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Assessing Growth Performance and Yield of Okra (*Abelmoschus esculentus* (L.) Moench) Using Slow-Release Fertilizer

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Abstract

The agricultural sector has contributed to environmental pollution, such as water and air pollution caused by the fertiliser used in agriculture is lost into the river or to the air through the leaching process. Studies in the literature have shown that slow-release fertiliser (SRF) application could help overcome the leaching problem as it releases its nutrients slower. In other words, SRF is expected to help maintain the nutrients' availability in the soil for a more extended period and extends the plants' nutrient uptake efficiency. The experimental design for this study was completely randomized design with 4 different treatments T0 (control) was treatment without fertilizer application; T1 (SRF applied once in a month); T2 (CF applied once in a month); T3 (SRF applied twice in a month) and T4 (CF applied twice in a month). This study aimed to compare the plant growth rate (plant height, number of leaves and plant yield) of using SRF and conventional fertiliser (CF) on okra (*Abelmoschus esculentus* L. Moench). This study shows that SRF does show a good option to promote the growth development of okra (plant height, number of leaves and chlorophyl content) but not on the yield.

1. INTRODUCTION

The application of fertiliser is commonly practised in agriculture. However, over fertilisation can harm the soil and the environment (Li et al., 2018), and leaching of fertiliser is a common problem in plantations of any crops. Nutrients available in the soil for plant growth and development could be disturbed due to this issue. Due to leaching problems, fertiliser must be applied more often, especially for the tropical planting area, to maintain the plants' high growth rate. Thus, more labour, cost, time, and energy will be needed to maintain the crops' usage's optimum nutrients. Not only that, the leaching problem has become the reason why the agriculture sector is one of the sectors that contribute to water and air pollution (Mateo-Sagasta et al., 2017). Agricultural pollution needs to be managed wisely to avoid long-term side effects that might be more dangerous for living things and the environment.

Researchers have developed one alternative to overcome the leaching issue: the slow-release fertiliser (SRF) as the solution. SRF is a coated fertiliser that is claimed to be effectively releasing its nutrients compared to conventional fertiliser (Lawrencia et al, 2021). SRF is a fertilizer coated with plastic resin or sulfur based polymers which slowly break down from water, heat, sunlight and/or soil microbes. Physical characteristics of SRF is that SRF is designed in a special form of highly pressed nugget size and it contains all necessary nutrients needed for plants. Whereas, the common fertilizer is in granule form and it is easy to diffuse in the soil and therefore nutrients were fast released. Current trends show that many researchers have developed their own coated formulation for the SRF (e.g. Bilal et al (2020), Taha et al (2020) and Baldanza et al (2018)). Based on the studies in the literature, SRF has been shown to reduce the negative impact of excessive usage of fertiliser on the environment. SRF is claimed to enhance the nutrient uptake for the plant by releasing the nutrients to the plant slowly over some time. Since SRF can help reduce the leaching rate, it is promising to help the agro-farmers minimise fertiliser application frequency and indirectly minimise labour costs for operation purposes

Okra or also known as ladies finger in England or 'bendi' in Malaysia. Okra's scientific name is

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Abelmoschus esculentus L. (Moench). The largest producer of okra in the world is India which is contributes to 70% of world production of okra. It was reported that in 2018, the production of okra in Malaysia 51 is 257 tonnes (FAOSTAT, 2020). For okra cultivation, it requires a long warm and humid growing period. Normally, it can grow under temperature between 24oC to 28oC. However, it also can survive in the hot humid area but not under a low temperature area as it is sensitive to frost. At a temperature beyond 40oC, flowers may desiccate and drop and eventually cause major yield losses. The ideal soil requirement for okra cultivation is well-manured loam soils, loose and friable. The pH of the soil is best at 6.0 to 6.8. Hence, Malaysia has a best feature for okra cultivation as the temperature and soil requirement needs are available in Malaysia.

So, this paper investigates whether the application of SRF is better than standard or common fertiliser (CF) or not. Okra has been chosen for this study as there is a lacking information in the literature for SRF on okra's plant growth in the literature. This study would validate whether SRF helps provide better nutrient uptake for okra's plant growth. The experiment also observes whether the type of fertiliser affects the chlorophyll content in the plants' leaves. Therefore, this study's results would benefit the agro-farmers to consider applying SRF in their okra farms.

