DOI: https://doi.org/10.4038/agrieast.v17i1.120 *AGRIEAST 2023 Vol.17 (1): 42-53*

Formulation and efficacy testing of vermi-tea based liquid organic fertilizers on green-amaranth (*Amaranthus viridis* L.) for home gardens

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Abstract

Sudden food shortage due to strict green agriculture policy, economic crisis, COVID pandemic situation instruct the importance of home level organic production of good quality fruits and vegetables. Therefore, an experiment was conducted to test the efficacy of organic liquid fertilizers formulated from fish, livestock's and plant wastes on leafy vegetable green Amaranth to promote home gardening. The liquid fertilizer was tested on Amaranth grown separately in vemicompost and garden compost. The 7 kg capacity pots were filled with two media (medium 1: vemicompost; medium 2: garden compost) and arranged in CRD with four replicates with each medium. Five plants of green-amaranth per pot were planted and treated with fish emulsion + vermi-tea (1:4=T1), cow urine + vermi-tea (1:4=T2), three leaves [Neem+ Giliricidia+ Candle bush] solution + vermi tea (3:1=T3), vermi tea (T4) and control (T5) at the rate of 50 mL/pot on 2nd, 4th and 6th week after planting. Agronomic and yield data were collected and subjected to ANOVA using SAS. Tukey's HSD multiple comparison test and PROC CORR was used to determine the best treatment combination at P <0.05. The results revealed that there was significant difference in N, P and K content of the treatments tested. The plant height, leaf area, number of leaves, root shoot ratio was significantly higher in fish emulsion + vermi-tea (1:4) [T1] and cow urine + vermi-tea [T2] at 8th weeks after planting in vermi-compost medium. There was strong and positive correlation (R^2 > 0.8) among yield parameters, and root: shoot ratio with N, P K content of the liquid fertilizers tested in vermi-compost medium. Therefore, this investigation concludes that the fish emulsion + vermi-tea (1:4) and cow urine + vermi-tea (1:4) are good combination to use as liquid fertilizer at the rate of 50mL/Pot to get best yield in vermi-compost medium.

Key words: *Cow urine, Fish emulsion, Green-amaranth, Three leaves solution, Vermi-tea*

Introduction

Malnutrition is a major public health challenge, especially in South Asian developing countries (Akhtar, 2016). The

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Received: 06.05.2023

Accepted: 22.06.2023

fast-growing global population, the unequal supply of secure food among the global population and the prevailing long pandemic situation would be the suspected causes for increased malnutrition which is going to affect many millions of people, especially in developing nations. A recent report says the malnutrition percentage in Sri Lanka varies from 21 - 67%, depending on the age group and socio-economic status, but there is no clear data on that (Damayanthi *et al.*, 2018). Apart from malnutrition, anemia among Sri Lankan children and pregnant women are another problem for health sector professionals (Amarasinghe *et al.*, 2017). Moreover, current economic crises of Sri Lanka would also worse the situation of the vulnerable groups due to the shortage of nutritional foods and their prices will make them unaffordable. Home-based production of organic fruits and vegetables would be an alternate and sustainable solution to overcome the issues.

Green amaranth (*Amaranthus viridis* L.) is an annual herb belonging to family Amaranthaceae and widely grown in Sri Lanka as an important leafy vegetable due to its rich source of Ca 330 mg/100 g, Fe 18.2, Mg 1842, P 52, K 3460, Na 108, Zn 10, Cu 300, Mn 8, Se 1.98 and Cr 0.92 mg (Sharma *et al.*, 2012). Moreover, green amaranth leaves and seeds have higher amount of antioxidants and other phytochemicals which are highly exploited in traditional Ayurvedic medicine as an antidote to many chronic diseases, therefore, the medical professionals prescribed green amaranth to be included in daily diet to meet the daily nutritional requirement (Sarker and Oba, 2019; Kumari *et al.*, 2018). Due its fast growth rate, short lifecycle (35-45 days), low space requirement for required production and high photosynthetic yield potential (C4-plant), high seed production and germination percentage, can be easily cultivated anywhere such as field, home garden, urban garden, vertical garden, soil less medium, and even as forage crop too for animals (Leukebandara *et al.*, 2015).

