

# Growth and yield of tomato plants (*Lycopersicum esculentum* Mill) grown in soil media containing several doses of inorganic fertilizers and sprayed with Lombok brown algae extracts

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## Growth and yield of tomato plants (*Lycopersicon esculentum* Mill) grown in soil media containing several doses of inorganic fertilizers and sprayed with Lombok brown algae extracts

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**Abstract.** Excessive use of inorganic fertilizers in the production of horticultural crops, increases production costs, decreases soil fertility and damages the environment. This article reports the growth and yield of tomato plants grown in soil media containing several doses of inorganic fertilizers and sprayed with Lombok brown algae extract. Tomato plants are grown in soil media containing inorganic fertilizers at a dose of 0, 50% or 100%. Then, each treatment plant was sprayed with 10% Lombok brown algae extract once a week during vegetative growth. The results showed that each Lombok brown algae extract had the same effect on NPK absorption, growth and yield of tomato plants. However, the effect of algae extracts on the absorption of essential elements, growth and yield of tomato plants is highly dependent on the dose of inorganic fertilizers supplied in the soil medium. The absorption of essential elements, growth and crop yields significantly increased in plants grown in soil medium containing 50% inorganic fertilizers and sprayed with 10% Lombok brown algae extract, compared to plants containing 0 inorganic fertilizers. This shows that the use of inorganic fertilizers can be reduced to 50% as long as the plants are sprayed with 10% Lombok brown algae extract.

### 1. Introduction

The excessive use of inorganic fertilizers in horticultural plant production, causes many disadvantages, such as reduces soil fertility, harm environment and increase production cost reducing farmers income. On the other hand, market demand for organic horticultural products, both in national markets and international markets, increases recently. Tomato plants are one of an important horticultural products, contain enough nutrition and have an economical values, to support human life and economy of



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farmers [1]. However, the use of inorganic fertilizers, such as urea, TSP and KCl, increases to the excessive of dose of level like 300 kg urea, 100 kg TSP and 100 kg KCl per hectare respectively. This practice creates many disadvantages, for the ecosystem and for the farmers income.

Many literatures reported that the capacity of root system of some plants to absorption ion through active transport mechanism tend to decrease to level 40-50% if the availability of ion in soil media in an abundant condition [2,3,4]. This is due to the reaction rate of enzyme involve in absorption and transport mechanism in root system, is very dependent on level of substrate [5]. Therefore, the excessive application of inorganic fertilizers to soil media will be absorbed maximally 50% by root system. The rest of them become leaching to the environment and accumulated as high concentration of ions, like nitrate, phosphate and chlorine in vegetation, which inactivating catalytic enzymes in cytoplasm. In addition with that, Nitrate leaching from excess application of inorganic fertilizers, like urea, to food and horticultural crop production system, resulted high nitrate accumulation in edible parts of some vegetables, which can harm human health, due to conversion of nitrate into nitrite, which is toxic ion for human health [6]. Finally, such kinds of products can't compete with other products both in national and international markets.

Market demand for horticultural organic products both in national markets and international markets, is increased from year to year, begin in 2001 [7] and continue to last decade [8]. Therefore, understanding natural resources which are cheap, easy to obtain and adaptive to environment to support agricultural system, is an important research topic recently. Such kind of natural resources, could be used as raw material for development of organic bio-stimulants and bio-fertilizers inducing absorption of mineral nutrition, growth and production of plants in low level of inorganic fertilizers, and possibly it could replace the use of synthetic bio-stimulants and inorganic fertilizers in agricultural production system.

Many researchers reported that macroalgae is an important source for developing organic bio-stimulants and bio-fertilizers. This because the macroalgae contains both plant growth hormones in liquid extract, and macro-micro essential elements in solid extracts [9, 10, 11]. Previously, it was reported that growth of corn increased around 48-62% when the plants sprayed single extract of red algae (*Laurencia obtuse*, *Corallina elongate* and *Jania rubens*) [12]. The effect of extract was increased into around 72,4% compared with control plants, when they were applied in mixture form. Other researcher also reported that other algae, such as *Ulva lactuca*, *Caulerpa sertulariodes*, *Padina gymnospora*, and *Sargassum liebmannii* extracts, induced germination and growth of tomato seedlings [13]. Previously, it was reported that the extract of those algae influenced growth of shoot and root system. Moreover, growth and yield of tomato and chili plants were increased when they were sprayed with *Gracilaria textorii* and *Hypnea musciformis* liquid extracts [14].

