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Growth of chilli plant (*Capsicum annum L.*) treated with combined organic and inorganic fertilizer with *Saccharomyces cerevisiae*

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Abstract. Biofertilizers are highly recommended, and widely explore its potential in agriculture. Combinations of fertilizers were treated on chili (*Capsicum annum L.*). An experiment was conducted at Sik, Kedah, to study the growth performance of chili plants by combined application of organic and inorganic fertilizer with biofertilizer. Eleven different fertilization treatments were conducted on Cili Kulai 1033, where *Saccharomyces cerevisiae* was incorporated as biofertilizer in nine of the treatments. The fertilization treatments were T1 (Control): (No manure + No fertilizer); T2 (NPK[12-12-17] + Poultry Manure [PM]): (5 g + 10 t/ha); T3 (NPK + PM + *S. cerevisiae*): (2.5 g + 10 t/ha + 1 g/L); T4 (2.5 g + 10 t/ha + 3 g/L); T5 (2.5 g + 10 t/ha + 5 g/L); T6 (3.75 g + 10 t/ha + 1 g/L); T7 (3.75 g + 10 t/ha + 3 g/L); T8 (3.75 g + 10 t/ha + 5 g/L); T9 (5 g + 10 t/ha + 1 g/L); T10 (5 g + 10 t/ha + 3 g/L); and T11 (5 g + 10 t/ha + 5 g/L). It was found that T11 significantly increased the plant height, number of leaves and leaf area of chili. Similarly, T11 gave the highest mean value in terms of plant height at 15, 45, and 75 days after transplanting (DAT) with 7.87, 22.66, and 57.39 cm. Meanwhile, at the same concentration and DAT, the mean value of the leaves number was 5.6, 21.6, and 56.6, respectively. However, T10 showed the maximum leaf area at 75 DAT with 59.40 cm². Overall, T11 consistently enhanced the chili growth compared to the standard treatment, T2. It suggests that T11 incorporated with *S. cerevisiae* can be applied as a biofertilizer in chili cultivation.

1. Introduction

Chili is one of the most essential and widely cultivated spice cum vegetable crops. It is scientifically known as *Capsicum annum*, which belongs to the Solanaceae family, and is closely related to tomato and tobacco. According to [1], although this genus contains almost 20 species, only 5 species are cultivated worldwide. The *Capsicum* species comprises numerous varieties of chili, with the heat varying greatly from mild to hot. *C. annum* is also known as pepper, chili, chile, chilli, aji, and paprika. It is an herbaceous plant with a densely branched stem. The height can reach up to 1.5 m, and some can be as short as less than 25 cm. Archaeological evidence also proved that peppers were among the oldest domesticated foods. Chili is originally from Mexico and gradually introduced into South Asia in the 1500s. It was incorporated into the local cuisines [2]. This plant can be grown on most soil types. However, it grows best on well-drained, fairly fertile loamy soils at pH 5.5–6.8. Chili thrives well in areas with an annual rainfall of 600–1250 mm. Harvesting is done manually with secateurs either in the morning or late evening. The fruits may be harvested either green or red



depending on their utilization. The harvesting duration is about 3–6 months, and the yield ranges from 10–24 mt/ha/season depending on variety, duration of harvest, and level of management [3]. Chili contains a blend of different vitamins and phytochemicals, phenols, and folate. It is a good source of vitamin A, B1, B2, Bc, C, and E, but the concentration depends on the cultivar [1].

At the end of the twentieth century, about 40% of the world's population depended on fertilizers to produce food [4]. Fertilizer is applied to satisfy the portion of the crop nutrient requirement that is available from the soil. The dependency of commercial and subsistence farming on inorganic fertilizers for the plants to grow up to their maximum is undeniable [5]. This is due to the effectiveness of the fertilizer on the plant, whereby inorganic fertilizer is equally rich in the three essential nutrients, nitrogen, phosphorus, and potassium (NPK), and further assisted by the plant's rapid absorption of the nutrients. According to [6], the dependency on inorganic fertilizer has caused the prices of these agricultural commodities to increase, making it less affordable to local farmers. Meanwhile, organic fertilizer has lower nutrient content, solubility, and nutrient release rates than inorganic fertilizers, rendering the latter's preference among farmers or any agricultural organization [7].