Due to the prevailing economic crisis, the formulation of nutritionally superior organic solid and liquid fertilizers would be an alternate to synthetic chemicals to save out going dollars. Nitrogen, phosphorous, potassium, calcium, and growth-promoting rhizobacteria rich in Vermi tea, fish emulsion from fish wastes, fermented cow urine, plant leave solution made from different plants and are being considered as the accessible and affordable liquid fertilizers made locally for organic home gardens. Many research reports evidenced that liquid collected after the passage of water through earthworm compost called Vermi tea which is rich in nutrients and plays an important role in plant growth and development, contribute to initiation of rooting, root growth, increase the soil organic matter and also preserve the environmental quality (Shivsubramanian and Ganeshkumar, 2004).

The fishing sector produces large amounts of waste in fish markets and processing industries (López-Mosquera *et al.*, 2011). Fish remains have also been traditionally used as fertilizer, given their wealth of nutritive elements (principally N and P) and their rapid decomposition. Nearly 75% of the total weight of the fish was generated as solid waste in the form of gut, head, skin, bones, fins and frames after processing. The fish wastes rich in nitrogen, potassium, phosphorus and trace minerals (Ghaly *et al.*, 2013) can serve as raw material. Fish emulsion is a liquid by-product of the fish meal (Abbasi, 2006).

The foliage of *Gliricidia sepium* has higher nutritional compositions as well as antifungal and antimicrobial properties (Lakmini *et al.*, 2012; Peiris *et al.*, 2015). Moreover, Gliricidia use as green leaf manure for increase soil fertility because it is rich in Nitrogen-2.4% (Kumar *et al.*, 2013). Candle bush (*Cassia alata*) plant under Leguminosae family (Oladeji *et al.*, 2020). Neem manure increases the nitrogen and phosphorous content in the soil (Lokanadhan *et al.*, 2012).

Liquid fertilizers are highly effective as they can absorb by aerial parts of the plants as well as roots. Moreover, liquid fertilizers save the spaces to store, and even can store indoors in urban apartments where the spaces are limited. Therefore, his research study was conducted to test the efficacy of vemi-tea based liquid fertilizers on the agronomic characteristics and productivity of the *A. viridis* while recycling bio-waste generated from agriculture, industries, forests in rural and urban areas lead to nutrient loss, environmental pollution and health risks (Yuvaraj *et al.*, 2021).

Materials and Methods

Experimental Location

The field experiment was carried out at the model organic home garden in the Faculty of Agriculture, and laboratory studies were carried out in laboratories of the Faculties of Agriculture and Technology, University of Jaffna, Kilinochchi, Sri Lanka.

Collection of garden compost and vermicompost

Vermicompost and garden compost were obtained from the integrated vemi, mushroom and home garden training unit of the Faculty of Agriculture located 9.317283 latitude, 80.400279 longitude.

Preparation of liquid fertilizers

Fish emulsion was prepared using fish waste collected from a single fish market at the Kilinochchi district. Fish waste was chopped and bones were removed. Fish waste (500 g) was mixed with 1.5 kg of saw dust and 50 g of brown sugar. Five liters of distilled water was added to the mixture and was allowed for fermentation in a cool, dark place for two weeks with daily gentle mixing. The two-weeks-old fermented mixer was filtered through muslin cloth and kept at room temperature (27±2 °C) until application.

Three-leaves solution was prepared using neem (*Azadirachta indica*), gliricidia (*Gliricidia sepium*) and candle bush (*Senna alata*) leaves which were collected from the home garden of the faculty of Agriculture, and chopped separately. Chopped neem, gliricidia and candle bush leaves (2.5 kg) were mixed with cow dung slurry at 1:1:1:1 (W/W) ratio, respectively in a 50 L container containing 25 L of water. The container was closed with lid and the mixer was allowed for fermentation for two weeks with daily gentle mixing and filtered through muslin cloth and kept at room temperature.

