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GROWTH AND YIELD OF *Aloe vera* IN RESPONSE TO DIFFERENT ORGANIC FERTILIZERS OR MANURES

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ABSTRACT

Aloe vera is the plant belongs to family Liliaceae. Aloe vera has acquired great commercial importance globally. In Aloe vera, researches clearly show that organic manures are more efficient compared to chemical fertilizers. This study investigated the growth and yield of Aloe vera in response to different organic fertilizers or manures. This research was laid out in Randomized Complete Block Design (RCBD) in the Crop Farm, Eastern University of Sri Lanka, as a polybag experiment with five treatments and four replicates from November 2019 to March 2020. The treatments are T1 (Control), T2 (Compost), T3 (Cow dung), T4 (Commercially available organic liquid fertilizer) and T5 (Jeewamirta). In almost all the growth and yield parameters showed a significant increase by compost (T2) and cow dung (T3) treatments compared to other treatments. In those significant parameters, between compost (T2) and cow dung (T3) treatments were shown non-significance in total leaf skin weight, total root fresh weight and leaf skin weight of largest leaf. Therefore, considering the growth parameters, yield parameters, and especially economic important parameter (gel dry weight) compost and cow dung could be recommended to enhance the growth and yield in the cultivation of Aloe barbadensis.

Keywords: Aloe barbadensis, Compost, Cow dung, Fertilizers, Jeewamirta

INTRODUCTION

Word "Alloeh" gives the meaning of "shining bitter substance" in Arabic, while the Latin word "vera" gives the meaning of "true"(Christaki and Florou-Paneri, 2010). Among its 400 species of *Aloe vera* (Moghaddasi and Verma, 2011), *Aloe arborescens* and *Aloe barbadensis* are the two popular species used in commercial cultivation (Manvitha and Bidya, 2014). It mainly grows in the dry regions of America, Europe, Asia and Africa (Surjushe et al., 2008).

The modified stem of *Aloe* consists of outer dark green parenchyma entrapping thick mucilaginous colourless gel inside it. Sabats' study indicated "around 98.5-99 % moisture content, and 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). Uses of *Aloe vera* are known for their medicinal, skincare properties, health, beauty (Surjushe et al., 2008) and food preservative properties (Manvitha and Bidya, 2014). *Aloe vera* leaf contains several medicinal activities, with hepatoprotective, immunomodulatory, anticancer, antiulcer, antioxidant, antidiabetic, antimicrobial and many other activities (Manvitha and Bidya, 2014).

Organic farming can be defined as an "ecological production system that promotes and enhances biological cycle and biodiversity in soil, crop and livestock. It is based on minimal use of off-farm inputs and management practices that restore, maintain and enhance ecological harmony" (Winter and Davis, 2006). Various researches have proved that composted organic matters can be used as growing media (Lucia, 2014). Therefore *Aloe vera* is tested with different organic fertilizers or manures in this study.

Indian farmers use Jeewamirta as a liquid organic fertilizer. It release nutrients more slowly and is kept in the soil for a longer period, accordingly, it makes sure longer residual effects, increased crop yield, and enhanced 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). Jeewamirta activates the soil microorganisms and maintains soil productivity (Jayappa and Narayana, 2013).

Bio-fertilizer is another organic fertilizer, which means the inoculation of microorganisms capable of converting the non-usable form nutrient elements to usable form through the biological process (Bandara et al., 2019). Bio-fertilizers are eco-friendly and support developing organic agriculture. To increase crop productivity Bio-fertilizers can deliver an eco-friendly weapon to farmers (Moorthy et al., 2012). Activities of beneficial soil organisms are enhanced by the addition of Bio-fertilizer though it improves soil structure. Provision of the nutrient through the Bio-fertilizer sustains the fertility and moisture of soil (Bandara et al., 2019).

Considering the uses and values of *Aloe vera*, it is necessary to find out a suitable recommendation for *Aloe vera* fertilization. Therefore, the present study was carried out to determine the growth and yield of *Aloe vera* in response to different organic fertilizers or manures.