Due to the high inorganic fertilizer price, some farmers depend largely on locally available organic fertilizers. They use organic fertilizer to reduce the toxic impact of inorganic fertilizer. Some studies claimed that organic fertilizers, including farmyard manure, chicken manure (CM), sheep manure, and biofertilizers, may be used for crop production as a substitute for chemical fertilizers [8]. However, these nutrient sources could not supply sufficient nutrients to crops at a bigger crop production scale, rendering the inevitable use of chemical fertilizers in agriculture. Chemical fertilizers, being the source of high nutrient content, obviously benefits crop production. Considering the advantages of organic manures and the use of high chemical fertilizers, it can be suggested that the integration of two sources of nutrients with the optimum level of usage may be the best solution to maintain soil health and sustain productivity. According to [9], the combined application of organic fertilizers and inorganic fertilizers had improved the growth and yield of cabbage. Moreover, a study incorporated *Saccharomyces* sp. in fertilizers, which improved the growth and yield of crops by increasing the photosynthetic activity and controlling the soil diseases [10]. Therefore, an experiment was conducted to evaluate the effects of incorporating inorganic and organic fertilizer with *Saccharomyces cerevisiae* at different application rates on the growth of *C. annum*.

2. Materials and Methods

2.1. Study site and land preparation

The study was conducted in an open field from July 2020 to December 2020 at Kampung Chong, Sik, Kedah (5°52' N; 100°44' E). The soil was confirmed as sandy loam in texture, with a pH range of 5.57–5.73 through soil analysis. The primary tillage was conducted at the end of September 2020 using a power tiller. The land was plowed thoroughly, followed by laddering. All the stubbles and uprooted weeds were removed. A total of nine seedbeds were prepared. The chili plot was replicated in the seedbed form with the length of 8 m, width of 1.5 m and 30 cm of height, with a 1-m distance between the seedbeds.

2.2. Plant materials and fertilizer

The chili variety used in this study was Cili Kulai 1033, purchased online. The seeds were treated with Betan 80 WG (a.i Captan 80%). Meanwhile, the inorganic fertilizer was Blue Special (with NPK content of 12:12:17:2+TE), while the organic fertilizer used was processed poultry manure (PM) of chicken dung. Both fertilizers were purchased from a local fertilizer shop. Yeast, *S. cerevisiae* (Mauripan®), used was also purchased online.

2.3. Field experiment

The seeds of Cili Kulai 1033 were sown in seedling trays using peat moss as the growth medium. The seedlings were raised and watered for six weeks. Then, the 6-week seedlings were transplanted to the

prepared seedbeds. The seedlings were transplanted 90 cm apart in a single line row. In total, there are 11 treatments consisted of the recommended level of processed poultry manure with varying rates of chemical fertilizer NPK (12:12:17) and three intensities of *S. cerevisiae* biofertilizer application, as shown in Table 1. A week before transplanting, organic fertilizer was applied on the seedbeds and plowed thoroughly except for Treatment 1 seedbed. Then, the 6-week seedlings were transplanted to the seedbeds at 90 cm apart. They were watered immediately to establish good root-soil contact. NPK was applied according to the respective dosage per plant at the 2nd, 7th, and 10th week after transplanting. The biofertilizer foliar of *S. cerevisiae* was applied early in the morning by spraying with different yeast doses, with a spraying volume of 320 L/ha 30 days after transplanting (DAT) [17]. The plant height, leaf area, and the number of leaves per plant were measured 15 and 30 days after treatment. Plant height was measured in cm from the soil to the apex of the longest leaf to deduce the average plant height. The number of fully opened leaves on randomly chosen ten sample plants of each treatment was counted, and average values were estimated. Meanwhile, the leaf area was estimated using the graph paper method from five leaves sample plants per plant.

Table 1. The treatments.

