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EFFECT OF ORGANIC AND INORGANIC LIQUID FERTILIZERS ON GROWTH AND YIELD OF *Centella asiatica* (L.) AND C*apsicum annuum* (L.) VAR. *annuum*

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ABSTRACT

The present study was conducted to find out the effect of liquid organic fertilizers and synthetic inorganic fertilizer on the growth and yield of *Centella asiatica* (L.) (Sinhala; Gotukola) and *Capsicum annuum* (L.) var. *annuum* (green chilli). Two experiments were set up according to randomized complete block design with six replicates for each plant species in a protected plant house at the Faculty of Agriculture, University of Ruhuna. Four organic liquid fertilizers (Vermiwash, Fish tonic, Jeevamruta and Compost tea) together with Albert's solution as synthetic liquid fertilizer were used as treatments. The number of leaves, fresh weight of leaves, dry weight of leaves, average length of the stalk, fresh weight and dry weight of the roots were taken as growth parameters of *C. asiatica* while the plant height, stem girth, number of pods and fresh weight of pods were recorded in *C. annuum*. The measured parameters for *C. asiatica* were not significantly different in Albert's solution, compost tea, jeevamruta and fish tonic while lower values were recorded in vermiwash. The girth of the stem was high in Albert's solution and fish tonic treated plants while the plant height was high in Albert's solution treated plants at flowering. However, the highest number of pods per plant and the fresh weight of pods per plant were recorded only by fish tonic treated plants in *C. annuum* var. *annuum*. The liquid organic fertilizers found to be effective replacement to the synthetic liquid fertilizer, Albert's solution to improve crop growth of *C. asiatica* L. and yield of *C. annuum* var. *annuum*.

Keywords: *Capsicum annuum*, *Centella asiatica*, Growth, Liquid organic fertilizers, Inorganic fertilizer

INTRODUCTION

Continuous usage of inorganic fertilizers makes the soil degrade seriously while destroying virgin and stable soil ecosystems (Zhang *et al*. 2018). This adversely interferes with niches in the ecosystems and causes many chronic diseases in human beings (Hurtado-Barroso *et al*. 2019). Starting from the green revolution up to the present scenario, usage of the huge amount of inorganic fertilizers made many negative impacts on the environment. Hence, today's correct decisions solve many upcoming complications related to inorganic fertilizer application in agriculture.

Albert's solution is one of the most popular inorganic nutrient package used to enhance plant growth and development. It is widely taken for hydroponics as well as open-field cultivations. This formulation has a wide scope of balanced nutrient ratios and it is a foundation product for a successful fertigation procedure. According to Edirimanna *et al*. (2019), best growth of seedlings of grafted jack fruit was recorded when spraying diluted Albert's solution (2g/L water). Similarly, Patil *et al*. (2008) have concluded that the highest tomato yield was recorded from the foliar application of 2 g/l Albert nutrition solution at 2, 4, 6, and 8 weeks after transplanting in open fields. Moreover, Kumarasinghe *et al*.

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(2019) have revealed that spraying of Albert's solution at the rate of 1.11g/L two times in two weeks interval optimize the growth of *in-vitro* Anthurium (var. 'Lalani') plantlets. Samarakoon *et al*. (2006) have used 2g/L water Albert's solution as the control treatment for lettuce cultivation using hydroponics. The use of organic fertilizer improves the sustainable productivity of soil while enriching its chemical, biological and physical properties (Cheng *et al*. 2020). At present, organic fertilizers have become an essential component in the plant nutrient system (Ahmad *et al*. 2016). Liquid organic fertilizers can be used to eliminate nutrient deficiency symptoms rapidly than other types of fertilizers (Fageria *et al*. 2009). They penetrate quickly into the soil while giving access to the plant root system to absorb nutrients (Wang *et al*. 2020). Some studies have proved that the application of liquid organic fertilizers has the capability of increasing uptake of some macro, micronutrients and enhance the soil organic matter content compared to other types of fertilizers (Browaldh 1992). Organic liquid fertilizers are enriched with N, P and K can make deep replacements of inorganic fertilizers containing similar nutrients such as urea, muriate of potash etc. In general, the application of organic fertilizers increases the availability of micronutrients such as zinc, manganese, iron and copper.

