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Impact of Fish Amino Acid and Boron Supplementation on the Growth and Yield Performance of Tomato (*Solanum lycopersicum*) Cultivated in Soil and Soilless Systems

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Abstract: An experiment was undertaken to evaluate the impact of fish amino acid (FAA) fertilizer and boron (B) supplementation on the growth and yield of *Solanum lycopersicum* (tomato) cultivated in both soil and soilless systems. The study comprised six treatments with four replications each, including Control group, as well as treatments involving FAA and B application. The experiment was conducted for 12 weeks using a factorial arrangement within a randomized complete block design (RCBD). Data were analyzed by using analysis of variance (ANOVA), SPSS software, and treatment means were compared using Tukey's Honest Significant Difference (HSD) test at a significance level of $P \leq 0.05$. The parameters assessed in this study included plant height, number of leaves, shoot and root biomass, media pH, fresh weight, and fruit number. The investigation into the impact of fish amino acid (FAA) application on the growth and yield of tomato in soilless culture was successfully conducted. The treatment involving 30 mL/L FAA (T3) demonstrated a statistically significant effect on the number of leaves and the results were like the treatment using AB fertilizer application (T5). Similarly, the study examining the impact of boron (B) on tomato growth and yield in soilless media was also successful. The combined application of 30 mL/L FAA with 1.87 mg/L B (T4) produced results on leaf number that were statistically like those observed with the AB fertilizer treatment (T6). These findings indicate that FAA and B applications positively impact certain growth parameters, suggesting their potential as alternative nutrient sources to reduce reliance on conventional chemical fertilizers.

Keywords: Fish amino acid, boron, tomato, soil system, soilless system

1. Introduction

The tomato, also known by its scientific name *Solanum lycopersicum*, is a member of the Solanaceae family. Other well-known species including potato, tobacco, pepper, and eggplant are also members of his family (Naika *et al.*,2019). Asia produced 109.04 million tonnes of tomatoes in 2017, and by 2018, that amount had grown to 109.30 million tonnes. In 2019, the production was 112.10 million tonnes, up 2.8 million tons (FAO, 2021). Despite being a perennial plant, tomatoes are grown as warm-season annual crops because of their sensitivity to frost. It can be cultivated in open areas as well as greenhouses. Additionally, it proved suitable for a range of climates, including hot, humid tropical and mild climates.

Any substance used to enrich the soil with nutrients to increase soil fertility, and, in turn, plant development is referred to as fertilizer. Fertilization increases the effectiveness of agricultural processes and results in higher-quality product recovery (Serpil, 2012). There are two forms of fertilizer which are solid and liquid. Solid fertilizer consists of powder, crystals, prill, granules, super granules, and briquettes. Meanwhile, liquid fertilizers are applied either directly or with irrigation water which is easier to handle and reduce labour requirement for plant maintenance (Kumar *et al.*, 2019).

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Liquid organic fertilizers include vital plant nutrients as well as helpful microbes that recycle organic matter. Microorganisms are essential to the fermentation process because they help break down the substrates. As a result of the fermentation process, liquid organic fertilizers are enriched with phytohormones such as auxins and cytokinins, as well as organic acids and various plant growth-promoting compounds. Utilizing liquid organic manure increases tomato plant nutritional availability and soil biological activity (Gore and Sreenivasa, 2011).

Fish amino acid is the name for the liquid organic manure produced from fish waste. Since it contains a variety of nutrients and amino acids, fish amino acid is extremely beneficial to plant and microorganism development (Priyanka et al., 2019). By providing carbon and nitrogen sources, amino acid fertilizer can stimulate microbial growth. It can also improve soil enzyme activity, which in turn can increase phosphorus activation and effectiveness. This, in turn, can increase the scale of root foraging, improve nutrient absorption, and boost shoot especially for bamboo plant (Zhao et al., 2025). As an additional fertilizer, fermented FAA is an organic acid that contains key compounds that affect how plants grow and develop according to Ramesh et al. (2020), who conducted research on Amaranthus.

Plants require micronutrients, commonly referred to as trace elements, in small levels for growth (Foth, 1990). The elements in question are iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), nickel (Ni), and chlorine (Cl). Extremely stunted growth, low production, dieback, and even plant mortality can be brought on by micronutrient deficits in plants. However, micronutrients are important because they can increase crop yields in plant production (Ganie et al., 2013).

Boron (B), an essential micronutrient, plays a critical role in normal plant growth and development. It is involved in numerous physiological and biochemical processes, including respiration, cell wall synthesis and lignification, cell division in meristematic tissues, formation of petals and leaf buds, maintenance of cell wall structural integrity, metabolism and transport of sugars and hydrocarbons, as well as phenol and nitrogen metabolism (Ahmad et al., 2012).

