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Research article

Liquid organic fertilizers for growth enhancement of *Abelmoschus esculentus* (L.) Moench and *Alternanthera sessilis* (L.) DC.

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Abstract: In the present study the influence of foliar application of liquid organic fertilizers on the growth performance of two popular vegetables *Abelmoschus esculentus* (L.) Moench and *Alternanthera sessilis* (L.) DC. was investigated. Six liquid fertilizers (F_1; poultry manure + *Tithonia diversifolia*, F_2; poultry manure + *Gliricidia. sepium*, F_3; poultry manure + *Leucaena leucocephala*, $F_{4;}$ fish waste + *Tithonia diversifolia*, F_5; fish waste + *Gliricidia sepium*, F_6; fish waste + *Leucaena leucocephala*) were formulated using leaves of the above plants, animal wastes, coconut husk ash and potable well water in weight proportion of 4: 2: 1: 60. Allowing six weeks for the decomposition, the extracts were filtered and the nutrient contents were determined using standard analytical procedures. The highest nutrient containing F_1, F_2 and F_4 were selected for the application on *A. esculentus* and *A. sessilis*. Individuals of the plants were separately sprayed with undiluted fertilizers, as well as with 50% and 25% strengths of the liquid fertilizers diluted with well water. Plants spayed with well water only and commercial liquid fertilizer were served as the control and the standard respectively. The selected fertilizers significantly ($p<0.05$) increased the growth and yield of both plant species. Compared with the control, F_1 recorded the highest number of fruits per plant of *A. esculentus*, while F_2 produced the highest fresh weight biomass per *A. sessilis* plant. These findings suggested that the foliar application of F_1 and F_2 can be used effectively to improve crop productivity of *A. esculentus* and *A. sessilis* respectively. The undiluted mixtures of F_1, F_2 and 25% diluted F_4 were the best strengths for growth enhancement of *A. esculentus*, whereas the undiluted F_1, F_2 and F_4 may be considered as the best strengths for growth improvement of *A. sessilis*.

Keywords: Okra - Sessile joyweed - Foliar application - Crop yield.

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INTRODUCTION

The indiscriminate use of synthetic chemical fertilizers in modern agriculture results in adverse effects on the environment, pollute agricultural products and affects human health. Hence, fertilization must be done in a proper way to protect the sustainability of the ecosystems. This suggests the need to search for new approaches of fertilization which is inexpensive, easy-to-use, effective and environmental friendly. The basis of sustainable agriculture is the use of locally produced and low cost biomass resources to rebuild and maintain the soil productivity. Proper processing and recycling of organic wastes for agriculture can greatly reduce the environmental pollution. And also it is a solution for the increasing cost of chemical and synthetic fertilizers. Improved public health and conservation of resources are the additional benefits of organic fertilizers (Kurdali & Shamma'a 2010).

Soil application is the most common method to supply essential nutrients for the plants which can cause harmful effects on soil microorganisms as well as on fertility of soil in general. In view of these reasons, an alternative method was required to fulfill the nutrient requirements of plants. So, the research on foliar fertilization was started (Fageria *et al.* 2009). Researchers later proved that the higher plants can also absorb mineral nutrients when applied as foliar sprays in appropriate concentrations. Although it has some

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disadvantages, under certain circumstances foliar application is most effective method to overcome plant nutritional disorders. It is now known that the foliar fertilization can effectively eliminate the deficiency symptoms within less time than soil fertilization (Fageria *et al.* 2009).