This is a good trend for sustainable development in agriculture and simultaneously saving biodiversity for the future (Bengtsson *et al*. 2005). According to Tennakoon *et al*. (1995), the application of organic fertilizers increases the nitrogen availability and biological activity of the soil. The resource-poor farmers have limited access to synthetic inorganic fertilizers due to high cost. Hence, nutrient availability at correct growth stages may be restricted (Odhiambo & Magandini 2008). However, organic fertilizers are available and the cost is also comparatively lower than synthetic fertilizers (Wang *et al*. 2018). Organic liquid fertilizer produced from biodegradable waste can be one of the economical and effective ways of solving the garbage disposal problem in the world (Le *et al*. 2018). Thus, the present study was designed to compare the effect of different liquid organic fertilizers and synthetic liquid fertilizer on growth and yield of *Centella asiatica* and *Capsicum annuum* var. *annuum*.

MATERIALS AND METHODS

Two experiments were conducted in a protected plant house at the Faculty of Agriculture, University of Ruhuna, from November 2019 to March 2020. The Average temperature and the light intensity inside the protected house were 40oC and 25,000 lux, respectively. Four different liquid organic fertilizers and asynthetic fertilizer (Albert's solution) were used as treatments (T1- Vermiwash, T2- Fish tonic, T3- Jeevamruta, T4- Compost tea, T5- Albert's solution). Both experiments were set up according to the randomized complete block design with six replicates.

For the preparation of vermiwash, one side open empty barrel (25 L) was taken and a hole was made in the sidewall of the lower quarter to accommodate a tap. The vermiwash unit was set up on the pieces of bricks to raise it and facilitate the collection of vermiwash. The barrel was filled as follows; a layer of brick pieces of 25cm was placed at the bottom of the barrel. Then 25cm layer of coarse sand and brick pieces layer was added. A layer of loamy sand (30-45cm) was placed on the top of the brick pieces layer. After that, about 500 earthworms were introduced into the barrel with their bedding materials. Cow dung and hay were added on the top of the soil layer and moistened for two weeks while opening the tap. After that, the tap was closed and a plastic pot (5L) was hung on the top of vermiwash unit as a sprinkler and allowed to sprinkle water into the barrel overnight. In the morning of the following day, vermiwash was collected by opening the tap. The pot was refilled with water in the evening to collect

vermiwash again the next morning (Rajasooriya & Karunarathna 2020). During that period the tap was closed firmly. Vermiwash was diluted with water by 1:10 (v/v) before applying to the plants.

One kilogram of fish waste was chopped and added into a plastic bucket of 15L volume to prepare the fish tonic (Hepsibha & Geetha 2019). Small pieces of 250g of jaggery and 250g of raw papaya were added to the mixture and mixed well while adding clean water. However, the procedure adapted by Hepsibha & Geetha (2019) was modified by adding of raw papaya to facilitate the digestion of fish bones. Further, Ranasinghe *et al*. (2019) emphasized that the papain extracted from papaya latex was successful in the hydrolysis of fish frames. Then the mixture was allowed for fermentation for two months. Fermented fish tonic was applied as fertilizer by diluting with water by 1:30 (v/v) ratio.

A modified procedure of Bethe *et al*. (2017) was used to brew the compost tea. According to that the compost tea was prepared by using well-matured 5kg of compost, 250g of jaggery and Gliricidia leaf (250g) extract suspending in chlorine-free water (50L). Then it was kept for 10-15 days while aerating throughout the period. However, in the present study jaggery was used instead of molasses while Gliricidea leaf extract was added to the compost tea to increase the nitrogen availability of the fertilizer mixture. Later, it was filtered into another container and stored at room temperature for 10 days in darkness with a periodic homogenization. Compost tea was diluted with water in 2:5 (v/ v) ratio.

