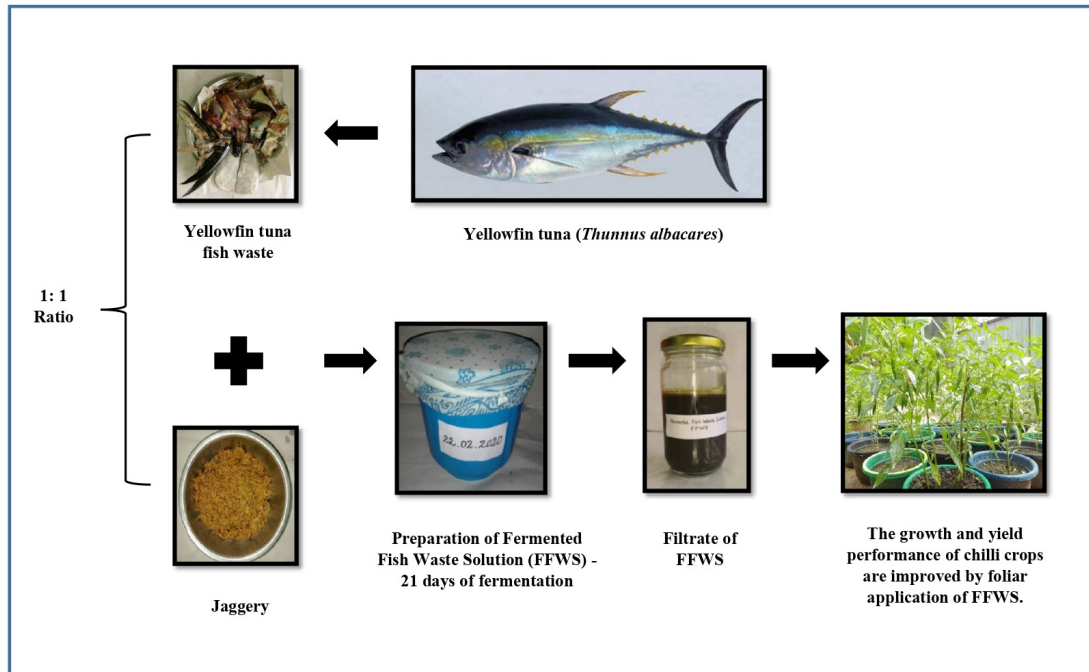


## SHORT COMMUNICATION

**Effects of foliar application of Fermented Fish Waste Solution from yellowfin tuna (*Thunnus albacares*) on growth and yield of MI-2 chilli (*Capsicum annuum*)**

A.F. Shama and J. Nimalan\*

**Highlights**

- Direct discharge of fish waste may cause environmental pollution.
- The Fermented Fish Waste Solution (FFWS) was prepared by fermenting fish waste from yellowfin tuna (*Thunnus albacares*) and jaggery.
- Chilli plants treated with FFWS showed promising results in growth and yield.
- 5% of FFWS can be used as an efficient and cost-effective choice.
- The potential of commercializing FFWS as a foliar fertilizer in organic farming is highlighted.

SHORT COMMUNICATION

## Effects of foliar application of Fermented Fish Waste Solution from yellowfin tuna (*Thunnus albacares*) on growth and yield of MI-2 chilli (*Capsicum annuum*)

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**Abstract:** Yellowfin tuna is the most popular fish species consumed by Sri Lankans, and the majority of waste generated during processing is not utilized properly. The waste of this species has been identified as a rich source of amino acids and micro-nutrients which are essential for plant growth, but they are dumped into the ocean, or disposed in landfills leading to pollution. The study was conducted to prepare a fermented fish waste solution (FFWS) from yellowfin tuna and evaluate its efficiency on the growth and yield of MI-2 chilli crops. The FFWS solution was prepared by using fish waste from yellowfin tuna and jaggery in a 1:1 ratio and kept for about 21 days for fermentation in a cool and well-ventilated location. The filtrate of FFWS was applied separately as a foliar spray in different concentrations (2.5%, 5% and 7.5%) on chilli plants (n = 10 per treatment) once in a week with a negative control. The height of the plants, number of leaves and number of branches were measured, and the number of flowers and fruits were counted weekly until the first harvest. According to the findings, crops subjected to FFWS started flowering earlier and showed better growth and yield than control crops. Overall, plants treated with 5% and 7.5% of FFWS promoted growth and yield similarly, without significant differences. According to the research results, the application of the 5% FFWS is a more cost-effective and affordable choice than the application of the 7.5% FFWS. Further study and commercialization of FFWS foliar fertilizer may promote environmentally-friendly agriculture and the effective use of fish waste, as well as provide better solutions for the current scenario in Sri Lanka to reduce the usage of synthetic fertilizer.

