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RESEARCH ARTICLE

# IMPACT OF ORGANIC AND CHEMICAL FERTILIZER COMBINATIONS ON GROWTH, YIELD, AND SOIL CARBON IN IN OIL PALM CULTIVATION AT TALGASWELLA ESTATE, SRI LANKA

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### ABSTRACT

**The success of oil palm cultivation hinges on factors such as planting material quality, management practices, and the availability of essential macro and micro-nutrients. Insufficient nutrient supply adversely impacts both vegetative growth and the ultimate yield in terms of quantity and quality. To address this issue, an experiment was conducted at Talgaswella Estate, belonging to Elpitiya Plantations PLC., situated in the Low Country Wet Zone (LCWZ) of Sri Lanka. The objective was to enhance the productivity and profitability of marginal oil palm lands. A ten-year-old oil palm field was chosen as the experimental site, employing a Randomized Complete Block Design (RCBD) with eleven treatments and three replicates, including an absolute control. Each trial plot consisted of six palm trees, totaling 198 trees in the experiment. Treatments involved varying combinations of Empty Fruit Bunches (EFB), Palm Oil Mill Effluent (POME), and Poultry Litter (PL), with and without chemical fertilizer. Soil, plant, and yield parameters were measured, and the data were analyzed using the Minitab statistical tool. After three years, results indicated that 100% organic fertilizer-received plots (T11) and 100% chemical fertilizer-treated plots (T2) exhibited significant increases in average fresh fruit bunch weight (22.81 Kg and 21.82 Kg), soil organic carbon percentage (3.00 and 2.23), and leaf chlorophyll content (78.79 and 75.07) of the 17th frond compared to T11 and T2 treated plots. Intermediate results were observed in the remaining fertilizer combined plots (T3, T4, T5, T6, T7, T8, T9, T10). The findings suggest that the use of organic fertilizer in marginal oil palm lands not only improves crop and soil factors but also contributes to environmental sustainability through the recycling of oil palm waste products. It is recommended to periodically apply organic fertilizer, especially on marginal oil palm lands, to enhance overall crop productivity and land sustainability.**

**Keywords:** Plant Growth, Oil Palm, Poultry Litter, Palm Oil Mill Effluent, Empty Fruit Bunches, Sri Lanka

## INTRODUCTION

Oil palm is a perennial tropical tree of the family Arecaceae, which is grown mainly for its oil. The oil palm comprises two main species: *Elaeis guineensis*, which is native to Africa, and *Elaeis oleifera*, native to South and Central America. Palm oil is widely used as cooking oil, as an ingredient in many processed foods, and as a substitute in butter making. Palm oil also has the potential as a bio-diesel and as a binding agent in cosmetics.

Oil palm was first introduced to Sri Lanka, as a commercial crop, about 50 years ago and established in the Galle District as a rain-fed perennial cash crop. The palm with its superior productive trait as an oil yielder along with its inherently large annual total production of dry matter, removes a considerable amount of nutrients from the soil it grows on. For its normal growth and

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development, the oil palm needs an uninterrupted supply of both macro and micronutrients in adequate quantities. Fertilizers are the most vital input that ensures optimum crop production which could be broadly classified into chemical and organic fertilizers (Dissanayake *et al*. 2019). The reliance on organic fertilizers dates back to man's earliest farming activities. Modern research on the use of organic manure for the cultivation of arable lands in Nigeria has been discussed by Hartley and Greenwood in the early years of 1933.

The sustainable production of oil palm involves looking into many aspects; i.e. land selection, planting materials, technical and administrative management, labour availability, harvesting efficiency, and environmental considerations. The success of producing economically sustainable yields will largely depend on the nature of the land and soils on which the palms are grown. To a large extent, these two factors will determine the associated management practices to be employed and its potential yield. The oil palm tree has a relatively shallow, coarse, and not very efficient root system, with a majority of its active roots confined to the upper 30 cm of the soil (Yahya *et al*. 2013). Therefore, to maintain an adequate nutrient supply to the palm, the soil nutrient concentration in the upper layers of the soil must be higher than that required for other similar crops. Since each soil has its special characteristics, it is very important to select the ideal soil for oil palm cultivation. When it is not the ideal soil type, then it is equally important to identify the limitations of the given soil and apply a package of soil management practices specifically tailored to the situation.