Except growth and yield, biochemical activities were also affected by algae extracts, like *Sargassum wightii* and *Caulerpa chemnitzia* extracts. Application of 20% of *Sargassum wightii* and *Caulerpa chemnitzia* stimulated growth of shoot and root, chlorophyll and carotenoid biosynthesis of *Vigna snensis* plants [15]. Similarly, *Ulva lactuca* liquid extract was also reported to increase growth, chlorophyll and proline biosynthesis in sunflower plants [16], gold cherry [17] and soybean [18]. Eventhough, all of the research reported only the effect of liquid extract on growth and yield of several species of plants, but there is no report about the effect of liquid extract on essential elements absorption, growth and yield of plants growing in several levels of inorganic fertilizers in soil media. It was also reported that there were 88 species of macro algae grown in coastal area of West Nusa Tenggara (NTB), 17 species of them were brown algae, which were found to be a potential for developing growth stimulant and organic fertilizers [19, 20]. It was found that Lombok brown algae extracts influenced growth and yield of rice plants [21], cucumber [22], tomato plants [23]. This article reports the effect of liquid extract of Lombok brown algae on growth and yield of tomato plants grown in soil media containing several doses of inorganic fertilizers. The results shown that application of 10% liquid extract of Lombok brown algae induced absorption of NPK, chlorophyll content, growth and yield of tomato plants grown in soil media containing 50% and 100% of organic fertilizers. Statistically, there were no different effect of liquid extract of algae on tomato plants grown in soil

media containing 50% and 100% inorganic fertilizers. The results indicate that application of 10% of Lombok brown algae extract could reduce the use of inorganic fertilizer into 50% dose of inorganic fertilizers in soil media, to gain maximum rate of essential elements, growth and yield of tomato plants.

## 2. Materials and methods

### 2.1. Design, time and place of experiment

The experiment was designed as factorial design, which is consisted of two factors, Lombok brown algae liquid extracts and dose of inorganic fertilizers. Lombok brown algae extract consisted of five treatments: **E0**, non sprayed with Lombok brown algae liquid extracts, **Scras**, sprayed with *Sargassum crassifolium* extract; **Seris**, sprayed with *Sargassum cristafolium* extract, **Saq**, sprayed with *Sargassum aquifolium* extract, **Tm**, Sprayed with *Turbinaria murayana* extract. Dose of inorganic fertilizers consisted of three treatments: **N0**, non supplied with inorganic fertilizers in soil media; **N50**, supplied with 50% dose inorganic fertilizers; **N100**, supplied with 100% doses of inorganic fertilizers. Therefore, there were 15 combination treatments. Since each treatment was replicated three times, therefore, there were 45 experimental pot.

### 2.2. Sample collection and extraction

Seaweed samples, such as *Sargassum crassifolium*, *Sargassum cristafolium*, *Sargassum aquifolium* and *Turbinaria murayana*, were collected in coastal beach area of Lombok, West Nusa Tenggara Indonesia. The samples were extracted according to modified procedure developed by [11]. Firstly, the samples were cleaned by rinsed with sea water and they were win dried in shadow place for three days. Then, each species of samples was cutted using scissor into small peaces, and they were blundered to make fine powders. Powder Lombok brown algae 1 (kg powder of each species) was placed in 15 L chemical flash separately. After that, 10 L distilled water was added to each flash, then they were homogenized by using magnetic stirrer for 30 minute. Moreover, the mixtures were boiled in 95°C water bath for 30 minute. Finally, the mixtures were filtered using whatman filter paper no.1. Supernatant obtained was known as 100% of liquid extract of brown algae.

### 2.3. Preparation of soil media and tomato seedlings

Soil media was prepared by addition 7 kg soil obtained from rice field in West Lombok. Inorganic fertilizers, such as urea, TSP and KCl, were added to soil media at day 10 and 30 after transplanting as procedure as follows: **N0**, no addition of inorganic fertilizers; **N50**, addition of 50% dose of inorganic fertilizers at day 10 and 30 after planting; **N100**, addition of 100% dose of inorganic fertilizers at day 10 and 30 after planting. In addition, tomato seedlings were prepared by sowing tomato seeds in plastic pot containing 7 kg soil and they were left to grow. The seedlings were ready to be transplanted when 21 days age.