**Keywords:** Chilli; Yellowfin tuna; Fish waste; Fermentation; Foliar spray

### INTRODUCTION

The world population is increasing geometrically and will reach nearly 10 billion in 2050 (Timsina, 2018). According to the Malthusian Theory, the population increased in a geometric progression, while food production increased in an arithmetic progression. Thus, the population grew faster than food production and tended to outstrip it quickly. So sustainable agriculture is necessary to combat hunger and ensure food security, but land scarcity and poor farming practices are the biggest challenges to meeting the demand for food production. Synthetic chemical fertilizers have become necessary to enrich the soil with nutrients and help to meet the food demand, but they leave dangerous imprints. (Hepsibha and Geetha, 2019). Thus, organic farming is the better solution to overcome these challenges.

Organic agriculture is one of the environmentally friendly alternatives that avoids the use of agrochemicals while improving the quality of deteriorated habitats. Bio-fertilizers are commonly used in crop production in organic farming systems. However, the traditional organic agricultural technique may not be able to meet the demand for food. Organic fertilizers are not widely available in large quantities, and in addition, their nutrient content may vary, and also take a longer time to enrich the soil with available nutrients (Phibunwatthanawong and Riddech, 2019). Lack of knowledge among the farmers is also one of the significant limitations promoting the use of organic fertilizers. Adapting new eco-friendly biotechnology approaches can help to meet the challenges and improve the quality and quantity of food production in a sustainable manner in organic farming. The application of FFWS is one of the biotechnological approaches and alternative methods to reduce the use of synthetic fertilizer.

Yellowfin tuna (*Thunnus albacares*) fish are found in tropical oceans all over the world and belongs to the Scombridae family (Collette *et al.*, 2001). Yellowfin tuna is consumed more enthusiastically in Sri Lanka than other species, as well as one of the major tuna-producing and processing countries in the Indian Ocean (Azhara *et al.*, 2018). When fishes are gutted, headed, and further processed, waste is produced. Usually, vast amounts of fish waste are not properly utilized. Unused fish waste is frequently disposed in landfills, incinerators, or by dumping into bodies of water (Kim, 2011). Most fish wastes are used to make fishmeal; the remaining ones are discarded; however, solid tuna waste contains high-quality proteins, making it a rich source of amino acids and micronutrients (Sayana and Sirajudheen, 2017). According to Baloch *et al.*, (2008), in addition to nitrogen, phosphorous, and potassium, organic fish fertilizer contains the majority of macro and micronutrients. These nutrients provide the required nutrients for plants to flourish and bloom.

In India, various studies were conducted to prepare the fertilizer from market fish waste, including several species of fish and a lack of research was observed in the preparation of FFWS exclusively from yellowfin tuna. Thus, preparing FFWS from yellowfin tuna fish waste is an appropriate approach to convert waste into a resource.

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Therefore, the current research was conducted to evaluate the efficiency of prepared FFWS on the growth and yield of MI-2 chilli crops.

## MATERIALS AND METHODS

### Experimental location

The experiment was conducted at Jayanthi Mawatha in Anuradhapura District, Sri Lanka. The district is located in the dry zone of North Central Province as well as in the DL1b agro-ecological zone of Sri Lanka.