Abelmoschus esculentus (L.) Moench (Okra/Ladies finger), a member of the Family: Malvaceae is a common vegetable as well as a plant used in indigenous medicine and *Alternanthera sessilis* (L.) DC. (Amaranthaceae) is a prostrate herb and widely used as a leafy vegetable in most Asian countries. According to the traditional practices of fertilization, a wide range of plant species can be used as a low cost source to formulate environmental friendly liquid organic fertilizers (LOFs) to improve the growth and productivity of crop/ornamental plants. There are large amount of scientific research which has directly investigated the impacts of *G. sepium* and *T. diversifolia* as nutrient sources (Gunapala & Amarasiri 1989, Heenkende *et al*. 2011). Akande *et al*. (2010) have stated that application of organic fertilizer; poultry manure, *Gliricidia* leaves and inorganic fertilizer enhance the growth and development of *A. esculentus* compared to untreated controls. The green biomass of *T. diversifolia* was recognized as a high nutrient-rich and effective nutrient source for low land rice and maize (Akanbi *et al.* 2007). Because of poultry manure's high nitrogen content, it has long been recognized as one of the most desirable manures to be used in the fertilization of crops (Maraikar 1996). This research study was an effort to formulate low cost, environmental friendly LOFs to enhance the growth and yield of *A. esculentus* and *A. sessilis* particularly in home gardening and urban agriculture.

MATERIALS AND METHODS

Tithonia diversifolia (Asteraceae), *Gliricidia sepium* (Fabaceae) and *Leucaena leucocephala* (Fabaceae), were selected, as they are known as nutrient-rich green manure used in traditional agriculture in Sri Lanka. Poultry manure and fish waste (heads, fins, bones, gills and inner parts) were selected, as they are used and valued as nutrient-rich animal wastes. Coconut husk ash was added mainly to supply potassium.

Formulation of different LOF combinations

To prepare different LOFs, the following combinations were selected: F_1; poultry manure + *T. diversifolia,* F_2; poultry manure + *G. sepium,* F_3; poultry manure + *L. leucocephala,* F_4; Fish waste + *T. diversifolia,* F_5; fish waste + *G. sepium,* F_6; fish waste + *L. leucocephala*. In each mixture, 360 g of fresh green leaves, 240 g of air dried poultry manure or fresh fish waste and 100 g of coconut husk ash were mixed with 6.0 L of potable well water in closed plastic containers stirred with a wooden stick and aerated for two hours daily to facilitate decomposition. After six weeks of decomposition, undiluted extracts were filtered using a cotton cloth and subjected to nutrient analysis.

Nutrient analysis of extracts

Total nitrogen (N) contents were determined by Kjedahl method (Bennabi *et al*. 2013) and phosphorus (P) by molybdovanadate method as described by Possingham & Obbink (1971). For the determination of Potassium (K), calcium (Ca), magnesium (Mg) and iron (Fe) contents, dry ashing was done at 500°C as described by Enders and Lehmann (2012) and were determined by atomic absorption spectrophotometry (GBC – Aventa 932B plus) at the Industrial Technology Institute, Colombo, Sri Lanka. The potable well water used for the fertilizer formulation and dilution was also analyzed for the presence of heavy metals by graphite furnace atomic absorption spectrophotometry (Model: Analytik Jena 400p). Based on the highest nutrient levels, the best LOFs were selected for foliar application.

Application of selected LOFs on A. esculentus

Seeds of *A. esculentus* (Cultivar : Haritha) spaced at 90 cm between two plants were sown in rows according to the recommendation given by Department of Agriculture in a completely randomized block design with five replicates in the soil beds. The experimental site was located in Kurunegala district, Sri Lanka, which has mean annual rainfall of 2000 ml, mean monthly temperature range from 30–37°C, and mean annual relative humidity of 70%. Water was supplied every other day to maintain the moisture level of the soil. Five milliliters of LOF was sprayed between 08.00–09.00 h once a week for two-week period, and then 15 ml of LOF was sprayed once a week during the next two weeks followed by spraying of 20 ml of LOF for the next four weeks on each plant as the plant grow. The plants in control beds were sprayed only with same volumes of well water and the growth parameters were compared with a standard treatment of a commercially available LOF "Maxicrop" which was diluted with potable well water as per the instructions before spraying. When plants were three months old (ripe fruits are available), shoot height, number of flowers, stem circumference, number of fruits, fruit weight and leaf area were measured to determine the best LOF for *A. esculentus*. Another experiment was carried out to determine the best strength of the prepared LOFs for foliar application in which the selected LOFs were diluted into 50% [F(50)] and 25% [F(25)] with potable well water for application on the plants, and the undiluted extract [F(U)] was also applied similarly.