### 2.4. Cultivation and treatments

The tomato seedlings were transplanted into plastic pot containing 7 kg soil. Application of inorganic fertilizers according to treatments as described above, was applicated two times at day 10 and 30 after planting respectively. Moreover, the application of liquid extract of Lombok brown algae, was conducted by spraying 10% of extract one a week during vegetative growth. Then, the plants were left to grow until harvesting time.

### 2.5. Analysis of chlorophyll, N, P and K content

Fresh tomato leaf (1 gram) was extracted with 10 ml of ethanol 96%, and homogenized using mortar to obtain homogen mixture according to the procedure developed by [24]. Then, the mixture was centrifugated with the speed 14,000 rpm for 5 minute at 4°C. The solution was filtered using whatman filter no. 1. Finally, the alequote was measured using spectrophotometer at wavelength 663 nm and



4-5 nm. The total of chlorophyll content was calculated according to formula. Moreover, analysis of P and K content in tissue was conducted according to modified procedure of [11] and [23]. Dried weed samples (0.5 g dry weight) were added with 5 mL of nitric acid in hot block in 400° C. Then, the samples were diluted ten times with ultra-filtered water (Milli-QIntegral, MilliporeSigma). All samples were analyzed in two replicates. Finally, the content of essential elements was measured using ICP-OES (Agilent technologies,US).

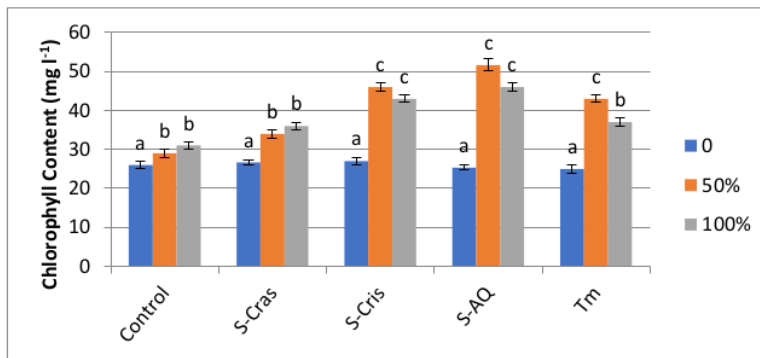
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### 3. Results and discussion

#### 3.1 Effect of liquid extracts and dose of inorganic fertilizers on chlorophyll content

Generally, dose of inorganic fertilizers supplied in soil media affected chlorophyll content in leaf of rice plants (Figure 1). Chlorophyll content increased in leaf of the plants supplied with 50% or 100% inorganic fertilizers. However, the chlorophyll content did not significantly different the rice plants supplied with 50% and 100% inorganic fertilizers. This indicates that the maximum level of inorganic fertilizer inducing biosynthesis of chlorophyll in leaf, is 50% of inorganic fertilizers. However, the application of inorganic fertilizers more than 50%, like 100%, did not induced chlorophyll biosynthesis in leaf.

Type of extract had different effect on chlorophyll content of tomato leaf (Figure 1). This effect was also dependent on the level of inorganic fertilizers in soil media. For example, in zero inorganic fertilizers in soil media, there were no effect of brown algae extract on chlorophyll content in leaf of tomato plants. However, in the plants supplied with 50% or 100% inorganic fertilizers in soil media, some brown algae extracts, such as *Sargassum cristafolium*, *Sargassum aquifolium* and *Turbinaria muraya* liquid extracts, induced chlorophyll content of tomato leaf. But that phenomena could not be seen in the plants sprayed with 10% *Sargassum crassifolium*. This indicates three type of brown algae species producing enough amount of phytohormones inducing chlorophyll biosynthesis in leaf. In contrast with *Sargassum crassifolium*, this species does not produce enough amount of phytohormone stimulating chlorophyll biosynthesis. Enzymes involve in the mechanism of chlorophyll biosynthesis require an optimum concentration of substrate to gain a maximum rate of biosynthesis reaction [2–5].