### Method for the Preparation of FFWS

Yellowfin tuna fish waste (head, bones, skin, fins, and viscera) was collected from the fish market, and 2 kg of fish waste was chopped into small pieces. An equal amount of jaggery (2 kg) was weighed and crushed. Fish waste and crushed jaggery were mixed together (1:1 ratio). Jaggery (a non-centrifugal sugar) was added in order to provide an important carbon source for microbial growth and facilitate the fermentation of the FFWS.

A 5-liter plastic bucket was chosen as a fermentation container. The bottom of the container was filled with crushed jaggery to avoid the contamination of pathogenic microbes, while the top was filled with a mixture of fish waste and jaggery. Finally, crushed jaggery was used as a top layer to avoid exposure of fish waste to the air born pathogenic microbes. To keep insects at bay and allow for aeration, the container was covered with a breathable cotton cloth. The fermentation setup was kept for about 21 days in a well-ventilated, out of direct sunlight, and animal-free environment. The filtrate was strained through a 0.5 mm fine sieve after 21 days of fermentation and stored in glass bottles in a cool location.

### Experimental design

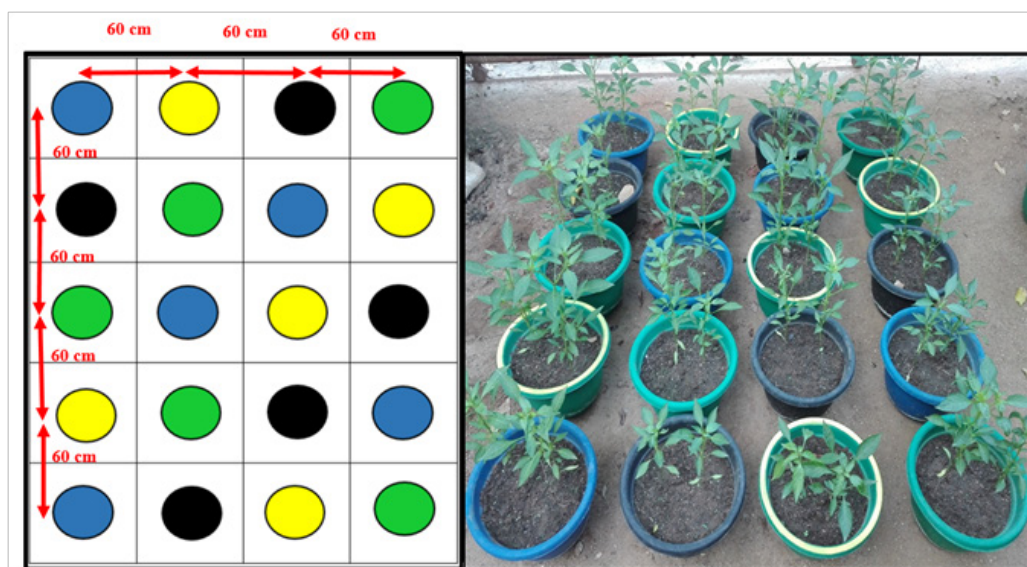
Completely Randomized Design (CRD) (Figure 1) was used to conduct the experiment including with four treatments: control (0% FFWS), 2.5% FFWS, 5% FFWS, and 7.5% FFWS (Table 1). There are five replicates of each treatment, with two plants in each pot ( $n = 10$  plants). The MI-2 Chilli Seedlings were transplanted 14 days after germination into 20 equal-sized plastic pots (7 L), which were filled with garden soil, cattle manure, and coir dust (2: 1: 1 ratio).

### Application of FFWS

Prepared FFWS was applied to the chilli crop leaves as a foliar fertilizer once in a week by spray bottle. The initial application of 5 ml per pot was made on the 21<sup>st</sup> day after seeding. After that, amount of this solution was increased with time by 10 ml and 15 ml on the 35<sup>th</sup> and 56<sup>th</sup> days after planting respectively (Table 2). The space between the two plants was maintained at 60 cm to allow the plant to grow independently and to avoid the drift effect while applying different concentrations of FFWS.