For the preparation of Jeevamruta, 15 L of water was filled into a plastic bucket and add 2 kg of cow dung and 1L of native cows' urine and mixed well. In addition to that 250g of jaggery, 500g of flour of sprouted green gram and a handful of clean soil were added (Gadewar *et al*. 2014; Kurubetta *et al*. 2017). Then mixed well and allowed for fermentation for two weeks. This fertilizer was diluted by 1:10 (v/v) with water before applying to the plants.

The commercially available Albert's solution was used as a synthetic inorganic liquid fertilizer with the recommended dosage of 10 grams diluted in 4.5 L of water.

Experiment 1: Evaluation of organic and inorganic liquid fertilizer on growth of *Centella asiatica*

Pots with 20 cm of diameter were filled with washed river sand. Five treatments were used (mentioned previously) in the experiment with six replicates. Hence, there were thirty experimental units. Same size and aged *C. asiatica* (bush type) plants were selected. Two weeks after establishment 100 ml of fertilizers solution was added per pot in three days interval. The number of leaves per pot, fresh weight of the leaves, dry weight of the leaves, average stalk lengths of the leaves, fresh weight of the roots and dry weight of the roots were recorded as growth parameters.

The number of leaves in one plant from each replicate was counted after two months of planting. Finally, the average leaf count was taken in six replicates of each treatment. The leaves were separated, keeping one inch from the root system. The fresh weight of the harvest was measured (g) using an electric balance. After recording the fresh harvest weight of the leaves, 1g of the sample was taken and oven-dried at 65°C for 72 hours to a constant dry weight. Before harvesting the shoots, the length of every stalk of leaves was measured. Finally, the average length of the stalk was taken for each treatment. Then, uprooted the plants and the total fresh weight of the roots was recorded (g) using an electric balance. After that the fresh weight was recorded and oven-dried at 65°C for 72 h to a constant weight. Finally, dry weight was recorded. The average of six replicates in

each treatment was recorded as the final dry root weight.

Experiment 2: Evaluation of organic and inorganic fertilizer on yield of *Capsicum annuum* var. *annuum*

Thirty pots with 20 cm of diameter were filled with potting mixture of sand, compost, topsoil in 1:1:1 ratio. Two weeks old healthy green chilli seedlings of variety MI-2 were planted as a single plant per pot. Fertilizer application was started two weeks after establishment and continued up to harvest. Every three days, 150 ml of liquid fertilizer was applied per pot. Yellowing of leaves in some plants was observed and controlled by spraying mixture of fresh cow dung with Gliricidia leaves extract in the early stage of plant development. The mixture was prepared mixing 1kg of fresh cow dung and fresh leaf extract of 200 g Gliricidia leaves in 10 L water. Similarly, a solution prepared using 100 g of crushed garlic mixed with 100 ml of water was sprayed twice a week for three weeks during vegetative phase of the plant growth to control the whiteflies. Plant height and girth of the main stem at 5cm above the soil level were measured at flowering. Number of pods and the fresh weight of the pods were measured at two months after planting. Electrical conductivity of the four liquid fertilizers were maintained in the range of 2.0 dS/cm^3 and EC levels were comparable among the treatments. All the data were analyzed using ANOVA by SAS software. The Duncan's Multiple Range Test was used to compare the means of treatments at 5% probability.

