



How organic fertilizers influence growth and yield of *Aloe barbadensis*?

A Viyasan*, S Sutharsan, S Srikrishnah

Department of Crop Science, Eastern University, Vantharumoolai, Sri Lanka

Abstract

Aloe vera, considered to be the most popular plant, belongs to the family Liliaceae. In *Aloe vera*, organic manures give more effective growth and yield compared to chemical fertilizers. This study investigated how organic fertilizers influence growth and yield of *Aloe barbadensis*. A polybag experiment with five treatments and four replicates in Randomized Complete Block Design was conducted in the Crop Farm, Eastern University, Sri Lanka, from November 2019 to March 2020. The treatments are control, compost, cow dung, commercially available organic liquid fertilizer and Jeewamirta tested for performances. Almost all the growth parameters and yield parameters showed a significant increase by compost and cow dung treatments compared to other treatments. In those significant parameters, between compost and cow dung treatments were shown non-significance in average leaf length, average leaf width, total leaf volume and total gel weight. This might be due to compost and cow dung increase soil fertility and delivered better results due to better nutrition by increasing cell division and elongation without hindering the nutrient uptake procedure. Therefore, considering the growth parameters, yield parameters and especially economic important parameter (gel weight), compost and cow dung could be recommended for the cultivation of *Aloe barbadensis* to improve growth and yield and those are environmentally friendly for Sustainable Agriculture.

Keywords: *aloe barbadensis*, compost, cow dung, fertilizers, jeewamirta

Introduction

Aloe vera's name originates from Arabic and Latin language origin. "Alloeh" means "shining bitter substance" in Arabic, while "vera" means "true" in Latin (Christaki and Florou-Paneri, 2010) [1]. The Greek scientists considered the *Aloe vera* plant as the universal remedy 2000 years back (Surjushe *et al.*, 2008) [2]. The Egyptians called *Aloe vera* "the plant of immortality." *Aloe barbadensis* is the Botanical name of *Aloe vera* plant. It is a xerophytic, perennial, succulent, shrubby, pea-green colour plant that belongs to the family Liliaceae (Surjushe *et al.*, 2008) [2]. Today in commercial cultivation, only two are the most popular species (Manvitha and Bidya, 2014) [3]; among its 400 species (Moghaddasi and Verma, 2011) [4] of *Aloe vera* are *Aloe barbadensis* and *Aloe arborescens* (Manvitha and Bidya, 2014) [3].

Aloe vera's origin is in northern parts of Africa; because of its easy farming, it has quickly spread worldwide (Grundmann, 2012) [5]. *Aloe* needs less water for living and can survive on beaches, saline soils and is resistant to insects and diseases (Moghaddasi and Verma, 2011) [4]. During Biblical times and Civilizations like Assyrians, Egyptians, and the Mediterranean has been used this plant for traditional and folk medicines (Grundmann, 2012) [5]. *Aloe vera* mainly grows in the dry regions of America, Europe, Asia and Africa (Surjushe *et al.*, 2008) [2].

The use of this plant has been known for centuries for its medicinal, skincare properties, health, beauty (Surjushe *et al.*, 2008) [2] and food preservatives (Manvitha and Bidya, 2014) [3].

Several studies have revealed that *Aloe vera* leaf contains many pharmaceutical activities, including anticancer, antioxidant, antimicrobial, antiulcer, antidiabetic, hepatoprotective, immunomodulatory and many activities (Manvitha and Bidya, 2014) [3].

This is a short-stemmed plant, the most usable part of this is the modified stem, which consists of outer dark green parenchyma entrapping thick mucilaginous colourless gel inside it. It is very rich in macro and micronutrients. Sabats' study indicated "around 98.5-99 % moisture content, the dry matter includes 55 % of polysaccharides, 17 % of sugars, 16 % of minerals, 7 % of proteins, 4 % of lipids and 1 % of phenolic compounds" in *Aloe vera* gel and also have many important vitamins and antioxidants in it (Sabat *et al.*, 2018) [6].

Due to the broad spectrum of application on human health, the products of *Aloe* have shown a strong demand in both national and international markets. The USA supplies 60-65 % share in the world market, while Latin American countries provide 20-25 % and India, China, and Australia have a market share of only 10 % in 2004 (Lavakumaran and Seran, 2014) [7].

In Sri Lanka, *Aloe* is believed to have been an essential part of health and wellbeing rituals since the ancient Ceylonese Royals. Marine and Coastal Resources Conservation Foundation (MCRFC) started a cultivation project in the Kalpitiya area by using *Aloe vera* plants to gain global recognition (Lavakumaran and Seran, 2014) [7]. The MCRFC negotiated with Janet Ayurveda (Pvt) Ltd for the supply, every month of 1,500 kilograms of *Aloe* leaves at a fixed price. When the supply was greater than the demand, the excess *Aloe* leaves became the recently popular *Aloe vera* drink. On average, a fisher family earns 5000 - 6000 Sri Lankan rupees per month from this cultivation. This increases their regular income by about 26 % (Lavakumaran and Seran, 2014) [7].

