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Impact of Using Blue Crab Shell Powder (BCSP) on Alteration of EC, pH, Leaf Greenness, and Growth of *Cucumis melo* var. Hamigua TA215 Seedlings

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Abstract: Seedling is the most important starting material for muskmelon production. Healthy seedling production can be addressed by finding appropriate seedling substrates. Blue crab shell powder (BCSP) has been used as a substrate additive to increase the growth and yield of agricultural produce. This research aimed to investigate the impact of using BCSP on the alteration of EC, pH, leaf greenness, and growth of *Cucumis melo* var. Hamigua TA215 seedlings. The substrates making up the treatments were 5, 10, and 15% BCSP, and peat moss was used as a control. Four treatments replicated three times were laid out in a Completely Randomized Design (CRD). The results showed that increasing EC and pH were attributed by increasing the BCSP. After 9 days of watering, a reduction of EC was found. On the contrary, pH in 15% BCSP adding treatment was gradually increased and reached the highest point at day 9. Alteration of EC and pH affected leaf greenness. The highest point of leaf greenness was found on day 1, consistent with increasing EC. Final growth was most significant for seedlings grown in peat moss (control) and tended to decrease as the percent BCSP increased. These are indicative that essential elements in BCSP resulted in leaf greenness appearance. It was growing of pH impact growths of seedlings. Reduction of the amount of BCSP might provide favorable conditions around root environments for the seedling development of muskmelon with healthy growth.

Keywords: Blue crab shell powder (BCSP); Melon; EC; pH; Leaf greenness

1. Introduction

Muskmelon (*Cucumis melo* L.) is a crop belonging to the Cucurbitaceae family. People worldwide relish it due to its flesh fruits with plenty of sweetness, aroma, and nutritional compounds, which share an economic value of 181.79 million United States dollars [1-3]. It originated in Africa and is dispersed to the rest of the economic zone of the world nowadays. Muskmelon is commercially cultivated as horticultural crops instead of growing under tropical or subtropical conditions, as it was done early [4]. Seedling is the most important starting material for the steps of muskmelon production. The longer hardening stage before transplanting and shortage of nutrition in seedling substrates affect the reduction of growth, yield, and taste of the produce. Healthy seedling production can be addressed by finding appropriate seedling substrates.

Blue swimming crab (BSC) is a global-demand seafood product harvested in several Indo-Pacific regions, such as Indonesia, Philippines, Vietnam, Cambodia, Malaysia, Thailand, India, and Sri Lanka [5]. In Thailand, major commercial fishing grounds distribute in the Gulf of Thailand provinces; Pattani, Prachuab-Kirikhan, Phetchaburi, Rayong, Surat Thani, Chonburi, Chanthaburi, Chumphon, Nakhon Si Thammarat, Narathiwat, Trat, and Songkhla as well as the Andaman Sea regions; Krabi, Phang Nga, Phuket, Trang, Satun, and Ranong [6]. The total catch of BSC was estimated at 25,712 tons, with 19,216 tons from the Gulf of Thailand and 6,496 tons from the Andaman Sea in 2013, and steadily increased every year since the 1960s. BSC is exported as fresh-cut crab, frozen, and canned products. There are shells as byproducts from fresh-cut crab product processing which have several advantages in rising productivity of agricultural production, low cost, and high biocompatibility named blue crab shell (BCS).

BCS has been used as a solid eliminator of toxins from wastewater [7-8], stabilizer of heavy metal contaminated soil and water [9-10], crab shell powder (CSP) as a plant diseases controller [11], growth substrate for insect-pathogenic fungus [12], growth substrate for bacteria which use as plant disease control [13-14], organic fertilizer [15-16], plant disease suppressor [11, 17], reducer of acidity soil [18], Meloidogyne suppressor [19], increasing seed germination [20-21].