RESULTS AND DISCUSSION

Effect of different fertilizers on growth parameters of *Centella asiatica*

The average number of leaves per pot was significantly different among treatments ($P < 0.001$). The significantly high number of leaves was recorded by T2 (Fish tonic), T3 (Jeevamruta), T4 (Compost tea) and T5 (Albert's solution) treated plants while the lowest number was observed in T1 (Vermi wash) (Figure 1). It was clear that three organic liquid fertilizers can produce as much as leaves produced by synthetic liquid fertilizer. Therefore, except vermiwash other organic liquid fertilizers could be used to enhance the number of leaves of *C. asiatica*. Comparatively few numbers of leaves per pot were recorded in all treatments may be due to the potting media used in the experiment. The growth media was washed-river sand where plant nutrients are not available. Therefore, the growth of the plant is the pure effect of the liquid fertilizer applied to the soil. According to the results reported by Shaheen *et al*. (2013), compost tea can be utilized as a soil amendment and have used for onion and found that the addition of compost tea resulted in higher total bulbs yield.

The fresh weight of the leaves per pot and dry weight of 1g of fresh leaves were significantly different between treatments where the highest value was recorded by Albert's solution treated plant while the lowest value was recorded in vermiwash supplied plants. However, the fresh weight of the plants treated with fish tonic, Jeevamruta and compost tea was not significantly different

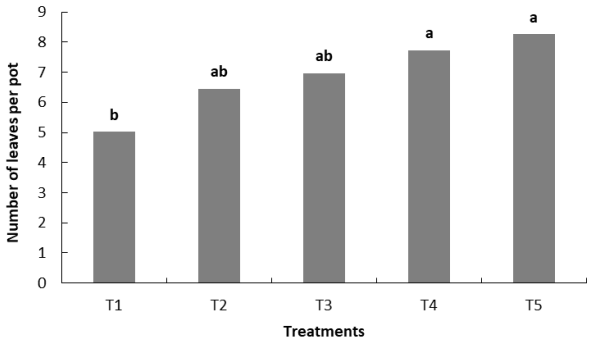

Figure 1: Effect of different liquid fertilizers on the number of leaves of *C. asiatica*. T_1- Vermiwash, T_2- Fish tonic, T_3- Jeevamruta, T_4- Compost tea, T_5- Albert's solution. Mean values indicated with the same letters on the column of the graph is not significantly different at *α=0.05*

Table 1: The effect of treatments on growth parameters of *Centella asiatica* at the significance level of α = 0.05 (n=6)

Treatment	Fresh weight of leaves (g/ pot)	Dry weight of *1g* of the leaves (g)	Stalk length (cm)	Fresh weight of roots (g/ pot)	Dry weight of roots (g/ pot)
T_1 - Vermiwash	6.67 [b]	0.33[b]	6.19[a]	4.54[a]	0.76[a]
T_2 - Fish tonic	7.22[ab]	0.43[ab]	6.68[a]	4.56[a]	0.77[a]
T_3 - Jeevamruta	7.06[ab]	0.45[ab]	7.34 [a]	6.20[a]	0.92[a]
T_4 - Compost tea	7.77[a]	0.58[a]	7.76 [a]	6.34[a]	0.92[a]
T_5 - Albert's solution	8.43[a]	0.70[a]	7.81 [a]	6.41[a]	0.9[7a]
CV	8.08	12.71	11.46	12.54	11.25

Note: Means indicate with similar letters in a column are not significantly different at α=0.05

from Albert's solution treated plants (Table 1). According to Balraj *et al*. (2014) liquid organic fertilizer prepared by fermented fish waste significantly increases the total yield of brinjal. The present study indicated the potential of replacing synthetic fertilizer from organic liquid fertilizer for leafy vegetables. Our findings are in tune with Rippy *et al*. (2004) where they used six organic growing systems using vermicompost, coconut coir, composted pine bark for tomato plants and reviled that, organically grown tomatoes in greenhouse are comparable to those grown conventionally, in relation with nutritional status, yield and development.