Chemical fertilizer usage increases crop production, but the overuse of chemical fertilizer has polluted the water and air, damaged the soil structure, hardens the soil, and releases greenhouse gases. Moreover, chemical fertilizers are

hazardous to human health and our environment (Fazeel *et al.*, 2019) [8].

“Organic production can be defined as an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimal use of off-farm inputs and on management practices that restore, maintain, and enhance ecological harmony” (Winter and Davis, 2006) [9]. Various researches have proved that composted organic matter can be used as growing media (Lucia, 2014) [10].

One of the liquid organic fertilizers is Jeewamirta which Indian farmers have used. Jeewamirta has been poorly investigated organic fertilizer. Efficiently and effectively using animal manure ensures sustainable crop productivity by immobilizing nutrients that are susceptible to leaching (Fazeel *et al.*, 2019) [8]. The nutrients in organic manure are released more gradually. They are kept for a longer time in the soil, making sure more prolonged remaining effects, higher crop yield and improved root development. It contains beneficial microorganisms, macronutrients, essential micronutrients, essential amino acids, growth-promoting factors like GA, IAA and many vitamins (Fazeel *et al.*, 2019) [8]. The addition of Jeewamirta activates the soil microorganisms and maintains soil productivity (Jayappa and Narayana, 2013) [11].

Biofertilizers are eco-friendly and necessary to sustainable agriculture and support developing organic agriculture. They can deliver a viable eco-friendly weapon to marginal and small farmers to increase crop productivity (Moorthy *et al.*, 2012) [12]. Bio-fertilizer application means inoculation of microorganisms capable of converting the non-usable form nutrient elements to a usable form through the biological process (Bandara *et al.*, 2019) [13].

Organic farming with bio-fertilizer provides several benefits to the growers by enhancing the physiochemical soil properties, an environmentally friendly farming technique. The addition of Biofertilizer enhances the activities of beneficial soil organisms and improves soil structure. Agricultural supplies from organic farming are good for human health. Provision of the nutrient through bio-fertilization sustains soil fertility and moisture (Bandara *et al.*, 2019) [13].

In Sri Lanka, unlike in India, there are only a few companies that engaged in bio-fertilizer production. Among them, the leading and the largest Bio-fertilizer manufacturer is Biofoods Pvt Ltd. They have the most comprehensive range of solid and liquid bio-fertilizer products.

Those are certified as organic inputs by the European Union (EU) through the Control Union (CU) inspection body that can certainly be used in certified organic cultivation for both local and export purposes (Bandara *et al.*, 2019) [13].

Therefore, this study was done with the following objective; To find how organic fertilizers influence growth and yield of *Aloe barbadensis*.

Materials and Methods

A polybag experiment was conducted from November 2019 to April 2020 in the crop farm of Eastern University, Sri Lanka. It is located in the latitude of 7° 43' N and the longitude of 81°42' E. This area is 10 m above the mean sea level; therefore, this area is categorized as the low country dry zone (DL2b) under the Agro-Ecological Zone of Sri Lanka. The annual mean temperature ranges from 30° to 36°C, and the mean annual rainfall varies from 1400 mm to

1680 mm. Nearly 60 % - 90 % of the soil type is classified as sandy loam.

This experiment was conducted using black colour polythene bags with four holes at the bottom of each polybag to facilitate excess water drainage. The polybags were 30 cm in diameter and 30 cm in height. 5 cm of the each polybag was left unfilled from the top by the soil to facilitate irrigation. The soil used for the filling was 100 % topsoil.

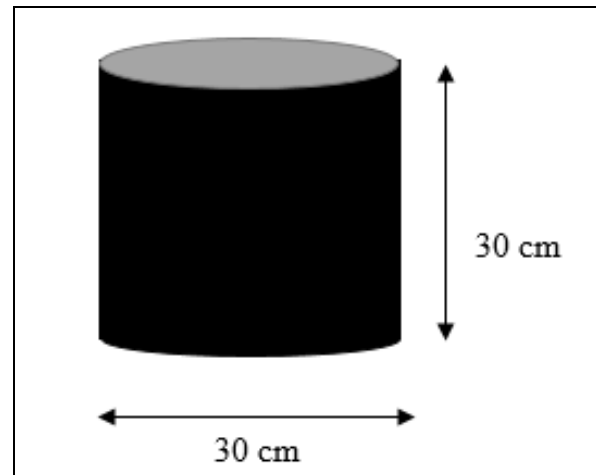


Fig 1: Dimensions of polybag

Three months old *Aloe vera* seedlings were selected for the experiment. The uniform seedlings were obtained from a home garden in Kiraankulam, Batticaloa, Sri Lanka.

