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Effect of Tailor-made Fertiliser and Medium on the Growth Rate and Yield of *Solanum Lycopersicum*

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This study evaluated the performance of tailor-made fertiliser formulated specifically for tomato (Solanum Lycopersicum) using different types of media. The effect of the medium on the growth rate and yield of tomato was investigated. The fertiliser for Solanum Lycopersicum was formulated using a fertigation technique and locally available fertiliser compounds based on the plant requirements. The experimental setup consisted of forty polybags of plants divided equally into two rows labelled R1 and R2, where R1 represents the tailor-made fertiliser while R2 represents the commercial fertiliser (the control). Two sets of media were investigated; a mixture of cocopeat, peat moss, and Rice Husk Ash (RHA) while the second set consisted of a mixture of cocopeat, peat moss, and zeolites. The pH of the medium and the growth rate, yield, and electrical conductivity (EC) of the fertiliser were observed and recorded. Other factors such as pest or disease attacks were observed as well. The findings show that the plants fed with tailor-made fertiliser yielded 64 tomatoes, 13 more tomatoes than the plants fed with commercial fertiliser (51 tomatoes). Meanwhile, the results of the different media show that the plants grown in zeolites gave 83 tomatoes, more than twice the yield of tomatoes grown on RHA (32 tomatoes).

1. Introduction

Tomato (Solanum Lycopersicum) is a popular crop in many parts of the world. It is one of the most important “protective foods” because of its special nutritive value and widespread production (Kumar et al., 2013). For normal growth and reproduction, tomato requires nutrients, which are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and molybdenum (Mo). Tomato production is based on yield and growth rate. The height of tomato plants increases significantly with increased levels of nitrogen. Factors such as nutrient requirement and growing method are very important to ensure the profitable production of tomato crops in terms of quantity and quality.
Figure 1 shows the relationship between the nutrient concentration in plant tissue and its yield or growth (Marschner, 1995). It can be observed that an adequate amount of nutrients gave better plant production.

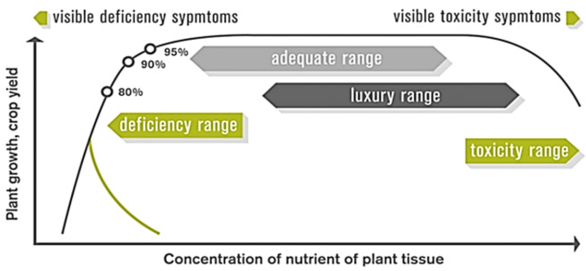

Figure 1: Plant nutrient requirement range (Marschner, 1995)

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When the nutrients fell into the deficiency range, fewer nutrients were supplied to the plant giving low yield and growth. An excessive level of nutrients could also reduce the plant yield due to toxicity. It could also increase the wastage of nutrients and the cost of the fertiliser and eventually degrade environmental quality. The growing method, which is important for the growth of the plant, can be divided into two; soil and soilless. In soil-based agriculture, soil is used as a medium to grow plants. In soilless-based methods, media other than soil are used to grow plants. There are three primary soilless methods: i) hydroponic, where the plant is grown in water; ii) aeroponic, where the plant is grown in the air or a misty environment; and ii) in cultures in the medium.

In this research, two sets of media were used: a mixture of cocopeat, peat moss, and Rice Husk Ash (RHA) and a mixture of cocopeat, peat moss, and zeolites. As cocopeat and peat moss mainly support the root of the plant, RHA and zeolites were also mixed in to supply nutrients. Rice Husk Ash (RHA) is a medium that enhances the nutrients needed by the plant because of its rich nutrient composition of 80.26 % Si, 0.38 % P, 1.28 % K, 0.21 % Mg, and 0.56 % Ca (Hashim et al., 1996). Zeolites are capable of increasing plant production levels, as they are carriers of nutrients and can act as a medium supplying free nutrients. Zeolites are useful for agriculture because of their large porosity, cation exchange capacity, and selectivity towards ammonium and potassium cations (Sangeetha and Paskar, 2016). Low concentrations of N, P, and K will negatively affect tomato growth, resulting in smaller fruits, as the rate of photosynthetic activity of the plant also drops sharply (Zekri and Obreza, 2003). On the contrary, Kumar et al. (2013) reported that a high nitrogen concentration of 275 ppm would reduce fruit size. The plant needs an adequate amount of nutrients to ensure that it can grow and produce a good yield, as well as to avoid nutrient wastage (Kumar et al., 2013). Generally, local commercial fertiliser contains high amounts of nutrients. As tomato has its nutrient requirements, an excessive level of nutrients could reduce tomato yield, possibly causing toxicity to the plant and eventually degrading environmental quality as a result of the pollution that occurs. This nutrient wastage will, in turn, increase the usage and production costs of fertiliser (Fandi et al., 2010). Using Rice Husk Ash (RHA) and zeolites as a medium can enhance the growth and production of tomato crops.