Effect of the treatment was not significant for the average length of the leaf stalk of the plants, fresh weight of the roots and dry weight of the roots. Length of leaves stalks is a genetic characteristic hence difficult to manipulate from fertilizers (Mazaheri *et al*. 2019). As fertilizers were frequently added to the rhizosphere roots can easily absorb nutrients from soil water solution. Therefore, root growth was limited in the present study. Xu *et al*. (2003) have proved that leafy vegetables grew better at later stages and resulted in a high total yield in organic fertilizers than chemical fertilizers, which contributed to the high nutrient sustainability. However, the present study was conducted to evaluate the effect of organic liquid fertilizer for early plant growth. Concentrations of sugars and vitamin C in leaves were significantly higher and the amount of nitrate was lower in organic fertilizer treated vegetables than chemical-fertilized vegetables (Xu *et al*. 2003). It is possible to produce vegetables with high quality and a high yield than or similar to that of chemical farming if the nutrients are optimally supplied through organic fertilizers such as 2.7:1.0:1.0 for rice bran: oil-seed sludge: fish meal, with molasses and microbial inoculants. Supporting our study, Zandvakili *et al*. (2019) have compared the effect of organic and inorganic fertilization on lettuce and found that low nitrate amount under organic fertilization produced high-quality lettuce for human nutrition. Moreover, Lim & Vimala (2012) found that when organic fertilizers such as poultry manure as the sole source of nutrients for leafy vegetables give higher or comparable yields to inorganic fertilizers. In contrast, Devkota & Jha (2013) revealed that many measured traits of *Centella asiatica* including leaf length, petiole length and leaf width were

Table 2: The effect of treatments on growth parameters of chilli (*Capsicum annuum* var. *annuum*) at significance level of α = 0.05 (n=6)

Treatment	Stem girth at flowering (cm)	Plant height at flowering (cm)	Number of fresh pods/plant
T_1 - Vermiwash	2.40^{c}	26.77^{c}	47.17^{b}
T_2 - Fish tonic	2.83^{ab}	30.78^{b}	67.67^{a}
T_3 - Jeevamruta	2.65^{bc}	24.63^{c}	43.50^{b}
T_4 - Compost tea	1.95^{d}	23.43^{c}	32.50^{c}
T_5 - Albert's solution	3.02^{a}	37.83^{a}	42.17^{b}
CV	10.37	10.47	14.65

Note: Means indicate with similar letters in a column are not significantly different at α=0.05

significantly higher in integrated manuring than in the individual application of organic and inorganic manures. Bhattacharya *et al*. (2017) suggest that maximum amount of secondary metabolites can be obtained from *C. asiatica* after the first month of cultivation under organic fertilizers over inorganic fertilizers. Zhang *et al*. (2017) investigated that individual and combination application of different organic ameliorants significantly changes nitrifying bacteria abundance, composition and diversity in the soil. Further, Hasan & Solaiman (2012) have supported our findings by analyzing the highest economic production, the highest net return, and the benefit-cost ratio of cabbage with the use of organic fertilizers.

Effect of different fertilizers on yield of green chili (*Capsicum annuum* var. *annuum*)

The stem girth ($P < 0.001$), plant height ($P < 0.001$), number of pods per plant ($P < 0.001$) and the fresh weight of the pods per plant ($P < 0.001$) were significantly different among treatments in chilli. The highest stem girth was recorded in Albert's solution applied plants at flowering. However, it was not significantly different from the stem girth recorded in fish tonic treated plants. Plant height was significantly greater in Albert's solution treated plants while the shortest plants were produced by compost tea (Table 2). Fish tonic treated plants produced the highest number of pods and the fresh weight (Figure 2) while plants treated with compost tea produced the least number of pods and the fresh weight. Balraj *et al*. (2014) used fish waste fermentation and found that it enrich the soil with required nutrients and influence the better conducting functions of xylem and phloem vessels in *Solanum melongena*.