2. MATERIALS AND METHODS

2.1 Treatment Preparation

The amount of NPK (12:12:17:2) fertiliser and slow-release fertiliser used for okra planting was one tan/ha as recommended by the Deputy of Agriculture, Malaysia (equivalent to 16g/polybag). The treatments of the study were as the Table 1. The type of medium used for okra planting can vary depending on the handlers' choice. Okra can be planted in most types of soil texture: for example, clay soil, peat soil and sandy loam soil. The most important point about choosing the medium was the soil's drainage, affecting the planting activity. For this study, the topsoil was used with sandy loam soil texture. Besides, peat moss and cocopeat were mixed well together with topsoil at ratio 1:1:1, respectively. All of the poly bags were ¾ filled with the mixture of the planting media. After two weeks from the sowing date, the best seedlings were chosen and transplanted to the poly bags. One seedling for one polybag. The transplanting process was done cautiously to avoid any root damage. After one week of the transplanting process, NPK fertilisers were applied. For the purpose of this study, SRF used was the commercialised one called GreenFeed and brought online. This SRF is coated by water-soluble Nitrogen and 'Zeolite'. A nugget of SRF (16g) was applied for each okra plant sample under T1 and T3. Meanwhile, 16g of CF was weighed and applied to plant samples under T2 and T4. Fertilisation for T1 and T2 was done once a month. While for T3 and T4, it was done every two weeks' time (twice per month). Weeding was done weekly. Organic pesticide using chillies, vinegar and water as the ingredients was applied twice a week. After 45 days from transplanting, the okra fruits were harvested by cutting the stem above the okra cap using a scissor. Mature fruit criteria were 10 to 12cm long and soft.

Table 1: List of Treatments

Treatment	**Description**
T0 (Control)	No fertilizer application
Treatment 1	Slow release fertilizer was applied once a month
Treatment 2	Conventional fertilizer was applied once a month
Treatment 3	Slow release fertilizer was applied twice a month
Treatment 4	Conventional fertilizer was applied twice a month

2.2 Parameter of Study

Growth parameters such as plant height, number of leaves were recorded weekly however for this study's result only the end of observation was presented. While for the chlorophyll content and total yield, observations were recorded at the maturity stage (i.e. 45 days after planting). Plant height was measured by using a measuring tape and chlorophyll content measured using Soil Plant Analysis Development (SPAD).

2.3 Statistical Analysis

One-way analysis of variance (ANOVA) was used to measure the significance of the differences between the treatments. All statistical test was performed using SPSS and Tukey's HSD test to compare the mean of each treatment at 5% significant level.

3. RESULT AND DISCUSSION

3.1 Effect of SRF and CF On the Plant Height of Okra

After 36 days of first fertiliser application, the height of okra plants is measured using a measuring tape, and the range of height of the plants is from 15.44cm to 32.57 cm. Not surprisingly, from the data collected in Figure 1, plant samples with fertiliser application show significantly greater height than the plant samples without fertiliser

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application (T0). The mean height of okra plant samples for T0 is the lowest, 15.44cm, followed by a 39.85% increment of T3, which is 25.67cm. Next, increase 42.17% of T2, which is 26.70cm, and 48.53% increase for T4, which is 30cm. Lastly, the highest mean height is plant samples from T1, 52.59% higher than T0, which equals 32.57cm. However, there are no significant differences between the mean height of treated plant samples using the Tukey HSD test.

Interestingly, from this observation, it was found that the mean plant height of T1 was likely similar to T4 with 7.89%. It shows that less frequency of slow-release fertiliser application could give better performance or as best as the regular frequency of conventional fertiliser application. The outcome from this experiment can be related to the unique feature of SRF, which it will release its nutrient after a certain period once it is applied to the soil (Liu et al., 2014). It is also supported by the study done by Trenkel in 2010, in which he found that SRF gives a better growth effect at the lower rate of application since it gives longer nutrient availability in the soil. Thus, SRF has better fertilisation efficiency (Sikora et al., 2020) and significantly impacted plant growth (Feng et al., 2020).