**Table 1:** Treatment organization of the research for different concentrations of FFWS (2.5, 5.0, and 7.5%) and control

Colour	Treatments	Composition
●	Treatment 1 (T1) - Control	0% FFWS
●	Treatment 2 (T2)	2.5% FFWS
●	Treatment 3 (T3)	5% FFWS
●	Treatment 4 (T4)	7.5% FFWS



**Figure 1:** The experimental design for the different treatments of FFWS (2.5, 5.0 and 7.5%) and control with the Completely Randomized Design (CRD) organization.

**Table 2:** Amount of applied FFWS in different concentrations (0, 2.5, 5.0, and 7.5%) in a week interval.

Treatment	Application of FFWS (ml)						
	21 <sup>st</sup> day	28 <sup>th</sup> day	35 <sup>th</sup> day	42 <sup>th</sup> day	49 <sup>th</sup> day	56 <sup>th</sup> day	63 <sup>th</sup> day
7.5% of FFWS	5 ml	5 ml	10 ml	10 ml	10 ml	15 ml	15 ml
5% of FFWS	5 ml	5 ml	10 ml	10 ml	10 ml	15 ml	15 ml
2.5% of FFWS	5 ml	5 ml	10 ml	10 ml	10 ml	15 ml	15 ml
0% of FFWS	5 ml	5 ml	10 ml	10 ml	10 ml	15 ml	15 ml

### Sample collection

All ten chilli plants ( $n = 10$ ) were taken from each treatment for measurement, and the mean value for each parameter was calculated. Nondestructive sampling was used to conduct the observations. The plant height, the number of leaves per plant, and the number of branches per plant were measured in the field once in a week from 28 to 63 days after planting. Six weeks after transplantation, the number of flowers was counted. After 63 days of transplantation, the pods were harvested (first time), the number of pods per plant was counted and length and width of the chili pods, and fresh weight of total chilli pods (only the mature pods) per crop were measured.

### Data analysis

Means with standard deviation for all numerical data were calculated by using SPSS Statistics 22 software. ANOVA analyses were done at  $\alpha=0.05$  significant level. Mean comparisons were done through Duncan's Multiple Range Test (DMRT) in SPSS software to compare the efficacy of each treatment on growth and yield parameters.

## RESULT AND DISCUSSION

### Effect of FFWS on growth parameters

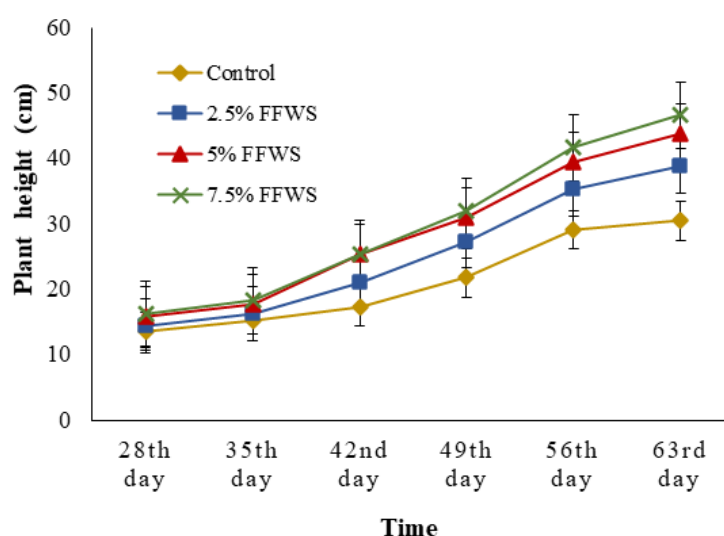
#### Height of Chilli crops

The Figure 2 shows the mean height of chilli crop for different treatments. Overall, the data revealed that the heights of the chilli crop differed significantly among

treatments ( $P = 0.0000$  at the 95% CI). In comparison to other treatments, 5% of FFWS-treated crops and 7.5% of FFWS-treated crops showed maximum height after 63 days of planting without significant difference (Figure 2). According to Srikumaran *et al.* (2017), different concentrations of "Gunapasalem" (the traditional name of FFWS) showed good outcomes in comparison to chemically treated okra plants. Cucumber vine length increased when 20 ml of fish waste extract was applied (Khandaker *et al.*, 2017). The similar effect is observed in current study in which increasing concentration of FFWS increases the plant height.