Application of selected LOFs on A. sessilis

Healthy leaf cuttings with 6–8 leaves of *A. sessilis* (Cultivar: Piliyandala) were transplanted in polybags (height and diameter each of 20 cm) filled with 750 g of garden soil. The plants were watered every other day to keep the soil moist. The polybags were laid out in a completely randomized block design with five replicates. As described above for *A. esculentus*, five milliliters of F(U), F(50) and F(25) of each LOF was sprayed once a week for a period of two months. The data were collected on length of the plant, number of branches, number of internodes, plant fresh weight and leaf area after a growth period of six weeks. The control plants were sprayed with potable well water and the growth parameters were compared with the standard treatment of Maxicrop.

Statistical analysis

Comparison of measured growth parameters over time with different treatments was performed by one way analysis of variance followed by Tukey's pair wise comparison tests using MINITAB 16 statistical software.

RESULTS

Reference to table 1, the highest nitrogen (N), phosphorus (P), calcium (Ca) and iron (Fe) concentrations were detected in the standard (Maxicrop), with the exception of potassium (K) and magnesium (Mg). Of all the formulated LOFs, the highest N levels were observed in the F_2 (1678.9 mgL^{-1}) followed by F_5 (1564.6 mgL^{-1}). The highest P (675.1 mgL^{-1}) and K (1924.4 mgL^{-1}) concentrations were observed in the F_1 combination, whereas the K content was significantly higher than that of K of the standard (1373.3 mgL^{-1}). Although F_4 contain the highest P content, it is much lower than that of the standard (831.8 mgL^{-1}). Of all the formulated LOFs, the highest Mg (169.1 mgL^{-1}), Ca (170.6 mgL^{-1}) and Fe (137.3 mgL^{-1}) levels were observed in the F_1 mixture. However, Mg concentration of F_1 was considerably higher than that of the standard (134.8 mgL^{-1}). The levels of cadmium, lead, zinc and copper of the well water used were below the detection limits.

Table 1. The nutrient levels of the formulated liquid organic fertilizers (Results are means of duplicate values and are in mg/L).

Fertilizer	N	P	K	Mg	Ca	Fe
F_1	1465.3	675.1	1924.4	169.1	170.6	137.3
F_2	1678.9	612.3	1120.9	108.5	157.5	124.0
F_3	1265.5	573.3	1047.3	117.4	82.3	87.3
F_4	1454.2	649.4	1834.5	151.9	149.3	121.7
F_5	1564.6	548.8	1028.8	113.2	103.1	112.5
F_6	1297.4	512.4	908.8	105.3	106.8	105.8
Standard	2876.4	831.8	1373.3	134.8	231.5	208.5
Control	87.5	99.4	237.3	58.8	61.2	21.5

Note: F_1; poultry manure + *T. diversifolia*, F_2; poultry manure + *G. sepium*, F_3; poultry manure + *L. leucocephala*, F_4; Fish waste + *T. diversifolia*, F_5; fish waste + *G. sepium*, F_6; fish waste + *L. leucocephala*.

Foliar application of different LOFs significantly influenced the growth performance of *A. esculentus* ($P<0.05$). Although the highest leaf area was observed with the standard, plants treated with F_1 possessed the highest values for all the other growth parameters, but were not significantly different from the standard (Table 2).

Table 2. Effect of selected liquid organic fertilizers on the growth performance of *A. esculentus**.

