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SELECTION OF SUITABLE GROWING SUBSTRATES AND QUALITY ASSESSMENT OF *Brassica* MICROGREENS CULTIVATED IN GREENHOUSE

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ABSTRACTS

Brassica microgreens are typically cultivated using a peat-based growing substrate with a higher production cost as this substrate must be imported from overseas. In Vietnam, a source of local bio-materials that could be used to replace imported peat, resulting in more affordable growing substrates. Several growing substrates for *Brassica* microgreens were evaluated in this study: GT1 (30% sand +20% organic soil + 50% coco coir), GT2 (75% coco coir + 25% rice husk), GT3 (75% coco coir + CaO 2.2 mg/kg + acid humic 0.41%) and imported peat GT4 (75% white sphagnum peat +25% vermiculite (size 4–6 mm). The local organic material coco coir GT3 was found to be as effective as the imported substrate for microgreen production. The material coco coir mixed with soil and sand could increase the risks of soil-borne disease infestation on *Brassica* microgreens. Microgreens grown in the substrate GT3 and GT4 had higher productivity and lower disease infestation levels than other tested substrates. Nitrate level and microbiological contamination (*E. coli* and *Salmonella* spp.) of *Brassica* microgreens cultivated in these substrates were determined to be at safe levels.

Keywords: greenhouse microgreens, growing media, fresh weight, dry weight.

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INTRODUCTION

Microgreens are an agricultural product grown and sold as a salad green, similar to sprouts and baby leafy vegetables. Microgreens, as the word suggests, are harvested while very small, after 7 to 21 days of growth from seed. Stems and cotyledons are harvested, and the root is left behind in the growth medium (Xiao et al., 2015; Sven, 2020). The first true leaves may or may not be present, depending on growth rate and preference. Unlike sprouts, the roots of microgreens are not consumed, making them a safer vegetable in general (Xiao et al., 2014). Consumers appreciate microgreens for their flavours and delicate texture which are preferable for chefs to make salads and other superfoods (Nolan, 2019). Compared with the production of mature vegetables, the production of microgreens could be affected less by environmental factors, because they require less time, fertilizers, space and inputs (Weber, 2017). Concerning the growing substrates for microgreen production, growers are using trays mixed with either soil or lose hydroponic substrates such as coconut fibre, peat, vermiculite and perlite. Growing substrates have significant impacts on the quality and yield of microgreens (Weber, 2017; Treadwell et al., 2010; Murphy et al., 2010). However, few publications actually compare different types of substrates used to grow microgreens. In Vietnam, *Brassica* microgreens have been grown mainly in a small area and using simple substrates with low costs and uncertain safety (Ha et al., 2011). Particularly, unsuitable selection of growing substrates could make risks of micro-bacterial infested microgreens that will affect directly human health. This study aimed to evaluate different substrates used for *Brassica* microgreen production in greenhouse, and their impacts on microgreen quality.

MATERIALS AND METHODS

Plant materials and growth greenhouse environment

Five varieties and one form of microgreens belonging to the *Brassica* genus of the Brassicaceae family (Table 1) were grown in a greenhouse located in Gia Khanh town, Binh Xuyen district, Vinh Phuc province of Vietnam (21^{o}20’N, 105^{o}38’E). The greenhouse shading net screen was opened automatically during the daytime and closed before darkness (about 1 hour before darkness). During the experimental period, the screens open when temperatures in the greenhouse exceed 34 ^{o}C, or the radiation level exceeds 600 watts/SM. Air humidity in the greenhouse was 80–85% and was controlled by a humidifier system.