We successfully used blue crab shell powder (BCSP) to increase the growth and yield of kaiware and sunflower microgreens [22]. However, no report has evaluated the impact of using BCSP on musk melon seedlings. Therefore, this research aimed to investigate the alteration of EC, pH, leaf greenness, and growth of *Cucumis melo* var. Hamigua TA215 seedlings.

2. Materials and Methods

Preparation of BCSP

Crab shells were cleaned under running tap water. The shells were dried at room temperature, then crushed into powder using a blender. After the shell powders were ground, they were maintained in a dry place at room temperature. The shell powders were used as solid substrates in the experiment. The experiment was carried out in a greenhouse at the Rajamangala University of Technology Thanyaburi in October 2021. Four treatments replicated three times were laid out in a Completely Randomized Design (CRD). The substrates making up the treatments were 5, 10, and 15% BCSP, and peat moss was used as a control.

Preparation of seedlings and growth performance analysis

We selected *Cucumis melo* var. Hamigua TA215 F1 by Known-you Seed (Thailand) Co., LTD. For testing, substrates were filled differently in the seed tray, which was placed over on drainage tray. The substrates were soaked overnight with water to achieve about 70-80% moisture. Germinated seeds, three days after seeding by incubation at room temperature without light, were planted into a seed tray. Each seedling was fed with 20 ml of water daily. Alterations of EC, pH, Leaf greenness, growth parameters, seedling height, leaf width, leaf length, stem fresh and dry weight, and root fresh and dry weight were recorded.

EC and pH analysis

During the experiment, the EC and pH of the substrates were measured for each treatment by taking the solution from the drainage tray with a syringe after daily watering. Measurements were carried out 3 times on day 1, day 5, and day 9 of the experiment.

Leaf greenness Analysis

The leaf greenness was measured by SPAD portable leaf greenness meter. Three SPAD measurements were averaged per expanded leaf in each treatment to represent one observation. Measurements were carried out 3 times on day 1, day 5, and day 9 of the experiment.

Statistical analysis

Analytical measurements and all collected data were presented by mean value with standard deviation. Each parameter was subjected to analysis of variance (ANOVA) by using CRD as an experimental design. Duncan's multiple range test (DMRT) was used to determine of differences between the treatment at 95% confidential ($p \leq 0.05$).

3. Results and Discussion

An increase in EC was attributed to an increase in BCSP. EC Alteration was found on days 5 and 9 (Table 1). On day 5, EC was higher than on day 1. On the contrary, the least amount of EC was observed on day 9, indicating essential elements dissolved daily since day 1. Consequently, solubility was therefore reduced on day 9. The appropriate EC for melon production under a hydroponic system is about 2.5 mS/cm [23]. Higher EC dues to adding BCSP at day 5 may affect unbalance of the nutrient requirement of vegetative growth. BCSP might contain more nutrients needed for the reproductive growth stage than the vegetative stage, such as Ca and Mg.

Table 1. Effect of different amounts of BCSP added into the substrate on electrical conductivity (EC) at days 1, 5, and 9.

Treatment	EC (mS/cm)		
	Day 1	**Day 5**	**Day 9**
Control	0.87	1.55	0.84
5%	1.80	2.27	1.10
10%	2.04	3.10	1.17
15%	2.10	3.19	1.25

For pH, the control treatment result was between 6.17 and 6.85 (Table 2). A higher pH was observed after adding BCSP. The most elevated pH was found in the amount of BCSP added (15%) on days 1, 5, and 9. A similar result was reported by studying the effect of crab residue in soil salinization and the development of melon. The increased crab residue concentration significantly increases the soil's pH [24]. An increase in pH was attributed to an increasing the day of the experiment, indicating the accumulation of essential element ions. The highest pH was found on day 9, adding 15% BCSP (8.34). On day 1, pH observation results of BCSP treatment were not reached 8.0 (6.17-7.31). pH observations over 8.0 were found on days 5 (6.80-8.23) and 9 (6.85-8.34), respectively. BCSP was the reason for the substrate pH value increase, which was unsuitable for growing melon seedlings. [25] reported that maintaining a pH between 6.0 and 6.5 is very important for muskmelon production.