Each pot was planted with one seedling. Irrigation was followed once a day in the evening during the experimental period. Fertilizers were applied according to the treatments. Jeewamirta was applied at a two-week interval from the first week after transplanting. Compost and cow dung were applied at the rate of 10 tons/ha as basal application. Commercially available organic liquid fertilizer (Eco Green Plus) was applied three days, one month, two months and three months after transplanting as per the recommendation to apply Eco Green Plus. Hand weeding was done in a two-week interval. The polybags were maintained weeds-free until the final harvest. For the control of pests and diseases, neem extract was applied once in two weeks.

Jeewamirta

Preparation of Jeewamirta liquid fertilizer: Components for preparation of Jeewamirta (for one acre) are indicated in

Table 01.

Steps involved with the preparation of Jeewamirta:

1. 10 l cow urine, 10 kg fresh cow dung, 2 kg pulse powder and 2 kg jaggery were added to a plastic container.
2. Then 200 l of clean water and hand full of living soil were added to that plastic container and mixed well with all ingredients.
3. After that, the container was covered by cotton cloth for three days for fermentation.
4. It was stirred twice every morning and evening to activate microbes. After three days, it was ready to apply and it can be used up to 8 days.
5. Before the application, the organic mixture was diluted ten times with water.

Table 1: Components for preparation of Jeewamirta (for one acre)

Ingredients	Quantity
Fresh cow dung	15 kg
Cow urine	15 l
Jaggery	2 kg
Pulse powder	2 kg
Water	200 l
Living soil	A Hand full

Treatments

Treatments’ code and description are indicated in TABLE 02.

The experiment consisted of five treatments and four replications. The description of each treatment is given in TABLE 02.

Before two days of transplanting, compost treatments were added to polybags and thoroughly mixed with the soil at the level indicated in TABLE 02. Before two days of transplanting, cow dung treatments were added to polybags and thoroughly mixed with the soil at the level indicated in TABLE 02. Commercially available organic liquid fertilizer (Eco Green Plus) was

diluted 160 times with water and applied for this experiment at the recommended level as indicated in TABLE 02, after three days, one month, 2-month and three months of transplanting as field application. Prepared Jeewamirta was diluted ten times with water and applied for this experiment at the recommended level as indicated in TABLE 02. Jeewamirta was applied at a two-week interval from the first week after planting.

The required liquid Biofertilizer was collected from the main laboratory in Naula, Dambulla, Sri Lanka, and brought to the farm. Liquid fertilizer was stored in a cool and well-ventilated area to provide the oxidative environment better to contain microorganisms in the end product, favourable for microorganisms.

Table 2: Treatments’ code and description

Treatment code	Description
T1	Control
T2	Application of Compost (10 t/ha)
T3	Application of Cow dung (10 t/ha)
T4	Application of commercially available organic liquid fertilizer (1 l/acre)
T5	Application of Jeewamirta (570 l/ha)

Experimental design

An experiment with five treatments and four replicates in Randomized Complete Block Design (RCBD) was arranged as shown in the layout.

Table 3

T1R1	T3R1	T5R1	T4R1	T2R1	Block I
T2R2	T5R2	T3R2	T1R2	T4R2	Block II
T5R3	T3R3	T2R3	T4R3	T1R3	Block III
T4R4	T3R4	T1R4	T5R4	T2R4	Block IV

The layout of the experimental design

Measurements

Collection and preparation of sample: Washed the *Aloe vera* leaves under tap water to eliminate foreign materials and dirt sticking to them. The spines and the thick dark green outer skin (epidermis) were peeled out manually using

a stainless-steel knife from the thick colourless parenchyma (or gel fillet). The fillets were cut into small slabs with a stainless-steel knife and stored in an airtight container until the parameters were taken to avoid moisture loss and contamination. *Convective drying of Aloe vera samples:* The air-drying procedure is affected by drying air velocity, air temperature, relative humidity, time of drying, loading density, etc. *Aloe vera’s* quality is most affected by the drying air temperature among the parameters listed above. Therefore the variation of nutritional qualities are considered here regarding temperature. Samples from the *Aloe vera* were dried in a laboratory tray dryer at 70°C drying air temperatures and ceased the process until no weight reduction or constant weight is attained. Before one hour from starting the experiment, the correct drying air temperature was adjusted by temperature indicator controlling unit to allow the internal environment to stabilize. The *Aloe vera* samples were loaded in the drying trays at a load density of 15 kg/m². Growth parameters: Number of leaves per plant: Leaves in every plant were counted in all treatments at a two-week interval from the 2nd week after transplanting up to the final harvest.