Label	Treatment
T1	No treatment - Control
T2	Recommended dose of Poultry manure (PM) (10 t/ha) + NPK (12:12:17) fertilizer (5g)– Standard
T3	Recommended dose of PM (10 t/ha) + NPK fertilizer (2.5g) + <i>S. cerevisiae</i> (1g/l)
T4	Recommended dose of PM (10 t/ha) + NPK fertilizer (2.5g) + <i>S. cerevisiae</i> (3g/l)
T5	Recommended dose of PM (10 t/ha) + NPK fertilizer (2.5g) + <i>S. cerevisiae</i> (5g/l)
T6	Recommended dose of PM (10 t/ha) + NPK fertilizer (3.75g) + <i>S. cerevisiae</i> (1g/l)
T7	Recommended dose of PM (10 t/ha) + NPK fertilizer (3.75g) + <i>S. cerevisiae</i> (3g/l)
T8	Recommended dose of PM (10 t/ha) + NPK fertilizer (3.75g) + <i>S. cerevisiae</i> (5g/l)
T9	Recommended dose of PM (10 t/ha) + NPK fertilizer (5g) + <i>S. cerevisiae</i> (1g/l)
T10	Recommended dose of PM (10 t/ha) + NPK fertilizer (5g) + <i>S. cerevisiae</i> (3g/l)
T11	Recommended dose of PM (10 t/ha) + NPK fertilizer (5g) + <i>S. cerevisiae</i> (5g/l)

2.4. Statistical analysis

The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. The difference between the mean value between the treatments and the growing stages were statistically analyzed using two-way ANOVA SPSS computer software program, IBM version 22 for all treatments.

3. Results and Discussion

The present investigation exhibited positive differential effects on chili growth in the different combinations of organic and inorganic fertilizer with biofertilizer. It was evident in the growth characteristic such as plant height, the number of leaves per plant, and leaf area.

3.1. Plant height

Plant height for the various treatment combinations on 15, 45, and 75 DAT of the seedlings to the seedbed is presented in Figure 1. All treatments showed superiority over the control treatment (T1), specifically at 45 DAT and 75 DAT of growth stages after biofertilizer foliar application. The plant height from all treatments ranged from 5.14 to 7.87 cm at 15 DAT, 12.53 to 22.66 cm at 45 DAT, and 24.39 to 57.39 cm at 75 DAT. Various changes in the plant height at different growth stages were found statistically insignificant. The results showed that the highest growth effects are produced by T11 at 75 DAT. In contrast, the T1 and T6 recorded the least plant height at similar growth stages. Although T11 showed a higher average plant height than T2 (standard treatment), the difference

between these treatments is insignificant. Hence, it can be said that the higher concentration of NPK improved the plant height. This could be due to better uptake and translocation of nitrogen in the growing plants. The result is similar to a study [12], where the increasing frequency of Agrimeth application did not affect the plant height significantly. Agrimeth enhanced the growth of chili by producing phytohormones beneficial in the absorption of macro and micronutrients in the soil and to stimulate plant growth. Another study [13] partially supports the present study, whereby foliar application of different yeast concentrations affected the height of cucumber in the first season. However, the insignificant result did not provide a clear representation of the size and abundance of the vegetative growth of the cucumber plant [13].

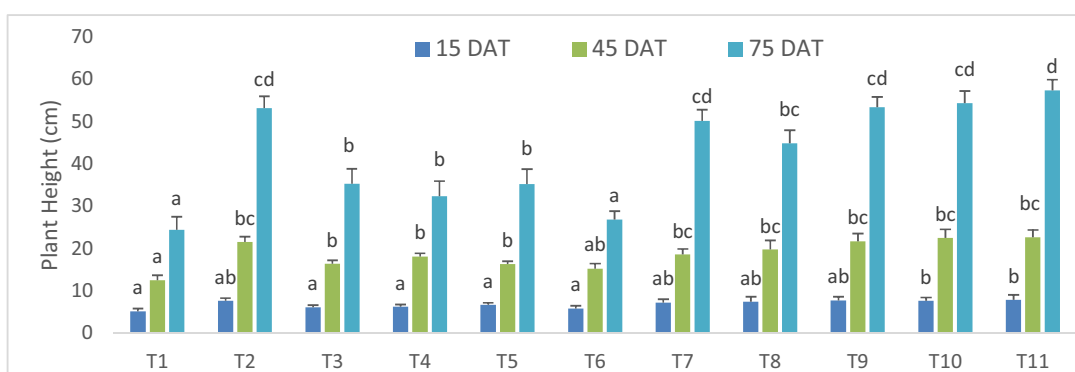


Figure 1. Effects of combined organic and inorganic fertilizers with biofertilizer on plant height (cm) of *C. annuum*. Data are the means of three independent replicated with standard errors shown by vertical bars. Bars with the same letter are not statistically different as determined by Tukey's HSD.

