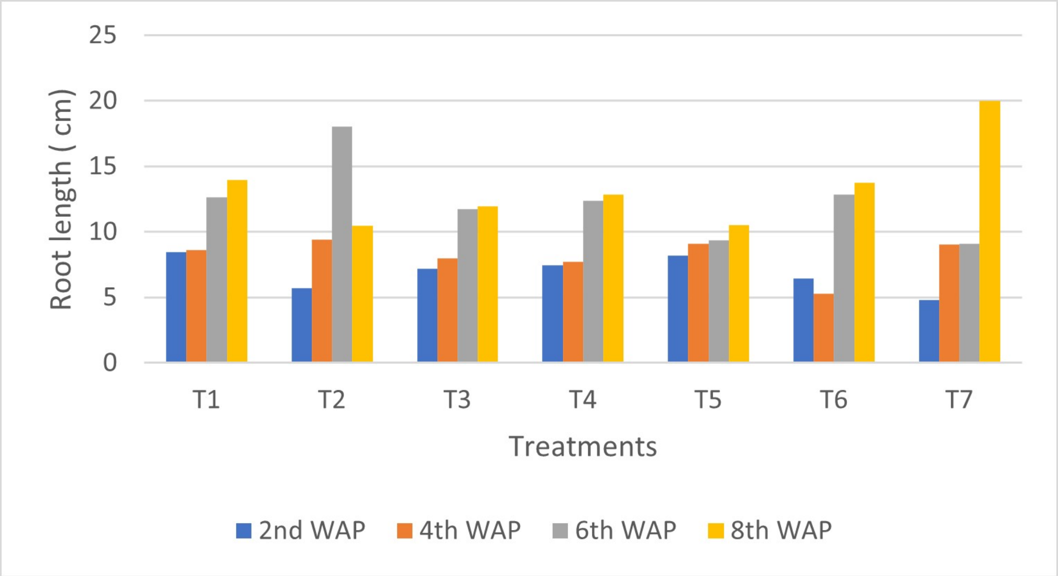

Figure 1: LOF application on average root number of the green bean

Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 7: LOF application on the average dry weight of leaves of green bean

Treatments	2^{nd} WAP	4^{th} WAP	6^{th} WAP	8^{th} WAP
T1	0.27±0.01a	1.50±0.84ab	3.28±0.98a	9.37±1.47b
T2	0.22±0.01ab	0.98±0.45abc	1.22±0.46b	19.05±1.38a
T3	0.20±0.01ab	1.76±0.56a	0.71±0.48b	4.85±0.87b
T4	0.15±0.01b	1.17±0.47abc	1.03±0.46b	13.80±1.46ab
T5	0.21±0.01ab	0.76±0.58bc	1.87±0.76ab	11.13±1.14ab
T6	0.18±0.01b	1.21±0.57abc	2.03±0.75a	9.86±1.57ab
T7	0.16±0.01b	0.68±0.56c	1.18±0.38b	9.27±1.63b
F test	*	*	*	*

Values represent the mean ± standard error of four replicates. F test :- *: P<0.05. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at a 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 8: LOF application on average dry weight of stem of green bean

Treatments	2^{nd} WAP	4^{th} WAP	6^{th} WAP	8^{th} WAP
T1	0.23±0.01	1.48±0.02a	1.35±0.01	2.58±0.12abc
T2	0.18±0.01	1.44±0.02a	1.78±0.01	4.31±0.45a
T3	0.19±0.01	1.37±0.04a	1.50±0.01	1.52±0.32c
T4	0.16±0.01	1.45±0.02a	1.88±0.01	3.63±0.27ab
T5	0.22±0.01	1.41±0.03a	1.59±0.01	3.39±0.12abc
T6	0.19±0.01	1.27±0.02b	1.39±0.01	2.01±0.07bc
T7	0.16±0.01	1.25±0.06b	1.55±0.01	1.83±0.08bc
F test	ns	*	ns	*

Values represent the mean ± standard error of four replicates. F test :- ns: not significant; *:P<0.05. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 9: LOF application on average dry weight of roots of green bean

Treatments	2nd WAP	4th WAP	6th WAP	8th WAP
T1	0.06±0.001	0.11±0.001	0.21±0.001	0.35±0.001ab
T2	0.08±0.001	0.10±0.001	0.14±0.001	0.67±0.001a
T3	0.06±0.001	0.06±0.001	0.13±0.001	0.18±0.001b
T4	0.08±0.001	0.03±0.001	0.20±0.001	0.47±0.001ab
T5	0.05±0.001	0.07±0.001	0.27±0.001	0.32±0.001ab
T6	0.04±0.001	0.05±0.001	0.23±0.001	0.28±0.001ab
T7	0.05±0.001	0.03±0.001	0.22±0.001	0.36±0.001ab
F test	ns	ns	ns	*

Values represent the mean ± standard error of four replicates. F test :- ns: not significant; *:P<0.05. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 10: LOF application on number of pods per plant in green bean