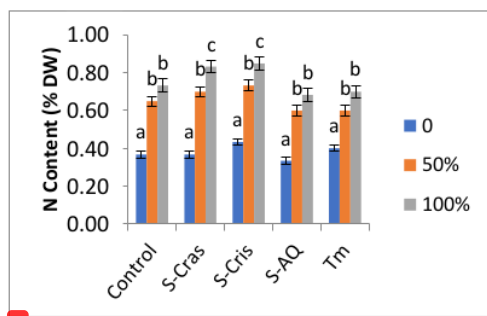
The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level.

**Figure 1.** Effect of Lombok brown algae extract on chlorophyll content of tomato plants grown in soil media containing 0, 50% or 100% doses of inorganic fertilizers.

#### 3.2. Effect of liquid extracts and dose of inorganic fertilizers on N, P and K content in tissue

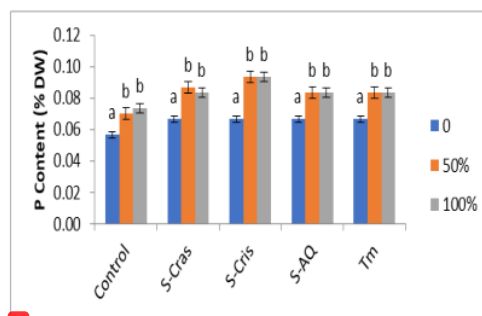
In general, N content (Figure 2), P content (Figure 3) and K content (Figure 2) in tissue of tomato plants were affected by dose of inorganic fertilizers added in soil media. Addition of inorganic

fertilizers with dose of 50% or 100% in soil media, increased significantly N, P and K content in tissue of tomato plants respectively, compared with those of control plants. However, there were no significantly different between the plants supplied with 50% and 100% inorganic fertilizers in soil media in term of N, P and K content in tissues. This indicates that the availability of N, P and K in soil media, induces absorption of essential elements by root system. However, the increase of absorption occurred until certain level (50% dose of inorganic fertilizers). But the increase of absorption did not occur in the media containing inorganic fertilizers more than that level (100%). This is due to the theoretically arguments that rate of essential element absorption and transport mechanism are dependent on optimum concentration of enzyme and substrat involve on such kind of mechanism [3, 5]. In that case then, when the concentration of substrate in soil media increase to above of optimum concentration, the enzymatic reaction become saturated, which finally the rate of reaction become constant. That is the reason why some plants can absorb essential elements in maximum rate when the availability of essential elements is in abundant condition [25].



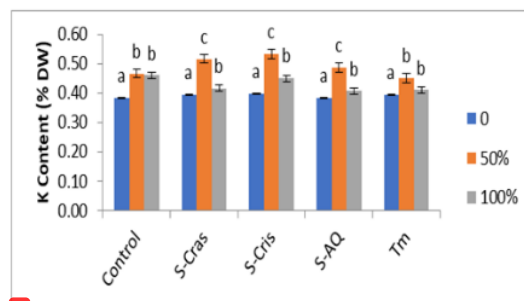
The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level.

Figure 2. Effect of Lombok brown algae extracts on N content of rice plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers



The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level.

Figure 3. Effect of Lombok brown algae extracts on P content of rice plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers



The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level

Figure 4. Effect of Lombok brown algae extracts on K content of rice plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers

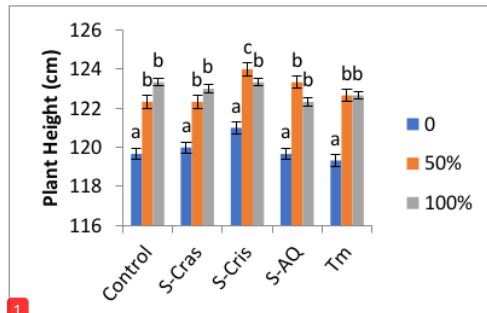
The data presented in Figure 2–4, clearly demonstrated that rice plants could absorb only 50% of inorganic supplied in soil media. The other amount of inorganic fertilizers, are leaching to

environment as toxic ions, like nitrate, phosphate and chlorine ions which are absorbed by other vegetation, leaching to irrigation system and well water. Abundant ions in vegetation and well water, will polluting humand food, due to conversion of those ions into toxic ions [26].