Table 2. Effect of different amounts of BCSP added into the substrate on pH at days 1, 5, and 9.

Treatment	pH		
	Day 1	**Day 5**	**Day 9**
Control	6.17	6.80	6.85
5%	7.19	8.18	8.27
10%	7.29	8.18	8.31
15%	7.31	8.23	8.34

Leaf greenness analysis was relatively high across BCSP treatments at values of >45 SPAD units of the whole experiment (Table 3). At day 1, leaf greenness was highest for seedlings grown in 15% BCSP added substrate, indicating differences in foliage greenness. This result was also found on day 5. A similar result was reported by studying the effect of crab shell powder on pea, gram, and tomato leaf greenness which crab shell powder promoted higher leaf greenness accumulation [20]. At day 9, the highest value was observed in a minimal amount of 5% BCSP instead of 15%, indicating accumulation of pH and reduction of EC-affected greenness of the leaf.

Table 3. Effect of different amounts of BCSP added into the substrate on leaf greenness at day 1, 5, and 9 of seedling grown.

Treatment	Leaf greenness (SPAD unit)		
	Day 1	**Day 5**	**Day 9**
Control	45.87 ± 3.07[b]	42.76 ± 5.66	42.68 ± 6.39
5%	54.70 ± 9.66[ab]	46.77 ± 5.19	47.26 ± 1.81
10%	52.40 ± 1.47[b]	48.80 ± 5.97	47.05 ± 2.58
15%	64.45 ± 0.64[a]	51.35 ± 3.61	45.50 ± 3.96
F-test	*	ns	ns
C.V. (%)	10.25	11.61	8.78

All the data are expressed as mean ± standard deviations. This means the different superscript letters in a column differ significantly ($p \leq 0.05$). ns, *=nonsignificant or significant, respectively.

During the experiment, growth parameters were measured on days 1, 5, and 9. Seedling height decreased as the percent BCSP increased (Table 4). However, there was no statistically significant difference found between treatments. Consistent with trends observed for seedling height, leaf width tended to decrease as the percent BCSP increased (Table 5). Different results were obtained by studying the effect of a crab shell on germination and plant height which found that crab shell promoted plant height [21]. According to [15], fresh crab shell fog dramatically increased Cucurbitaceae's plant height.

Table 4. Effect of different amounts of BCSP added into the substrate on the seedling height at day 1, 5, and 9 of seedling grown.

Treatment	Seedling height (cm.)		
	Day 1	**Day 5**	**Day 9**
Control	3.18 ± 0.42	5.10 ± 1.02	5.92 ± 1.46
5%	3.30 ± 0.14	4.38 ± 1.02	5.47 ± 1.33
10%	3.00 ± 0.71	4.27 ± 1.24	5.17 ± 1.10
15%	3.00 ± 0.10	3.50 ± 2.26	4.60 ± 0.85
F-test	ns	ns	ns
C.V. (%)	16.84	29.44	22.12

All the data are expressed as mean ± standard deviations. This means the different superscript letters in a column differ significantly ($p \leq 0.05$). ns=nonsignificant.

Table 5. Effect of different amounts of BCSP added into the substrate on leaf width at day 1, 5, and 9 of seedling grown.

Treatment	Leaf width (cm.)		
	Day 1	**Day 5**	**Day 9**
Control	1.37 ± 0.15	1.70 ± 0.31	1.86 ± 0.17
5%	1.13 ± 0.21	1.63 ± 0.23	1.78 ± 0.10
10%	1.08 ± 0.45	1.63 ± 0.16	1.64 ± 0.42
15%	0.75 ± 0.07	1.55 ± 0.14	1.60 ± 0.07
F-test	ns	ns	ns
C.V. (%)	29.25	14.11	15.96

All the data are expressed as mean ± standard deviations. This means the different superscript letters in a column differ significantly ($p \leq 0.05$). ns=nonsignificant.