Fermented cow urine was prepared using 5 L of cow urine collected from cattle shed of the Faculty of agriculture, and allowed for 7 days to ferment and filtered.

Vermi-tea was collected from the concentrated leachates of the vermiculture unit which contain the bedding materials of teak leaves and cow dung at the ratio of 3:1 with exotic earthworm *Eisenia fetida*.

Potting media preparation and planting

The pot experiments were carried out under dry zone field conditions. A total of 40 clean pots with a capacity of 7 kg were selected. Twenty pots were filled with 5 kg of Media 1 (~~Vermicompost~~: sand: soil was mixed at 1.5:1:1 ratio), and another 20 pots were filled with 5 kg of Media 2 (Garden compost: sand: soil was mixed 1.5:1:1 ratio). Each pot was planted with 5-10 seeds of *A. viridis*. Other agronomic practices were followed as per the recommendation of the Department of Agriculture (DOA), Sri Lanka. Two weeks after germination, thinning out was done to keep five seedlings per pot.

Experimental design

The field experiment was carried out in a Completely Randomized Design (CRD) with five treatments and four replications (Table 1). Treatments were applied at the rate of 50 mL/pot on the 2^{nd} ,4^{th} and 6^{th} week after planting using a hand sprayer.

Table 1: Composition of the treatment tested in both media

Treatment	Liquid fertilizers	Concentration ratio
T1	Fish emulsion + vermi-tea	1:4
T2	Cow urine + vermi-tea	1:4
T3	Three-leaf solution + vermi-tea	3:1
T4	Vermi-tea + water	1:2
T5	Water (Control)	-

Data collection and statistical analysis

The nutrient content of the prepared liquid fertilizers was determined. Nitrogen (N) was analyzed by semi-micro Kjeldahl method), Phosphorous (P) percentage was measured by vanado-molybdate yellow spectrophotometric method at the wavelength of 450 nm (Jackson, 2005), and Potassium (K) percentage were measured by flame photometer [JENWAY- PFP7] (Jackson, 2005). pH value and EC value of the organic liquid fertilizers were measured using pH meter [DKK-TOA(HM-30P)] and an Electrical Conductivity meter [DKK-TOA(CM-42X)], respectively. PH and EC were also measured using digital pH meter and EC meter.

The height of the plant, number of leaves, root length, fresh weight, dry weight and leaf area and root: shoot ratio were measured 7^{th} and 8^{th} weeks (harvesting stage) after planting. The leaf area, leaf length and leaf width were measured using a scale described by leaf area meter. Plants were kept in an oven at 60 ^{o}C for drying, and dry weights were measured until constant weight was obtained. All the measured data were subjected to the one-way ANOVA using SAS 9.4 (SAS Institute Inc., Cary, NC, USA). Tukey's HSD multiple comparison test was used to determine the best treatment combination at P <0.05. Correlation coefficients among the nutritional values of the liquid fertilizers, leaf number and leaf area in different growing media were calculated using the function PROC CORR using the same statistical software.

Results and Discussion

Physiochemical properties of liquid fertilizers tested

This study shows that the N, P and K content are significantly different among the treatments, at P <0.05 (Fig 1).

Significantly highest N content of 108 mg/L was recorded in fish emulsion + vermi-tea mixture (T2), whereas the N content in Cow urine + vermi-tea (T1), Three-leaf solution + vermi-tea (T3) and Vermi-tea + water (T4), was 50% lower compared to T2 and was not significantly different among them.

The P content of T1 and T2 was significantly on par with T3 and T4 at P <0.05. The highest P content of 139.2 mg/L was recorded in T1 whereas the lowest P content of 72.2 mg/L was recorded in T4. The K content of the liquid fertilizers were between 95.2 - 318.6 mmol/L. Significantly highest K content (318.6 mmol/L) was recorded in T2 where as K content in other liquid fertilizers was significantly lower and 50% compared to T2. The pH range of all the liquid fertilizers tested was 7.3 to 8.2. The EC values fell in the range of 12.1 to 25.5.

