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A Study on the Effect of Bittern Treatments with Organic Fertilizers on the Growth of Tomato

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Abstract

Bittern, a byproduct of the solar salt production process has been studied for its potential to become a cost-effective fertilizer due to its high ion concentration. However, high salt toxicity and low levels of phosphorus and nitrogen have affected its ability to supply the plant's nutritional requirements on its own fully. Here we observe its success as a fertilizer when paired with known organic, nutritional sources such as *Gliricidia sepium* and Vermi-wash in the growth of Tomato (*Solanum lycopersicum*) a crop of high commercial value and nutrition, that is cultivated in Sri Lanka during both agricultural seasons. These two components when added to diluted Bittern were able to provide nutrients that Bittern did not contain. Certain combinations of ratios of the three components were revealed to be more successful than others with the combination of Bittern 25%, Gliricidia leaf pulp, and Vermi-wash 25% leading to a 63% overall increase in growth parameters, surpassing the increment of its respective control group. This indicated that Bittern could be utilized to develop a substitute for expensive inorganic fertilizers by pairing it with other low-cost, organic nutritional sources such as *Gliricidia sepium* and Vermi-wash. This may also be a more environmentally friendly substitute for synthetic fertilizers.

Keywords**:** Bittern; Tomato; *Gliricidia*; Vermi-wash; Growth

Introduction

As a country with a major part of its economy based in the agricultural sector, Sri Lanka imports a major portion of its fertilizer needed to maintain and increase crop production. The use of these synthetic fertilizers has a detrimental effect on the environment. In addition, when production is insufficient, Sri Lanka depends on imports of crops to meet the needs of the population. Tomatoes are one such crop of which Sri Lanka has imported $2.2M as processed tomatoes while exporting only $ 41.5K (Observatory of Economic Complexity (OEC), n.d.). Hence the cultivation of healthy, high-yield crops throughout the year, and the development of efficient fertilizer to aid in crop production is a priority of all the stakeholders involved.

Bittern was studied for its potential as a fertilizer due to its high concentrations of K+, Ca2+, and Mg2+ demonstrating an ability to improve the exchangeable K+ in soil when applied to supply the potassium requirement of adult coconut palm (Herath & Chamara, 2018). When applied to develop as a multi-nutrient fertilizer Bittern showed significantly improved growth rates in Green Gram at an optimum dosage of 390ppm (Perera et al., 2015). Bittern when compared with Brine, revealed itself to be the superior source of potassium, improving crop growth, gas exchange, yield, and nutrient uptake (Trivedi et al., 2017). However, its potential is limited by salt toxicity and low levels of nitrogen and phosphorus (Raghunathan, 2003). Hence components that are low cost, rich in nitrogen and phosphorus, and have zero or minimum adverse effects on the environment could be tested alongside Bittern to increase its effectiveness as a fertilizer.

Tomato, like most plants, requires nitrogen, phosphorus, and potassium for its growth and survival (Seedforth Agro, 2023). Gliricidia sepium foliage is known to have a nitrogen content of 35,500 ppm (Agyeman et al., 2013) However, it proved to be unsuccessful as a sole nutrient source as well (W.G.D. Lakmini, 2007b). Additionally, as stated by Mahto et al., 2019 the average composition of Vermi-wash contains roughly 17,000 ppm of phosphorus which is higher than that of Gliricidia leaf matter and Bittern. Hence in this study, it was hypothesized that organic fertilizers: Gliricidia sepium and Vermi-wash would improve the potential of Bittern as a fertilizer by providing nutrients unavailable in Bittern. By using fertilizer mixtures comprising of components that are readily accessible and low cost to provide the major nutrients necessary for plant growth and development, the study hoped to explore a possible product that can address the need for an easily available and cost-effective fertilizer that increases the yield of Tomato.

Materials and Methods

Experimental Site

The Bittern solution was obtained from Maha Lewaya, Sri Lanka Salt Limited-Hambantota. Seeds from the Thilina variety of Tomato were obtained. The experiment was carried out in a controlled Net house and Greenhouse environment, available at SLIIT (Sri Lanka Institute of Information Technology) before and after treatments respectively.