Sound agronomic practices coupled with efficient nutrient management could support an optimal supply of balanced fertilizers while in the meantime maintaining good ground cover, recycling of residues, and soil and water conservation (Biswas *et al*. 2002). All of these measures should contribute to improved yields.

Judicial manuring of palms aimed at providing adequate nutrients promote healthy vegetative growth, produce maximum economic oil palm yield, and build resistance to pests and diseases (Dayana *et al*. 2012). In balanced nutrient applications, fertilizer requirement is calculated, based on nutrients removed by plants, immobilized in the soil, and lost from the system due to runoff and seepage. In this exercise, one needs to integrate the use of mineral fertilizers, palm residues (Damanhuri, 1998) and palm oil mill wastes (Cotxarrera, 2002), which are plentifully available within plantations, aimed at sustainable nutrient management. It is important to adopt a policy of refraining from burning available biomass residues during the replanting of oil palm trees. This biomass represents a valuable reservoir of nutrients, making its preservation crucial. An innovative replanting technique in which the young palms are planted into the residue rows, has realized a significant saving on the amount of chemical fertilizers, in the range of at least 50% of the standard fertilizer rate over 5 years (Khalid and Chan, 2009).

Improving the fertility status of oil palm lands could be a major strategy to enhance the productivity of oil palm. The easiest way to address this aspect is through the application of organic fertilizers which may include compost, cow dung, poultry manure, green manure, and animal wastes (Karanatsidis and Berova, 2009). Nutrients of palm oil plantations were mainly, removed at the harvest and it can be replaced by recycling empty fruit bunches, uprooted trunks (Hasanthi and Palihakkara, 2020), and palm oil mill effluent (POME). Both of these have high Potassium (K) levels and can be used as a replacement for KCl at a rate of 2:1 (Roe and Cornforth, 2000). The ash of empty fruit bunches is strongly alkaline and thus can enhance soil pH which in turn increases soil microbial activity with elevated release of Nitrogen (N) from soil organic matter (Roe and Cornforth, 2000). Both POME and EFB consist of all these essential nutrients in reasonable amounts. Aliyu (2012) found that POME is a very useful source of high organic load and can be effectively used as a nutrient supplement, a cheap renewable residue from within. Lam and Lee (2011) discussed that POME is very hygroscopic and can be used as phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca) sources in oil palm cultivation. Similarly Loh *et al*. (2013) described that composted oil palm waste has a positive impact on soil physical attributes and microbial rejuvenation due to adequate amounts of beneficial mineral elements, improved organic carbon; improved cation exchange capacity (CEC), water-holding capacity and C: N ratio. Uwumarongie-Ilori *et al*. (2012) demonstrated that oil palm seedlings can grow undisturbed with organic fertilizer amendments with vigorous growth, high chlorophyll and nitrogen contents on organic manures. They further elaborated that oil palm seedlings grown with organic fertilizers were healthier than seedlings grown with inorganic fertilizers which contained metal impurities. Further, they argued that organic fertilization is environmentally friendlier compared with the use of inorganic fertilizers which is costly and sometimes not readily available within the plantation (Uwumarongie *et al*. 2012).

Nitrogen is an essential nutrient for the uninterrupted growth of the plant. The oil palm needs nitrogen in large amounts for both its vegetative as well as reproductive growth phases. Phosphorus, though is an indispensable nutrient, the palm requires it in far smaller amounts than N and K. Phosphorus plays an important on both the growth of the plant and its productivity. Potassium is not only essential for photosynthesis and the synthesis of protoplasm but it is also a regulating factor in the water economy of the plant (Barrington *et al*. 2002). Therefore, it is of paramount importance for a healthy plantation, to have a well-balanced nutrient regime right from the beginning.