Growth performance of *Amaranthus viridis* in medium 1 (Vermi-compost medium)

Mean number of leaves per plant, leaf area, root length, fresh weight, dry weight per plant and plant height significantly varied at 7-8 weeks after planting among the treatments tested at P <0.05 (Table 2). The mean number of leaves per plant, fresh weight and dry weight per plant were in the range of 8.75± 0.9-7.5±1.0; 1.77± 0.47-1.44± 0.24 g and 0.65± 0.20-0.53± 0.11g, respectively 7th weeks after planting; and 11.25± 1.5-8.75± 0.5; 4.77± 2.268-2.62± 1.27g and 1.23± 0.24-0.856± 0.15g, respectively in 8th weeks after planting. Even though the root length in 7th and 8th week after planting was varied from 12.02± 0.99-17.92± 2.04 and 12.59± 1.97-21.91± 1.47, respectively, the root length was optimum in 8th weeks after planting. The root:shoot ratio was optimum at 8 weeks after planting, and root:shoot ratio showed strong positive correlation with the N concentration in vermicompost medium with the R^2 value of 0.72 (Fig. 2). The highest number of leaves was recorded in T1 (11.25± 1.5) (Fig. 3). There were significant changes in all the parameters recorded at 8th weeks after planting indicates the 8th weeks after planting would be ideal for harvesting of green-amaranth.

The highest and most significant mean leaf area of 17.3± 3.7 per plant was recorded in 7th week after planting in T1 where as in 8th week after planting the highest significant mean leaf area of 22.89± 4.6 was recorded in T2, but not significantly different when compared to T1. The non-significant root lengths of 21.59± 1.77 cM and 21.91± 1.47 cM, respectively were recorded in T1 and T2 at 8 weeks after planting, but these root lengths were significantly on par when compare to other treatments.

Plant heights were significantly different in T1 and T2 when compare to other all treatments tested at 7 and 8 weeks after planting. The maximum height of 27.13± 4.27 cM was recorded in T1 at 8 weeks after planting.