METHODOLOGY

The research was carried out from November 2019 to April 2020 in the crop farm. It is situated in Eastern University, Sri Lanka, with a latitude of 7° 43' N and a longitude of 81°42' E. This place falls under the agro ecological zone of low country dry zone (DL2b) at an altitude of 10 m above the mean sea level. Type of soil of this area is sandy regosol, mean annual rainfall is 1400 mm to 1680 mm and temperature is 30° to 36°C.

In this experimentation, black colour polybags of 30 cm diameter and 30 cm height were used. To drain excess water, four holes were made at the base of each of these polybags. Bags were filled with top soil leaving 5 cm from the top of the polybag.

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

Each pot was planted with one seedling. Plants were irrigated once a day in the evening. Fertilizers were applied according to the treatments. Jeewamirta was sprayed (570 l/ha) in liquid form at a two-week interval from the first week after transplanting until the destruction of the plants. Compost and cow dung were incorporated with soil in solid form at the rate of 10 tons/ha as basal application. Commercially available organic liquid fertilizer (Eco Green Plus) was sprayed (1 l/acre) three days, one month, two months and three months after transplanting as per the recommendation. Hand weeding was done in two-week intervals. 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

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

Treatments

Five treatments and four replications were arranged in Randomized Complete Block Design (RCBD) for this experiment.

Table 1: Treatments' code and description

Treatment code	Description
T1	Control (without fertilizers)
T2	Application of Compost (10 t/ha)
T3	Application of Cow dung (10 t/ha)
T4	Application of commercial organic liquid fertilizer (1 l/acre)
T5	Application of Jeewamirta (570 l/ha)

Before two days of transplanting, compost was added to polybags at the level indicated in the table above and completely incorporated with the soil. The compost was made up of vegetable waste, sawdust, locally available organic wastes, garden prune, and cow dung. Before two days of transplanting, cow dung was added to polybags and completely incorporated with the soil at the level indicated in the table above. Commercial organic fertilizer was diluted 160 times with water and applied for this experiment at a recommended level, as indicated in the table above, after three days, one month, two months, and three months of transplanting as field application. Prepared Jeewamirta was diluted ten times with water and applied for this experiment at a recommended level as indicated in the table above. From the first week after transplanting Jeewamirta was applied at a two-week interval until the destruction of the plants. Required liquid fertilizer (Eco Green Plus) 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 for better provision of the oxidative environment to contain microorganisms in the end product, which is favourable for microorganisms.

Measurements

Collection and preparation of sample

The plants were harvested 20 weeks after transplanting. The whole plants were carefully uprooted without damaging any roots by washing them in water and the measurements were taken.

The plants were washed to get rid of the foreign materials and dirt sticking to them. The spines in the leaves and the thick dark green outer skin (epidermis) were peeled out manually from the thick colourless parenchyma (or gel fillet) and were cut into small slabs with a stainless-steel knife. Those were stored in airtight container until the parameters were taken to avoid moisture loss and contamination.

Convective drying of Aloe vera samples

Quality of the *Aloe vera* is most affected by the drying temperature; therefore, the variation of nutritional qualities concerning temperature is considered here. The *Aloe vera* samples were loaded on the drying trays at a load density of 15 kg m^{-2}. The samples were dried at 70ºC. The drying process is ceased until no weight reduction or constant weight is attained.