Leaf size

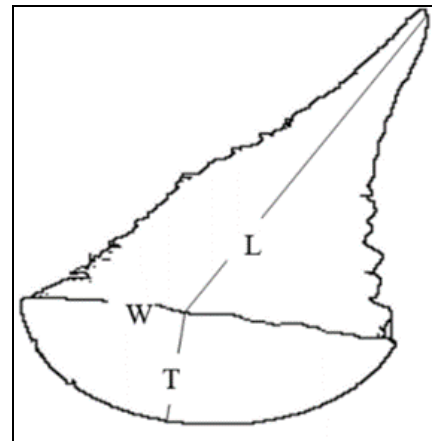


Fig 2: Approximate geometry of *Aloe vera* leaf.

Leaf length: The leaf length (cm) of each leaf in every plant were measured in all treatments using a metre scale. After the final harvest, this measurement was taken when destructing the plant. **Leaf width:** The leaf width (cm) of each leaf in every plant were measured in all treatments by a Vernier calliper (Yamato, Japan). After the final harvest, this measurement was taken when destructing the plant.

Leaf thickness: Leaf thickness (cm) of each leaf in every plant were measured in all treatments by a Vernier calliper (Yamato, Japan). After the final harvest, this measurement was taken when destructing the plant.

Leaf volume (cm³): The volume was calculated by the formula given by Sabat *et al.* (2018) ^[6] as below:

$$V = \frac{L}{12} \pi W T$$

Where;

V= Volume of the leaf, mm

L= Length of the leaf, mm

W= Width of the leaf, mm

T= Thickness of the leaf, mm

Leaf weight per plant (g): Leaves of every plant were cut into pieces, and their fresh weight (g) was measured in all treatments using an electronic balance (Hanon Instrument, China). Skin weight per plant (g): Leaf skin fresh weight (g) of every plant were measured in all treatments using an electronic balance (Hanon Instrument, China). After the final harvest, this measurement was taken when destructing the plant. The dry weight of leaf skin per plant (g): Leaf skin of every plant were cut into small pieces and placed in paper trays, and then they were dried at 105°C in the oven until gain a constant weight. Their dry weight (g) was measured in all treatments using an electronic balance (Hanon Instrument, China). After the final harvest, this measurement was taken when destructing the plant.

Largest leaf: The leaf with the highest volume is considered the largest leaf among the other plant leaves. All parameters were measured in other leaves also were measured for the largest leaf.

Gel weight (g): Leaf gel fresh weight (g) of every plant were measured in all treatments using an electronic balance (Hanon Instrument, China).

Yield parameters: Yield: The total average yield of each replication was measured in all treatments. The dried product's percentage yield is the amount of dried powder from drying fresh *Aloe vera* fillets. It can be calculated by Sabat *et al.* (2018) [6]

$$\text{Yield}(\%) = \frac{\text{Powder obtained (g)}}{\text{Fresh fillet (g)}}$$

Moisture content: It was calculated using the following equation (Sabat *et al.*, 2018) [6] by the method described in AOAC (1990).

$$\text{Moisture content}(\%) = \frac{\text{Weight of water present (g)}}{\text{Weight of dry matter present (g)}} \times 100$$

Gel recovery: Gel recovery was calculated using the following equation,

$$\text{Gel recovery, \%} = \frac{\text{Gel weight}}{\text{Leaf fresh weight}} \times 100$$

Analysis of data: Data measured were statistically analysed using SAS 9.04. And the Duncan Multiple Range Test was done for the mean comparison within treatments at a 5 % significant level.

Results and Discussion

TABLE 03. and TABLE 04. shows the effects of different organic fertilizers on the plant characteristics of *Aloe vera* at 20 WAP.

Table 3. Effects of different organic fertilizers on the plant characteristics in *Aloe barbadensis*

Treatment	Total leaf area (cm ²)	Total leaf fresh weight (g)	Leaf gel weight of the largest leaf (g)	Leaf fresh weight of the largest leaf (g)	Gel recovery (%)	Total gel weight (g)	Average leaf length (cm)
Control (T1)	154.66 ± 19.57 ^c	135.53 ± 19.53 ^c	17.16 ± 4.75 ^b	31.53 ± 6.21 ^c	40.66 ± 4.82 ^b	57.83 ± 15.62 ^b	19.34 ± 1.03 ^b
Compost (T2)	353.71 ± 59.27 ^a	360.92 ± 63.59 ^a	51.50 ± 13.62 ^a	77.66 ± 18.34 ^a	53.08 ± 3.42 ^a	194.43 ± 38.25 ^a	25.55 ± 2.06 ^a
Cow dung (T3)	300.73 ± 12.57 ^{ab}	303.18 ± 8.71 ^{ab}	39.26 ± 2.68 ^{ab}	67.84 ± 3.01 ^{ab}	54.67 ± 2.14 ^a	165.80 ± 8.31 ^a	25.40 ± 0.85 ^a
Commercial organic fertilizer (T4)	172.01 ± 22.76 ^c	166.16 ± 20.47 ^c	25.11 ± 5.48 ^b	40.98 ± 7.11 ^{bc}	51.74 ± 5.01 ^a	88.72 ± 17.94 ^b	20.87 ± 1.48 ^b
Jeewamirta (T5)	234.17 ± 15.75 ^{bc}	214.81 ± 15.99 ^{bc}	26.17 ± 2.94 ^b	45.07 ± 4.16 ^{bc}	49.65 ± 0.83 ^a	106.95 ± 9.21 ^b	21.50 ± 0.58 ^{ab}
F-test	*	*	*	*	*	*	*

The value represents the mean ± standard error of four replicates.