Table 1. Five varieties and one form of microgreens belonging to *Brassica* genera assayed

Commercial name	Scientific name (genus and species)	Growth duration (day)	Number of seeds per cell	Seed index (g/tray)
Red cabbage	*Brassica oleracea*. var. *capitata* f. *rubra* Paterm	9	12	17.7
Broccoli	*Brassica oleracea* var. *italica* Plenck	9	12	17.7
Mizuna	*Brassica rapa* var. *nipposinica* (Bailey) Hanelt	8	10	8.8
Green mustard	*Brassica juncea* (L.) Czern.	12	10	8.8
Pak choy	*Brassica rapa* var. *chinensis* (L.) Kitam.	8	10	8.8

Note: The number of seeds used for the sowing on the styrofoam tray.

The styrofoam trays (70 × 46 cm, height 5 cm, 442 cells “2 × 2 cm”) were used in this experiment. The trays were washed and sterilized under a chlorine solution of 200 ppm for 3 minutes, and then dried naturally for 24 hours in the greenhouse.

This study used the seeding machine (Model ALFA65 Urbinati, Italia) in order to ensure the targeted number of seeds per cell of the tray. A number of seeds, varying based on the seed index of each variety were sown in four growing substrates (Table 2). After sowing, sown trays were irrigated manually using a water nozzle and then placed into a dark germination room under full climate control, maintaining a 24/7 temperature of 25 ^oC and relative humidity of 85−90%. After 24 hours in the germination room, the trays started to germinate and were taken out and placed on the aluminium benches in the greenhouse. Each day, 500 ml of $Ca(NO_3)_2$ solution 100 ppm was irrigated to each tray to further stimulate seedling growth. Irrigation time was at 8:30 am and 3:30 pm. All trays were monitored to protect plants from wilting or dying of water lacking. Three trays were designed for each treatment. Each experiment was carried out simultaneously for three replicates with a growth duration (period from sowing until harvesting) for each microgreen variety ranging from 8 to 12 days (Table 1).

Table 2. Nutrient characterization of four growing substrates used for growing microgreens

Substrates	GT1	GT2	GT3	GT4
Origin	Vietnam	Vietnam	Vietnam	Import
Ingredients	30% sand +20% organic soil + 50% coco coir	75% coco coir + 25% rice husk	75% coco coir + CaO (2.2 mg/kg), acid humic 0.41%	75% white sphagnum peat +25% vermiculite (size 4–6 mm)
pH (H_2O)	6.2	6.0	6.5	6.2
EC (mS cm^-)	1.4	0.4	0.8	0.6
Moisture content (%)	48	38	55	41

Growth measurements and yield of microgreens grown in different substrates

Microgreens of each tray were harvested by cutting the seedling just above the surface of the growing substrate with a sterilized knife as recommended (Xiao et al., 2012). Microgreen samples were harvested after growth duration for each variety (Table 1). The experiments were carried out in a randomized block design with four growing substrates and five *Brassica* microgreens for three different biological replicates. Each replicate used for the measurements consisted of 10 cells. Ten cells of each microgreen variety were randomly selected on the diagonal of each tray and measured to determine germination rate (%), shoot height (cm) and disease infestation (%). Furthermore, another 10 randomly selected cells for each variable were used to assess both fresh microgreen yield (FW) (g/m^2) and dry weight (g/m^2) at harvest. The germination rate and disease infestation rate of each microgreen variety grown in each substrate was calculated by the following formulas:

$$\text{Germinnation rate } (\%) = \frac{\text{Number of germinated seeds}}{\text{Number of seeds sown}} \times 100$$

$$\text{Disease infestation rate } (\%) = \frac{\text{Number of damaged plants}}{\text{Total number of plants checked}} \times 100$$

Common diseases damaged on microgreens were monitored and evaluated including damping-off, root rots, and grey mold on leaves caused by the fungus *Botrytis.* The shoot height was measured with a ruler from the stem base to the top of the seedling. Fresh microgreen biomass harvested from each growing substrate treatment was placed into pre-weighed foil cups and weighed. After FW data was measured, samples were placed into a drying oven at 80 ^oC for 48 h, and then DW (g/m^2) data were measured.