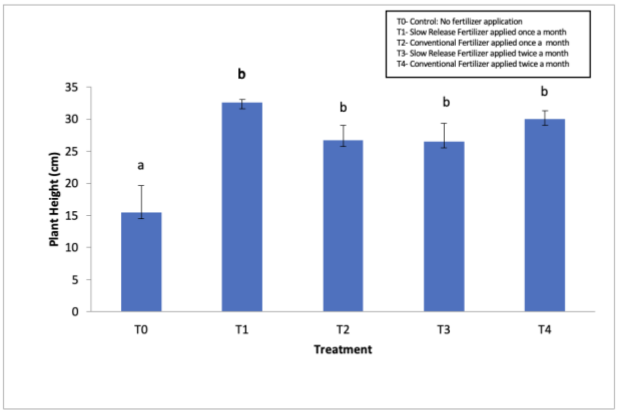

Figure 1: Effect of different application frequencies of Slow Release Fertilizer and Conventional Fertilizer on the okra plant height. Data are the means of five independent replicates with standard deviation shown by vertical bars. Means with a different letter (s) indicate significant difference by Tukey's test at $P \leq 0.05$.

3.2 Effect of SRF and CF On the leaves number of Okra

Figure 2 shows the mean number of okra leaves for all treatments. Again, as expected, the okra plant treated with fertiliser (T1, T2, T3 and T4) significantly increased the leaves number of okra compared to the control (T0) with the average leaves number from 2.8 to 8.33. T1 has the highest mean number of leaves, 8.33, followed by T4, T2, T3 and T0, 8, 7, 5.67 and 2.8, respectively.

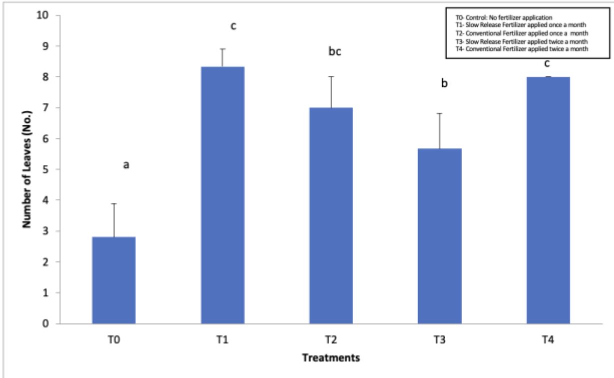

Figure 2: Effect of different application frequencies of Slow Release Fertilizer and Conventional Fertilizer on the number of leaf or okra plants. Data are the means of five independent replicates with standard deviation shown by vertical bars. Means with a different letter (s) indicate significant difference by Tukey's test at $P \leq 0.05$.

In addition, a significant difference in the number of leaves of which the plant treated with SRF (T1 and T3). The number of leaves for T1 and T3 was 6 and 8, respectively. Even though both treatments used the same type of fertiliser, their results were significantly different as the frequency of fertiliser application was different. From this observation, it can be concluded that higher SRF application gives fewer leaves than the low SRF application. This finding is supported by past research, which stated that the SRF applied at a higher dosage with frequent fertilisation gives the smaller value of the parameter (Niemiec & Komorowska, 2018).

Generally, the higher the fertiliser rate applied, the higher the plant growth (Hariyadi et al., 2018). However, according to Deng et al. (2018), plant growth is affected by the frequency of fertiliser application. Similar to this finding, Albornoz & Lieth (2015) demonstrated that any further increase of fertilisation at a certain level would reduce plant growth productivity due to decreasing stomatal conductance.

3.3 Effect of SRF and CF On the Chlorophyll Content of Okra

The chlorophyll content of the okra plant samples was measured by using a SPAD meter as in Figure 3. All treatments do not significantly increase chlorophyll content, where the average mean value for all treatments ranged from 48.83nm to 35.7nm. However, the treated okra plants show significantly higher chlorophyll content as compared to the control T0. The treatments with an application rate once a month show that SRF (T1) has higher chlorophyll content than CF treatments (T2 and T4). T1 is 0.43% (48.83nm) higher than T4 (48.62nm) and

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7.23% higher than T2 (45.3nm). This recent study was in line with a study conducted by Costamagna et al. (2020) on strawberry plants where coated fertiliser (slow-release fertiliser) gave 13.37% higher chlorophyll content than uncoated fertiliser with the values of 41.9nm and 36.3nm, respectively.