In the present study, similar yields were given from Albert's solution, Vermiwash and Jevamruta while those are not significantly different from each other. The highest amount of chili pods per plant might be due to its vigor and the higher number of leaves per plant (Khan *et al*. 2014). A similar experiment was conducted by Khandaker *et al*. (2017) using the fish tonic, vermicompost, cow dung, peat moss and chicken manure for *Capsicum annuum* and found that vermicompost gave the highest values for plant height, number of leaves, stomatal conductance, chlorophyll content, and number of flower buds. Results of the present experiment are following the basic findings of Ram *et al*. (2015) who reported that vermicompost and panchagavya considerably enhance the yield of chilli crop. According to Azarmi *et al*. (2008), ascorbic acid, soluble and insoluble solids, pH, titrable acidity, and also germination percentage were maximized with the use of organic fertilizer treatments. For chilli, organic manure combination effect analysis was done by Reddy *et al*. (2017) and

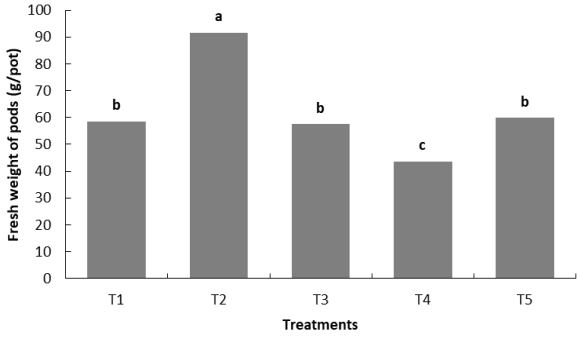

Figure 2: Fresh weight of the pods per plant in different treatments at two months after planting. T_1- Vermiwash, T_2- Fish tonic, T_3- Jeevamruta, T_4- Compost tea, T_5- Albert's solution. Mean values indicated with the same letters on the column of the graph is not significantly different at *α=0.05*

revealed that application of vermicompost, leaf manure and combinations of organic fertilizers had a significant effect on the quality and quantity parameters of chili. However, Edwards & Fletcher (1988) have revealed that harmful microorganisms like Pythium and Fusarium spores are dispersed by earthworms. Some other researchers have investigated the potential of entering microplastic particles in to the environment with organic fertilizers from bio waste composting and fermentation (Weithmann *et al*. 2018). Some other environmental impacts like ammonia emission through fermentation of organic fertilizers are also analyzed by researchers (Erwiha *et al*. 2020) and fertilizer decisions should consider ammonia emission as well as practices for their reduction. Results of the present experiment are in agreement up to some extent with the findings of Boraiah *et al*. (2017) who used Jevamruta and cattle waste for chili cultivation which showed that there was a significant difference in yield of *Capsicum annum* per hectare with the application of Jevamruta. Singh & Lal (2019) emphasized that Jevamruta treated plants contained higher values of chlorophyll 'a', 'b' and carotenoids. That study further suggested that Jevamruta was potent enough to resist the plants in proper growth under induced stress conditions. Karanatsidis & Berova (2009) also found that applying organic-N fertilizer provided vigorous plants while giving positive effects upon the functional activities like photosynthesis and respiration. Now there is a trend of identifying novel organic fertilization methods for chilli for sake of the long term wellbeing of humans (Deore *et al*. 2010).

CONCLUSION

Liquid organic fertilizers of compost tea, Jeevamruta and fish tonic except vermiwash showed a potential to be replaced chemical fertilizer (Albert's solution) for the growth of *Centella asiatica* under local conditions. For *Capsicum annuum* var. *annuum* fish tonic was reported to have a better yield than inorganic fertilizer. Further, Jeevamruta and vermiwash can also effectively be used instead of inorganic Albert's solution. Among the liquid organic fertilizers, compost tea and fish tonic showed significant performance on growth and yield of *Centella asiatica* and *Capsicum annuum* var. *annuum*, respectively.

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Author Contribution

KMCF conceptualized and designed the study. KMFC and GASE performed the experiments. GASE and EMUIE analyzed and interpret the data. All authors contributed in drafting the manuscript and KMCF critically revised the manuscript.