Quality assessment of microgreens grown in the greenhouse environment

Harvested microgreens from each variety grown in each substrate were sent to the laboratory of Vietnam National Institute of Food Control (Cau Giay dist., Ha Noi city, Vietnam) for analyses of nitrate (NO_3^-) concentration and harmful micro-organism evaluation (*E. coli* and *Salmonella* spp.). The standard limit of NO_3^- concentration (mg per fresh kg) and microbiological contamination level in each sample must be met by the standard regulated by World Health Organization (WHO).

On each tested substrate, 20 g of harvested fresh micro greens on each tray of each variety were mixed and washed with distilled water; then, put the samples in specific packets and placed in a drying oven at 80 ^oC for 48 h. These samples were powdered after parching and extracted with 0.2% acid citric solution. One gram was selected per sample and 100 mL of solution was added to samples and placed in a shaker device for 20 to 30 minutes to combine samples and solutions. Then extraction was done by filter paper and juice was kept in a specific bottle. Then, NO_3^- residue was recorded by spectrophotometer and Palin test (photometer 7100).

Harmful micro-organism analyses were performed to evaluate the microbiological contamination of four tested growing substrates and microbial growth levels on each microgreen variety. For detection and enumeration of *Escherichia coli* and *Salmonella* spp. contamination, the analysis standards were used below:

For *E. coli:* TCVN 7924-2:2008, ISO 16649-2:2001;

For *Salmonella* spp.: TCVN 10780-3:2016, ISO/TR 6579-3:2014.

Cost of growing substrates for microgreen production

Selecting a suitable growing substrate for microgreen production was based on the calculation of a cost-benefit model on each substrate used to produce each microgreen variety. Total production cost per kg of microgreen harvested (VND/kg) was determined by the sum of direct material costs (seeds, growing substrate) and labour cost; and then calculated gross profit margin (%) which is just the percentage of the selling price that is profit as the following formula:

$$\text{Margin } (\%) = \frac{\text{Selling price per kg } (\text{VND}) - \text{cost per kg } (\text{VND})}{\text{Selling price per kg } (\text{VND})} \times 100$$

Statistical analysis

Data were collected and analyzed. SPSS software was used to analyze the variance of differences using the ANOVA test statistically. LSD test was applied to compare the treatment means at 0.05 level of confidence.

RESULTS AND DISCUSSION

Evaluation of different growing substrates on seed germination and seedling height

The germination rate of red cabbage, broccoli, mizuna, green mustard and Pak choy microgreens was highest, with 90.3%, 80.9%, 82.3% and 86.2%, respectively in white sphagnum peat mixed with vermiculite (GT4), which showed reduction for the same microgreens by 87.6%, 77.3%, 81.9% and 80.4%, respectively in coco coir substrate (GT3); 78.7%, 72.5%, 81.4% and 75%, respectively in coco coir plus rice husk, and 71.7%, 75.6%, 74.8% and 69%, respectively in coco coir mixed with soil. As can be seen in Table 3, the quality of growing substrates had a significant influence on the germination percentage of red cabbage and green mustard, which show the lowest value of 71.9% and 69%, respectively in coco coir plus soil (GT1 substrate). The substrate GT4 (white sphagnum peat plus vermiculite) and GT3 (coco coir mixed humic fertilizer) exhibited a maximum seedling height than the rest of the tested growing substrates. Red cabbage, broccoli, mizuna, green mustard and Pak choy showed the lowest seedling length when sown in GT 1 (coco coir mixed with soil) and GT2 (coco coir plus rice husk), ranging from 5.9 cm to 6.6 cm (Table 3).