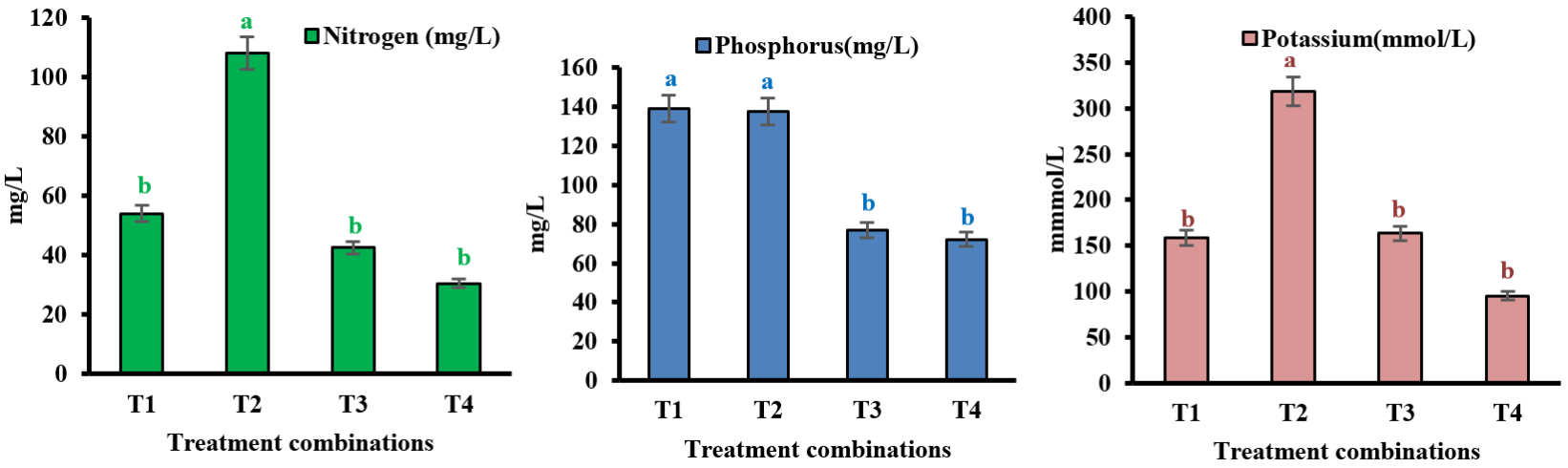

Figure 1: Nitrogen, Phosphorus and Potassium content of the liquid fertilizers tested

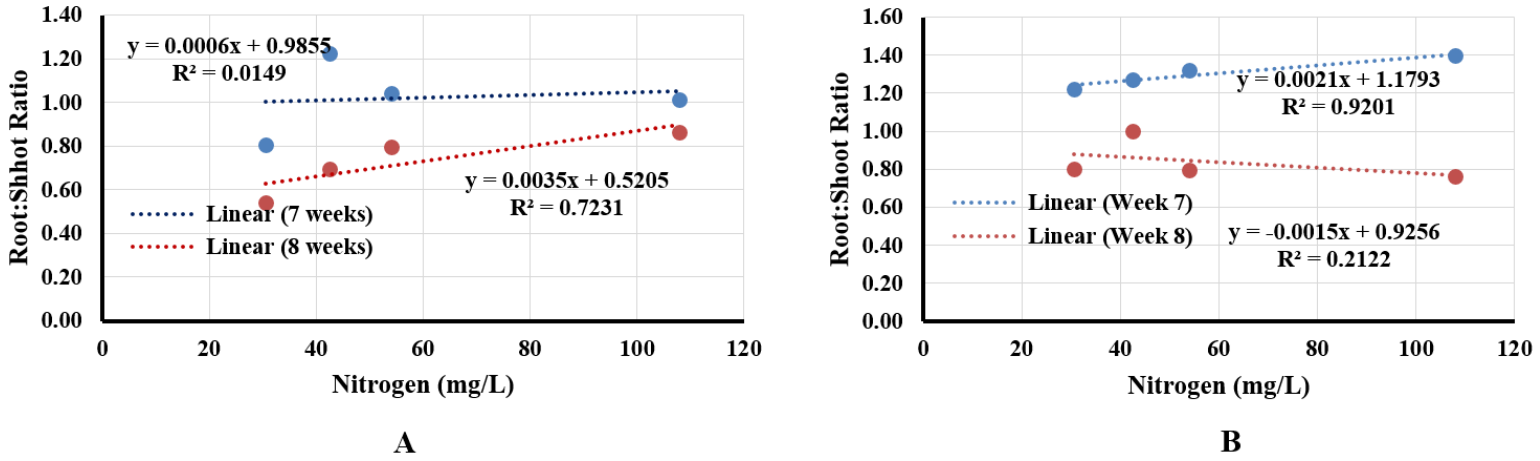

Figure 2: Root: Shoot ratio correlation with nitrogen concentration in A) vermi-compost medium; B) Garden compost medium 7 and 8 weeks after planting

Table 2: Growth and yield parameters of *Amaranthus viridis* in vermicompost medium