#### Number of leaves per plant

The study revealed that the number of leaves per plant was dynamically increased with the time in all treatments. The number of leaves was significantly higher in 7.5% FFWS-applied crops compared to other treatments. The 7.5% FFWS-treated crops showed the highest number of leaves ( $201.5 \pm 49.90$ ) per plant (Table 3). Present study shows that application of 5% FFWS increased the number of leaves per plant which is in accordance with the study by Deore *et al.* (2010), in which the treatment of 3% of new organic liquid fertilizer made with fish waste showed the maximum number of leaves per plant in *Capsicum annum*. Furthermore, Srikumaran *et al.*, (2017) stated that application of 10% concentrated "Gunapasalem" is a liquid fertilizer made from fish by the fermentation process increases significantly high number of leaves per plant in okra. The application of 20 ml of fish waste extract resulted



**Figure 2:** Mean height ( $\pm$  SD in cm) of *Capsicum annum* plants subjected to different FFWS treatments (0% FFWS (Control), 2.5% FFWS, 5% FFWS, 7.5% FFWS) with the time (days).



in the highest number of leaves in *Cucumis sativus*, which functioned as a growth regulator (Khandaker *et al.*, 2017), which may be the reason for the increase in the number of leaves per plant. Prepared 5% FFWS show the similar effect on chilli crops.

#### Number of primary branches per plant

The mean number of branches increased with dosage. On the 35<sup>th</sup> day, FFWS applied chilli plants started to produce branches while no branches were observed in control and the number of branches continuously increased over time.

Table 4 shows that 7.5% and 5% FFWS-treated chilli crops showed a high number of branches per plant compared to 2.5% FFWS treatment, while the least number of branches was produced in the control. FFWS-treated crops showed the highest number of branches on the 63<sup>rd</sup> day of the plantation. Similar results were obtained from the treatment of 3% of organic liquid fertilizer made with fish (Deore *et al.*, 2010). The findings of this study show similarity with those of a study by Baloch *et al.* (2008), which showed that in addition to nitrogen, phosphorous, and potassium, organic fertilizer contains the majority of macro- and micronutrients. These nutrients provide plants with the nutrients they require to flourish and have a significant impact on the number of branches that each plant produces.

#### Effect of FFWS on yield parameters

##### Number of days taken for flowering

Generally, incessant flowering of the chilli crops starts 60 – 90 days after sowing (Khaing *et al.*, 2016). In this study,

FFWS-treated crops required a minimum of 59 days after seeding for the initiation of flowering when compared to the control (Table 5). The present results are in agreement with the findings of Wahla *et al.* (2014), who reported that the application of L-Tryptophan enabled plants to initiate flowering early. In addition, fish protein hydrolysates act as bio-stimulants as well as this fertilizer biologically increases the induction of flowering, improved fruit setting, and reduced fruit drop (Yakhin *et al.*, 2017).

**Table 5:** Mean number of days taken for flowering of chilli plants under different levels of FFWS (2.5, 5.0 and 7.5%) and control.

Treatment	Mean number of days taken for flowering $\pm$ SD
7.5% of FFWS	59.50 $\pm$ 1.08 <sup>c</sup>
5% of FFWS	60.10 $\pm$ 1.19 <sup>bc</sup>
2.5% of FFWS	61.10 $\pm$ 1.37 <sup>b</sup>
Control	80.80 $\pm$ 1.31 <sup>a</sup>

Each value represents the Mean  $\pm$  SD of replicates (n=10); values represent with the same superscript letter along the column are not significantly different (P<0.05).

##### Number of flowers per plant

The study's overall findings revealed that FFWS-treated crops produced the higher number of flowers compared to control crops. The highest number of flowers per plant was recorded in 7.5 % FFWS-treated crops (28.40  $\pm$  2.17) and the lowest number was observed in the control (8.10

**Table 3:** Mean number of leaves per chilli plant treated with different levels of FFWS (2.5, 5.0 and 7.5%) and control.