Table 3. Influence of growing media on germination rate and seedling height at harvest

Media	Germination rate (%)					Seedling height (cm)				
	RC	B	M	GM	PC	RC	B	M	GM	PC
GT1	71.7 ± 9.3c	75.6 ± 6.7a	74.8 ± 9.8b	69.0 ± 8.1c	79.9 ± 6.7b	6.2 ± 0.4b	5.8 ± 0.3b	5.9 ± 0.4c	6.0 ±0.3b	6.2 ± 0.5c
GT2	78.7 ± 6.7b	72.5 ± 10.2a	81.4 ± 7.1ab	75.2 ± 7.0bc	80.2±1 0.5b	6.4 ± 0.3b	6.4 ± 0.5b	6.6 ± 0.4b	6.3 ± 0.4b	6.5 ± 0.6bc
GT3	87.6 ± 5.7a	77.3 ± 10.6a	81.9 ± 9.2ab	80.4 ± 10.2ab	78.1 ± 9.6b	6.8 ± 0.5a	6.6 ± 0.3a	6.9 ± 0.3a	6.9 ± 0.3a	6.8 ± 0.4ab
GT4	90.3 ± 3.5a	80.9 ± 9.8a	82.3 ± 3.7a	86.2 ± 7.6a	90.0 ± 1.8a	7.2 ± 0.4a	7.2 ± 0.3a	6.7 ± 0.4a	7.1 ± 0.3a	7.1 ± 0.2a
	P<0.001 F=14.65	P=0.311 F=1.24	P=0.152 F=1.88	P<0.001 F=1.88	P=0.014 F = 4.15	F<0.001 F=9.76	F<0.001 F=22.8	F<0.001 F=16.4	F<0.001 F=17.1	F=0.001 F=7.18

Note: Values marked with the same letter within the columns do not differ significantly 5% level of confidence. RC = Red cabbage; B = Broccoli; M = Mizuna; GM = Green mustard; PC = Pak choy. GT1 - Coco coir mixed soil and sand; GT2 - Coco coir mixed with rice husk; GT3 - Coco coir mixed with CaO and Humic fertilizer; GT4 - Imported substrate, white sphagnum peat mixed with vermiculite.

The possible reason could be white sphagnum peat mixed with vermiculite possessed optimal water holding capacity and aeration that facilitates the entire germination process. The white sphagnum peat and vermiculite are not available in Vietnam and must be purchased from overseas resulting in a production cost increase. In Vietnam, a source of coco coir is available and used widely for nursery and greenhouse crop production. This source is also an alternative substrate for the importation of white sphagnum peat mixed with vermiculite which has a much higher cost (Thuong & Minh, 2020). The result of Abad et al. (2001) and Bewley (1997) showed that growing substrate should have optimal water holding capacity of 55 to 70% v/v and aeration 20 to 30% v/v for imbibition, hydration of protoplasm and restoration of enzymatic activity that promotes seed germination. Additionally, coco coir mixed with soil and sand or rice husk showed low bulk density that facilitates movement of air and water that are essential for seed germination, but aeration of these substrates during the microgreen growth period needs to be evaluated more. Similar to Soane (1990) reported that substrates with a higher amount of organic matter could increase seed emergence and aerated irrigation during the growing period. Moreover, Muchjajib et al. (2014) suggested that using local organic biomaterials (such as coco coir dust, sugarcane filter cake, and vermicompost) in microgreen production gives benefits for not only maximizing fresh yield but also saving production cost. This study suggested that using local coco coir mixed with a small amount of fertilizer (organic humate fertilizer and calcium oxide CaO) that facilitates seed germination could be a good source to replace imported substrate sphagnum and vermiculite that are quite costly.

