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Enhancing Melon Growth and Fruit Quality through Optimal Fertilizer Volume and Biostimulant Application

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Abstract

Melons offer numerous health benefits and are widely enjoyed. However, the potential of foliar spray as a plant growth and fruit quality enhancer, as well as efficient fertilizer use, remains underexplored. This study aimed to investigate the impact of combining 5% zeolite and cocopeat with varying fertilizer and biostimulant volumes on melon growth and quality. Using Khaitongkam F_2 generation melon, this study was conducted under a netted rain shelter with a fertigation system. Despite successful germination and transplanting, results showed no significant differences between two fertilizer volumes (A and B) on growth and fruit quality. Volume A boosted growth rate (27.16±0.48 cm/day) but reduced fruit weight, diameter, and length. Conversely, volume B increased fruit size while slightly lowering growth rate. Biostimulants negatively affected fruit attributes. In conclusion, volume B fertilizer optimization balanced growth and quality, while zeolite, volume A, and biostimulants showed no significant effects.

Keywords: Melon; zeolite; fertilizer; biostimulants; fertigation; growth

Introduction

In the modern era, the rapid urbanization-induced climate changes have escalated the demand for food due to population expansion. This underscores the necessity for more efficient agricultural production systems to meet global needs. *Cucumis melo* L., commonly referred to as melon, is a pivotal source of agricultural income across the world and holds significant economic importance as a widely cultivated fruit species (Buczkowska & Nurzyńska-Wierdak, 2020).

Recent years have witnessed a growing interest in optimizing fruit quality and plant growth in melons through the utilization of zeolite and biostimulants. Zeolites find application in agriculture through inclusion in fertilizers, soil enhancement, and utilization as slow-release fertilizers, bolstering agricultural production and environmental sustainability (Mondal et al., 2021). The efficacy of zeolites as nutrient delivery systems lies in the potential of nano-zeolites and their synthesis methods to enhance nutrient and pesticide conveyance, offering long-term advantages over conventional fertilizers. Zeolites, both natural and synthetic, are investigated for their potential to deliver nutrients and function as carriers. They bolster nutrient retention and soil quality by increasing nutrient absorption capacity. Key plant nutrients such as calcium, magnesium, microelements, nitrogen (N), and potassium (K) are encompassed within this nutrient-zeolite interaction.

Biostimulants are natural substances known to enhance plant vitality, growth, and disease resistance. Their efficacy extends to both horticultural and agricultural crops, enhancing nutritional efficiency and stress tolerance (Drobek et al., 2019). Agrodyke organic fertilizer, known for accelerating plant growth and bolstering soil fertility, contains not only essential nutrients but also a substantial organic carbon content. This content enhances soil fertility, root development, water, and nutrient absorption, thereby promoting overall plant growth (Astiari et al., 2018). Similarly, potassium sulfate (SOP), a biostimulant, contributes significantly to fruit growth and quality. Potassium plays a vital role in various plant functions, including enzyme activation, nutrient absorption, and assimilate transportation (Heikal, 2017).

This study aimed to enhance melon growth and quality through optimized nutrient utilization and effective nutrient promotion. Integrating zeolite into the growth medium has potential implications for agriculture, capitalizing on prior research affirming its benefits. Notably, this study strived to achieve a balanced fertilizer application for improved melon market quality, focusing on sweetness enhancement. This advancement could pave the way for zeolite's widespread adoption, offering slow-release fertilization and cost-effectiveness to enhance crop yields (Wen et al., 2022).

Materials and methods

The experiment was carried out in accordance with the methodology outlined by Mukhtar and Abd Samad (2022). In this study, the experimentation revolved around the utilization of Khaitongkam F_2 generation seeds of the melon variety. The initial objective centred on the application of zeolite, employing two distinct treatments: the control treatment, composed entirely of cocopeat, and the Z1 treatment, which combined 95% cocopeat with 5% zeolite. The control treatment encompassed 1500 grams of cocopeat per polybag, while the Z1 treatment integrated 75 grams (w/v) of zeolite with 1425 grams of cocopeat.

The second objective encompassed the application of differing fertilizer volumes, designated as treatments VA and VB. These treatments both employed 100% cocopeat along with an identical fertilizer formulation, differing solely in the amount of fertilizer administered. The third objective involved the use of biostimulants B1 (agrodyke) and B2 (potassium sulphate) as treatments. Both treatments used 100% cocopeat and were administered similarly to the preceding ones.