In Sri Lanka, since all oil palm cultivation have been previously cultivated mostly with rubber and tea, these lands are naturally poor in soil fertility status. This could only lead to low growth, yields, and productivity of palm trees. When this happens in the fields that have been earmarked as marginal, it poses the management companies a considerable problem due to low productivity.

The use of large quantities of chemical fertilizers for better yields has become a serious environmental issue (Jeong and Kim, 2001). To overcome such problems, the use of organic materials (manure) provides a readily environmentally friendly solution. Organic materials will help to increase soil carbon levels. In turn, it will help to increase chemical fertilizer use efficiency as well (Mohammad *et al*. 2012 and Satriawan *et al*. 2016).

Since the oil palm industry has been growing steadily over the past years, it has led to increasing volumes of waste material; especially the empty fruit bunches (EFB) and Palm Oil Mill Effluent (POME) (Dayana *et al*. 2012). Oil palm mill effluent (POME, EFB) releases its nutrients to the soil within 10 months of its introduction (Moradi, 2014). Therefore, the present study was conducted with the dual intention (objectives) of finding a solution to the disposal of waste material accumulated in oil palm factories over the years and to improve the productivity of marginally yielding oil palm fields. In Sri Lanka, Marginal/poorly managed rubber plantations were mainly converted to oil palm cultivation compared to other large-scale growers in the world (Dissanayake *et al*. 2019). Oil palm plantations in the world were highly depending on inorganic fertilizers including Sri Lanka and higher portion of the Cost of Production (COP) clams for inorganic fertilizers. Therefor this study focused on the possibility to cultivate marginal oil palm plantations with available organic fertilizers.

## MATERIALS AND METHODS

The research was conducted at Talgaswella Estate, belonging to Elpitiya Plantations PLC., situated in the Low Country Wet Zone of Sri Lanka within the WL2a agro-ecological zone. The experimental design employed a Randomized Complete Block Design (RCBD) with eleven treatments denoted as T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, and T11, each having three replicates. Data collection was carried out on six palm trees within each treatment.

Fertilizer mixtures were formulated based on a nitrogen (N) supply of 0.63 kg per palm per year. This was achieved through the use of the recommended inorganic fertilizer mixture supplemented with potassium (K) and phosphorus (P) as per guidelines (refer to Table 1). Fertilizer applications were executed according to Table 1, divided into three equal doses, applied at four-month intervals, and consistently maintained throughout the research period by trained workers. The study focused on a ten-year-old oil palm field, comprising 33 plots, each housing six palm trees.

Organic treatments encompassed varied quantities of Empty Fruit Bunches (EFB), Palm Oil Mill Effluent (POME), and Poultry Litter (PL). Application of treatments occurred at four-month intervals following the standard fertilizer application, which comprised three applications per year (refer to Table 1). In the inorganic fertilizer treatment, the application adhered to plantation recommendations, while the organic manure