Treatments	1st picking	2nd picking	3rd picking
T1	4.0	13.0	10.0
T2	8.0	14.0	12.0
T3	4.0	9.0	9.0
T4	4.0	8.0	9.0
T5	4.0	13.0	11.0
T6	3.0	8.0	7.0
T7	3.0	8.0	7.0
P value	0.005	0.062	0.062
Chi-Square value	18.67	12	12

Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 11: LOF application on average Length of pods per plant in green bean

Treatments	1st picking	2nd picking	3rd picking
T1	17.85±1.02	19.75±2.10ab	20.30±1.87a
T2	16.0±0.98	19.15±2.14ab	19.55±1.68ab
T3	18.05±1.14	18.25±1.98ab	17.75±1.73ab
T4	17.05±1.14	19.05±1.74ab	19.25±2.47ab
T5	18.85±1.47	21.50±2.47a	19.85±2.43a
T6	13.65±1.38	19.55±1.88ab	17.05±1.97b
T7	17.95±1.46	16.95±1.47c	18.30±1.87ab
P value	ns	*	*
Chi-Square value	18.67	12	12

Values represent the mean ± standard error of four replicates. F test :- ns: not significant; *: P<0.05. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at a 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Dry Weight of Roots

The effect of LOF on the average dry weight of the roots of green beans from the 2nd WAP to the 8th WAP is given in Table 9. The average dry weight of the roots at the 2nd, 4th, and 6th WAP was found to be the same for all tested treatments (P>0.05), according to the results. At 8th WAP, the highest increase in root dry weight was recorded in T2. Several studies reported that the application of foliar sprays of nutrients promotes root development. Aydin and Demirsoy (2020) stated that Liquid Vermicompost and Seaweed application increased the dry root weight of Tomato. In this experiment, LOF with poultry

Table 12: LOF application on the average girth of pods per plant in green bean

Treatments	1st picking	2nd picking	3rd picking
T1	3.50±0.98a	3.55±1.17ab	3.50±1.09a
T2	3.30±0.97a	3.85±1.68a	3.10±1.11b
T3	3.15±1.12a	3.25±1.34ab	2.75±0.98c
T4	3.55±1.14a	3.55±1.19ab	2.75±0.99c
T5	3.45±0.98a	3.75±1.57a	3.45±1.47a
T6	2.05±0.97b	3.05±1.19b	2.85±0.92bc
T7	3.50±1.17a	3.55±1.13ab	3.00±1.03bc
F test	*	ns	*

Values represent the mean ± standard error of four replicates. F test :- ns: not significant; *: P<0.05. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at a 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 13: LOF application on average fresh weight of pods per plant in green bean

Treatments	1st picking	2nd picking	3rd picking
T1	26.12±1.12	124.10±2.47bc	124.60±2.31abc
T2	20.88±1.17	161.30±2.46a	143.45±1.52a
T3	17.11±0.98	105.90±1.97cd	108.00±1.36bcd
T4	22.28±1.12	103.15±1.94cd	100.40±1.24cd
T5	26.16±1.47	145.15±1.63ab	129.55±2.14ab
T6	11.77±0.68	100.90±1.37cd	89.45±0.99d
T7	26.02±1.19	88.95±0.98d	83.80±0.92d
F test	ns	**	**

Values represent the mean ± standard error of four replicates. F test :- ns: not significant; *: P<0.01. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at a 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

Table 14: LOF application on average dry weight of green bean pods per plant

Treatments	1st picking	2nd picking	3rd picking
T1	2.74±0.08	19.05±1.11a	15.20±1.14a
T2	2.85±0.05	14.25±1.25ab	17.55±1.19a
T3	2.24±0.05	11.50±1.10b	11.60±1.12b
T4	3.06±0.06	9.80±0.98b	10.65±0.98b
T5	3.03±0.01	11.85±1.13b	17.00±1.13a
T6	1.99±0.09	10.15±0.98b	8.77±0.67bc
T7	2.91±0.06	9.45±0.67b	7.30±0.87c
F test	ns	*	**

Values represent the mean ± standard error of four replicates. F test :- ns: not significant; *: P<0.05; *: P<0.05. Means followed by the same letter in each column are not significantly different according to Duncan's Multiple Range Test at 5 % level. Control (T1), 5t/ha dried poultry manure as basal with 0.5% (T2), 1% (T3), 1.5% (T4) of (v/v) vermiwash, 0.5% (T5), 1% (T6) and 1.5% (T7) of (v/v) vegetable waste solution as a foliar spray

manure application may impact root development at the matured stage of the plant and also, it causes the dry weight of roots. Rongting *et al.*, (2017) reported that the most significant increases in root dry weight, total length, surface area, volume, tips, and thick root length were due to the application of LOF.