'*' and 'ns' represents significant at and non-significant at P<0.05 respectively.

Means followed by the same superscripts in the same column are not significantly different at the 0.05 probability level according to DMRT.

Table 4: Effects of different organic fertilizers on the plant characteristics in *Aloe barbadensis*

Treatment	Average leaf width (cm)	Total leaf volume (cm ³)	Plant height (cm)	Number of leaves per plant	Average leaf thickness (cm)	Yield (%)
Control (T1)	1.6739 ± 0.1192 ^c	64.93 ± 21.05 ^b	19.55 ± 2.17	8.25 ± 0.75	0.7163 ± 0.0702	0.2370 ± 0.0266
Compost (T2)	2.4112 ± 0.1330 ^a	210.20 ± 37.22 ^a	28.43 ± 3.18	9.50 ± 0.65	1.0099 ± 0.0354	0.3595 ± 0.1113
Cow dung (T3)	2.3146 ± 0.0772 ^a	161.57 ± 6.58 ^a	27.98 ± 1.74	9.00 ± 0.41	0.9581 ± 0.0449	0.2504 ± 0.0477
Commercial organic fertilizer (T4)	1.9965 ± 0.0968 ^b	106.23 ± 20.58 ^b	23.85 ± 3.03	8.00 ± 0.41	1.0788 ± 0.1670	0.3296 ± 0.0425
Jeewamirta (T5)	2.0262 ± 0.0313 ^b	107.76 ± 13.30 ^b	24.90 ± 1.34	9.25 ± 0.85	0.8596 ± 0.0234	0.2173 ± 0.0359
F-test	*	*	ns	ns	ns	ns

The value represents the mean ± standard error of four replicates.

'*' and 'ns' represents significant at and non-significant at P<0.05 respectively.

Means followed by the same superscripts in the same column are not significantly different at the 0.05 probability level according to DMRT

Total leaf area (cm²)

TABLE 03. shows the effects of different organic fertilizers on the total leaf area of *Aloe vera* at 20 WAP. The data showed that compost (T2) application had the highest total leaf area than control plants.

The highest total leaf area was recorded in T2, followed by T3, T5, T4, and the minimum total leaf area was recorded in T1 at 20 WAP.

This significant increase in total leaf area due to the application of compost to the T2. It may be due to compost increase soil fertility, cell division and cell elongation. Application of compost could increase nitrogen use efficiency and restoring soil quality, especially soil biodiversity; therefore, the plant can gain more nutrients than other treatments. The same trend was observed by Chowdhury *et al.* (2018) [15] and Hasanuzzaman *et al.* (2008) [14] in *Aloe vera*.

Total leaf fresh weight (g)

TABLE 03. Shows the effects of different organic fertilizers on the total leaf fresh weight of *Aloe vera* at 20 WAP. The data showed that the compost application had the highest total leaf fresh weight compared to control plants.

The highest total leaf fresh weight was recorded in T2, followed by T3, T5, T4, and the minimum total leaf fresh weight was recorded in T1 at 20 WAP.

This significant increase of total leaf fresh weight due to the application of compost to the T2. It may be due to compost increase soil fertility, cell division and cell elongation. Using manure was most effective in increasing leaf weight per plant was supported by findings of Hasanuzzaman *et al.* (2008) [14], Pichgram (1987) [17] and Saha *et al.* (2005) [16]. Patke *et al.* (2018) [18] observed the highest total leaf fresh weight (371.86 g) using compost. After mineralization the nutrients release was gradual and slow. Such controlled but a regulated supply of nutrients increased N, P, K uptake, which brought about higher growth and yield.

Leaf gel weight of the largest leaf (g)

TABLE 03. Shows the effects of different organic fertilizers on the leaf gel weight of the largest leaf of *Aloe vera* at 20 WAP. The data showed that the compost application had the highest leaf gel weight of the largest leaf than control plants. The highest leaf gel weight of the largest leaf was recorded in T2, followed by T3, T5, T4, and the minimum leaf gel weight of the largest leaf was recorded in T1 at 20 WAP.

This significant increase of leaf gel weight of the largest leaf due to compost application to the T2. It may be due to an increased cell division and elongation without hindering the nutrient uptake procedure, which delivered better results due to better nutrition.