Influence of growing substrates on disease infestation of Brassica microgreens at harvest

Table 4 showed that the disease infestation rate of all microgreens was highest when cultivated in substrate GT1 (coco coir mixed sand and soil), with 8.1%

on red cabbage, 9.6% on broccoli, 9.3% on mizuna, 5.9% on green mustard and 7.8% on Pak choy. This rate on all microgreen varieties showed a significant reduction in the substrate GT4, ranging from 2.9% to 4.1%. The most serious threat to microgreen production appears to be *Pythium*, *Fusarium*, *Rhizoctonia* and *Phytophthora* which can cause pre-or post-emergence damping-off and root rot (McGehee et al., 2019; Holmer et al., 2013). In this study, coco coir mixed with soil and sand (GT1 substrate) are prone to the emergence of damping-off disease caused by soil-borne pathogenic fungi that resulted in the highest disease infestation rate of all microgreens tested. Microgreens infested diseases would affect directly fresh yield at harvest and could cause a decrease in post-harvest microgreen quality. This study suggests that growing substrates and seeds for microgreen production should be treated before sowing in order to minimize risks of damping-off emergence.

Table 4. Disease infestation rate of *Brassica* microgreens at harvest, grown in different substrates

Media	Disease infestation rate (%)				
	RC	B	M	GM	PC
GT1	8.1	9.6	9.3	5.9	7.8
GT2	4.1	6.7	5.7	4.1	4.8
GT3	7.1	5.2	5.9	5.1	4.8
GT4	4.1	2.9	3.3	2.9	2.9

Note: RC = Red cabbage; B = Broccoli; M= Mizuna; GM = Green mustard; PC = Pak choy.

Influence of growing media on fresh weight (FW) and dry weight (DW) at harvest

Table 5 showed that growing substrates had a significant influence on the fresh weight and dry weight of all microgreen varieties ($p < 0.05$). Red cabbage, broccoli, mizuna, green mustard and Pak choy had the highest values, with 871.2, 669.3, 796.9, 780.7 and 750.1g fresh weight and 37.4, 28.6, 34.2, 33.3 and 28.9 g dry weight, respectively, in white sphagnum peat plus vermiculite (GT4 substrate), which exhibited significant reduction for the same microgreens at 20.6, 6.6, 9.1, 20 and 11.2% (fresh weight) and 13.9, 19.4, 11.9, 15.5 and 12.7% (dry weight) respectively in coco coir mixed with soil, sandy or rice husk. This result could be explained that growing substrates mixed with soil and sand kept good moisture for seed germination. Some farmers prefer substrates mixed with soil, claiming it produces microgreens with more flavour, better texture and longer shelf life (Nolan, 2019). However, substrates with soil could produce poor aeration and risks of soil-borne fungus diseases that cause a reduction of fresh yield. In this study, microgreens sown in the substrate GT3 had as high fresh and dry weight as the substrate GT4. Coco coir mixed organic humate fertilizer and calcium oxide might supply nutrients and facilitate higher yield.

Evaluation of quality of Brassica microgreens grown in different substrates

Table 6 and Table 7 presented the nitrate residue and bacterial contamination (*E. coli* and *Salmonella* spp.) of microgreen varieties grown on different growing substrates. Generally, the limits detected for nitrates and bacteria in all tested microgreen samples were within the legal limits recommended by European Union Regulation no. Regulation (2011) and WHO (2011) standard; therefore, from the point of view of nitrates and microbiological contamination, microgreens grown on these tested substrates are safe. In this study, we suggest that growing substrates for microgreen production should not be mixed with soil that could be a source of soil-borne fungus disease and bacteria infestation.

Table 5. Influence of growing media on fresh weight (FW) and dry weight (DW) at harvest