Haque et al. (2011) did a study to investigate how nitrogen and boron affected tomato production and growth. In this analysis, both the fertilizers evaluated independently and together. The best results were seen in plant height, flower cluster count, fruit cluster count, fruit plant count, fruit weight plant (kg), fruit weight plot (kg), and fruit production (ton/ha). Ullah et al. (2024) also did a study on effect of boron on growth and seed yield of pea cultivar which the results showed the significant affected on pea growth and seed production by foliar boron application (0.75%).

The AB Mix nutrient is frequently utilized in Indonesian hydroponic systems. The composition of the nutrients in AB Mix that are given to plants must be suitable. It will hinder less-than-ideal plant growth if it is absent or present in excess (Lestari, 2009). A nutrient solution is one of the most important variables affecting the yield, quality, and production of hydroponically grown plants. The concentration of AB Mix significantly impacted the quantity, length, and width of leaves and consumption part wet weight on pakchoy (Rahmawati et al., 2024).

Any technique for growing plants that does not use soil as a rooting medium and instead uses irrigation water to supply the inorganic nutrients the roots need to grow is known as soilless culture. Nutrient solution is the result of dissolving fertilizers containing the nutrients that must be delivered to the crop in irrigation water at the necessary concentration (Savvas et al., 2013). It is believed that crops cultivated in soilless media have higher quality than crops grown in soil. By regulating meteorological conditions and the type of fertilizers used, the growing environment is maintained. However, it is crucial to choose the proper substrates and growing media (Rauf et al., 2022).

This issue drove several researchers to take steps to develop an organic fertilizer that farmers could use without leaving biodiversity and the environment at risk. The aim of this research is to discover how tomato cultivation and growth in soil and soilless media are affected by the application of boron and fish amino acids.

2.0 Materials and Methods

2.1 Plant Materials

The tomato seedlings underwent a 14-day germination period at the nursery. The seedlings were transferred to the polybags 14 days after they had hardened off. Each polybag included 10 kg of topsoil (soil media) and 1 kg of cocopeat (soilless media).

Fish amino acid (FAA) was formulated by combining waste material from long-jawed mackerel with molasses in a 1:1 ratio to produce a liquid organic fertilizer. The mixture underwent a fermentation process for a duration of three weeks, after which it was filtered. The resulting filtrate was then applied in varying volumes as experimental treatments in the study.

The experiment utilized two types of fertilizers: FAA and AB fertilizer, the latter serving as the control treatment (Table 1). Fertilizer treatments were applied directly to the growing media twice per week, while B was administered as a foliar spray once per week. The experimental design followed a randomized complete block design (RCBD) with five replications per treatment. Data collection was carried out over a period of 12 weeks following planting.

Table 1: Experimental treatments applied to soil and soilless growing media

	Treatments
T1	Control (No treatment)
T2	1.87 mg/L B
T3	30 ml/L FAA
T4	30 ml/L FAA + 1.87 mg/L B
T5	AB fertilizer
T6	AB fertilizer + 1.87 mg/L B

2.2 Plant Height

Plant height for each treatment was measured weekly using a standard measuring tape, and the measurements were systematically recorded.

2.3 Number of Leaves

The number of leaves per plant in each treatment was determined on a weekly basis, and the data were recorded accordingly.

2.4 Shoot Biomass

All aerial parts of the plants from each treatment group were harvested, placed in labeled envelopes according to treatment identification, and subsequently oven-dried at 70°C for 24 hours. After drying, the shoot biomass was determined by weighing the samples using a digital balance.

2.5 Root Biomass

Root systems from each treatment were carefully collected and similarly placed in labeled envelopes. These samples were oven-dried at 70°C for 24 hours, after which their dry weight was measured using a digital scale.

2.6 Soil pH

Soil pH was assessed using a calibrated pH meter, following a standardized ratio of fresh soil to distilled water of 1:2.5 (w/v). The measurements were conducted under consistent laboratory conditions to ensure accuracy.

2.7 Fresh Fruit Weight and Total Fruit Count

Tomato fruits were harvested upon reaching physiological maturity (red ripening stage). For each plant, the total number of fruits was counted, and the fresh weight was recorded using a digital scale. Data were recorded individually for each plant.

2.8 Soil Organic Matter Analysis

Soil samples collected for organic matter analysis were submitted to a certified analytical laboratory, where standardized procedures were employed to determine organic matter content.

2.9 Statistical Analysis

The experiment was conducted using a factorial arrangement within a Randomized Complete Block Design (RCBD). Data were statistically analyzed using the Statistical Package for the Social Sciences (SPSS). One-way analysis of variance (ANOVA) was applied to assess treatment effects, followed by Tukey's Honestly Significant Difference (HSD) test for multiple comparisons. Statistical significance was determined at $P \leq 0.05$.