TRT	Leaf area		Root length		Fresh weight		Dry weight		Plant Height		Root : Shoot Ratio	
	Week 7	Week 8	Week 7	Week 8	Week 7	Week 8	Week 7	Week 8	Week 7	Week 8	Week 7	Week 8
T1	17.3± 3.76^{a}	21.508± 5.8^{a}	17.92± 2.04^{a}	21.59± 1.77^{a}	1.77± 0.47^{a}	4.65± 1.28^{a}	0.65± 0.20^{a}	1.12± 0.16^{a}	17.17± 1.35^{a}	27.12± 4.27^{a}	1.04^{b}	0.80^{a}
T2	16.97±1.90^{b}	22.89± 4.61^{a}	17.69± 0.92^{a}	21.91± 1.47^{a}	1.74± 0.27^{a}	4.77± 2.26^{a}	0.84± 0.25^{a}	1.22± 0.23^{a}	17.5± 1.18^{a}	25.32± 3.68^{a}	1.01^{b}	0.87^{a}
T3	14.91±3.76^{b}	13.85± 1.70^{bc}	17.14± 0.91^{a}	17.78± 1.04^{b}	1.70± 0.19^{a}	2.83± 1.32^{ab}	0.52± 0.11^{a}	0.85± 0.15^{b}	14.0± 1.77^{b}	19.85± 3.23^{b}	1.22^{a}	0.69^{b}
T4	14.80±4.08^{b}	16.35± 4.65^{b}	12.02± 0.99^{b}	12.59± 1.97^{b}	1.65± 0.12^{a}	2.61± 1.27^{b}	0.58± 0.02^{a}	0.90± 0.08^{b}	14.9± 3.35^{b}	23.17± 6.71^{ab}	0.81^{b}	0.54^{b}
T5	10.86±1.31^{b}	11.11± 1.72^{c}	13.77±3.12^{ab}	15.62± 2.78^{ab}	1.44± 0.23^{a}	2.72± 0.45^{ab}	0.61± 0.10^{a}	0.89± 0.03^{b}	15.07±3.35^{ab}	22.9± 4.93^{b}	0.91^{b}	0.68^{b}

Values with the same alphabets are not significantly different according to the Tukey's HSD at 95% confidence interval.

Table 3: Growth and yield parameters of *Amaranthus viridis* in garden compost medium

	Leaf area		Root length		Fresh weight		Dry weight		Plant Height		Root : Shoot Ratio	
TRT	**Week 7**	**Week 8**	**Week 7**	**Week 8**	**Week 7**	**Week 8**	**Week 7**	**Week 8**	**Week 7**	**Week 8**	**Week 7**	**Week 8**
T1	15.05± 2.71^{a}	17.51± 3.27^{a}	19.91±1.36^{a}	19.95±1.41^{a}	1.54± 0.27^{a}	4.92±1.03^{a}	0.58± 0.16^{a}	1.63± 0.18^{a}	15.07± 2.56^{a}	25.05±3.83^{a}	1.32^{ab}	0.80^{a}
T2	14.30± 2.61^{a}	16.46± 3.58^{a}	18.33±2.68^{a}	18.52±2.12^{a}	1.44± 0.12^{a}	4.06±0.79^{a}	0.46± 0.21^{a}	1.00± 0.14^{a}	13.12±1.10^{ab}	24.32±2.75^{a}	1.40^{a}	0.76^{ab}
T3	15.19± 2.67^{a}	17.61± 3.53^{a}	18.67±2.08^{a}	19.33±2.08^{a}	1.23±0.214^{a}	3.62±0.99^{a}	0.70± 0.28^{a}	0.99±0.092^{a}	14.7± 1.50^{a}	19.32±3.92^{b}	1.27^{b}	1.00^{a}
T4	11.78± 4.80^{a}	17.23± 3.60^{a}	17.11±3.92^{a}	18.00±3.78^{a}	1.56±0.229^{a}	3.32±1.71^{a}	0.64± 0.29^{a}	0.94± 0.19^{a}	14.0± 3.07^{a}	22.5± 4.43^{a}	1.22^{b}	0.80^{a}
T5	10.87± 1.80^{a}	15.20± 5.43^{a}	13.30±2.94^{a}	13.58±2.83^{a}	1.16±0.214^{a}	3.17±0.49^{a}	0.45± 0.17^{a}	0.90± 0.06^{a}	11.05± 2.45^{b}	22± 4.71^{ab}	1.20^{b}	0.62^{b}

Values with the same alphabets are not significantly different according to the Tukey's HSD at 95% confidence interval.