Treatment	Mean number of leaves per plant $\pm$ SD					
	28 <sup>th</sup> day	35 <sup>th</sup> day	42 <sup>th</sup> day	49 <sup>th</sup> day	56 <sup>th</sup> day	63 <sup>rd</sup> day
7.5% of FFWS	11.90 <sup>a</sup> $\pm$ 1.79	21.50 <sup>a</sup> $\pm$ 2.71	49.40 <sup>a</sup> $\pm$ 5.25	85.80 <sup>a</sup> $\pm$ 14.24	154.20 <sup>a</sup> $\pm$ 42.95	201.50 <sup>a</sup> $\pm$ 45.90
5% of FFWS	11.50 <sup>ab</sup> $\pm$ 0.70	18.10 <sup>b</sup> $\pm$ 2.76	46.60 <sup>a</sup> $\pm$ 8.00	82.50 <sup>ab</sup> $\pm$ 8.97	149.30 <sup>a</sup> $\pm$ 31.04	191.9 <sup>ab</sup> $\pm$ 34.75
2.5% of FFWS	10.70 <sup>ab</sup> $\pm$ 1.16	16.30 <sup>b</sup> $\pm$ 3.16	38.00 <sup>b</sup> $\pm$ 14.49	70.40 <sup>b</sup> $\pm$ 25.31	128.10 <sup>a</sup> $\pm$ 52.25	162.20 <sup>b</sup> $\pm$ 45.77
Control	10.30 <sup>b</sup> $\pm$ 1.42	11.70 <sup>c</sup> $\pm$ 2.00	18.00 <sup>c</sup> $\pm$ 4.47	34.90 <sup>c</sup> $\pm$ 7.92	66.10 <sup>b</sup> $\pm$ 8.27	85.80 <sup>c</sup> $\pm$ 9.50

Each value represents the Mean  $\pm$  SD of replicates (n=10); values represent with the same superscript letter along the column are not significantly different (P<0.05)

**Table 4:** Mean number of branches per chilli plant treated with different levels of FFWS (2.5, 5.0 and 7.5%) and control.

Treatment	Number of branches $\pm$ SD				
	35 <sup>th</sup> day	42 <sup>th</sup> day	49 <sup>th</sup> day	56 <sup>th</sup> day	63 <sup>rd</sup> day
7.5% of FFWS	1.80 $\pm$ 0.63 <sup>a</sup>	8.50 $\pm$ 1.84 <sup>a</sup>	20.7 $\pm$ 5.98 <sup>a</sup>	40.3 $\pm$ 14.16 <sup>a</sup>	51.8 $\pm$ 8.64 <sup>a</sup>
5% of FFWS	1.20 $\pm$ 0.79 <sup>b</sup>	7.80 $\pm$ 1.40 <sup>a</sup>	19.2 $\pm$ 4.34 <sup>a</sup>	37.5 $\pm$ 9.55 <sup>a</sup>	49.0 $\pm$ 5.73 <sup>a</sup>
2.5% of FFWS	0.80 $\pm$ 0.79 <sup>b</sup>	4.70 $\pm$ 2.63 <sup>b</sup>	16.2 $\pm$ 8.82 <sup>a</sup>	28.8 $\pm$ 17.28 <sup>a</sup>	40.7 $\pm$ 14.68 <sup>b</sup>
Control	0.00 $\pm$ 0.00 <sup>c</sup>	1.10 $\pm$ 0.99 <sup>c</sup>	5.3 $\pm$ 3.47 <sup>b</sup>	10.8 $\pm$ 2.93 <sup>b</sup>	19.5 $\pm$ 3.37 <sup>c</sup>

Each value represents the Mean  $\pm$  SD of replicates (n=10); values represent with the same superscript letter along the column are not significantly different (P<0.05)

$\pm 1.52$ ) (Table 6). Furthermore, the use of 20 ml of fish waste extract increased the number of blooms in cucumber (Ellyzatul *et al.*, 2018), which is consistent with the current study, which disclosed similar results with 5% FFWS-treated crops.