The high C-added rates with the composting rate improved soil physical properties, such as bulk density, porosity, and water-holding capacity, which provide agronomic and environmental benefits. In general, soil physical properties were improved with compost application (Evanylo *et al.*, 2008). The same trend was observed by Rakibuzzaman *et al.* (2019) [20] in *Aloe vera*.

Leaf fresh weight of the largest leaf (g)

TABLE 03. shows the effects of different organic fertilizers on the leaf fresh weight of the largest leaf of *Aloe vera* at 20 WAP. The data showed that the compost application had the

highest leaf fresh weight of the largest leaf than control plants.

The highest leaf fresh weight of the largest leaf was recorded in T2, followed by T3, T5, T4, and the minimum leaf fresh weight of the largest leaf was recorded in T1 at 20 WAP.

This significant increase of leaf fresh weight of the largest leaf due to compost application to the T2. Most effective way to increase leaf weight per plant is using manure was supported by findings of Hasanuzzaman *et al.* (2008) [14], Pichgram (1987) [17] and Saha *et al.* (2005) [16]. Patke *et al.* (2018) [18] observed the highest total leaf fresh weight (371.86 g) using compost.

Gel recovery (%)

TABLE 03. Shows the effects of different organic fertilizers on the gel recovery of *Aloe vera* at 20 WAP. The data showed that the application of cow dung, compost, commercial organic fertilizer and Jeewamirta had the highest gel recovery when compared to control plants.

The highest gel recovery was recorded in T3, followed by T2, T4, T5, and the minimum gel recovery in T1 at 20 WAP.

This significant increase in gel recovery due to cow dung application to the T3 and compost to T2. It delivered better results due to better nutrition by increasing cell division and elongation without hindering the nutrient uptake procedure. Using manure may effective in increasing gel weight per plant.

Total gel weight (g)

TABLE 03. Shows the effects of different organic fertilizers on the total gel weight of *Aloe vera* at 20 WAP. The data showed that the compost and cow dung application had the highest total gel weight compared to control plants.

The highest total gel weight was recorded in T2, followed by T3, T5, T4, and the minimum total gel weight was recorded in T1 at 20 WAP.

This significant increase of total gel weight due to compost application to the T2 and cow dung to T3. Due to organics' application, it helped increase the cell division and elongation without hindering the nutrient uptake procedure, which increased total gel weight (Hasanuzzaman *et al.*, 2008) [14]. Most effective way to increase leaf weight per plant is using manure was supported by findings of Hasanuzzaman *et al.* (2008) [14], Pichgram (1987) [17] and Saha *et al.* (2005) [16]. According to Celik *et al.* (2017) for soil quality, soil organic matter is a crucial attribute that impacts soil aggregation and accordingly increases water infiltration. Same trend was observed by Patke *et al.* (2018) [18] and Rakibuzzaman *et al.* (2019) [20] in *Aloe vera*.

Average leaf length (cm)

TABLE 03. Shows the effects of different organic fertilizers on the average leaf length of *Aloe vera* at 20 WAP. The data showed that the compost and cow dung application had the highest average leaf length compared to control plants.

The highest average leaf length was recorded in T2, followed by T3, T5, T4, and the minimum average leaf length was recorded in T1 at 20 WAP.

This significant increase of average leaf length due to compost application to the T2 and cow dung to T3. It was due to the beneficial effect in soil properties and plant growth by organic matter (Dexter, 1988; Tisdall & Oades,

1982; Uyanoz *et al.*, 2002) [22, 23, 24]. A similar results was reported by Hasanuzzaman *et al.* (2008) [14] in *Aloe vera*. Patke *et al.* (2018) [18] observed the highest leaf length by using compost (48.32 cm). The minimum average leaf length was recorded in control. The results was due to the failure to produce cell expanse in *Aloe* plant. This result was also reported by Bates (1971) [25] and Saha *et al.* (2005) [16].

Average leaf width (cm)

TABLE 04. Shows the effects of different organic fertilizers on the average leaf width of *Aloe vera* at 20 WAP. The data showed that the compost and cow dung application had the highest average leaf width compared to control plants.

The highest average leaf width was recorded in T2, followed by T3, T5, T4, and the minimum average leaf width was recorded in T1 at 20 WAP.

This significant increase of average leaf width due to the compost application to the T2 and cow dung to T3. It may be due to compost and cow dung increase soil fertility, cell division and cell elongation. A similar trend was observed by Hasanuzzaman *et al.* (2008) [14] in *Aloe vera*. Hasanuzzaman *et al.* (2008) [14] observed the highest leaf length (5.11 cm) using cow dung. The minimum average leaf length was recorded in control. The results was due to the failure to produce cell expanse in *Aloe* plant. This result was also reported by Bates (1971) [25] and Saha *et al.* (2005) [16].