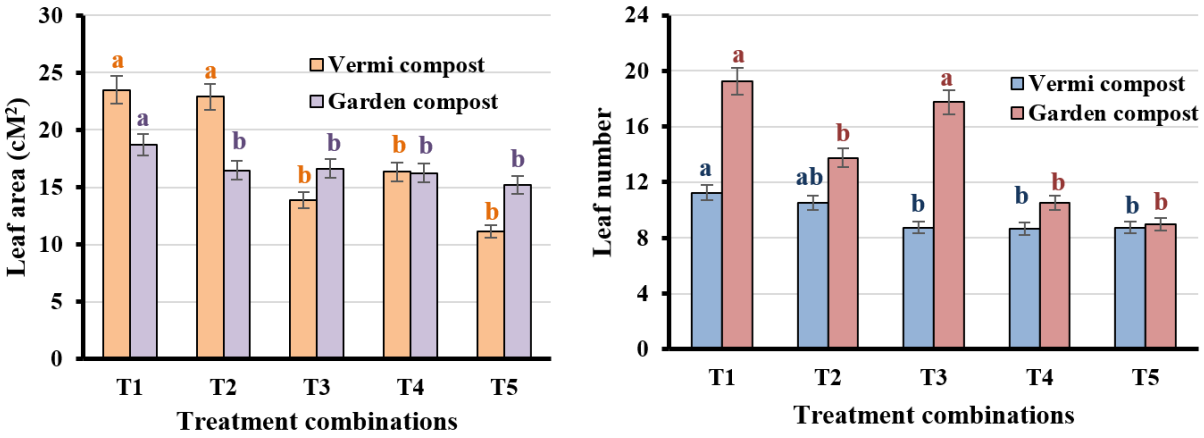

Figure 3: Yield parameters of *Amaranthus viridis* in different liquid fertilizer combinations tested 8 weeks after planting

Growth performance of *Amaranthus viridis* in medium 2 (Garden compost medium)

In the medium 2 (Garden compost), the growth parameters were significantly different among the treatments at P <0.05. This study shows the Significantly highest mean leaf area per plants and mean leave number of 17.71±3.27 and, 19.25±0.95 respectively were recorded in T1 at 8 weeks after planting, (Fig 3) and is on par with T2.

Mean root length, fresh and dry weight per plant were not significantly different among the treatments tested at P <0.05. Anyhow, the highest root length, fresh, dry weight per plant, and plant height of 19.95± 1.41 cM, 4.92± 1.03 g, 1.63± 0.18 g and 25.05±3.83 cM, respectively were recorded in T1 (Table 3).

Correlation analysis of yield parameters *Amaranthus viridis* versus nutrient composition

Person's correlation analysis between yield parameters such as leaf area and number of leaves versus N, P and K of the liquid fertilizers tested showed that leaf number and leaf area of the plants grown in vermi-compost medium positively correlated (>0.6) with the with N, P and K content of the liquid fertilizers tested and whereas leaf number and leaf area of the plants grown in garden-compost medium exhibited no correlation (R^2 <0.5) (Table 4). The correlation coefficient of N versus leaf number and leaf area of the plants grown in vermi-compost medium were 0.65 and 0.87, respectively, and where as in garden-compost medium were 0.39 and 0.3, respectively. The correlation coefficient of P and K versus leaf number and leaf area of the plants grown in vermi-compost medium were 0.85 & 0.95 and 0.58 & 0.82, respectively.

Table 4: Pearson's correlation analysis of yield parameters of *Amaranthus viridis* versus N,P and K content of the liquid fertilizers tested

Yield parameter	Medium	N	P	K
Leaf number	Vermi-compost	0.65*	0.85*	0.58*
	Garden-compost	0.39	0.20	0.51*
Leaf area	Vermi-compost	0.87*	0.95*	0.82*
	Garden-compost	0.30	0.63*	0.38