As mentioned above, zeolites are useful for agriculture because of the large porosity that enables them to capture excessive nutrients (Sangeetha and Paskar, 2016). Meanwhile, RHA can be used as a medium stabiliser to improve the strength and characteristics of the medium without causing any harm to the environment (Rathan et al., 2016). This research aims to formulate and analyse a precise tailor-made fertiliser and compare it to commercial fertiliser. In specific, this study aims to investigate the effect of different media on the growth rate and yield of Solanum Lycopersicum.

2. Methodology

2.1 Material and equipment

The materials used in this study were Solanum Lycopersicum seeds, cocopeat, peat moss, Rice Husk Ash (RHA), zeolites fertiliser, and fertiliser elements. The equipment used included fertiliser tanks, an aquarium pump (30 W), an operation timer, black polybags, an electronic weighing balance, a measuring tape, a pH meter, and an EC meter.

2.2 The design of fertiliser formula

The fertiliser was formulated according to the tomato's nutrient requirement. The concentration of the formulated fertiliser and commercial fertiliser are given in Table 1.

Table 1: Concentration of formulated and commercial fertilisers

Nutrient element	Concentration (mg/L)	
	Formulated fertiliser	Commercial fertiliser
$Ca(NO_3)_2$	1,000	1,130
KNO_3	750	1,000
$MgSO_4$	550	560
MKP	250	175
Iron (Fe)	25.0	16.4
Manganese (Mn)	6.0	1.5
Boron (B)	3.0	3.0
Zinc (Zn)	2.0	2.0
Copper (Cu)	0.8	0.8
Molybdenum (Mo)	0.2	0.2

2.3 Preparation of irrigation nutrient solution, system, and scheduling

The fertiliser solutions were prepared according to the concentration listed in Table 1 at pH 5.5 to pH 6.8 and electrical conductivity (EC) of 1.8 dS/cm, which are suitable conditions for tomato plants. An automated irrigation system was prepared with an operation timer and a 200 W pump for each fertiliser solution tank. Each pump outlet was connected to a 16 mm low-density polyethylene (LDPE) pipe, which, in turn, was connected to a 1 mm capillary tube that was then inserted into a dripper. The irrigation was scheduled five times a day during the daytime with an average of 10 min/d in the growth stage. During the fruiting stage, the duration was increased to an average of 16 min/d until the end of the season.

2.4 Preparation of the testbed for the tomato

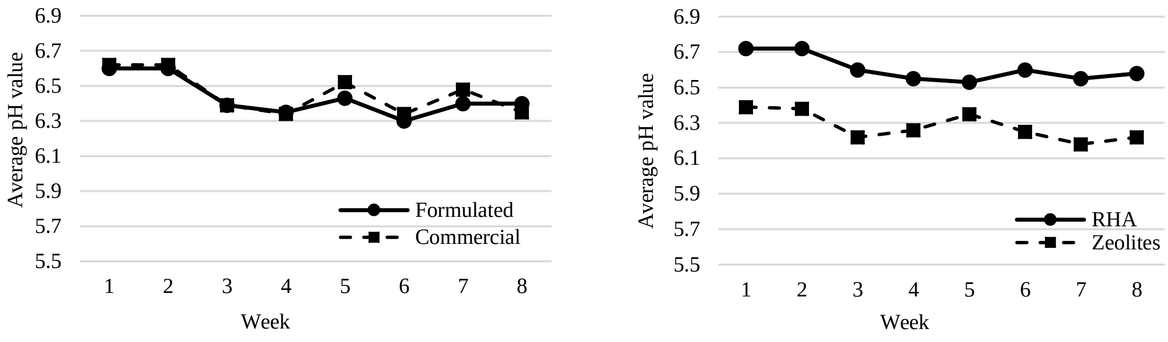
The testbed was designed for 40 tomatoes to be planted in polybags, as shown in Figure 2c. Twenty plants were treated with the formulated fertiliser while another 20 plants were treated with commercial fertiliser. Based on Figure 2a, the media used consisted of a mixture of cocopeat with Rice Husk Ash (RHA) (left) and cocopeat with zeolite fertiliser (right) according to a ratio of 7:3 for each medium. The matured tomato plants were then transplanted (Figure 2b) to the prepared media and the irrigation scheduling was started from the first day of the transplant.