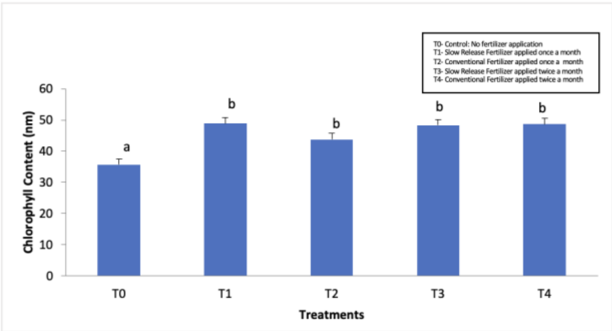

Figure 3: Effect of different application frequencies of Slow Release Fertilizer and Conventional Fertilizer on the chlorophyll content of okra plant. Data are the means of five independent replicates with standard deviation shown by vertical bars. Means with a different letter (s) indicate significant difference by Tukey's test at $P \leq 0.05$.

The chlorophyll content of the leaf is related to the nitrogen taken from the soil by the plants (Bojovic & Markovic, 2009). In this study, SRF efficiently release the nutrients at a slower rate and frequency, thus, would provide better nutrient availability in the soil. In connection to this, SRF will increase the soil's nitrogen availability and indirectly contribute to root system development and nutrient absorption capacity (Wang et al., 2020).

3.4 Effect of SRF and CF On the total Yield of Okra

At the end of the study period, the fruits were harvested and result was shown in Figure 4. The okra plants for the control treatment (T0) do not produce any fruits, so there are zero yields. Meanwhile, T4 has the highest yield, 42.3g and followed by T2 with 41.8g. The okra plants treated with SRF; T3 and T1 (shows total yield 29.23g and 26.5g, respectively. However, using the Tukey HSD test, there were no significant differences among the treatments applied with fertilisers.

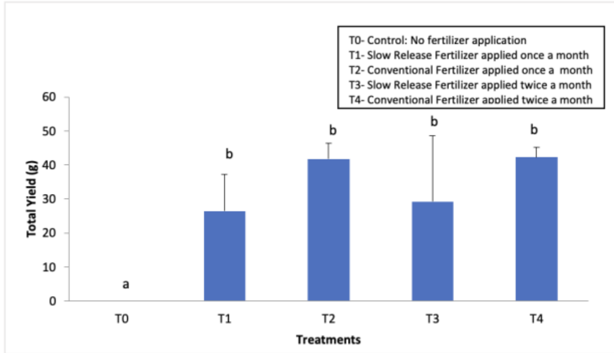

Figure 4: Effect of different application frequencies of Slow Release Fertilizer and Conventional Fertilizer on the total yield of okra plant. Data are the means of five independent replicates with standard deviation shown by vertical bars. Means with a different letter (s) indicate significant difference by Tukey's test at $P \leq 0.05$.

These recent results have shown that conventional fertiliser exhibit higher in term of yields as compared to slow-release fertiliser. It might be due to SRF releases its nutrients too slow. Hence, it is not meet the crop growth demand. Conversely, this result did not follow previous studies where SRF gave a significant yield of selected plants (Costamagna et al., 2020, Rop et al., 2019 and Wang et al., 2020).

Moreover, some of the okra plant samples were attacked by aphids and leaf rollers during the observations. Hence, it is one of the reasons that contributed to the low yield for the plant samples of the treatment. These pests and diseases attack will significantly negatively impact the total yield, which led to 26% to 36% yield losses (Cerda et al., 2017).

4. CONCLUSION

In conclusion, it was observed that T1 (Slow-release fertiliser applied once in a month) had a significant increase in the number of leaves by 31% and 66% as compared to the T3 (SRF applied twice in a month) and T0 (control), respectively. In terms of plant height and chlorophyll content, all treatments showed no significant increase in okra plants, except T0. Even though no significant difference, T1 shows the highest mean value of plant height and chlorophyll content with 32.57cm and 48.83cm, respectively. On the other hand, all the treated okra plants do not significantly increase the total yield. Instead, the application of SRF at T1 and T3, CF application at T2 and T4 showed greater okra yield with the percentage value of 30% and 37%, respectively. Overall, CF application at T2 was found to be the optimum

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fertiliser application frequency in terms of the total yield of okra. This study also shows that CF fertiliser was more efficient in providing good nutrients for the okra plant as the okra reaches the mature stages faster rather than SRF, which provides only good nutrient uptake at vegetative growth.

As a recommendation, since SRF in this current study does not show a good effect on the selected parameter of okra growth and yield, further study should be carried out by using a higher rate with a different frequency of SRF on other crops species. This information is vital to know the optimum rate and frequency for the best plant growth and yield.

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