There were statistically significant differences between treatments at days 1, 5, and 9 of leaf length measurement. The highest severity was observed after adding 15% BCSP into peat moss. Leaf length was most significant for seedlings grown in peat moss (control) (Table 6).

Table 6. Effect of different amounts of BCSP added into the substrate on leaf length at day 1, 5, and 9 of seedling grown.

Treatment	Leaf length (cm.)		
	Day 1	**Day 5**	**Day 9**
Control	2.63 ± 0.42^{a}	3.73 ± 0.42^{a}	4.03 ± 0.10^{a}
5%	2.30 ± 0.17^{a}	2.98 ± 0.77^{a}	3.45 ± 0.59^{a}
10%	1.90 ± 0.60^{ab}	2.90 ± 0.47^{a}	3.41 ± 0.41^{a}
15%	1.20 ± 0.28^{b}	1.75 ± 0.35^{b}	2.60 ± 0.14^{b}
F-test	*	*	*
C.V. (%)	22.63	19.68	12.52

All the data are expressed as mean ± standard deviations. This means the different superscript letters in a column differ significantly ($p \leq 0.05$). *=significant.

Seedling growth tended to be susceptible to high percent BCSP added. Final stem fresh and dry weight was most significant for seedlings grown in peat moss (control) and managed to decrease as the percent BCSP increased (Table 7). Consistent with trends observed for stem fresh and dry weight, root new and dry weight was most significant for seedlings grown in peat moss (control) and tended to decrease as the percent BCSP increased. 5% BCSP was less severe to the growth of seedlings than other amounts. A similar result was reported by studying the effect of crab residue in soil salinization and the development of melon which the increase in the concentration of crab residue significantly reduces plant growth [24]. The EC and pH in the substrate changed during cultivation, while changes in the content of components in the leaf were maximum. Interferences of photosynthetic compounds may cause a reduction in growth. Therefore, proper pH and EC in the muskmelon root environment are essential. The results were unlike those reported in maize, where dry weight increases after cultivation in the amendment of acid soils using crab shell powder [18].

Table 7. Effect of different amounts of BCSP added into the substrate on stem fresh and dry weight and root fresh and dry weight at day 9 of seedling growth.

Treatment	Stem fresh weight (g)	Stem dry weight (g)	Root fresh weight (g)	Root dry weight (g)
Control	1.12 ± 0.34^{a}	0.10 ± 0.04^{a}	0.57 ± 0.23^{a}	0.04 ± 0.01^{a}
5%	1.03 ± 0.17^{ab}	0.11 ± 0.02^{a}	0.51 ± 0.26^{a}	0.04 ± 0.03^{a}
10%	1.02 ± 0.29^{ab}	0.09 ± 0.03^{ab}	0.27 ± 0.13^{ab}	0.02 ± 0.01^{ab}
15%	0.67 ± 0.03^{b}	0.05 ± 0.02^{b}	0.19 ± 0.06^{b}	0.01 ± 0.00^{b}
F-test	*	*	*	*
C.V. (%)	26.34	33.14	48.29	0.00

All the data are expressed as mean ± standard deviations. This means the different superscript letters in a column differ significantly ($p \leq 0.05$). *=significant.

4. Conclusions

Seedling is the most important starting material for the steps of muskmelon production. Healthy seedling production can be addressed by finding appropriate seedling substrates. Blue crab shell powder (BCSP) has been used as a substrate additive to increase the growth and yield of agricultural produce. However, no report has evaluated the impact of using BCSP on musk melon seedlings. The present study found that increased EC and pH were attributed to an increase in the amount of BCSP. 5% BCSP was less severe to the growth of seedlings than other amounts. The EC and pH in the substrate changed during cultivation, while changes in the content of components in the leaf were maximum. Interferences of photosynthetic compounds may cause a reduction in growth. Reduction of the amount of BCSP might provide favorable conditions around root environments for the seedling development of muskmelon with healthy growth.

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