Substrates	FW (g/m²)					DW (g/m²)				
	RC	B	M	GM	PC	RC	B	M	GM	PC
GT1	725.5 ± 93c	540.4 ± 75.4b	627.8 ± 78.4b	535.6 ± 56.8b	593 ± 76.3c	32.7 ± 5.4ab	24.1 ± 4.8ab	23.9 ± 2.9c	23.6 ± 3.8b	24.9 ± 3.3b
GT2	653.2 ± 112bc	539.1 ± 98.8b	616.9 ± 101.3b	588.6 ± 61.3b	664.9 ± 98.2bc	30.8 ± 6.6b	23.1 ± 4.4b	24.8 ± 2.4c	24.2 ± 3.2b	26.1 ± 3.3b
GT3	782.7 ± 162.7ab	653.9 ± 133.4a	711.5 ± 150.2ab	700.2 ± 136a	670.9 ± 79.2b	34.8 ± 8.9ab	29.4 ± 6.8a	29.5 ± 7.0b	29.8 ± 6.5a	24.1 ± 0.8b
GT4	871.2 ± 91.5a	669.3 ± 96.9a	796.9 ± 111a	780.7 ± 115.2a	750.1 ± 59.2a	37.4 ± 4.6a	28.6 ± 6.1a	34.2 ± 4.5a	33.3 ± 6.2a	28.9 ± 2.0a
	P=0.004 F=5.45	P=0.013 F=4.22	P = 0.006 F=4.93	P<0.001 F=11.3	P=0.003 F=5.87	P=0.201 F=1.63	P=0.056 F=2.8	P<0.001 F=9.56	P=0.001 F=7.32	P=0.003 F=5.86

Note: RC = Red cabbage; B = Broccoli; M= Mizuna; GM = Green mustard; PC = Pak choy.

Table 6. The residue of nitrate on *Brassica* microgreens cultivated in different growing substrates

Substrates	Nitrate residue (mg/kg fresh)					Allowed residue
	RC	B	M	GM	Min	Max
GT1	135.6	98.2	104	120.5	140.8	300
GT2	89.2	115.6	125	165	198	300
GT3	135	108.2	97.5	90.4	145.2	300
GT4	125.8	85.8	90.5	130	128.3	300

Note: RC = Red cabbage; B = Broccoli; M= Mizuna; GM = Green mustard; PC = Pak choy.

Table 7. Bacterial contamination level of harvested *Brassica* microgreens cultivated in different growing substrates

Substrate	*E. coli* (CFU/g)					*Salmonella* spp. (CFU/25 g)				
	RC	B	M	GM	PC	RC	B	M	GM	PC
GT1	10^1	0	0	10^1	0	KPH	KPH	KPH	KPH	KPH
GT2	0	0	0	0	0	KPH	KPH	KPH	KPH	KPH
GT3	0	0	0	0	0	KPH	KPH	KPH	KPH	KPH
GT4	0	0	0	0	0	KPH	KPH	KPH	KPH	KPH

Note: RC = Red cabbage; B = Broccoli; M= Mizuna; GM = Green mustard; PC = Pak choy.

Nitrates are compounds considered as possible negative effects on human health, and most part of the daily intake of nitrates by foods is concerned with fresh vegetable consumption (Santamaria, 2006; Iammarino et al., 2014). The residue of nitrate in all tested microgreens was detected on growing substrates. The highest nitrate residue (165 mg/100 g fresh) was found on green mustard microgreen grown in GT2 substrate, while the lowest nitrate residue was on broccoli microgreen in GT4 with 85.5 mg/100 g fresh, but still, be lower than legal levels.

Concerning microbiological contamination of all microgreen varieties, *E. coli* was observed only on microgreens grown in coco coir mixed with soil and sand but was within the acceptable limit. *Salmonella* spp. was not found on microgreens grown in all tested substrates. This study showed that using clean water for irrigation in microgreen production had lower microbiological contamination than those grown in soil reported by Balkhair (2016). Similar to the report of Johnny (2017), the risks of bacteria and fungus disease contamination on microgreens are lower than in unprotected plants grown in soil or in field conditions. Xiao et al. (2014) indicated that initial inoculation levels of microgreen seeds could proliferate significantly *E. coli* strains during microgreen growth. Also, Gioia et al. (2017) revealed that seeds should be treated with NaOCl solution before sowing to eliminate microorganisms from the seed surface. However, in this study, the source of microbial contamination may occur on the source of soil and sandy mixed coco coir substrate before sowing. It is essential to control the source of initial raw materials of growing substrates to minimize risks of bacteria and fungus contamination. This study suggests that selecting raw material for growing substrates with suitable microbiological characteristics is an important aspect to ensure high quality and safe microgreen production in the greenhouse.