3.2. Number of leaves per plant

The emergence of new leaves is important because each new leaf will lead to the formation of a flower at the opposite site. Figure 2 shows the recorded data of 15 plants for each treatment under various combinations of organic, inorganic fertilizer, and biofertilizer application. All treatments show a positive increase in the number of leaves at all stages, except the control treatment (T1). It is evident that the treatment T11 (10 t/ha of PM + 5 g of NPK + 5 g/L of *S. cerevisiae*) recorded the highest average number of leaves at 15, 45, and 75 DAT with 5.6, 21.6 and 56.6. T11 is significantly higher than T1 at all growth stages. Nevertheless, the difference between the treatments of similar organic and inorganic fertilizer application rates with biofertilizer (T9, T10, and T11) and without biofertilizer (T2) application is insignificant. The data also showed that the increasing level of chemical fertilizer increased the number of leaves, corresponding to the study [14]. In the study, the number of fronds recorded in the T3 (70% chemical fertilizer + 30% biofertilizer) plot is higher and has developed more fronds with leaves compared to the other treatments, which was also statistically insignificant. The study on oil palm reported that the biofertilizer could influence aerial growth of the crops and increase the number of leaves. An experiment conducted by [15] gave similar results as the present study, where the application of dry yeast compound as a foliar spray at a rate of 4 cm/L gave the maximum number of leaves compared with other treatments. However, the present study is contradictory to [16], whereby the application of *Azospirillum* was proven to significantly increase the number of leaves per plant compared to *Azotobacter*. The application of *Azospirillum* recorded a significant and consistent increase in the number of leaves compared to *Azotobacter*. The paper justified that the increase in the number of leaves was highly due to the increased nitrogen level. Likewise, [17] stated that yeast extract could act as a biological and rich source of phytohormones, sugar, vitamins, enzymes, amino

acids, and minerals. Yeast has stimulatory effects on cell division and protein synthesis, nucleic acid, and chlorophyll to form leaves.

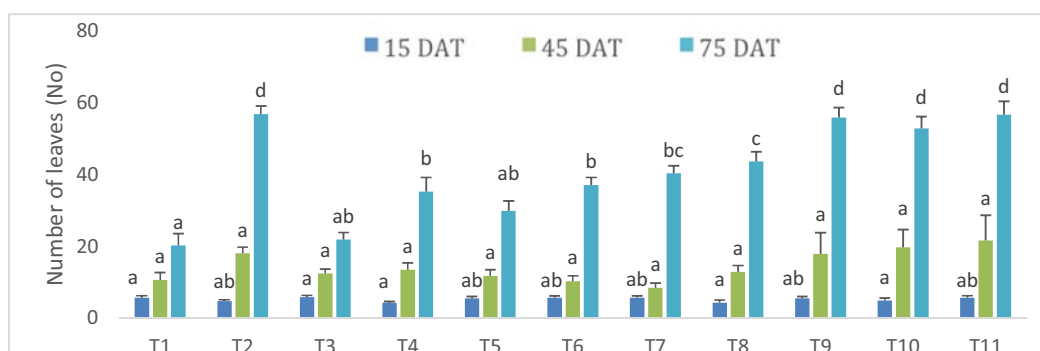


Figure 2. Effects of combined organic and inorganic fertilizers with biofertilizer on number of leaves per plant of *C. Annuum*. Data are the means of three independent replicated with standard errors shown by vertical bars. Bars with the same letter are not statistically different as determined by Tukey's HSD.