Brown algae extracts tested in this experiments, such *Sargassum crassifolium*, *Sargassum cristafolium*, *Sargassum aquifolium* and *Turbinaria murayana* extracts, did not affect N (Figure 2), P (Figure 3) and K (Figure 4) contents of tomato plant tissues. This indicates that phytohormones in liquid extracts of those brown algae species, can't stimulate absorption of N, P and K by root system of rice plants.

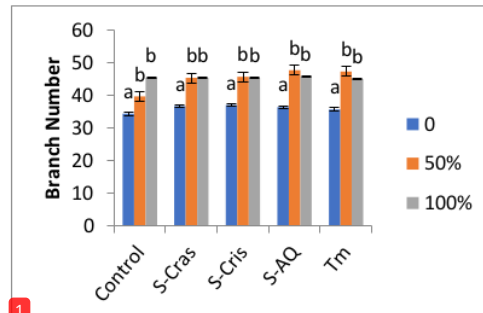
### 3.3. Effect of liquid extracts and dose of inorganic fertilizers on growth

Growth parameters such as plant high (Figure 5), branch number (Figure 6), shoot dry weight (Figure 7) and root dry weight (Figure 8), were influenced by dose of inorganic fertilizers supplied in soil media. Application of 50% or 100% inorganic fertilizers in soil media, increased significantly growth of tomato plants compared with control plants which were not added with inorganic fertilizers in soil media. Eventhough, there were no significant response on growth parameters between the plants supplied with 50% and 100% inorganic fertilizers in soil media. This indicates that the optimum dose of inorganic fertilizers should be added to soil media to gain maximum growth of tomato plants is 50% dose of inorganic fertilizers. The implication of thus, is the use of inorganic fertilizers could be reduced into 50% dose. These indicates that tomato plants only need 50% dose of inorganic fertilizers in soil media to support maximum growth when the plants sprayed with 10% brown algae extracts. This due to the fact that maximum capacity of enzymes involve in ion absorption by root system and transport mechanism in xylem to support growth depend on the concentration of substrat in soil media [3, 5, 6]. Therefore, application of 100 % dose of inorganic fertilizers in soil media, is uptaken maximally only 50%, and another 50% leaching to environment as toxic ion polluting environment.



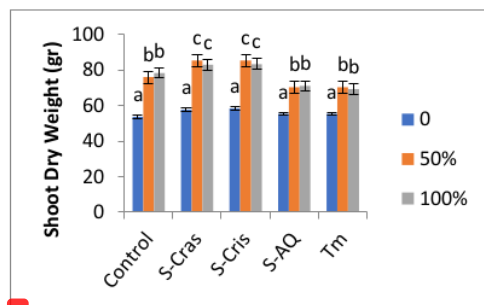
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**Figure 5.** Effect of Lombok brown algae extracts on plant height (cm) of tomato plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers.



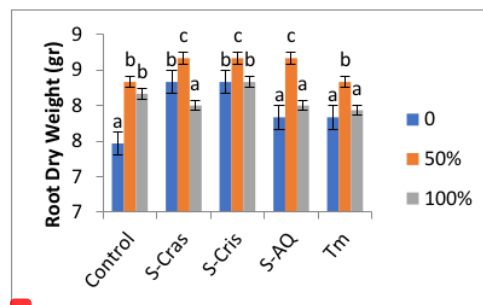
The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level.

**Figure 6.** Effect of Lombok brown algae extracts on branch of tomato plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers.



The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level.

**Figure 7.** Effect of Lombok brown algae extracts on shoot dry weight of tomato plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers



The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level.

**Figure 8.** Effect of Lombok brown algae extracts on root dry weight of tomato plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers

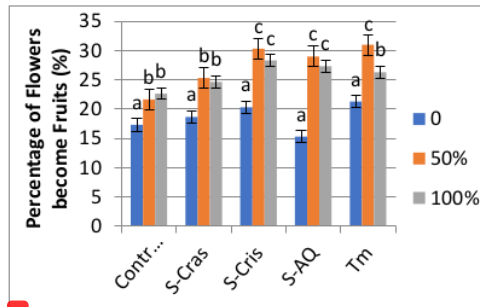
Different with dose effect, brown algae extracts did not affected significantly growth parameters, such as plant high (Figure 5) and branch number (Figure 6) of tomato plants. However, shoot (Figure 7) and root (Figure 8) dry weight had different response to several brown algae extracts. For instance, there were no different response on shoot dry weight between the plants sprayed with 10% *Sargassum aquifolium* or *Turbinaria murayana* with that of control plants. Eventhough, spraying *Sargassum crassifolium* or *Sargassum cristafolium* extract increased significantly shoot dry weight of tomato plants. Similar phenomena also found on response of root growth on the application of brown algae extracts (Figure 8). Root growth did not response significantly on the spraying *Turbinaria murayana* extract. However, the spraying 10% *Sargassum crassifolium*, *Sargassum cristafolium* or *Sargassum aquifolium* stimulated root growth of tomato plants. These data indicate that different species of brown algae has different content of phytohormones which ultimately induces the growth of plants differently [11, 21–23].