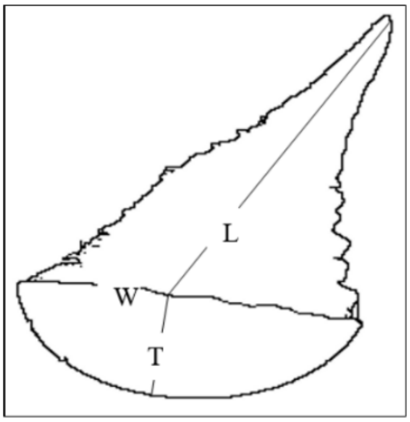

Fig. 1: Approximate geometry of Aloe vera leaf

The measurements (leaf length, leaf width, leaf thickness, total leaf weight, leaf skin weight, gel weight, leaf skin dry weight, gel dry weight, root weight, root dry weight and number of lateral roots) were taken after destructing the plant after the final harvest. Leaf length was measured using a meter ruler. Leaf width and leaf thickness were measured by a Vernier caliper (Yamayo, Model: 101-300, Japan). Leaf volume was calculated by the formula given by Sabat et al. (2018) as below:

$$\left[V = \frac{L}{12}\,\pi\,\mathrm{W}\,\mathrm{T}\right]$$

Where;
V= Leaf volume
L= Leaf length
W= Leaf width
T= Leaf thickness

The leaf with the highest volume is considered as the largest leaf of the plant. The number of lateral roots were counted. Leaf skin and the roots were cut into small pieces and they were dried at 105°C until a constant weight was gained by using the oven (Gemmy, Model: YCO-010, Taiwan). Leaf skin fresh and dry weight, gel dry weight, and weight of roots were measured using an electronic balance (Hanon, Model: FA2204, China). The moisture content was determined by using the method described in AOAC (1990). It was calculated by the formula given by Sabat et al. (2018) as below:

$$\left[\begin{aligned} &Moisture\ content(\%)\\ &= \frac{Weight\ of\ water\ present\ (g)}{Weight\ of\ dry\ matter\ present\ (g)} \times 100\end{aligned}\right]$$

Analysis of data

Data were statistically analysed by SAS 9.04 and the mean comparison within treatments was achieved by the Duncan Multiple Range Test at a 5 % significant level.

RESULTS AND DISCUSSION

Gel Parameter

Total gel dry weight

The data showed that the compost application had the highest total gel dry weight compared to control plants. The maximum total gel dry weight was in T2, after that T3, T4, T5, and minimum total gel dry weight was in T1 at 20 WAP.

This considerable rise of total gel dry weight because of the compost treatment to the T2. It may be due to compost increase soil fertility, cell division and cell elongation. This enhanced results due to the faster decomposition of organic manure. Compost increases protein synthesis by increasing the nitrogen availability and ultimately resulting more dry matter production, which was in agreement with Babalad (2005). The high amount of C in the compost provides agronomic and environmental benefits by improving the soil physical properties (Evanylo et al., 2008). Controlled but regulated supply of nutrients from compost increased N, P, and K uptake. It helps higher growth and yield in *Aloe vera*. A similar finding has been reported by Lucia (2014).

Total gel moisture content (DB)

There is no significant difference between treatments; by considering the mean value, maximum total gel moisture content was in T5 after that T3, T1, T2, and minimum total gel moisture content was in T4 at 20 WAP.

This rise of total gel moisture content is because of the treatment of Jeewamirta to the T5. Jeewamirta holds the water well and similar finding has been reported by Devakumar et al. (2014).

Leaf Parameters

Total leaf skin dry weight

The data showed that the compost application had the highest total leaf skin dry weight compared to control plants. The maximum total leaf skin dry weight was in T2, after that T3, T4, T5, and minimum total leaf skin dry weight was in T1 at 20 WAP.

This considerable rise of total leaf skin dry weight because of the compost treatment to the T2. It may be due to compost increase soil fertility, cell division and cell elongation. It may be due to compost increase soil fertility, cell division and cell elongation. This enhanced results due to the faster decomposition of organic manure. Compost increases protein synthesis by increasing the nitrogen availability and ultimately resulting more dry matter production, which was in agreement with Babalad (2005). Compost application build-up N in soil and it contribute to the surge of nitrates in those treatments over time (Hepperly et al., 2009). Similar results were observed by Lucia (2014) in Aloe vera.

Leaf thickness of the largest leaf

This data showed that the compost application had the highest leaf thickness of the largest leaf compared to control plants. The maximum leaf thickness of the largest leaf was in T2, after that T3, T5, T4, and minimum leaf thickness of the largest leaf was in T1 at 20 WAP.