Growth parameter	F_1(U)	F_2(U)	F_4(U)	Standard	Control
Shoot height (cm)	152.6 ± 3.4^a	121.2 ± 4.8^b	138.4 ± 7.5^{ab}	152.0 ± 2.6^a	90.4 ± 6.6^c
Number of flowers	43.0 ± 1.8^a	23.0 ± 2.9^b	18.0 ± 1.5^b	43.0 ± 1.3^a	15.0 ± 5.3^c
Stem circumference (cm)	5.3 ± 0.9^a	4.2 ± 0.7^b	4.7 ± 0.8^b	5.2 ± 0.9^a	2.7 ± 0.5^c
Number of fruits/plant	38.0 ± 1.2^a	21.0 ± 1.3^b	15.0 ± 1.6^b	40.0 ± 1.6^a	13.0 ± 1.2^c
Leaf area (cm^2)	295.2 ± 1.4^b	306.2 ± 1.5^a	307.6 ± 1.1^a	309.2 ± 1.2^a	260.6 ± 2.7^c
Fruit weight (g)	47.7 ± 2.1^a	24.8 ± 1.6^c	27.1 ± 1.9^c	39.6 ± 1.3^b	24.8 ± 1.3^d

Note: * Values are means of five replicates ± standard error; Means with the same letter in a row are not significantly different at $p<0.05$, F_1; poultry manure + *T. diversifolia*, F_2; poultry manure + *G. sepium*, F_4; Fish waste + *T. diversifolia*, F_1 (U) - undiluted F_1, F_2 (U) - undiluted F_2, F_4 (U) - undiluted F_4

Table 3a, b, c. Effect of three strengths of the selected liquid organic fertilizers on the growth performance of *A. esculentus**.

Treatment	Shoot height (cm)	Number of flowers	Stem circumference (cm)	Number of fruits/plant	Leaf area (cm^2)	Fruit weight (g)
(a) *Effect of three strengths of the F_1 on the growth performance of A. esculentus*						
F_1 (U)	152.6 ± 3.3^a	43.0 ± 1.8^a	5.3 ± 0.9^a	38.0 ± 1.2^a	295.2 ± 1.3^a	47.7 ± 2.1^a
F_1 (50)	178.8 ± 3.8^b	26.0 ± 1.5^b	4.9 ± 0.9^b	21.0 ± 1.6^b	299.4 ± 1.1^a	44.0 ± 1.6^b
F_1 (25)	140.8 ± 8.3^a	24.0 ± 1.4^b	3.5 ± 0.6^b	22.0 ± 1.4^b	293.1 ± 0.8^a	29.3 ± 2.1^c
(b) *Effect of three strengths of the F_2 on the growth performance of A. esculentus*						
F_2 (U)	121.2 ± 4.8^b	23.0 ± 2.9^b	4.2 ± 0.7^c	21.0 ± 1.3^c	306.2 ± 1.5^b	24.8 ± 1.6^d
F_2 (50)	116.4 ± 4.8^c	18.0 ± 2.1^{bc}	4.7 ± 0.8^c	16.0 ± 2.0^d	305.8 ± 0.8^c	20.3 ± 1.5^{de}
F_2 (25)	125.0 ± 2.6^c	16.0 ± 1.3^c	3.8 ± 0.7^c	13.0 ± 1.2^d	298.8 ± 0.7^c	17.8 ± 1.1^e
(c) *Effect of three strengths of the F_4 on the growth performance of A. esculentus*						
F_4 (U)	138.4 ± 7.5^d	18.0 ± 1.5^d	4.7 ± 0.8^d	15.0 ± 1.6^{2e}	307.6 ± 1.0^d	27.1 ± 1.9^f
F_4 (50)	136.2 ± 7.5^d	24.0 ± 2.8^d	3.2 ± 0.5^e	23.0 ± 1.8^e	308.1 ± 1.1^d	17.7 ± 1.7^g
F_4(25)	124.8 ± 7.76^d	24 ± 1.63^d	4.0 ± 0.75^e	21.0 ± 1.8^e	302.2 ± 0.8^d	15.3 ± 1.8^g
Standard	152.0 ± 2.6	43.0 ± 1.3	5.2 ± 0.9	40.0 ± 1.6	309.2 ± 1.2	39.6 ± 1.3
Control	90.4 ± 6.6	15.0 ± 5.4	2.7 ± 0.5	13.0 ± 1.3	260.6 ± 2.7	24.8 ± 1.3

