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Comparison among Chemical, GAP and Organic method for tea cultivation in Vietnam

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This study aimed to compare the chemical, GAP and organic production methods on tea cultivation in Vietnam. The experiments were separately setup as RCBD with 4 replications in two tea varieties namely PH8 and PH9. The results showed that all the application methods were better effective on tea yield than the non-treated control. The chemical and GAP method gave significantly higher percentages of yield increasing, which were calculated by pair comparing of yield disparity between the non-treated control and the application methods, as compared to the organic method, with the values ranged of 52.86- 63.96, 46.03- 67.87 and 36.98- 52.10 %, respectively. In most the cases, all the treated methods were significantly highly effective or tended to give higher effectiveness on the controlling of the investigated tea insects and diseases as compared to the control. The efficiency for insect and disease control of the GAP method was not significantly different from the chemical and organic ones. It seems that the GAP method is more friendly and safe to the environment and the consumer's health than the chemical method because it reduced the use of chemical inputs compared to the chemical one. On the other hand, the GAP method tended to give higher sensory evaluation score of green tea than the other methods. In conclusion for the present study, the GAP method could be recommended to apply for safety tea production in Vietnam.

Key words: tea cultivation, Chemical method, GAP method, Organic method, comparison

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Introduction

Tea (*Camellia sinensis* (L.). O. Kuntze) is a perennial crop (Vo, 2006). For sustaining a high productivity of tea, the soil needs regular supplementation with fertilizers, which were identified by field trials that for sustaining a crop of 2,300 kg made tea/ha, nitrogen was not exceeding 140 kg, phosphate was 20-50 kg and potash was not exceeding 140 kg (Barooah, 2008).

In fact, to get a high yield of tea leaves, tea growers in Vietnam have tendency to use fertilizers at high rates or to emphasize only nitrogen while phosphate and potash are used in alternate, and the combination of them as well organic matter supplementation are often not considered properly. Such imbalanced nutrition leads to decline of productivity (Barua, 1990), normally causes considerable leaching and runoff loss of fertilizers leading to pollute surrounding water sources (Barooah, 2011), and easily leads to degrade tea-cultivated soil if organic matters are not sufficiently supplemented (Panigrahi, 1993). Furthermore, over nitrogen application might cause NO_3 residue in tea leaves that damage consumer's health. Besides that, in Vietnam, tea is usually grown in slope lands, which are often eroded, and run-off during rainfall (Anderson and Ingram, 1993). Therefore, the high intensity without enough organic matter supplemented together with global climate change would be main reasons for soil degradation, which is one of the main causes of depressing tea productivity. On the other hand, high intensity together with imbalance fertilizing usually brings about more pests and diseases in tea fields. The main method has been used to control insects and diseases of tea in Vietnam is still chemical method with the use of insecticides and fungicides. Nevertheless, these agricultural inputs have negative effects on human health and the environment (Voorrips *et al*., 2004), and if they are applied over a long period it may result in plant pathogens developing their resistance (Kim and Hwang, 2007), cause rapid conversion of innocuous species into pests, and leave undesirable pesticide residues in products (Soytong *et al*., 1999). Tea has become a popular beverage with every passing day (Chen *at al*., 2012). Consumers have increasingly requested tea products of high quality and safety. Therefore, it is asking tea growers to produce their products that are not only high quality but also must be more safety to human health. To obtain these, several crop production method have been promoted to apply, those are good agricultural practice (GAP), pesticide-free production (PFP) or organic production method.

Microbial products, which work as bio-control agents and bio-organic fertilizers for bio-agricultural production, have been researched and developed for over 15 years, and were successfully applied to GAP, PFP, commercial scale organic farm, or in combined application for integrated pest management (Soytong *et al*., 2006). Mycofungicides and fungal bio-fertilizers are being recommended to use for crop production not only due to their capacity of control plant diseases and increase crop yield in an environmentally friendly manner (Kaewchai *et al*., 2009) but also due to its protection toward consumers' health by creating safe agricultural products. Biofertilizers, which include materials derived from useful living organisms (Chen, 2006), help to improve crop yield by increasing availability, uptake or absorption of nutrients (Wani and Lee, 2002). In recent years, several fungal taxa have been successfully formulated as biofertilizers for organic or GAP crop production, e.g. *Penicillium bilaiae* was formulated as a commercial product named Jumpstart® (Burton and Knight, 2005), which was applied to increase dry matter, phosphorus uptake and seed yield in canola (*Brassica napus*) (Burton and Knight, 2005); several *Trichoderma* species have been formulated as marketed fungal biofertilizers named PLantmate®, Tricho® or Bioorganic Plus (Kaewchai *et al*., 2009), which help to improve mineral uptake, release minerals from soil and organic matter, and enhance plant hormone production (Yedidia *et al.,* 1999). Some species of *Aspergillus* have been also reported to be able to solubilize of inorganic phosphate (Barroso *et al*., 2006), or to be potassium releasing fungus (Lian *et al*., 2008). Various fungal species can be used as biological control agents against various pathogens, several of them have been successfully formulated as mycofungicides or biological control products, for example, *Ampelomyces quisqualis* was formulated as AQ10 Biofungicide for the control of powdery mildew of cucumber and mango (Shishkoff and McGrath, 2002; Azmy, 2014); *T.harzianum* strain T-22 was formulated as biofungicides named RootSield and Plant Shield, which has capacity for controling a wide range of crop pathogens including *Botrytis cinerea, Fusarium, Pythium, Rhizoctonia* in many plants such as corn, soybean, potato, tomato, beans, cotton, peanut, etc. (Khetan, 2001; Paulitz and Belanger, 2001); some *Chaetomium* species were formulated as a biofungicide, which has been successfully applied in the field to control various fungal pathogens in various crops (Soytong *et al*., 2001, 2005; Sibounnavong *et al.,* 2006, 2012; Kean *et al*. 2010; Tann *et al.* 2011).