**Table 1: Treatment combination and amount of fertilizer added per plant /year**

| Plot No | Fertilizer/ type | Qty. - Kg | Prize-Per/Kg | Total Cost – Rs. | N/Kg | K/Kg | Additional K/Kg | P/Kg | Additional P/Kg |
|---|---|---|---|---|---|---|---|---|---|
| **T1** | No fertilizer | | | | | | | | |
| **T2** | E.R.P. | 3.0 | 15.00 | 45.00 | | | | | |
| | S.A. | 3.0 | 30.00 | 90.00 | | | | | |
| | M.O.P | 2.5 | 30.00 | 75.00 | - | - | | - | |
| | **Total** | | | **210.00** | **0.63** | **1.50** | | **1.02** | |
| **T3** | C F-50% | 1.49 | 24.71 | 36.82 | 0.312 | 0.424 | | 0.894 | |
| | P L-20% | 2.09 | 4.00 | 8.36 | 0.062 | 0.026 | | 0.035 | |
| | EFB 80% | 22.49 | 0.50 | 11.25 | 0.251 | 0.134 | | 0.098 | |
| | **Total** | | | **102.20** | **0.625** | **0.584** | **1.526** | **1.027** | |
| **T4** | C F-50% | 1.49 | 24.71 | 36.82 | 0.312 | 0.424 | | 0.894 | |
| | PL-10% | 1.04 | 4.00 | 4.16 | 0.031 | 0.013 | | 0.017 | |
| | EFB -90% | 25.26 | 0.50 | 12.63 | 0.282 | 0.151 | | 0.111 | |
| | **Total** | | | **99.21** | **0.625** | **0.588** | **1.52** | **1.022** | |
| **T5** | C F 50% | 1.49 | 24.71 | 36.82 | 0.312 | 0.424 | | 0.894 | |
| | PL-20% | 2.09 | 4.00 | 8.36 | 0.067 | 0.026 | | 0.035 | |
| | POME80% | 14.39 | 0.50 | 7.20 | 0.251 | 0.125 | | 0.109 | |
| | **Total** | | | **98.60** | **0.630** | **0.575** | **1.541** | **1.038** | |
| **T6** | CF 50% | 1.49 | 24.71 | 36.82 | 0.312 | 0.424 | | 0.894 | |
| | PL-10% | 1.04 | 4.00 | 4.16 | 0.031 | 0.013 | | 0.017 | |
| | POME90% | 16.17 | 0.50 | 8.09 | 0.282 | 0.140 | | 0.122 | |
| | **Total** | | | **95.20** | **0.625** | **0.577** | **1.538** | **1.033** | |
| **T7** | C F-75% | 2.249 | 24.71 | 55.57 | 0.472 | 0.640 | | 1.349 | |
| | PL-20% | 1.046 | 4.00 | 4.18 | 0.031 | 0.013 | | 0.017 | |
| | EFB 80% | 11.24 | 0.50 | 5.62 | 0.125 | 0.067 | | 0.049 | |
| | **Total** | | | **104.38** | **0.628** | **0.720** | **1.300** | **1.415** | |
| **T8** | C F-75% | | | 55.57 | 0.472 | 0.640 | | 1.349 | |
| | PL-10% | | | 2.08 | 0.015 | 0.006 | | 0.008 | |
| | EFB 90% | | | 7.03 | 0.157 | 0.084 | | 0.061 | |
| | **Total** | | | **103.17** | **0.644** | **0.730** | **1.283** | **1.418** | |
| | **Total** | | | **146.03** | **0.628** | **0.292** | **2.013** | **0.175** | **2.485** |
| **T9** | C F-75% | | | 55.57 | 0.472 | 0.640 | | 1.349 | |
| | PL-20% | | | 4.18 | 0.031 | 0.013 | | 0.017 | |
| | POME80% | | | 3.60 | 0.125 | 0.062 | | 0.054 | |
| | **Total** | | | **102.57** | **0.628** | **0.715** | **1.308** | **1.420** | |

*Table 1 Continued …*

| Plot No | Fertilizer / type | Qty. - Kg | Prize-Per/Kg | Total Cost – Rs. | N/Kg | K/Kg | Additional K/Kg | P/Kg | Additional P/Kg |
|---|---|---|---|---|---|---|---|---|---|
| **T10** | C F-75% | 2.249 | 24.71 | 55.57 | 0.472 | 0.640 | | 1.349 | |
| | PL-10% | 0.52 | 4.00 | 2.08 | 0.015 | 0.006 | | 0.008 | |
| | POME90% | 8.99 | 0.50 | 4.50 | 0.157 | 0.078 | | 0.068 | |
| | **Total** | | | **100.94** | **0.644** | **0.724** | **1.293** | **1.425** | |
| **T11** | PL | 10.46 | 0.50 | 5.23 | 0.314 | 0.130 | | 0.046 | |
| | EFB | 14.06 | 0.50 | 7.03 | 0.157 | 0.084 | | 0.061 | |
| | POME | 8.99 | 4.00 | 35.96 | 0.157 | 0.078 | | 0.068 | |
| | **Total** | | | **146.03** | **0.628** | **0.292** | **2.013** | **0.175** | **2.485** |