#### Number of chilli pods per plant

At the first harvest, the mean quantity of chilli pods per crop differed according to the treatment. FFWS-treated plants produced significantly more chilli pods than control plants, but equivalent results were found in 7.5% and 5% FFWS-treated crops ( $P = 0.05$  at the 95% CI) (Table 6). According to Kanchan (2019), the organic fertilizer fishmeal showed a high yield in chilli at first harvest, and the use of 20 ml of fish waste extract boosted the number of cucumber fruits (Ellyzatul *et al.*, 2018). The highest number of fruits per plant may be due to a more significant number of leaves per plant. The findings are consistent with those of Roychaudhury *et al.* (1995), who observed that the number of fruits per plant increased with nitrogen application as the number of leaves increased. FFWS is a rich source of nitrogen, which may have increased the total number of leaves and fruits per plant in current study.

**Table 6:** Mean number of flowers and chilli per plant under different levels of FFWS (2.5, 5.0 and 7.5%) and control.

Treatment	Mean number of flowers per plant $\pm$ SD	Mean number of chilli pods per plant $\pm$ SD
7.5% of FFWS	28.40 $\pm$ 2.17 <sup>a</sup>	21.00 $\pm$ 2.00 <sup>a</sup>
5% of FFWS	24.80 $\pm$ 1.87 <sup>b</sup>	20.20 $\pm$ 1.87 <sup>a</sup>
2.5% of FFWS	14.30 $\pm$ 1.77 <sup>c</sup>	10.50 $\pm$ 1.58 <sup>b</sup>
Control	8.10 $\pm$ 1.52 <sup>d</sup>	3.50 $\pm$ 1.08 <sup>c</sup>

Each value represents the Mean  $\pm$  SD of replicates ( $n=10$ ); values represent with the same superscript letter along the column are not significantly different ( $P<0.05$ ).

#### Length and width of chilli pods

The mature dark-green color pots were identified visually and collected for measurement at the first harvest (the 63<sup>rd</sup>

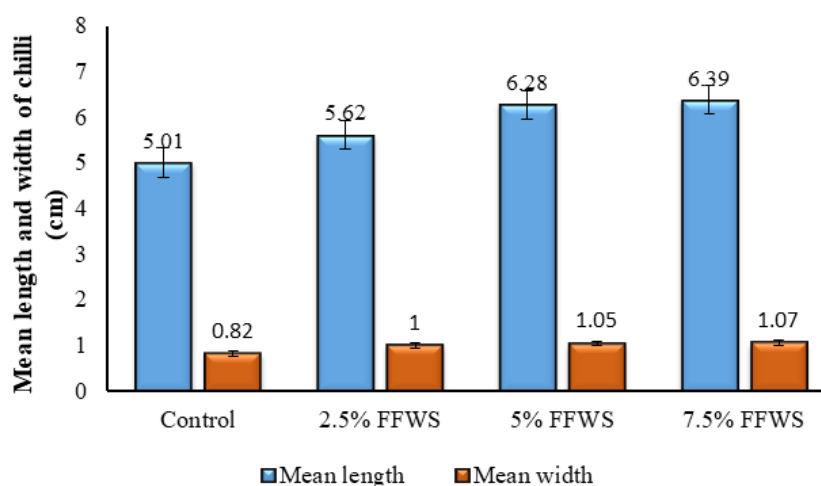
day after transplantation), there were differences in the length and width of the chilli pods between treatments and controls. The average length of the chilli pods differed significantly from the control ( $P=0.05$  at 95% confidence interval) (Figure 3). There was no discernible difference between crops treated with 5% FFWS and those treated with 7.5 percent FFWS. Longer chilli pods were collected from crops treated with 5% FFWS and 7.5 percent FFWS. The width of chilli pods from all FFWS-treated crops was similar, although substantially higher than the control (Figure 3). The results support the idea that foliar spraying of fish waste digested with papain enzyme increased the length of the okra plant's fruit (Ranasinghe *et al.*, 2019). Roychaudhury *et al.*, (1995) observed an improvement in fruit size with increasing nitrogen contents in organic fertilizer; it may be the reason for application of the 5% FFWS produced longer chillies.