Number of Pods per Plant

As indicated in Table 10, the use of LOF had a substantial (P<0.05) impact on the number of pods per plant at 1st picking. This was supported by the P value of 0.005 and the chi-square value of 18.67. LOF application significantly increased the number of pods per plant in T2 may be a result of its vigor and more leaves per plant, it produces the most pods per plant. Jajuk *et al.* (2017) reported that the better average soybean pod yields per plant can be achieved by using LOF. A minimum number of pods was observed in T6 and T7 at 1st picking. Wazir *et al.*, (2018) also noted that the highest number of pods were produced by each pea plant as a result of the phosphorus that was given to the soil by treating banana peels. Poultry manure contains more phosphorus content and it may cause the pod yields of green beans.

Length of Pods

The use of LOF during the 2nd and 3rd picking considerably influenced the length of the pods ($P<0.05$), as indicated in Table 11. The LOF application significantly increased the pod length in T5 at 2nd picking. However, there was no significant difference between T5 and T1, T2, T3, T4, and T6 in the length of pods. It may be due to the presence of micronutrients which are involved in the cellular mechanism and respiration that affect positively for improvement in fruit size (Polara *et al.*, 2017). The minimum length was shown in T7 at 2nd picking. The reason may be high concentration of vegetable waste solution contains high pH and it may inhibit plant growth produce malformed pods and decrease the length of pods. At 3rd picking, the highest value was noted in T1. The various liquid organic fertilizer sources may have provided all the nutrients needed for vegetative growth. Shehata and El-Helaly (2010) reported that Vermicompost treatment had no discernible effect on pod length in bush beans (*Phaseolus vulgaris*) compared to compost treatment.

Girth of Pods

It is demonstrated how the foliar application of LOF affected the average girth of green bean pods from the first picking to the third picking as shown in Table 12. The average girth of pods varied significantly ($P<0.05$) among the studied treatments. At 1st picking, the maximum girth of a pod was in T4 followed by T1, and T7 while the minimum girth of pods was observed in T6. At 2nd picking, the greatest value was in T2 followed by T5 and at 3rd picking, the highest value was observed in T1. However, there was no significant difference between T1 and T5 in an increase in the grith of pods. It could be due to the optimum amounts of nutrients received by plantlets exposed to both treatments. The application of macronutrients together with micronutrients increases the length of pods. These results confirmed with Crouch and Staden (1991) indicated that Seaweed Liquid Fertilizer (SLF) is unable to adequately meet the requirements of growth parameters due to enough amounts of the macro and micro components Ca, Mg, K, and P.

Fresh Weights of Pods

The foliar application of LOF, as indicated in Table 13 considerably affected the fresh weight of green bean pods. At the second and third picking, there was a significant difference ($P<0.01$). At 2nd WAP, the maximum fresh weight of pods was observed in T2. However, there was no significant difference between T2 and T5 in the increased fresh weight of pods. The increased fresh pod weight of beans caused by the application of poultry manure may be linked to the plant nutrients that were released being easily soluble, which improved the soil's nutritional status and water-holding capacity. The outcomes matched those of Sanwal et al (2007) 's research on turmeric (*Curcuma longa*). According to Premsekhar and Rajashree (2009), the application of organic manure increased the production of okra and improved nutrient delivery to the plants. At 3rd picking, the maximum weight was noted in T2. However, there was no significant difference between T2 and T5, T1. It could be due to plantlets grown at these treatments not receiving the optimum amount of nutrients. Optimum concentrations of nutrients influence the fresh weight of pods of green bean plantlets.

Dry Weight of Pods

Table 14 provides information regarding the effects of LOF application on the dry weight of pods. The effect of LOF application on the dry weight of pods was found non-significant ($P>0.01$) at 1st picking. However, there was a substantial difference in the second ($P<0.05$) and third ($P<0.01$) pickings respectively. At 2nd picking, the highest value was observed in T1. However, there was no significant difference between T1 and T2. At 3rd picking, the highest value was noted in T1. However, there was no significant difference between T1 and T2, T5. This is due to the relationship between the dry weight of pods and their fresh weight. Also, the availability of water affects the process of dry weight. Plant dry weight and fresh weight are significantly impacted by fungus inoculation because fungi have hyphae that can more effectively absorb nutrients and water (Amiroh *et al.*, 2021). Islam *et al.*, (2016) reported that Legume pod dry weight was substantially greater in the Vermicompost treatment than it was in the compost and farmer's practice treatments.

CONCLUSION

In comparison to the control treatments, the results showed that 5t/ha of poultry manure with liquid organic fertilizer considerably ($P<0.05$) improved the growth and yield of green beans. The plant treated with 5/ha poultry manure with 0.5% vermiwash (T2) increased the number of leaves and branches per plant, plant height at 8th week after planting, and fresh and dry weights of pods were high at 2^{nd} and 3^{rd} picking. Among the tested treatments 5t/ha poultry manure as basal with foliar spray of 0.5% (T2) would be the most suitable for green bean cultivation in red-yellow podzolic soil. Further studies are needed to investigate different soil to commercialize it.

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