Calculating the cost and profit of microgreens grown in different growing substrates

The performance and fresh yield of each microgreen variety in each growing substrate were different, resulting in changes in the cost of substrate used. As can be seen in Table 8, the substrate cost of GT1 (coco coir plus soil and sand) was the lowest of all microgreen varieties, ranging from 22,568 VND/kg to 30,571 VND/kg microgreen harvested. Concerning the imported substrate GT4, the cost of substrate for one kg of microgreen was highest, with 64,727 VND/kg broccoli; 57,753 VND/kg Pak choy; 55,494 VND/kg green mustard; 54,365 VND/kg mizuna and 49,727 VND/kg red cabbage. The cost of the substrate is only one of the production cost parameters, and profit is a deciding factor in selecting suitable growing substrates. Moreover, the quality of the substrate would have a direct influence on the fresh yield and performance of microgreens. In this study, microgreens grown in cheaper substrates of GT1 and GT2 had a lower yield that could result in increased production cost per kg at harvest. Table 9 showed that all microgreens grown in GT3 substrate had the highest profit rate, with 26.06% on red cabbage, 21.64% on broccoli, 21.18% on green mustard, 20.74% on mizuna and 16.03% on Pak choy. Using local substrate GT1 on green mustard microgreen had no efficiency, while red cabbage grown in this substrate had the highest profit with 20.21%. Compared with other substrates, using GT1 could be not suitable to be used in large-scale microgreen production because of low economic efficiency. Concerning the imported substrate GT4, although the performance and yield of microgreens in this substrate were highest, the profit of microgreens was quite low which is due to the higher price of imported substrate GT4.

Table 8. Cost of each growing substrate on each microgreen variety grown in the greenhouse

Substrate	Cost of growing substrate per kg microgreen harvested (VND/kg)				
	RC	B	M	GM	PC
GT1	22,568	30,298	26,083	30,571	27,603
GT2	31,693	38,407	34,124	35,171	31,132
GT3	35,927	43,003	39,527	40,164	41,913
GT4	49,727	64,727	54,365	55,494	57,753

Note: RC = Red cabbage; B = Broccoli; M= Mizuna; GM = Green mustard; PC = Pak choy.

Table 9. Calculation of production cost and profit margin of microgreens grown in different growing substrates

Substrate	RC		B		M		GM		PC	
	Cost (VND/kg)	Margin (%)	Cost (VND/kg)	Margin (%)	Cost (VND/kg)	Margin (%)	Cost (VND/kg)	Margin (%)	Cost (VND/kg)	Margin (%)
GT1	75,79	20.21	118,54	5.17	85,35	10.15	108,21	-3.06	85,49	5.00
GT2	85,30	10.20	120,20	3.83	89,53	5.76	99,70	5.04	77,36	14.04
GT3	70,24	26.06	97,94	21.64	75,30	20.74	82,76	21.18	75,57	16.03
GT4	79,73	16.07	117,33	6.13	85,40	10.10	92,77	11.64	86,89	3.45

Note: RC = Red cabbage; B = Broccoli; M= Mizuna; GM = Green mustard; PC = Pak choy.

CONCLUSION

Growing substrates had a significant influence on the productivity of *Brassica* microgreen varieties grown in the greenhouse. Using an imported substrate of white sphagnum mixed with vermiculite showed better performance of all microgreens than other tested substrates; however, microgreens grown in this imported substrate are quite costly. In Vietnam, there are some local materials that could be substituted for imported peat and vermiculite, resulting in more affordable growing substrates. In this study, producing microgreens sown in coco coir mixed with humate fertilizer and calcium oxide could give an as good performance as imported peat, and with affordable production cost. In order to minimize risks of fungus disease and bacteria infestation on substrates, the source of local raw materials needs to be treated before use.

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