Total leaf volume (cm³)

TABLE 04. Shows the effects of different organic fertilizers on the total leaf volume of *Aloe vera* at 20 WAP. The data showed that the compost and cow dung application had the highest total leaf volume compared to control plants.

The highest total leaf volume was recorded in T2, followed by T3, T5, T4, and the minimum total leaf volume was recorded in T1 at 20 WAP.

This significant increase in total leaf volume due to compost application to the T2 and cow dung to T3. The application of organics helped increase cell division and elongation without hindering the nutrient uptake procedure, which increased leaf volume (Hasanuzzaman *et al.*, 2008) [14].

Plant height (cm)

TABLE 04. Shows the effects of different organic fertilizers on the plant height of *Aloe vera* at 20 WAP. There is no significant difference between treatments; considering the mean value highest plant height was recorded in T2 followed by T3, T5, T4, and the minimum plant height was recorded in T1 at 20 WAP. This increase in plant height due to the application of compost to the T2.

It delivered better results due to better nutrition by increasing cell division and elongation without hindering the nutrient uptake procedure. It was due to the beneficial effect in soil properties and plant growth by organic matter (Hasanuzzaman *et al.*, 2008) [14]. Patke *et al.* (2018) [18] observed the highest plant height by using compost (45.63cm)

Number of leaves per plant

TABLE 04. Shows the effects of different organic fertilizers on the number of leaves per *Aloe vera* plant at 20 WAP.

There is no significant difference between treatments; considering the mean value highest number of leaves per plant was recorded in T2, followed by T5, T3, T1, and the minimum number of leaves per plant was recorded in T4 at 20 WAP. This increase in the number of leaves per plant due to the application of compost to the T2.

It may be due to increased cell division. It was due to the beneficial effect in soil properties and plant growth by organic matter (Hasanuzzaman *et al.*, 2008) [14]. Patke *et al.* (2018) [18] observed the highest number of leaves per plant using compost (9.22). A similar trend was observed by Hasanuzzaman *et al.* (2008) [14] in *Aloe vera*.

Average leaf thickness (cm)

TABLE 04. Shows the effects of different organic fertilizers on the average leaf thickness of *Aloe vera* at 20 WAP. There is no significant difference between treatments; considering the mean value highest average leaf thickness was recorded in T4 followed by T2, T3, T5, and the minimum average leaf thickness was recorded in T1 at 20 WAP.

This increase in average leaf thickness due to the application of commercial organic fertilizer to the T2. It may be due to Commercial organic fertilizer contains many active microbes. A similar trend was observed by Bandara *et al.* (2019) [13] in onion.

Yield (%)

TABLE 04. Shows the effects of different organic fertilizers on the yield of *Aloe vera* at 20 WAP. There is no significant difference between treatments; considering the mean value highest yield was recorded in T2 followed by T4, T3, T1, and the minimum yield recorded in T5 at 20 WAP. This increase in yield due to the application of compost to the T2. It delivered better results due to better nutrition by increasing cell division and elongation without hindering the nutrient uptake procedure. A similar finding has been reported by Saha *et al.* (2005) [16].

Relationship between parameters

The relationship between total leaf fresh weight - total gel weight, total leaf area - total gel weight, total leaf volume - total leaf fresh weight and total leaf area total leaf volume, of *Aloe* leaves, are shown in Fig.03, Fig.04, Fig.05, and Fig.06 respectively.

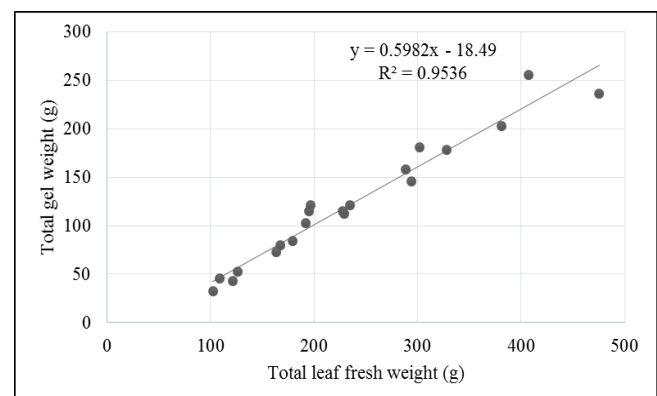


Fig 3: Relationship between total leaf fresh weight and total gel weight of *Aloe vera*.