Note: *Values are means of five replicates ± standard error; Means with the same letter in a column are not significantly different at p<0.05, F_1; poultry manure + *T. diversifolia,* F_2; poultry manure + *G. sepium,* F_4; Fish waste + *T. diversifolia,*

In order to determine the best strength of F_1 fertilizer, two dilutions were made with well water, and the results obtained revealed that the treatments significantly affected the growth performance of *A. esculentus* (P<0.05) (Table 3a). F_1(U) treatment produced plants with significantly higher number of fruits, flowers, shoot diameter and fruit weight compared with F_1(50) and F_1(25). The highest shoot diameter and leaf area values were obtained with F_1(50). Application of the three strengths of F_2 also significantly influenced the growth of *A. esculentus.* The standard maxicrop treatment had a significant influence on most of the growth parameters except the shoot diameter (Table 3b). Application of F_2(U) produced plants with the highest number of fruits, fruit weight and number of flowers. The highest shoot diameter and shoot height were obtained with the treatment of F_2(50) and F_2(25) respectively. The effects of the three strengths of F_4 fertilizer on the growth performance of *A. esculentus* are presented in table 3c. Among the three strengths, the highest values were observed in the plants treated with the F_4(U), and the results were significantly different from those obtained with the standard treatment. According to the Tukey's pair wise comparison, the F_4(U) values for the number of fruits, shoot height, number of flowers, stem circumference and leaf area were not significantly different from the F_4(50) and F_4(25) except the fruit weight.

Another experiment was conducted to determine the best LOF for the growth enhancement of *A. sessilis.* As evident from table 4, F_2(U) treatment recorded significantly higher values for plant length, leaf area, plant fresh weight and number of branches. The number of internodes was not much affected with the fertilizer treatments. Treatment with the three different strengths of F_1 had a positive impact on plant length and plant fresh weight of *A. sessilis* (Table 5a). However, significant differences in growth parameters were not observed with the application of three different strengths of F_1.

Table 4. Effect of selected liquid organic fertilizers and the standard on the growth performance of *A. sessilis**

Growth parameter	F_1(U)	F_2(U)	F_4(U)	Standard	Control
length of plant (cm)	37.0 ± 2.0^b	45.4 ± 2.5^a	35.4 ± 1.8^b	41.4 ± 1.5^{ab}	26.2 ± 1.1^c
Number of internodes	7.0 ± 0.5^{ab}	8.0 ± 0.5^a	7.0 ± 0.5^{ab}	9.0 ± 0.3^a	5.0 ± 0.5^b
Number of branches	9.0 ± 0.4^{bc}	13.0 ± 0.7^a	8.0 ± 0.8^{bc}	9.0 ± 0.6^b	7.0 ± 0.4^c
Leaf area (cm^2)	5.9 ± 0.2^b	7.3 ± 0.1^a	6.3 ± 0.1^b	7.3 ± 0.1^a	4.7 ± 0.1^c
Plant fresh weight (g)	9.6 ± 0.2^b	11.6 ± 0.3^a	9.2 ± 0.1^b	10.6 ± 0.2^b	5.4 ± 0.2^c

Note: *Values are means of five replicates ± standard error; Means with the same letter in a row are not significantly different at p<0.05. F_1 (U) - undiluted F_1, F_2 (U) - undiluted F_2, F_4 (U) - undiluted F_4

Shown in table 5(b) are the results obtained with three different strengths of the F_2 fertilizer. As can be seen, F_2 recorded a significant effect on plant length, number of internodes, number of branches, fresh weight and leaf area of *A. sessilis* (p<0.05). Among the three different strengths of F_2, the highest values were observed with the F_2(U) treatment, where a significantly higher fresh weight was observed than that with the other two strengths. The growth of *A. sessilis* enhanced in general as the strength of the F_4 increased (Table 5c). Application of F_4(U) produced plants with the highest length, number of internodes and number of branches, fresh weight and leaf area.