#### 3.4. Effect of liquid extracts and dose of inorganic fertilizers on yield

Like growth parameters, yield parameters, such as percentage flowers become fruit (Figure 9), fruit number per plant (Figure 10) and fruit weight per plants (Figure 11), were also influenced by dose of inorganic fertilizer application in soil media. All parameters increased significantly in the plant supplied with 50% or 100% inorganic fertilizers in soil media, compared with those of control plants. However, there were no significant different on those parameters between the plants supplied with 50% and 100% inorganic fertilizers in soil media. This indicates that the application of 50% dose of inorganic fertilizers is an optimum dose to gain maximum yield of tomato plants. This application could reduce cost production of tomato plants and more adaptive to environment. Critically, application 50% dose of inorganic fertilizers provides optimum substrate for enzyme involve in absorption and transport mechanism in root system to support maximum rate of essential element absorption, growth and yield of plants [3, 4].

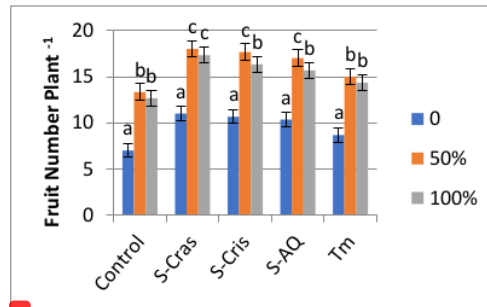
In general, the application of 10% brown algae extracts influenced yield parameters, such as percentage of flower become fruit (Figure 9), fruit number per plant (Figure 10) and fruit weight per plant (Figure 11). Yield parameters were increased by the application of 10% brown algae extracts. Since this application affected element essential absorption and growth, then the spraying brown algae extracts stimulate yield of tomato plants. This phenomena is consistent with the effect of brown algae extracts on several plants, like rice [20] and corn [26].





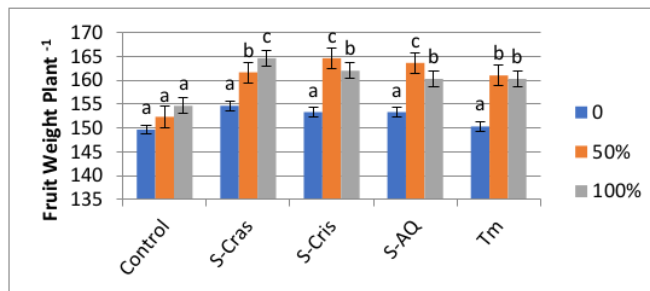
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**Figure 9.** Effect of Lombok brown algae extracts on percentage of flowers become fruit (%) of tomato plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers



The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level.

**Figure 10.** Effect of Lombok brown algae extract on fruit number per plant of tomato plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers



The value in bar chart followed by different alphabets indicating significantly different based on HSD test at 5% significant level.

**Figure 11.** Effect of Lombok brown algae extracts on fruit weight per plant of tomato plants grown in soil media containing 0.50 or 100% dose of inorganic fertilizers.

## 2 Conclusion

Addition of 50% dose of inorganic fertilizers increased NPK absorption, growth and yield of tomato plants to a similar level with the tomato plants grown in soil media containing 100% dose of inorganic fertilizers. Similar, spraying 10% Lombok brown algae extracts during vegetative growth could stimulate NPK absorption, growth and yield of tomato plants grown both in 50% and 100% dose of inorganic fertilizers. This implies that the application of 50% dose of inorganic fertilizers in combination with spraying 10% Lombok brown algae extracts could induce growth and yield of tomato plants to maximum level.

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