3.0 Results and Discussion

3.1 Plant Height and Number of Leaves

Table 2 shows the effect of FAA and boron on plant height and number of leaves in soil and soilless media of tomato. For plant height, results showed that there was no significant effect in both organic and inorganic fertilizers treatments compared to control in soil media while for soilless media, the results T5 showed significant effect compared to control.

On the other hand, for plant leaves both organic and inorganic fertilizers also did not show the significant effect compared to control in soil media. In contrast, to treatments in soilless media, the result showed that there was significant effect showed between the treatments. Treatments T3 and T5 show significantly higher compared to control. The treatment in soilless media showed a considerable effect that may be attributed to both dramatically increased photosynthetic efficiency and higher N availability from soilless. Treatment with fish amino acids increased metabolic activity and cell division, increasing plant height at all growth stages. Priyanka et al. (2019) indicated that fish amino had significant amounts of minerals and amino acids that boosted paddy production, supporting these findings.

For B treatments, results showed that there was significant effect on plant height compared to control in soil media. Treatments T4 showed significantly higher than control. Besides, for treatments in soilless media, treatment T6 showed significant effect compared to controls. Meanwhile, for number of leaves, results showed that there was significant effect on plant number of leaves compared to control in soil media. For soil media, treatments T4 showed a significant effect on plant height. For treatments in soilless media, treatments T4 and T6 showed a significant effect compared to control. These results were supported by Camacho-Cristóbal et al. (2015) who found that boron can increased photosynthetic rate and caused the plants to grow taller and promote vegetative growth. Boron is necessarily for cell elongation and division, which improves plant development and plant height. Regarding boron (B) application, the results indicated no statistically significant differences in the number of leaves among the treatments. The previous research showed that boron treatments significantly enhanced the capacity of tomato plants for photosynthesis and can stabilize leaf structure (Xu et al., 2021). The results were match with the findings.

Table 2: Effects of FAA and Boron on mean plant height and number of leaves in soil and soilless media

Treatments	Soil		Soilless	
	Plant Height (cm) (Means ± Std. Error)	**Number of Leaves (Means ± Std. Error)**	**Plant Height(cm) (Means ± Std. Error)**	**Number of Leaves (Means ± Std. Error)**
T1	57.26 + 30.26^{a}	13.11 + 3.74^{a}	36.65 +22.62^{ab}	9.17 +3.45^{a}
T2	65.24 +36.33^{a}	14.83 + 4.28^{ab}	30.63 +23.79^{a}	9.14 +2.53^{a}
T3	79.81 +44.8^{ab}	15.25 + 5.03^{ab}	59.36 +41.46^{bc}	12.86 +5.03^{b}
T4	99.67 +59.97^{b}	16.75 + 6.04^{b}	60.31 +39.41^{bc}	14.22 +4.83^{b}
T5	81.53 +43.57^{ab}	14.56 +4.15^{ab}	68.47 +39.37^{c}	13.50 +4.21^{b}
T6	81.69 + 44.38^{ab}	15.83 +4.62^{ab}	74.51 + 46.73^{c}	13.31 +4.05^{b}

3.2 Root Biomass and Shoot biomass

Table 3 shows the results of the e*ffects of FAA and AB fertilizer on the means of root and shoot* biomass in soil and soilless media. Either organic or inorganic fertilizers, the results did not show the significant difference in soil and soilless media for root and shoot biomass. For treatments using boron also showed that there were no significant effects on shoot and root biomass of tomato. These results differ from those reported by *Gad et al.* (2007), who found that the application of organic fertilizer significantly enhanced the fresh and dry biomass of tomato shoots and roots.

Table 3: Effects of FAA and Boron on mean of root and shoot biomass in soil and

soilless media

Treatments	Soil		Soilless	
	Root Biomass (%) (Means ± Std. Error)	Shoot Biomass (%) (Means ± Std. Error)	Root Biomass (%) (Means ± Std. Error)	Shoot Biomass (%) (Means ± Std. Error)
T1	21.81 +5.56 [a]	17.97 +1.10[a]	17.03 + 0.39[a]	16.20 + 3.45[a]
T2	23.19 +1.74[a]	17.17 +0.68[a]	16.36 + 1.72[a]	16.16 + 2.53[a]
T3	21.83 +3.66[a]	18.40 + 0.73[a]	14.75 + 1.24[a]	31.86 + 5.03[a]
T4	24.35 +2.18[a]	19.90 + 2.74[a]	11.66 + 4.77[a]	21.72 + 4.83[a]
T5	19.91 +1.60[a]	18.05 + 0.41[a]	12.47 + 0.64[a]	20.71 + 4.21[a]
T6	17.64 + 1.45[a]	12.57 + 2.66[a]	12.19 + 2.13[a]	33.56 + 4.05[a]