In the experimental setup, fertilizer and water were delivered through a main HDPE pipe and then distributed to individual microtubes via a supply LDPE pipe. Subsequently, the mixture was dripped into the plant media using a dripper system, facilitating nutrient absorption by the roots.

All treatments employed the same fertilizer formulation, with variations in the quantities used. The preparation of the fertilizer began with the stock solution AB, wherein the concentrations of macronutrients and micronutrients in fertilizers A and B differed. These stock solution fertilizers were combined according to the formulated mixture, ensuring equal volumes of both A and B. The fertigation process involved a 400-gallon fertilizer tank, with water added until the specified EC value was achieved. This mixture was then directed into the fertigation system via the main and supply pipes, microtubes, and dripper, and subsequently absorbed by the growing medium.

The germination process spanned 10 to 15 days until the plants developed at least four leaves. It involved peat moss, seedling trays, black plastic wrap, and rock melon seeds. The media underwent treatment with a 30% bleaching agent (specifically Clorox) and were washed for a day. Following this, each polybag received 1.5 grams of dolomite to stabilize the pH. During the transplanting phase, germinated seeds were carefully moved to polybags, ensuring adequate moisture content in the media beforehand.

In the realm of plant maintenance and harvesting, pruning constitutes a practice wherein leaves are removed to conserve water and optimize fertilizer usage. This pruning procedure was regularly executed throughout the experiment, predominantly during the initial weeks spanning from week 2 to week 6. During this phase, leaves numbered 1 to 6, as well as leaves numbered 11 and beyond, were subject to trimming. Upon reaching week 7, a top pruning action was undertaken, entailing the removal of leaves numbered 25 and above. Furthermore, as the plants attained a maturity ranging from 50 to 56 days, five leaves located beneath the fruits were carefully removed. During the flowering phase, which extended from 15 days after transplant (DAT) to 35 DAT, manual pollination was performed.

Subsequent to reaching 65 DAT, the melons were harvested, marking the culmination of the growth season. The drip system responsible for supplying nutrients and water ceased a few days prior to harvest, a strategic move to prevent an excess supply of nutrients and water. The melons were physically gathered, with comprehensive data collected for each individual fruit. A subset of fruits from each treatment group was randomly chosen for Brix detection, accomplished using Brix Refractometers. The data collection process encompassed parameters such as fruit weight, fruit diameter, and fruit length.

Table 1: Different Fertilizer Volumes for Melon Fertigation

Week	Quantity (mL/day)		EC (mS/cm)
	Volume A	Volume B	
1	250	300	1.2
2	500	512	1.5
3	700	780	1.5
4	800	800	1.5
5	1200	900	1.5
6	1200	1260	2.0
7	1500	1260	2.5
8	1500	1500	3.0
9	1800	1800	3.0
10	800	800	3.0

In this study, a comparison was made between the means of two groups for three parameters using the Independent Samples T-test. The homogeneity of variance was assessed using Levene's test, and the presence of a statistically significant difference between the two treatments was determined through the t-test. The data analysis was conducted using Statistical Package for Social Science (SPSS) version 27.

Results and discussion

Table 2 demonstrates the uniformity in growth rate, fruit weight, fruit diameter, and fruit length between the control group (media with 100% cocopeat) and the Z1 treatment group (media with the addition of 5% zeolite), with corresponding significant levels of 7.05, 1.11, 0.90, and 0.03. When examining Table 2, it becomes evident that the mean growth rate of the control group (23.93±0.51 cm/days) is comparatively lower than that of the Z1 treatment group (27.33±1.96 cm/days). Notably, Table 2 illustrates that there were no substantial disparities in fruit quality, including fruit weight, fruit diameter, and fruit length. In particular, the mean fruit weight of the control group (0.36±0.02 kg) was significantly lower than that of the Z1 group (0.40±0.05 kg), with a p-value of 0.49 ($p > 0.05$). The fruit diameter did not exhibit a notable difference between the control and Z1 groups, as indicated by a p-value of 0.40 ($p > 0.05$), with mean values of 27.02±0.64 cm for the control group and 28.22±1.19 cm for the Z1 group. Similarly, the p-value of 0.35 ($p > 0.05$) indicates the absence of a significant distinction in fruit length, with mean values of 8.54±0.29 cm for the control group and 9.06±0.43 cm for the Z1 group.