CF= Chemical Fertilizer PL= Poultry Litter EFB= Empty Fruit Bunches, POME= Palm Oil Mill Effluent E.R.P. = Eppawala Rock Phosphate S.A.= Sulphate of Ammonia M.O.P = Muriate Of Potash

treatment aimed to balance nutrients, including nitrogen (N), phosphorus (P), potassium (K), and magnesium (Mg). Treatments were applied over a two-year period preceding data collection, with subsequent data collection occurring at monthly and six-month intervals.

Bunch weight data from each plant in the trial plots were recorded at ten-day intervals after the initiation of data collection. Soil samples were collected and subjected to analysis for pH, organic carbon, phosphorus (1.5 pH, Borax Extraction Method), potassium, and magnesium (1N, 7pH, Ammonium Chloride Extraction Method) at six-month intervals post the start of data collection. Leaf samples were manually collected from the 17th frond of each palm for the analysis of chlorophyll content, following the methodology outlined by Fairhurst and Mutert (1999).

On a monthly basis, frond count and inflorescence count were manually recorded, and chlorophyll content was measured using a SPAD (Soil Plant Analysis Development) meter. The oil content of the fruits was analyzed at AEN oil palm factory using the FOSS DA1650 instrument. All data underwent analysis using Minitab, and mean separations were performed using the Duncan's Multiple Range Test (DMRT) at a significance level of $\alpha \leq 0.05$.

## RESULTS AND DISCUSSION

The study aimed to examine the effects of total chemical fertilizers (Sulphate of Ammonia 03 Kg, Muriate of Potash 2.5 Kg, Eppawala Rock Phosphate 03 Kg per tree per annum) versus total organic fertilizer (Poultry Litter 7.5 Kg, Empty Fruit Bunches 20.3 Kg, Palm Oil Mill Effluent 13.0 Kg per tree per annum) on soil organic carbon percentage, fresh fruit bunch weight, and chlorophyll content of the 17$^{th}$ frond in individual treatments.

### Changes in Soil Organic Carbon Percentage with Treatments

Before the application of treatments, the average soil organic carbon in the experimental area was 1.09%. After three years, plots treated with 100% chemical fertilizer (T2) showed an average soil organic carbon of 2.23%, while those treated with 100% organic fertilizer (T11) exhibited a higher average of 3.00%. In comparison, the values for the second year were 1.99% and 2.05% for T2 and T11, respectively. Notably, the plots receiving 100% organic fertilizer displayed significantly higher soil carbon percentages in the third year (Table 2).

### Effect of treatments on Fresh Fruit Bunch weight

At the end of three years, the average fresh fruit bunch weight for plots receiving 100% chemical fertilizer was 21.82 Kg, while the 100% organic fertilizer-treated plots exhibited a higher average of 22.81 Kg (Table 3). Plots treated with a combination of 50% chemical and 50% organic fertilizer (T5) resulted in fresh fruit bunch weights of 20.20 Kg and

20.90 Kg in the second and third years, respectively. Moreover, plots treated with 75% chemical and 25% organic fertilizer (T9) showed higher yields in the third year compared to 50% chemical and 50% organic fertilizer combinations but lower yields than 100% organic fertilizer-treated plots (T11). Research conducted in Malaysia has demonstrated the positive impact of organic fertilizer, such as oil palm waste (EFB), on plant growth and yield (Michael *et al.* 2022).