Plant Preparation

The Tomato seeds were planted in coir pellets and treated with water. Once germination occurred the seedlings were treated with water and diluted Albert solution. Seedlings were then transplanted into cylindrical polybags, 20cm in height. Each polybag was filled with moist coir dust and the transplanted seedlings were treated with non-diluted Albert solution and water.

Treatments

For treatments, liquid Bittern was diluted with water to get concentrations of 25% and 50%. A blended pulp was made from Gliricidia leaf matter to apply to the plants, Vermi-wash (50ml diluted in 1L of water) and Albert solution (2g in 1L of water) were prepared as instructed by the supplier. Table 1 represents the treatment mixtures applied to each group.

Table 1. Combinations of treatment mixtures used for each group

Test Group	Fertilizer Treatment
Control	Albert solution
T1a	Bittern 25%
T1b	Bittern 50%
T3a	Bittern 25% + Gliricidia leaf pulp 10g
T3b	Bittern 50%+ Gliricidia leaf pulp 10g
T5a	Bittern 25% + Vermi-wash 75%
T5b	Bittern 50% + Vermi wash 50%
T7a	Bittern 25% + Gliricidia leaf pulp 10g + Vermi-wash 25%
T7b	Bittern 50% + Gliricidia leaf pulp 10g + Vermi-wash 50%

Treatment for all groups commenced 6 weeks after germination and was subjected to eight treatments at five-day intervals. The replicates of all groups were arranged in a completely randomized block design. Plants were manually irrigated three times during the interval between treatments.

Data collection and recording

A quantitative analysis was done using data for the number of plant leaflets, number of plant leaves, stem width, and plant height as parameters to represent vegetative growth. The number of plant leaflets and leaves of each replicate was manually counted during the first four treatments and ceased with the beginning of leaf fall. Stem width was measured in three areas of the stem of each plant using a vernier caliper and plant height was measured with a meter ruler, from the base to the tip of the plant.

Statistical Analysis

A One-way ANOVA analysis was conducted for the data regarding the Number of Leaflets, Number of Leaves, Plant height, Stem width, and overall summary of growth response using Minitab Software Version 22.1.

Results and Discussion

The effect of treatment on vegetative growth was measured using the four parameters, leaflet count, leaf count, plant height, and stem width.

Analysis of Leaf and Leaflet Count

According to Figure 1A and 1B treatment groups T7a had the highest increment in their leaf and leaflet count growth compared to the rest of the treatment groups all of which (except for T5a in Figure 1B) is less than that of their respective control group. These parameters measure the short-term growth of 20 days before leaf fall started and show that T7a was the most effective treatment for the response of leaf growth during the early growth stage.

Analysis of Stem Width

Figure 1C shows the highest increase in stem width in treatment group T1a, T3a, and T7a within the treatment groups. However, the control groups showed a higher increase in stem width than all treatment groups.

Analysis of Plant Height

In Figure 1D the response to treatment in terms of height was less in every treatment group when compared to their respective control group. Groups T3a and T7a show the most increase in height among the treatment groups.

An analysis of all the vegetative growth parameters in Figure 1E shows that the growth is highest in groups T7a and T3a in descending order. The overall decreased growth in groups treated with 50% Bittern is consistent with the studies conducted by Liyanage et al., 2018 and Perera et al., 2015 as mentioned before, which showed that high concentrations of Bittern led to growth retardation. Both studies contribute to the possible reasoning that high Bittern concentrations of 50% or more would cause salt toxicity to the plant and retard its growth and development and hence the same explanation may be applicable in this context.

The treatment groups T1a and T1b had the least positive response in the growth of vegetative parameters hence proving that Bittern cannot be used as the sole nutrient source for a tomato plant.