Table 2: Effect of zeolite on plant growth and fruit quality

Treatment	Growth rate (cm/days)	Fruit weight (kg)	Fruit diameter (cm)	Fruit length (cm)
Control	23.93 ± 0.51^{a}	0.36 ± 0.02^{a}	27.02 ± 0.64^{a}	8.54 ± 0.29^{a}
Z_1 (5% zeolite)	27.33 ± 1.96^{a}	0.40 ± 0.05^{a}	28.22 ± 1.19^{a}	9.06 ± 0.43^{a}

Notes: Z1 = 95% Cocopeat + 5% Zeolite. Different letters indicate a statistically significant difference ($p < 0.05$). Data were expressed as mean ± standard error mean (SEM) of analysis (N=5).

Zeolites are known to exert influence on the physical, chemical, and biological attributes of soil, augmenting nutrient dynamics and enhancing retention capacity (Mondal et al., 2021). In light of the findings from this study, the amalgamation of 5% zeolite with cocopeat did not yield any noticeable repercussions on either plant growth or fruit quality. The examination revealed no significant disparities in terms of fruit weight, fruit diameter, and fruit length. However, a significant distinction emerged in growth rate, as detailed in Table 2. Interestingly, the mean growth rate for the treatment lacking 5% zeolite outperformed that for the zeolite-incorporated treatment.

Presumably, the incorporation of zeolite is theorized to ameliorate the physical and chemical attributes of the growth medium for plants (Jakkula et al., 2018). Nonetheless, the findings indicate that a modest proportion of zeolite actually led to diminished plant growth efficiency. This observation aligns with the report by Szatanik-Kloc et al. (2021), asserting that even at maximal application rates, the minimal proportion of zeolite introduced to the soil contributed to the lack of discernible effects from soil zeolitization within the experiment. It is noteworthy, however, that the possibility of employing a higher percentage of zeolite to amplify soil-specific surfaces was suggested, and a parallel approach was adopted when integrating cocopeat and zeolite. Furthermore, the absence of zeolite's influence on plant growth and fruit quality could potentially be attributed to factors beyond its concentration. Thus, in the context of Khaitongkam melon plants, the infusion of 5% zeolite exhibited no observable effects on their growth and the quality of their fruits.

Table 3 indicates the two different fertilizer volumes were compared based on the statistical analysis. The results for the application of different fertilizer volumes on plant growth and fruit quality. The outcomes of the investigation into the influence of diverse fertilizer volumes on plant growth and fruit quality are presented in Table 3. The analysis conducted revealed that there were no statistically significant discrepancies between treatment VA and treatment VB across all the parameters under examination. Notably, the growth rate, as assessed, exhibited no notable variance between these two treatments ($t(8) = 0.66$, $p = 0.53$). However, treatment VA demonstrated a slightly elevated mean growth rate (27.16±0.48 cm/days) in comparison to treatment VB (26.74±0.42 cm/days), hinting at a potential enhancement in plant growth through treatment VA.

Conversely, noteworthy disparities emerged in terms of fruit quality, specifically concerning fruit weight, diameter, and length, attributable to the variation in fertilizer application volumes. Notably, plant weight, fruit diameter, and fruit length exhibited an upward trend with the increase in fertilization volume. Noteworthy variance was detected in fruit weight (t (8) = -1.92, p = 0.09) between treatments VA and VB, with treatment VB (0.57±0.04 kg) boasting the highest mean compared to treatment VA (0.47±0.03 kg). Additionally, treatment VB showcased a substantial divergence in fruit diameter (t (8) = -2.03, p = 0.08), displaying a greater mean (33.70±0.44 cm) relative to treatment VA (30.00±1.77 cm). Moreover, the utilization of fertilizer volume B within treatment VB led to a significant elevation in the mean fruit length (11.30±0.54 cm) compared to treatment VA (9.60±0.48 cm), with a marked distinction (t (8) = -2.35, p = 0.05).

Table 3: Effect of different fertilizer volumes on plant growth and fruit quality

Treatment	Growth rate (cm/days)	Fruit weight (kg)	Fruit diameter (cm)	Fruit length (cm)
VA	27.16 ± 0.48^a	0.47 ± 0.03^a	30.00 ± 1.77^a	9.60 ± 0.48^a
VB	26.74 ± 0.42^a	0.57 ± 0.04^a	33.70 ± 0.44^a	11.30 ± 0.54^a

Notes: VA = Fertilizer volume A, VB = Fertilizer volume B. Different letter indicates statistically significance difference (p <0.05). Data were expressed as mean ± standard error mean (SEM) of analysis (N=5).