**Effect of Treatments on 17$^{th}$ Frond Chlorophyll Content**

After one and three years of the trial, the average chlorophyll values for plots receiving 100% chemical fertilizer (T2) exhibited a decreasing trend (75.89 and 75.07, respectively), while 100% organic fertilizer-treated plots (T11) showed an increasing trend (76.60 and 78.79 in the first and third years, respectively). Notably, leaf chlorophyll values were significantly lower in T1 in the third year compared to other treatments (Table 4). All inorganic fertilizer-applied plots (50%, 75%, and 100%) had significantly lower chlorophyll values compared to 100% organic fertilizer-applied plots. The application of

**Table 2: Change of soil organic carbon levels with time (years)**

| Treatment | Initial soil carbon level % | increment of soil carbon % | | |
|---|---|---|---|---|
| | | First year | Second year | Third year |
| T1 | 1.09 | 0.01$^{c}$ | 0.01$^{d}$ | 0.03$^{f}$ |
| T2 | 1.09 | 0.25$^{a}$ | 0.56$^{b}$ | 0.35$^{e}$ |
| T3 | 1.09 | 0.19$^{a}$ | 0.46$^{b}$ | 0.55$^{d}$ |
| T4 | 1.09 | 0.20$^{a}$ | 0.03$^{c}$ | 0.60$^{c}$ |
| T5 | 1.09 | 0.16$^{a}$ | 0.05$^{c}$ | 0.55$^{d}$ |
| T6 | 1.09 | 0.21$^{a}$ | 0.05$^{c}$ | 0.65$^{c}$ |
| T7 | 1.09 | 0.06$^{bc}$ | 0.03$^{c}$ | 0.62$^{c}$ |
| T8 | 1.09 | 0.07$^{b}$ | 0.04$^{c}$ | 0.68$^{b}$ |
| T9 | 1.09 | 0.06$^{bc}$ | 0.01$^{d}$ | 0.71$^{b}$ |
| T10 | 1.09 | 0.04$^{bc}$ | 0.01$^{d}$ | 0.70$^{b}$ |
| T11 | 1.09 | 0.07$^{b}$ | 0.89$^{a}$ | 0.95$^{a}$ |

Values in each column followed by the same letters are not significantly different (P=0.05) according to Duncan's Multiple Range Test (DMRT) means separation.

**Table 3: Average bunch weights over time (years)**

| **Treatment** | **First year average bunch weights (kg)** | **Second year bunch weight increment (kg)** | **Third year bunch weight increment (kg)** |
|---|---|---|---|
| T1 | 19.0 | -0.25$^{e}$ | -0.2$^{e}$ |
| T2 | 20.58 | 0.74$^{a}$ | 0.5$^{d}$ |
| T3 | 19.5 | 0.3$^{c}$ | 0.6$^{d}$ |
| T4 | 19.4 | 0.1$^{c}$ | 0.6$^{d}$ |
| T5 | 20 | 0.2$^{c}$ | 0.7$^{c}$ |
| T6 | 20.1 | -0.25$^{e}$ | 0.8$^{b}$ |
| T7 | 20.2 | -0.2$^{e}$ | 0.85$^{b}$ |
| T8 | 20.5 | -0.1$^{c}$ | 0.75$^{c}$ |
| T9 | 20.5 | 0.0$^{d}$ | 0.95$^{a}$ |
| T10 | 20 | 0.4$^{b}$ | 0.9$^{a}$ |
| T11 | 21.18 | 0.63$^{a}$ | 1.0$^{a}$ |

Values in each column followed by the same letters are not significantly different (P=0.05) according to Duncan's Multiple Range Test (DMRT) means separation.

organic fertilizers appeared to induce leaf chlorophyll content due to the promotional effect on nitrogen (N) and magnesium (Mg), essential constituents of chlorophyll.