3.3. Leaf area (cm^2)

Although all green parts of a plant can carry out photosynthesis, it mainly occurs in the leaves due to the abundance of chloroplasts. Hence, in this study, the leaf area data helped ensure the growth of the chili plant. Data on the leaf area affected by the different treatments are shown in Figure 3. It proved that all treatments showed significant influence over the control treatment (T1), which recorded the least leaf area at 75 DAT. The maximum leaf area at 75 DAT is 59.57 cm^2 and 59.40 cm^2 by T11 (10 t/ha of PM + 5 g of NPK + 5 g/l of *S. cerevisiae*), followed by T10 (10 t/ha of PM + 5 g of NPK + 3 g/L of *S. cerevisiae*). The differences between T11, T10, and standard treatment (T2) found are statistically insignificant, despite the treatments with biofertilizers exhibited a higher average leaf area than the standard treatment. These treatments recorded higher results than the standard treatment (T2). Like the plant height and number of leaves, all treated chili plants showed a significantly higher leaf area than the control. A study [18] explained how biofertilizer affects the leaf area by increasing it gradually during growth from germination, with the highest increase recorded at 120–180 days after planting. They believed the addition of biofertilizer increased water permeability and drainage, air permeability, and reduced soil resistance and surface scum. A study reported that the application of dry yeast foliar stimulated most vegetative growth characters, e.g., the leaf area of snap bean plants and some chemical compounds of snap bean leaves and fruits, leading to a higher yield of snap bean plants [15]. The author also claimed that better growth results could be due to high levels of endogenous hormones in treated plants, which could be interpreted by cell division and cell elongation.

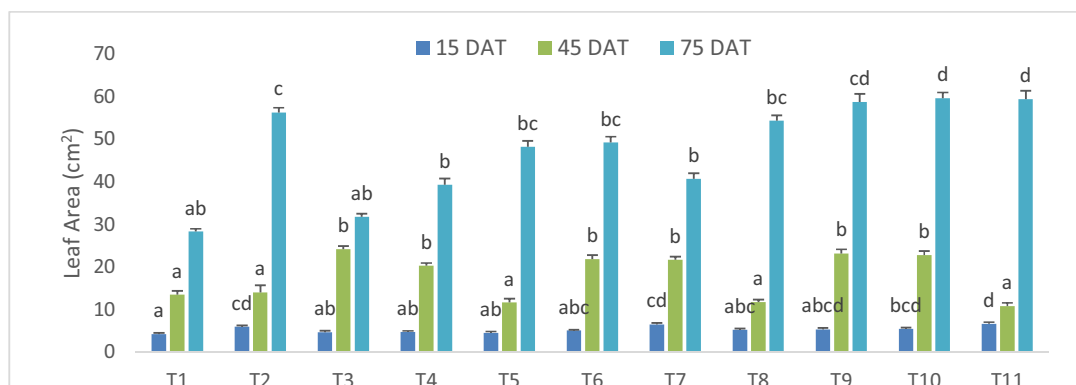


Figure 3. Effects of combined organic and inorganic fertilizers with biofertilizer on leaves area (cm²) of *C. annuum*. Data are the means of three independent replicated with standard errors shown by vertical bars. Bars with the same letters are not statistically different as determined by Tukey's HSD.

4. Conclusion

The treatments of combined organic and inorganic fertilizer with biofertilizer on the growth of chilies in this study are successful in increasing plant growth at various growth stages. Higher plant growth was observed at 45 and 75 DAT, especially after biofertilizer application. The best treatment was T10, i.e., the recommended dose of PM (10 t/ha) + NPK fertilizer (5 g) + *S. cerevisiae* (3 g/L). Even though T11 recoded a higher result than T10, the difference between the treatments was insignificant. Hence, T10 is the best and economically suitable treatment in this study. This study also proved that *S. cerevisiae* has the potential as a biofertilizer. More studies can be done on biofertilizers by incorporating different methods of preparation or application in the future. This study supported that the addition of biofertilizer *S. cerevisiae* into the fertilization regime influenced plant growth. Instead of solely depending on organic or inorganic, combining biofertilizer into the treatments will improve plant growth and obtain a better yield.

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