Table 3 delineates the impact of heightened fertilizer volume during the stages of fruit development, revealing a notable augmentation in fruit weight, fruit diameter, and fruit length within treatment VB as compared to treatment VA. Nonetheless, it's essential to acknowledge that applying a standard fertilizer volume and maintaining electrical conductivity during the initial stages failed to exert a significant influence on the growth rate. This aspect is intricately connected to the constituents present in the fertilizer application. Notably, during the early phases, an elevated phosphorus concentration was observed to hinder vegetative growth while simultaneously enhancing yield. Nevertheless, our findings indicate that employing a combination of early application of fertilizer volume A with heightened electrical conductivity followed by the subsequent introduction of fertilizer volume B featuring lowered electrical conductivity substantially fostered the growth rate. This approach, however, corresponded with a reduction in fruit weight, fruit diameter, and fruit length.

Earlier research corroborates the assertion that elevated nitrogen levels in fertilizers promote shoot and leaf development during the vegetative growth phase. Nevertheless, this can lead to a decline in fruit quality as the provision of excessive nutrients overshoots the plant's optimal requirement during its initial stages. Furthermore, supplementary investigations have demonstrated that excessive potassium levels in fertilizers diminish the absorption of magnesium and calcium by plants due to the crop's heightened potassium uptake (Wang et al., 2017). Consequently, while the application of fertilizer volume B in this study may have curtailed plant growth, the results underscore its preference due to its substantial enhancement of fruit quality. Notably, fruit development remained unaffected despite the reduction in plant growth. Additionally, a pivotal determinant influencing shelf life and consumer purchase decisions resided in fruit quality.

Examination of the impact of foliar application on both plant growth and fruit quality is detailed in Table 4. The outcomes of the data analysis within Table 4 offer insights into the effects of biostimulants on plant growth and fruit quality. The independent sample t-test indicated that, aside from fruit diameter, control and treatment B1 exhibited no statistically significant discrepancies across all parameters. Notably, the growth rate for both control and B1 showcased no significant variance (t (8) = -0.78, p = 0.46). It's worth mentioning that control displayed a lower mean growth rate (27.16±0.48 cm/days) when juxtaposed with treatment B1 (28.15±1.17 cm/days) (as depicted in Table 4).

Interestingly, a converse relationship was identified, where an elevation in the growth rate corresponded with a marked reduction in fruit parameters, including fruit weight, fruit diameter, and fruit length.

With respect to the application of biostimulants, specifically SOP, there was no significant discrepancy in fruit weight between control and treatment B1, registering a p-value of 0.85 (p < 0.05). The mean fruit weight for treatment B1 (0.46±0.08 kg) was similarly found to be significantly lower than that of the control (0.47±0.03 kg). In contrast, a notable distinction was observed in fruit diameter between control and B1, with a p-value of 0.02 (p < 0.05). The mean fruit diameter for treatment B1 (24.32±0.85 cm) also exhibited a significant decrease when compared to control (30.00±1.77 cm) (as outlined in Table 4). However, in terms of fruit length, no substantial difference was observed (t (8) = 1.02, p = 0.34), with the mean fruit length of B1 (8.84±0.57 cm) measuring slightly lower in comparison to control (9.60±0.48 cm).

Table 4: Effect of different fertilizer volumes on plant growth and fruit quality

Treatment	Growth rate (cm/days)	Fruit weight(kg)	Fruit diameter(cm)	Fruit length(cm)
Control B_1	27.16 ± 0.48^a	0.47 ± 0.03^a	30.00 ± 1.77^a	9.60 ± 0.48^a
B_1 (with SOP)	28.15 ± 1.17^a	0.46 ± 0.08^a	24.32 ± 0.85^b	8.84 ± 0.57^a
Control B_2	26.74 ± 0.42^a	0.57 ± 0.04^a	33.70 ± 0.44^a	11.30 ± 0.54^a
B_2 (with Agrodyke)	27.01 ± 0.49^a	0.64 ± 0.09^a	33.50 ± 0.57^a	10.10 ± 0.48^a

Notes: B1 = Treatment with SOP and B2 = Treatment with Agrodyke. Different letters indicate a statistically significant difference ($p < 0.05$). Data were expressed as mean ± standard error mean (SEM) of analysis (N=5).