Table 5a, b, c. Effect of three strengths of selected liquid organic fertilizers on the growth performance of *A. sessilis**

Treatment	length of plant (cm)	Number of internodes	Number of branches	Leaf area (cm^2)	Plant fresh weight (g)
(a) *Effect of three strengths of F_1 on the growth performance of A. sessilis*					
F_1 (U)	37.0 ± 2.0^a	7.0 ± 0.5^a	9.0 ± 0.4^a	5.9 ± 0.2^a	9.6 ± 0.2^b
F_1 (50)	34.8 ± 1.3^a	7.0 ± 0.6^a	13.0 ± 0.7^a	5.4 ± 0.2^{ab}	8.1 ± 0.1^{ab}
F_1 (25)	32.6 ± 1.1^a	6.0 ± 0.5^a	8.0 ± 0.7^a	4.7 ± 0.14^b	7.4 ± 0.18^b
(b) *Effect of three strengths of F_2 on the growth performance of A. sessilis*					
F_2 (U)	45.4 ± 2.5^b	8.0 ± 0.5^b	13.0 ± 0.7^a	7.3 ± 0.1^c	11.6 ± 0.3^a
F_2 (50)	39.8 ± 1.8^{bc}	7.0 ± 0.3^b	10.0 ± 1.0^b	5.5 ± 1.2^c	9.9 ± 0.2^b
F_2 (25)	37.0 ± 2.2^c	7.0 ± 0.6^b	9.0 ± 0.7^{bc}	6.3 ± 0.3^c	6.8 ± 0.2^c
(c) *Effect of three strengths of F_4 on the growth performance of A. sessilis*					
F_4 (U)	35.4 ± 1.8^d	7.0 ± 0.5^d	8.0 ± 0.8^d	6.3 ± 0.1^d	9.2 ± 0.1^b
F_4 (50)	31.8 ± 1.4^d	6.0 ± 0.5^d	8.0 ± 0.5^d	5.6 ± 0.1^e	7.6 ± 0.1^a
F_4(25)	30.0 ± 1.5^d	7.0 ± 0.4^d	7.0 ± 0.7^d	5.2 ± 0.1^e	6.5 ± 0.2^b
Standard	41.4 ± 1.5	9.0 ±0.3	9.0 ± 0.6	7.3 ± 0.1	10.6 ± 0.3
Control	26.2 ± 1.2	5.0 ± 0.5	7.0 ± 0.4	4.7 ± 0.1	5.4 ± 0.2

Note: *Values are means of five replicates ± standard error; Means with the same letter in a column are not significantly different at $p<0.05$, F_1; poultry manure + *T. diversifolia*, F_2; poultry manure + *G. sepium*, F_4; Fish waste + *T. diversifolia*

DISCUSSION

This study attempted to formulate liquid organic fertilizers (LOFs) using widely available terrestrial plants, animal manure, fish waste and coconut husk ash and test the efficacy of the formulated LOFs on the growth performance of *A. esculentus* and *A. sessilis* plants. The plant materials used to formulate the LOFs were *T. diversifolia*, *G. sepium* and *L. leucocephala* leaves. *T. diversifolia* leaves were decomposed faster than the other two types of leaves, due to the lower content of lignin (6.5%) and polyphenols (1.6%) in *T. diversifolia* leaves (Olabode *et al.* 2007). The rate of decomposition of *L. leucocephala* leaves was very low, probably due to the presence of high amounts of lignified tissues. Based on the nutrient levels present, F_1, F_2 and F_4 LOFs were selected as the best fertilizer mixtures for the foliar application. F_1 and F_4 recorded the highest K contents probably due to the high K levels present in *T. diversifilia* leaves as recorded by Nagarajah & Amarasiri (1977).