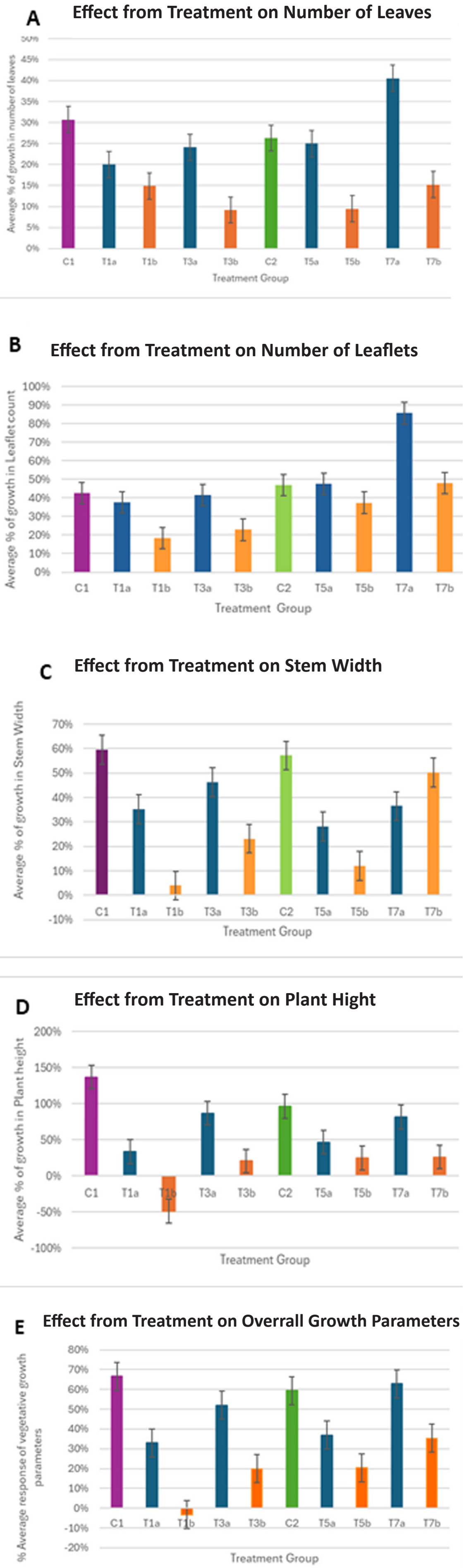

Figure 1. The plant growth response to treatments is shown from the change in; A) Number of leaves after 20 days of treatment ($P<0.05$) B) Number of leaflets after 15 days of treatment C) Stem width after 25 days of treatment ($P<0.05$) D) Plant height after 25 days of treatment ($P<0.05$) E) Average response of all vegetative growth parameters shown in Figure A, B, C, and D ($P<0.05$).

The overall analysis of the parameters shows that the groups treated with mixtures of Bittern 25% and Gliricidia pulp (T3 and T7a) showed the best growth response in vegetative growth parameters. In a study conducted to analyze the amount of Albert solution that can be replaced by the leaf extract of Gliricidia sepium, it was concluded that the leaf extract could not be used to replace Albert as the control replicates showed higher and better growth than the treated. This infers that Gliricidia leaf extract alone is unlikely to be an effective fertilizer (W.G.D. Lakmini, 2007a). However, the results gained in this study can be used to conclude that the combination of Gliricidia and 25% Bittern is a much more successful combination due to the absence of a decline in the growth of the plant. As suggested by Mahto et al., 2019 Vermi-wash has a low nitrogen content, which would cause the treated group T5 to have a low nitrogen supply, explaining its low growth response. However, its high phosphorus content as compared to that of Gliricidia leaf matter, would explain the group T7a showing the highest overall vegetative growth and development.

Conclusions

The most successful combination of mixtures to increase the growth and development of Tomato is Bittern 25%, 10g of Gliricidia leaf pulp, and Vermi-wash 25%. Bittern cannot be used as the sole nutrient of the plant and Bittern concentration of 50% and above are toxic to the plant. The above-mentioned combination of ingredients has the potential to be developed into a more cost-effective, easily available and a more environmentally friendly fertilizer option for Tomato cultivation.

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