This considerable rise of leaf thickness of the largest leaf is due to compost application to the T2. Compost provided better results due to increased cell division and elongation without hindering the nutrient uptake (Hasanuzzaman et al., 2008). A similar finding has been reported by Hasanuzzaman et al. (2008) and Patke et al. (2018).

Leaf width of the largest leaf

The data showed that the compost application had the highest leaf width of the largest leaf compared to control plants. The maximum leaf width of the largest leaf was in T2, after that T3, T4, T5, and minimum leaf width of the largest leaf was in T1 at 20 WAP.

This considerable rise in leaf width of the largest leaf is because of the compost treatment to the T2. Compost increase soil fertility, cell division, cell elongation and plant growth. A similar trend was observed by Hasanuzzaman et al. (2008) in Aloe vera. Hasanuzzaman et al. (2008) observed maximum leaf width (5.11 cm) by using cow dung. The minimum average leaf width was recorded in the control. This result was supported by Bates (1971) and Saha et al. (2005).

Total leaf skin weight

The data showed that compost and cow dung had the highest total leaf skin weight compared to control plants. The maximum total leaf skin weight was in T2, after that T3, T5, T4, and minimum total leaf skin weight was in T1 at 20 WAP.

This considerable rise in total leaf skin weight because of the compost treatment to the T2 and cow dung to T3. It may be due to compost increase soil fertility, cell division and cell elongation. This result was supported by the findings of Hasanuzzaman et al. (2008), Pichgram (1987) and Saha et al. (2005). Furthermore, a similar finding has been reported by Patke et al. (2018).

Leaf skin weight of the largest leaf

The data showed that compost and cow dung had the highest leaf skin weight of the largest leaf than control plants. The maximum leaf skin weight of the largest leaf was in T2, after that T3, T5, T1, and minimum leaf skin weight of the largest leaf was in T4 at 20 WAP.

This considerable rise of leaf skin weight of the largest leaf is due to the compost application to the T2 and cow dung to T3. It may be due to compost and cow dung increasing soil fertility, cell division and cell elongation. This result was supported by the findings of Hasanuzzaman et al. (2008), Pichgram (1987) and Saha et al. (2005). And similar finding has been reported by Lucia (2014) and Patke et al. (2018)

Leaf volume of the largest leaf

There is no significant difference between treatments; by considering the mean value maximum leaf volume of the largest leaf was in T2, after that T3, T5, T4, and the minimum leaf volume of the largest leaf was in T1 at 20 WAP.

This rise of leaf volume of the largest leaf is due to the compost treatment to the T2. Compost provided better results due to increased cell division and elongation without hindering the nutrient uptake (Hasanuzzaman et al., 2008).

Root Parameters

Total root fresh weight

The data showed that compost and cow dung had the highest total root fresh weight compared to control plants. The maximum total root fresh

Table 2: Growth and yield characters of *Aloe vera* in response to different organic fertilizers or manures.

Treatment	Total gel dry weight (g)	Total leaf skin dry weight (g)	Leaf thickness of the largest leaf (cm)	Leaf width of the largest leaf (cm)	Total leaf skin weight (g)	Total root fresh weight (g)
Control (T1)	0.1416 ± 0.0461c	0.4623 ± 0.0273c	0.9375 ± 0.1143b	2.5375 ± 0.3091c	33.09 ± 7.13b	10.01 ± 0.62b
Compost (T2)	0.5937 ± 0.1031a	2.4863 ± 0.3647a	1.4250 ± 0.0968a	4.1625 ± 0.3896a	80.66 ± 14.57a	17.01 ± 2.09a
Cow dung (T3)	0.4251 ± 0.0970b	1.6086 ± 0.3912b	1.2000 ± 0.0890ab	3.6750 ± 0.3256ab	78.38 ± 4.24a	14.86 ± 1.05a
Commercial organic fertilizer (T4)	0.2746 ± 0.0433bc	0.7271 ± 0.1666c	1.0125 ± 0.1008b	3.2250 ± 0.3660bc	38.12 ± 6.05b	9.68 ± 0.89b
Jeewamirta (T5)	0.2418 ± 0.0523c	0.6654 ± 0.1084c	1.0375 ± 0.0375b	3.2125 ± 0.1297bc	50.33 ± 5.16b	15.12 ± 1.54a
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 0.05 probability level according to DMRT.