Hence, the organic matter used to amend soil can be considered the source of supplying those nutrients through mineralization plus improving physical and chemical properties of the soil because of the ability of organic fertilizer to release nutrients gradually through the growing season (Arisha *et al.* 2003). Similarly, Comte *et al.* (2013) have emphasized that organic fertilization improves soil fertility in oil palm lands, mainly in the small-scale plantations (<30 ha), in a short-time period (3-5 years) while this response to organic fertilizer cannot be the same in different soil classes. The study site's soil type is Red Yellow Podzoilc. In general, an increase of soil nutrients was observed in every research plot and the nutrient content of treated plots was higher in comparison to the control. It is also observed the pH values of all

**Table 4: Change of chlorophyll content values of the 17th frond in SPAD units over time - first (2020) and second (2021) year**

| Treatment | First year chlorophyll value (SPAD Units) | Chlorophyll value change in the second year | Chlorophyll value change in the third year |
|---|---|---|---|
| **T1** | 68.2 | -1.7$^{e}$ | -1.5$^{e}$ |
| **T2** | 75.89 | -0.32$^{d}$ | -0.5$^{c}$ |
| **T3** | 74.63 | -0.01$^{c}$ | -0.3$^{c}$ |
| **T4** | 74 | 0.2$^{b}$ | 0$^{d}$ |
| **T5** | 74.4 | 0$^{c}$ | -0.5$^{c}$ |
| **T6** | 72.5 | 1.4$^{a}$ | 0$^{d}$ |
| **T7** | 74.9 | 0$^{c}$ | 1$^{b}$ |
| **T8** | 74 | 0.2$^{b}$ | 1$^{b}$ |
| **T9** | 75.5 | 0.1$^{b}$ | 1.2$^{a}$ |
| **T10** | 75.5 | 0.3$^{b}$ | 1$^{e}$ |
| **T11** | 76.6 | 0.69$^{d}$ | 1.5$^{a}$ |

Values in each column followed by the same letters are not significantly different (P=0.05) according to Duncan's Multiple Range Test (DMRT) means separation.

**Table 5: Analysis of soil nutrient improvement (P, K, Mg in ppm & pH) with time**

| Treatment | P initial | P Increment 2nd year | K initial | K Increment 2nd year | Mg initial | Mg Increment 2nd year | pH initial | pH change 2nd year |
|---|---|---|---|---|---|---|---|---|
| **T1** | 7 | 3.8 | 17 | 0.4 | 9 | 0 | 5.3 | 0.8 |
| **T2** | 14 | 11 | 17 | 23 | 6 | 26 | 5.3 | 0.8 |
| **T3** | 16 | 6 | 16 | 12.3 | 10 | 9 | 5.1 | 0.8 |
| **T4** | 9 | 5 | 15 | 3 | 8 | 11 | 4.9 | 0.9 |
| **T5** | 15 | 7 | 16 | 4 | 7 | 14 | 4.8 | 0.9 |
| **T6** | 12 | 7 | 18 | 6 | 8 | 14 | 4.5 | 1 |
| **T7** | 14 | 6 | 15 | 6 | 7 | 13 | 5.2 | 0.5 |
| **T8** | 28 | 0.5 | 18 | 5 | 7 | 16 | 4.9 | 0.7 |
| **T9** | 18 | 3 | 16 | 4 | 9 | 14 | 4.8 | 0.9 |
| **T10** | 22 | 1 | 16 | 6 | 8 | 18 | 5 | 0.5 |
| **T11** | 42 | 0.2 | 42 | 0.2 | 8 | 27 | 5.2 | 0.2 |

the plots were observed to be within a favorable range for the growth of oil palm (Table 5).