R^2 values with * indicates the significant at P <0.05

The macronutrients N, P and K are necessary for the optimum growth of the plant. Nitrogen promotes the growth of leaves and stems, P promotes the reproduction and K promotes the resistance to pest and diseases. In this current investigation, number of leaves and leaf area was significantly higher when either fish emulsion or cow urine are mixed with vermi-tea in vermi-compost medium than garden compost medium. Among the liquid fertilizers investigated, N, P and K level were high in cow urine + vermin tea: 1:4. Deepthi *et al.* (2021) reported that the nutrient composition of the vermi tea varied with the materials used for vermi-composting. Therefore, in the current investigations different components were mixed with different ratio of the vermi-tea to compare and to determine which combination would be suitable to provide optimum nutrient green amaranth in two different media to get optimum yield. Deepthi *et al.* (2021) found that growth and yield parameters of *A. viridis* were significantly higher in 100% vermi-ponics, Therefore, current findings suggest that instead of 100% vermi-ponics, fish emulsion or cow urine can be mixed in a ratio to improve the yield components.

The liquid organic waste urine from the dairy industry is extensively being used, as fermented liquid organic fertilizer, growth promoter, pesticides, etc., as it contains 95% water, 2.5% urea, and remaining 2.5% contains mineral salts, hormones and enzymes (Pradhan *et al.*, 2018). Due to the nutritional qualities, cow urine may be having an ability to increase the all-growth parameters significantly (Choudhary *et al.*, 2017). Anna Safitri *et al.* (2019) reported that mixing of cow urine with various EM solutions can improve the N, P and K content of the resultant liquid fertilizers.

Fish emulsion is the nutrient rich extracts from the fish wastes. It can boost the plant growth and yield by providing essential nutrients and alter the biological, physical and chemical composition of the soil and suppress the diseases causing pathogens by enrichment of secondary metabolites produced by the beneficial biota (Abbasi, 2003; 2011). El-Tarabily *et al.* (2003) reported that fish emulsion plays a major role in plant growth by supplying nutrients and precursors for PGRs needed for the plant growth even in less fertile sandy soil by promoting the growth of beneficial soil living plant growth promoting bacterial and actinomycete isolates which are capable of producing auxins, gibberellins and cytokinins. Tiwari *et al.* (2017) reported that the application of liquid manure and fish oil emulsion improved the growth, yield and quality of broccoli (KTS-1) but the effect of fish oil emulsion was not good to crop. Maji *et al.* (2017) reported that vermi-compost is the rich source of humic acid to promote the plant root by improving microbial community around the

root zone. Vermi-composted compost from the plant and animal wastes consist maximum microbial population, phyto hormones than the compost derived from the ordinary process, which not only induces the plant growth but also protect from harmful plant pathogens and positively correlate the growth and yield of the tomato (Ravindran *et al.*, 2016; 2019). These evidences are tally and strongly support with the current findings.

Conclusion

The investigation concludes that the Vermi-tea with either cow urine or fish emulsion at the concentration ratio of 4:1 could be used as liquid fertilizer to get optimum yield from green amaranth. The yield of green amaranth was high when vermi-compost used as growing medium than garden compost. Findings recommend vermi-tea with cow urine or fish emulsion could be effective liquid nutrient supplement to get better growth and yield of green amaranth at affordable prices for urban green agriculture.

Recommendation

In the pandemic situation, continuous supply of green leafy and other vegetables would be difficult from the urban areas due to lockdowns as well as prices are high due to unavailability of inputs for inorganic agriculture. Therefore, the liquid fertilizers tested in the study would be useful for the promoting urban home gardens to produce organic leafy and other vegetables continuously at home, even in apartments levels to mitigate the daily nutritional requirements and prevent the malnutrition and anemic problems prevailing among the children and pregnant women. Moreover, fish emulsion and cow urine can be used as a substitute or supplement for inorganic fertilizers which has been banned in Sri Lanka to promote green agriculture.

Acknowledgement: This research was carried out in JICA research and laboratory complex, Faculty of Agriculture, University of Jaffna. The authors thank the Japanese Government for providing equipment facilities through the JICA grant.

Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this paper.

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