Table 3: Growth and yield characters of *Aloe vera* in response to different organic fertilizers or manures

Treatment	Leaf skin weight of the largest leaf (g)	Total gel moisture content (DB) (%)	Leaf volume of the largest leaf (cm^3)	Number of total lateral roots	Total root dry weight (g)
Control (T1)	8.23 ± 1.82b	44173.65 ± 6192.53	18.06 ± 6.07	14.25 ± 1.93	0.4083 ± 0.0283
Compost (T2)	20.33 ± 4.20a	36208.96 ± 10336.09	58.34 ± 12.75	20.25 ± 1.65	0.9650 ± 0.3241
Cow dung (T3)	19.39 ± 1.28a	44358.73 ± 8181.69	38.50 ± 2.36	16.00 ± 3.58	0.7546 ± 0.1434
Commercial organic fertilizer (T4)	7.94 ± 1.08b	31842.07 ± 4229.70	24.97 ± 4.52	15.25 ± 2.17	0.4526 ± 0.1004
Jeewamirta (T5)	11.60 ± 1.52b	51730.35 ± 11870.43	27.01 ± 2.30	11.75 ± 1.80	0.6558 ± 0.0982
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 0.05 probability level according to DMRT.

weight was in T2, after that T5, T3, T1, and minimum total root fresh weight in T4 at 20 WAP.
This considerable rise of total root fresh weight because of the compost treatment to the T2, cow dung to T3 and Jeewamirta to T5. It may be due to Jeewamirta having the highest bacterial and actinomycetes population, which promotes root growth and root development (Fazeel et al., 2019). Compost increases total porosity and changes the distribution of pore sizes in soils (Celik et al., 2017). Maximum root fresh weight (9.8 g) was observed by Saha et al. (2005) in *Aloe vera*.

Total root dry weight

There is no significant difference between treatments; by considering the mean value, the maximum total root dry weight was in T2 after that T3, T5, T4, and minimum total root dry weight was in T1 at 20 WAP. This rise of total root dry weight because of the compost treatment to the T2. Compost increases total porosity and changes the distribution of pore sizes in soils (Celik et al., 2017). Furthermore, it may be due to compost positively responsive with a higher amount of compost.

Number of total lateral roots

There is no significant difference between treatments; by considering the mean value maximum number of total lateral roots was in T2 after that T3, T4, T1, and the minimum number of total lateral roots was in T5 at 20 WAP.
This increase in the number of total lateral roots is due to the compost application to the T2. It may be due to compost providing the essential nutrient which resulted the maximum cell growth. Compost increases total porosity and changes the distribution of pore sizes in soils (Celik et al., 2017).

CONCLUSIONS

Aloe vera has a strong demand in both national and international markets due to its uses and values and it is more responsive to nutrients. Organic fertilizer plays an important role in increasing production, improving quality and sustaining soil fertility and organic matters can be used as growing media. Therefore *Aloe vera* is tested with different organic fertilizers or manures in this study. In almost all the growth and yield parameters showed a significant increase by compost (T2) and cow dung (T3) treatments compared to other treatments. In those significant parameters, between compost (T2) and cow dung (T3) treatments were shown non-significance in total leaf skin weight, total root fresh weight and leaf skin weight of largest leaf. Therefore, considering the growth parameters, yield parameters, and especially economic important parameter (gel dry weight) compost and cow dung could be recommended to enhance the growth and yield in the cultivation of *Aloe barbadensis*.

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