3.3 pH Media and Organic Matter

Table 4 showed the results of the effects of FAA fertilizer and boron application on the means of pH media and organic matter content in soil and soilless media. Either organic or inorganic fertilizers, the results did not show the significant different in soil and soilless media for pH media. These results were in line with those seen by Johari et al. (2020) in their experiment on okra plants, demonstrating that the applied FAA did not cause the pH of the soil to increase. For boron application T6 showed the significant different compared to control in soilless culture media. This was proved by Phibunwatthanawong and Riddech (2019), which were liquid organic fertilizers, which is a recycled organic matter, containing both beneficial microorganisms and vital plant nutrients. During the fermentation process, microorganisms play a crucial role in decomposing substrates and enhancing the organic matter content.

Table 4: Effects of FAA and Boron on mean of pH media and organic matter content in soil and soilless media

Treatments	Soil		Soilless	
	pH (Means ± Std. Error)	OM (ppm) (Means ± Std. Error)	pH (Means ± Std. Error)	OM (ppm) (Means ± Std. Error)
T1	5.83 + 0.4[a]	20.62 + 1.8[a]	6.33 + 0.2[a]	76.60 + 1.8[b]
T2	5.83 + 0.4[a]	18.58 + 4.4[a]	6.17 + 0.2[a]	71.30 + 3.1[ab]
T3	5.00 + 0.0[a]	19.37 + 0.9[a]	5.83 + 0.2[a]	73.22 + 5.4[ab]
T4	5.00 + 0.0[a]	18.13 + 0.4[a]	5.67 + 0.3[a]	74.02 + 2.6[ab]
T5	5.33 + 0.4[a]	17.88 + 1.1[a]	5.67 + 0.17[a]	69.60 +5.1[ab]
T6	6.00 + 0.0[a]	18.60 +0.2[a]	5.83 + 0.17[a]	56.75 + 4.7[a]

3.4 Number of fruits and fresh weight

Table 5 shows the results of the effects of FAA and B on mean of number of fruits and fresh weight on soil and soilless culture media. Results showed that there were no significant effects on number of fruits and fresh weight of tomato in soil culture media compared to control in soil media. Meanwhile, for treatments in soilless media, treatment T5 showed the significant effect on the number of fruits and fresh weight compared to control. For boron treatment, the results showed that there were no significant effects on both parameters in soil and soilless media. Murillo et al. (2015) reported that the differences in fresh weight between the organic fertilizer-treated plants and the unfertilized control plants may be caused by the stimulation of the synthesis of different metabolites, such as amino acids and proteins, which would encourage the accumulation of biomass.

Table 5: Effects of FAA and B on mean of number of fruits and fresh weight in soil and soilless media

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Treatments	Soil		Soilless	
	Number of fruits (Means ± Std. Error)	Fresh weight (g) (Means ± Std. Error)	Number of fruits (Means ± Std. Error)	Fresh weight (g) (Means ± Std. Error)
T1	$2.33 + 1.5^{a}$	$124.67 + 94.1^{a}$	$0.00 + 0.0^{a}$	$0.00 + 0.0^{a}$
T2	$3.00 + 1.2^{a}$	$196.33 + 98.4^{a}$	$0.00 + 0.0^{a}$	$0.00 + 0.0^{a}$
T3	$8.33 + 1.7^{a}$	$721.33 +29.4^{a}$	$5.33 + 0.7^{ab}$	$422.67 + 51.0^{ab}$
T4	$4.67 + 0.7^{a}$	$449.33 + 131.5^{a}$	$3.00 + 1.5^{ab}$	$291.33 + 162.8^{ab}$
T5	$12.33 + 6.2^{a}$	$868.67 +443.1^{a}$	$11.67 + 5.0^{b}$	$818.33 + 340.4^{b}$
T6	$6.67 + 1.8^{a}$	$434.67 + 135.4^{a}$	$3.00 + 2.5^{ab}$	$282.00 + 245.5^{ab}$

4. Conclusion

In conclusion, the results on study of effects of FAA application on growth and yield of tomato in soilless media were successfully achieved. Treatment with 30 mL/L FAA (T3) showed the significant effect on plant number of leaves and the result was like the result using AB fertilizers (T4). Meanwhile, studies on effects of boron application on growth and yield of tomato in soilless media were also successful. Treatment 30 mL/L FAA + 1.87 mg/L B (T4) gave similar result to treatment (T6) on plant number of leaves. This study demonstrated that the application of fish amino acid and boron positively influences specific aspects of plant growth and development. Therefore, these substances may serve as potential alternatives to conventional chemical fertilizers, contributing to a reduction in their usage.

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Conflict of Interest

The authors declare no conflicts of interest.

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