The highest nitrogen contents were observed in the fertilizer mixtures which contained *G. sepium* leaves confirming the findings of Renuka & Wijesundara (2013). The use of *G. sepium*, a member of the nitrogen fixing plant family, Fabaceae as a green manure is well known. According to the results obtained for *A. esculentus*, the highest number of fruits, shoot height, stem circumference, fruit weight and the number of flowers were observed in the plants treated with F_1, but the highest leaf area was observed in the F_4 treated plants due to the higher nitrogen content of the F_4 fertilizer combination (Table 1). The higher K levels present in the F_1 fertilizer resulted in the increase in flower and fruit formation, suggesting the F_1 combination to be the best fertilizer to enhance the fruit production of *A. esculentus.* In agreement with our results, increase in plant growth and fruit quality of *A. esculentus* by the application of liquid sea weed fertilizer has already been observed by Zodape *et al*. (2008), with the application of F_1 fertilizer. The current results are also in agreement with the findings of Ademiluyi (2012), where the application of high amounts of *T. diversifolia* in to the soil resulted in higher vegetative and reproductive growth, suggesting the presence of the required nutrients in correct proportion in *T. diversifolia* leaves. Taking all growth parameters observed in to consideration, the F_1(U) was selected as the best performing fertilizer for *A. esculentus.* The values observed for most of the growth parameters with F_2 (U) were higher than the F_2 (50) and F_2 (25) treatments suggesting the F_2 (U) to be the best strength for the application on *A. esculentus.* Both the F_4 (U) and F_4 (50) were performed in a more or less similar manner. Therefore in terms of cost effectiveness the F_4 (50) fertilizer mixture could be recommended for the growth enhancement of *A. esculentus.*

As recorded by Mahaliyana *et al*. (2016), 2N: P: 2K fertilizer ratio is the best combination for *A. sessilis* to obtain optimum growth performance in agriculture. Confirming the results obtained by Mahaliyana *et al.* (2016), the highest growth performance of *A. sessilis* was observed in this study with the application of F_2 fertilizer containing N: P: K in a similar ratio. Therefore it can be concluded that F_2 fertilizer to be the best LOF for *A. sessilis*. The undiluted liquid fertilizer of F_1, F_2 and F_4 was the best strength for growth enhancement of *A. sessilis.*

To formularize the general usage of the tested LOFs for *A. esculentus* and *A. sessilis*, further in-depth studies are required as crop productivity is also dependent on agro climatic zones and microhabitats. Further studies should also be conducted on the presence of any pathogenic microorganisms and sterilization of the prepared LOFs using low cost technologies, e.g. steaming before foliar application.

CONCLUSION

Application of leaf-based liquid manures containing plant extracts in organic farming is both effective and ecologically sustainable method of supplying additional nutrients to crop plants with an appropriate, low cost level of technology to suit the circumstances of most families. The results obtained in this study are suggestive of the possibility of using *T. diversifolia*, *G. sepium*, *L. leucocephala*, poultry manure, fish waste and coconut husk ash in combination can be used for the effective formulation of LOFs that can be used as environmental-friendly alternative to chemical fertilizers to increase the growth performance of *A. esculentus* and *A. sessilis.* Out of the three fertilizer combinations tested, F_1 proved to be the best LOF for *A. esculentus*, whereas F_2 proved to be the best LOF for *A. sessilis*. F_1 and the standard 'Maxicrop" showed more or less similar performance. The undiluted F_1, F_2 and F_4(50) may be used as the best strengths of eco-friendly natural organic fertilizers to effectively increase the growth and yield of *A. esculentus* while the undiluted F_1, F_2 and F_4 seems to be the best strengths for *A. sessilis*. The findings of the present study indicate that the prepared fertilizers have a great potential to enhance the growth and yield of *A. esculentus* and *A. sessilis*.

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