The dataset similarly portrays outcomes where the independent sample t-test indicated that, akin to the previous scenario, control and treatment B2 displayed no statistically significant differences across all parameters, except for fruit diameter (Table 4). Notably, the growth rate for both control and B2 demonstrated no noteworthy variance (t (8) = -0.42, p = 0.69). It's pertinent to note that control exhibited a slightly lower mean growth rate (26.74±0.42 cm/days) in comparison to treatment B2 (27.01±0.49 cm/days) (as indicated in Table 3). Interestingly, as the growth rate heightened, a considerable decrease was observed in fruit parameters, including fruit weight, fruit diameter, and fruit length. Turning attention to the application of the biostimulant Agrodyke (B2), no significant variance in fruit weight emerged between control and treatment B1, demonstrating a p-value of 0.49 ($p < 0.05$). The mean fruit weight for treatment B2 (0.64±0.09 kg) was similarly found to be significantly lower than that of the control (0.57±0.04 kg). Similarly, in the context of fruit diameter, no substantial difference was noted (p-value: 0.79, $p < 0.05$), with the mean fruit diameter for treatment B2 (33.50±0.57 cm) registering a corresponding decrease when compared to control (33.70±0.44 cm) (as depicted in Table 4).Nonetheless, no significant distinction was detected concerning fruit length (t (8) = 1.66, p = 0.14), with the mean fruit length of B2 (10.10±0.48 cm) measuring somewhat lower in contrast to control (11.30±0.54 cm).

The outcomes derived from the analysis presented in Table 4 underscore the contrast between the impact of the two employed biostimulants, namely agrodyke and potassium sulfate. The application of these biostimulants did not yield any noticeable effects on plant growth or fruit quality. Agrodyke treatment showcased superior results in terms of fruit weight, length, and diameter in comparison to the potassium sulfate treatment. This outcome can be attributed to agrodyke's utilization of slow-release organic fertilizers derived from natural sources, providing plants with essential nutrients. By delivering a well-balanced supply of nutrients, including macronutrients (such as nitrogen, phosphorus, and potassium) and micronutrients, agrodyke contributes to enhancing plant growth and development. This can lead to improved vegetative growth, heightened melon yield, and overall robust plant development (Cakmakci et al., 2017). The plant growth and fruit quality remain unaffected by low concentrations of biostimulants, primarily because the available nutrients are insufficient for fruit development. According to research conducted by Ertani et al. (2014), when biostimulants are applied at low levels, their ability to improve nutrient uptake may be compromised, potentially resulting in suboptimal nutrient availability and utilization.

It is noteworthy that the lower concentrations of biostimulants fail to impact plant growth and fruit quality due to the insufficiency of nutrients available for fruit development. Regarding the concentration of potassium sulfate applied through foliar spray, a mere 0.1% concentration may prove inadequate to significantly enhance fruit quality. Potassium assumes a crucial role in improving various aspects of fruit quality, encompassing size, color, flavor, and nutritional composition. The overall quality of melon fruits can be enhanced by ensuring a sufficient supply of potassium, such as potassium sulfate, as demonstrated in the study by Kyriacou et al. (2018). Notably, a study by Maathuis (2013) suggests that low potassium levels can lead to hindered growth, reduced shoot and root development, and an overall slowdown in plant progress. Furthermore, potassium deficiency can impede fruit development and reduce fruit size, while also impacting fruit quality through decreased sugar content and altered taste.

Conclusion

The incorporation of 5% zeolite failed to yield any noticeable enhancement in melon growth or fruit quality. Similarly, in the pursuit of optimizing growth parameters, the comparison between two distinct fertilizer volumes, A and B, did not result in any significant effects on fruit weight, fruit diameter, or fruit length. The slight disparity in volume between these two fertilizers demonstrated no discernible influence on the melon plants. Furthermore, the attempt to enhance fruit weight, fruit diameter, and fruit length through the application of biostimulants via foliar spray did not produce the intended outcome. The administered concentration of biostimulants proved to be insufficient in furnishing the necessary nutrients for a substantial improvement in the quality of melon fruits. In summation, the introduction of a low percentage (5% w/v) of zeolite did not manifest any impact on melon plants. Correspondingly, variations in fertilizer volume and the concentration of biostimulants applied via foliar spray did not yield significant repercussions on melon yield.

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