**Comparison of Total Edible Oil Production**
Throughout the two-year trial period, 100% organic fertilizer-treated plots consistently showed increased yields compared to 100% chemical fertilizer-treated plots (Table 3). Specifically, 100% organic fertilizer (T11) resulted in significantly higher palm oil yields compared to 100% chemical fertilizer (T2) and various combinations of chemical and organic fertilizers (T3, T4, T5, T6, T7, T8, T9, T10) (Table 6). This suggests that the application of organic fertilizer not only improves oil yield but also contributes to soil health, representing an environmentally friendly agronomic practice (Table 2) Considering the cost aspect, chemical fertilizer (T2) incurred higher costs than organic fertilizer (T11), confirming that chemical fertilizers are more expensive for oil palm cultivation in Talgaswella estate, Sri Lanka (Table 7).

## CONCLUSION

In conclusion, the application of 100% organic fertilizer resulted in a clear increase in fresh fruit bunch weight, soil organic carbon levels, and chlorophyll content of the 17th frond compared to control and 100% chemical

**Table 6: Total edible oil production under different treatments (2nd Year)**

| Treatment | No. of Bunches/ ha | Average bunch wt. Kg (2nd year) | Total Bunch wt. Kg/ ha | Oil % Against 100% organic fertilizer |
|---|---|---|---|---|
| **T1** | 338 | 20.76 | 7016 | **85[d]** |
| **$T_2$** | 448 | 21.32 | 9551 | **92 [c]** |
| **$T_3$** | 450 | 19.80 | 8910 | **96 [b]** |
| **T4** | 419 | 19.5 | 8170 | **93[c]** |
| **T5** | 421 | 20.2 | 8504 | **96 [b]** |
| **T6** | 419 | 19.85 | 8317 | **93[c]** |
| **T7** | 434 | 20.0 | 8680 | **96[b]** |
| **T8** | 429 | 20.4 | 8751 | **92[c]** |
| **T9** | 440 | 20.5 | 9020 | **96[b]** |
| **T10** | 441 | 20.4 | 8996 | **92[c]** |
| **$T_{11}$** | **443** | **21.80** | **9657** | **100 [a]** |

Values in each column followed by the same letters are not significantly different (P=0.05) according to Duncan's Multiple Range Test (DMRT) means separation.

**Table 7: Variable cost of fertilizing with the treatments**

| Treatments | Fertilizer Cost/ tree/ application LKR | Application cost/ application tree LKR | Total cost/ tree/ application LKR |
|---|---|---|---|
| **T1** | | 0 | 0 |
| **T2** | 210 | 13 | 223 |
| **T3** | 102.20 | 63 | 165,2 |
| **T4** | 99.21 | 63 | 162.21 |
| **T5** | 98.60 | 63 | 161.6 |
| **T6** | 95.20 | 63 | 158.2 |
| **T7** | 104.38 | 63 | 167.38 |
| **T8** | 103.17 | 63 | 166.17 |
| **T9** | 102.59 | 63 | 165.59 |
| **T10** | 100.94 | 63 | 163.94 |
| **T11** | 146.03 | 50 | 209.03 |

Application cost of Chemical fertilizer is LKR 13 and organic fertilizer is LKR 50 fertilizer-treated plots. This improvement is attributed to the enhanced soil environment from continuous organic fertilizer use, promoting improved soil nutrient content. Notably, the highest oil yield was recorded with 100% organic matter application. Additionally, a mixture of organic matter had a significant impact on oil production in marginal oil palm cultivations, offering a sustainable solution to the disposal of palm oil mill effluent (POME) and empty fruit bunches (EFB). These findings contribute to the overall productivity of the oil palm industry in the low country wet zone (WL2a) of Sri Lanka. Moreover, the application of organic fertilizer proves to be a cost-effective alternative compared to chemical fertilizers. The study recommends further research with low-cost, freely available organic fertilizer combinations for marginal oil palm plantations.

## AUTHOR CONTRIBUTION

IR, DUH designed the study. DUH, IR and A performed the Impact of Organic and Chemical Fertilizer Combinations on Growth, Yield, and Soil Carbon in Talgaswella Estate experiments. DUH and IR analyzed the data. DUH, IR and A wrote the paper with input from all authors. All authors discussed the results and commented on the manuscript.

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