#### Mean weight of total chilli pods per crop at first harvest

The mean weight of chilli pods per plant varied according to treatment and increased with increasing concentration of FFWS. The mean weight of chilli pods per crop for different treatments was significantly different from the control; according to the overall findings of this study, crops treated with 7.5 % FFWS showed the highest yield. Mean weight of chilli pods per crop was similar in plants treated with 5% FFWS and 7.5%FFWS (Table 7). Ranasinghe *et al.* (2019) found that foliar application of fish waste hydrolyzed with papain enzyme resulted in the maximum fruit weight in okra, similar to the present study's findings. Furthermore, several studies have shown that macro- and micronutrients are more critical for the growth and development of *Capsicum annum*. Likewise, sufficient nitrogen, phosphorus, and potassium provided by organic fertilizer aid in the production of vigor and taller chilli plants (Khandaker *et al.*, 2017), and mineral nutrients positively impact red chilli growth (Khan *et al.*, 2014).

#### Cost effectiveness of using FFWS

Cost effectiveness of FFWS is another important factor that determines farmer approval (Table 08).



**Figure 3:** Mean length and width of chilli pods subjected to different percentages of FFWS (2.5, 5.0, and 7.5%) and control.

**Table 7:** Weight of total chilli pods per crop treated with different levels of FFWS (2.5, 5.0 and 7.5%) and control at first harvest.

Treatment	Mean weight of chilli pods/per plant (g) $\pm$ SD
7.5% of FFWS	40.50 $\pm$ 5.93 <sup>a</sup>
5% of FFWS	38.50 $\pm$ 5.95 <sup>a</sup>
2.5% of FFWS	18.20 $\pm$ 3.80 <sup>b</sup>
Control	5.6 $\pm$ 1.78 <sup>c</sup>

Each value represents the Mean  $\pm$  SD of replicates (n=10); values represent with the same superscript letter along the column are not significantly different (P<0.05).

**Table 08:** Estimated cost of the production of 2.5 Liters of FFWS in Sri Lankan Rupees (SLR).

Expenditure	Amount	Cost / kg (SLR)	Total Cost (SLR)
Jaggery	2 Kg	350.00	700.00
Yellowfin tuna waste	2 Kg	100.00	200.00
Labour Cost/hour	7 hours	250.00 $\times$ 7	1,800.00
Total Expenditure			2,700.00

### Calculations

Total yield of FFWS (stock solution)	= 2.5 liters
Production cost (total)	= SLR 2,700.00
Cost of production/1 ml of FFWS	= 2,700.00/2500 ml
	= 1.08 SLR/ml
5% FFWS is considered as the standard	= 5 ml stock FFWS / 100 ml water
Total Volume of 5% FFWS used for 10 plants (6 sprays)	= 70 ml (as per the Table: 2)
Total Volume of FFWS stock solution	= 5 / 100 $\times$ 70 ml
	= 3.5 ml
Unit price for stock FFWS	= SLR 1.08 / 1 ml
Total cost for 10 plants /2.5m <sup>2</sup>	= 3.5 $\times$ 1. 08
	= 3.78 SLR
Number of Chilli seedlings cultivated per acre (Standard)	= 22,200
Total cost for Chilli cultivation (6 time spraying / acre)	= 22,200 $\times$ 0.378
	= SLR 8391.6 / acre

The cost of production of this homemade fish waste solution could be comparatively lower than commercialized growth promoters and other commercialized fish liquid solution available in markets, thus making FFWS is affordable to farmers involved in organic farming.

### CONCLUSION

The application of FFWS as a foliar spray on chilli crops at 7-day intervals enhanced the growth and yield performances compared to the control. The chilli plants treated with FFWS also bloomed earlier. Even though both 5% and 7.5% FFWS foliar treatments showed similar outcomes without significant differences, farmers can get benefit from the use of 5% FFWS by increasing yields and lowering the cost of agricultural production and farming expenditures. The commercialization and application of FFWS foliar fertilizer may be one of the more environmentally friendly approaches to sustaining organic farming practices. It will be appropriate for the current scenario of Sri Lankan

government policy to encourage organic farming and find alternatives to synthetic fertilizer.

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