Figure 2: (a) RHA and zeolites, (b) matured tomato plants and (c) site of experiment

3. Results and discussion

3.1 Soil pH

Based on Figure 3a, no significant differences in the average soil pH could be observed between the formulated fertiliser and commercial fertiliser. The average pH from week 1 to week 8 for the formulated fertiliser was pH 6.45 ± 0.25 while the commercial fertiliser showed pH 6.49 ± 0.30. This trend indicates that the acidity of the



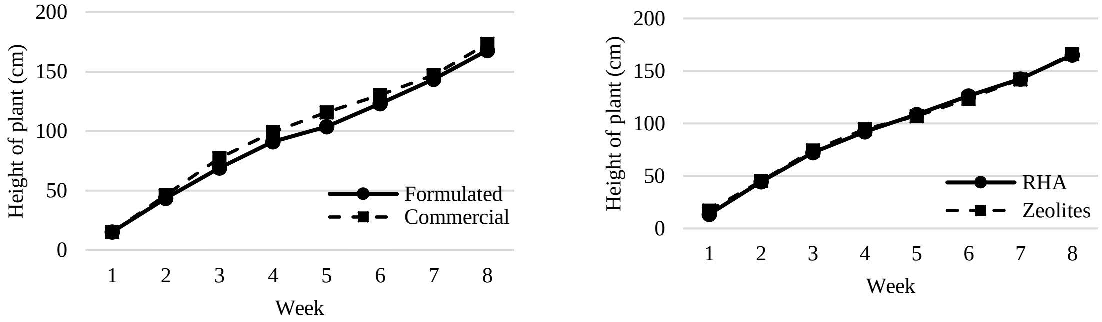
(a) (b)

Figure 3: Average soil pH from for different (a) fertiliser and (b) medium

soil increased over time. Hence, the application of appropriate treatments had maintained the pH at an optimum level, so eventually, no buffer solution was needed to obtain the desired pH for the crop. Based on Figure 3b, both the zeolites and the RHA showed increased acidity but the zeolites were more acidic than RHA. As proof, Japanese farmers have used zeolite rock for years to control the moisture content and offensive odour of animal wastes and to increase the pH of acidic volcanic soils (Sangeetha and Paskar, 2016). Meanwhile, RHA neutralises soil acidity faster than conventional limestone due to its base content and the reactivity of these bases in the soil (Islabao et al., 2014). Based on the results, the average pH from week 1 to week 8 for RHA was pH 6.64 ± 0.19 while the commercial fertiliser displayed pH 6.29 ± 0.24 on average.
According to Tomato Jos (2014), tomatoes are moderately tolerant to a wide variety of pH, but they tend to grow best in soils with pH 5.5 to pH 6.8, which are slightly acidic to neutral. This is because tomato plants will do well in acidic soils as long as they receive an adequate nutrient supply. When the pH is slightly acidic, iron, manganese, and zinc will be available at low levels. This is not a problem because tomato plants only need very small amounts of these nutrients. Macronutrients such as nitrogen, potassium, and phosphorus should be highly available because the tomato plant will require a large uptake of these nutrients for growth (Chenhall, 2012). The average soil pH of the formulated fertiliser, the commercial fertiliser, and the zeolites and RHA medium was found good for the growth of the tomato plant, as all of them had pH 5.5 to pH 6.8. It is important to know the optimal pH range for crops to ensure the highest crop yields and the best growing conditions (Fernandez and Hoeft, 2012).

3.2 Plant growth

The results of the plant growth were measured based on the height of the plant, as shown in Figure 4. Based on Figure 4a, the plants growing in the formulated fertiliser and the commercial fertiliser were observed to have slightly similar heights. The average height of the plant in the formulated fertiliser from week 1 to week 8 was 118.07 ± 59.01 cm while the plant in the commercial fertiliser had a 113.55 ± 62.04 cm average height in the same period.



(a) (b)

Figure 4: Height of plant for different (a) fertiliser and (b) medium

From week 3 to 6 i.e. at the flowering and fruit-set stages, the plant in the formulated fertiliser was shorter than that of the commercial fertiliser by approximately 10 cm. This was due to the lower amount of nitrogen (N) in the formulated fertiliser compared to that of the commercial fertiliser. For tomato plants, nitrogen uptake is initially slow but rapidly increases during the flowering stages. Nitrogen is the most limiting nutrient for tomato growth and is required in large amounts for optimum production because tomato plants remove large amounts of N from the soil (Sainju et al., 2003). Nitrogen deficiency may cause stunted spindly growth or in other words, shorten the height of the plant. However, the formulated fertiliser is still better than the commercial fertiliser because the tomato plant needs to focus more on yield than height. The results in Figure 4b show that there were no significant differences in the height of the plant using both RHA and zeolites as a medium. The high silica content in Rice Husk Ash (RHA) helped improve the shoot and the root of the plant. Zeolite fertiliser enhanced the performance of the plant growth by enhancing the plant's ability to store large amounts of water due to zeolites' high porosity. The average height of the plant treated with RHA was 116.03 ± 64.86 cm while the plant in the zeolites had an average height of 115.60 ± 55.98 cm.