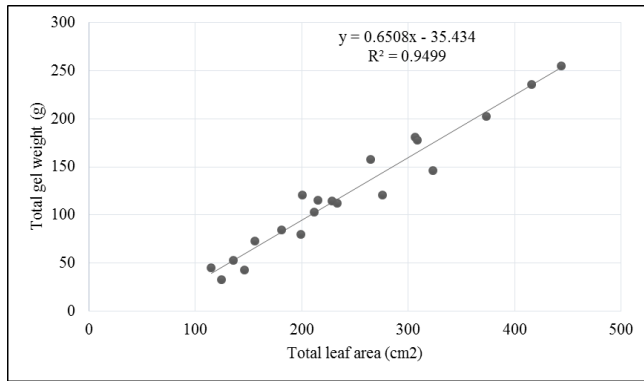


Fig 4: Relationship between total leaf area and total gel weight (g) of *Aloe vera*.

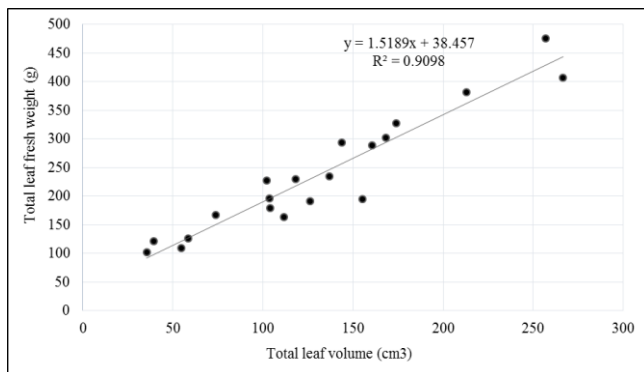


Fig 5: Relationship between total leaf volume and total leaf fresh weight (g) *Aloe vera*.

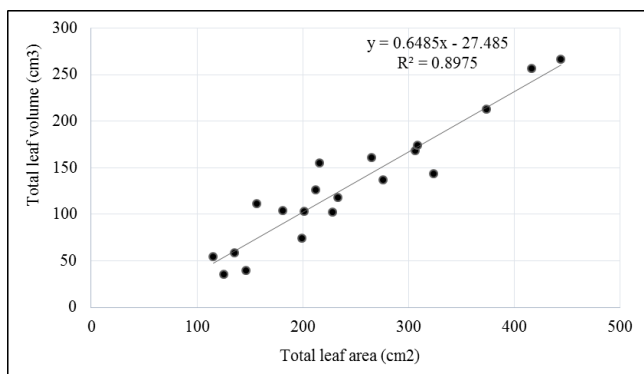


Fig 6: Relationship between total leaf area and total leaf volume of *Aloe vera*.

Total leaf fresh weight and total gel weight: During experimentation, it was observed that total leaf fresh weight and total gel weight had some relationship (Fig.03). The results indicate a positive correlation ($R^2 = 0.9536$) between total leaf fresh weight and total gel weight. The same trend was observed by Sabat *et al.* (2018) [6] in *Aloe vera*. Hence, total leaf fresh weight could be used for estimating total gel weight and vice versa.

Total leaf area and total gel weight: During experimentation, it was observed that the total leaf area and total gel weight had some relationship (Fig.04). The results indicate a positive correlation ($R^2 = 0.9499$) between total leaf area and total gel weight. Hence, the total leaf area could be used for estimating total gel weight and vice versa.

Total leaf volume and total leaf fresh weight: During experimentation, it was also observed that total leaf volume and total leaf fresh weight had some relationship (Fig.05). The results indicate a positive correlation ($R^2 = 0.9098$)

between total leaf volume and total leaf fresh weight. Hence, total leaf volume could be used for estimating leaf fresh weight and vice versa.

Total leaf area and total leaf volume: During Experimentation, it was also observed that the total leaf area and total leaf volume had some relationship (Fig.06). The results indicate a positive correlation ($R^2 = 0.8975$) between total leaf area and total leaf volume. Hence, the total leaf area could be used for estimating total leaf volume and vice versa.

Conclusions

Due to the wide use of *Aloe vera*, it has a strong demand in both national and international markets. It is more responsive to nutrients because it is a succulent plant. Therefore, nutrient management must be an essential factor. Organic fertilizer plays a vital role in increasing production, improving quality and sustaining soil fertility.

Almost all the growth parameters and yield parameters showed a significant increase by compost (T2) and cow dung (T3) treatments in comparison with commercially available organic liquid fertilizer (Eco Green Plus) (T4), Jeewamirta (T5) and control (T1). In those significant parameters, between compost (T2) and cow dung (T3) treatments were shown non-significance in average leaf length, average leaf width, total leaf volume and total gel weight. This might be due to compost and cow dung increase soil fertility and delivered better results due to better nutrition by increasing cell division and elongation without hindering the nutrient uptake procedure. Between total leaf fresh weight and total gel weight there was a positive correlation ($R^2 = 0.9536$).

Therefore, considering the growth parameters, yield parameters and especially economic important parameter (gel weight), the compost and cow dung could be recommended for the cultivation of *Aloe barbadensis* to improve growth and yield and those are environmentally friendly for Sustainable Agriculture.

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