3.3 Fruit yields of Solanum Lycopersicum

The formulated fertiliser gave a higher cumulative weight of fruits per week compared to commercial fertiliser, as shown in Figure 5a. Based on the nutrient element concentration of tomato, the level of phosphorus (P) in the formulated fertiliser was higher than that of the commercial fertiliser. This is because P helped the tomatoes produce many flowers in its early growth stage and early setting of fruits (Sainju et al., 2003). As a result, the increase in the number and production of tomato fruits also indirectly increased the weight of the fruits. Besides that, a lower cumulative weight was seen in the fruits of the plant in the commercial fertiliser due to the high amounts of nitrogen (N) in it. According to Caralampides (2012), high amounts of N can lead to excessive vegetative growth (Caralampides, 2012). In fact, excessive N promotes vegetative growth over reproductive growth and causes a delay in fruit growth and reduced yields. Based on Figure 5b, the cumulative weight of the fruits per week for the plant in zeolites rose more dramatically than RHA, correlating to the pH value of the zeolites and the RHA shown in Figure 3b. Both zeolites and RHA showed increased acidity, with zeolites being more acidic than RHA. This result shows that zeolites are a more suitable medium for the tomato plant, as tomato plants tend to grow best in soils with pH 5.5 to pH 6.8, i.e. slightly more acidic soil.

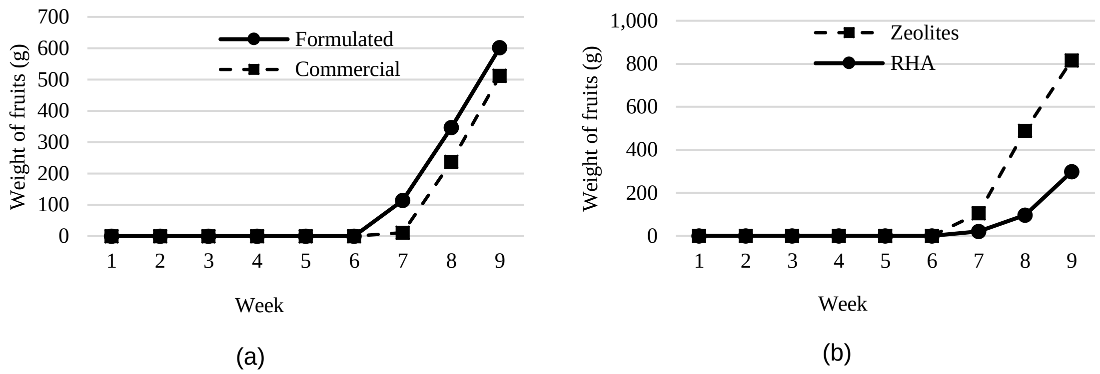


Figure 5: The cumulative weight of the tomato fruits for different (a) fertiliser (b) medium

Figure 6 shows the tomato fruit at the harvesting stage. Since the formulated fertiliser and the commercial fertiliser had similar and adequate amounts of magnesium, the tomato yield from the plants in both fertilisers

Figure 6: Tomato yields

had an even-ripening and well-formed fruit. This is because the maximum requirement of magnesium at the fruit ripening stages had been fulfilled; thus ensuring the quality of fruit produced.

4. Conclusion

In conclusion, this study compared the performance of specially formulated fertiliser and commercial fertiliser. The formulated fertiliser gave better results compared to local commercial fertiliser. In particular, the plant in the formulated fertiliser had a higher yield than the one in the commercial fertiliser. The plant in the formulated fertiliser produced 602 g of fruit, while the plant in the commercial fertiliser produced 512 g of fruit over 9 weeks of observation. Besides that, the zeolites proved to be a good medium for growing tomato crops and showed a faster growth rate than Rice Husk Ash (RHA). Using zeolites as the plant growth medium gave 816 g of fruits compared to RHA, which only gave 298 g of total fruit. The high acidity of zeolites also made it a good medium for the growth of the tomato plants, as the plants tend to grow best in soils with pH 5.5 to pH 6.8.

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