In recently, safe tea production has been interested in Vietnam, and organic tea is just at the first step. Therefore, this study was aimed to compare the chemical method with GAP and organic production methods on tea cultivation and to find out a better method for safe tea production in Vietnam.

Materials and Methods

The field experiment (EXP) was separately done in two tea varieties namely PH8 and PH9 at Northern Mountainous Agricultures and Forestry Science Institute (NOMAFSI) (Phu Tho province, Vietnam), and setup as Randomized Complete Block Design (RCBD) with four replications. The dimension of each individual plot was 5.6 m in length x 3.5 m in breadth, which covered the area of 20.16 m^2. The experiment presented four treatments including non-treated control, chemical method, good agricultural practice (GAP) method, and organic method, which were applied the same for both the experiments.

T1=Non-treated control: only maintained without any treatment

T2=Chemical method: applied with chemical inputs (100%) consisted of 7.2 kg Urea, 6.8 kg Super phosphate and 2.0 kg KCl; fertilizing three times per year which were on March (40% of total quantity), May (30%) and Jul (30%); insecticide, Abamectin 20 cc/20L and fungicide, Carbendazim 15 cc/8L were used to control tea insects and diseases;

T3=GAP method: applied with biological inputs (50%) consisted of 25 kg of bio-organic fertilizer *AT* VISINH (1000 kg/1600 m^2), 60 cc of liquid bio-fertilizer *AT* VISINH (50 cc/20 L), 120 g of bio-insecticide *AT* B.M.I (Metarhizium, Beauveria and Paecilomyces) (100 g/20 L) and 24 g of Chaetomium bio-fungicide *AT* KETOMIUM (20 g/20 L), which were equally applied on March, May and July, and alternatively applied with chemicals inputs (50%) consisted of 3.1 kg Urea, 3.4 kg Super phosphate and 1.0 kg KCl applied on April (30% of total quantity), June (40%) and August (30%); the chemical inputs of insecticides (Abamectin 20 cc/20 L) and fungicides (Carbendazim 15 cc/8L), and the biological inputs of bio-insecticides and bio-fungicides were alternatively used for tea insects and diseases control;

T4=Organic method: applied with biological inputs (100%) consisted of 50 kg of bio-organic fertilizer *AT* VISINH (1000 kg/1600 m^2), 120 cc of liquid bio-fertilizer *AT* VISINH (50 cc/20 L), 240 g of bio-insecticide *AT* B.M.I (Metarhizium, Beauveria and Paecilomyces) (100 g/20 L) and 48 g of Chaetomium bio-fungicide *AT* KETOMIUM (20 g/20 L). They were equally applied for 6 times on months such as March, April, May, June, July and August;

Data were collected in regard to the height of tea bush (m), the width of plucking table (m), the length of a flush shoot (cm) (consisted of one bud and two leaves), the density of tea shoots (shoots/m^2), the weight of tea shoots (g/shoot) and the yield of fresh tea leaves (tons/ha). All those parameters were investigated following the method of Nguyen V.T. (1998). Growth parameters of the two tested tea varieties were measured two times during experiment, of which the first time (pre-treatment observation) was done before experiment and the second one was done when the experiment was getting on time for finishing. The height of a tea bush was measured from the ground to its plucking table surface, where exposes its shoots, and in which the width of plucking table was measured at two ways that were perpendicular to each other. Some main tea insects (thrips, green leafhopper and red spider mite, and the leaf pot disease) were also observed following the method of Nguyen V.H. (1998). Quality of the green tea, which was processed from the tea leaves of each treatment of each experiment, was also sensory evaluated following the Vietnamese Standard TCVN 3218-1993. The Data were statistical analysis and the means of the treatments were compared using Duncan's Multiple Range Test (DMRT) at P=0.05 on Sirichai Statistics software (Informer. com).

Results

Effect of the application methods on the growth parameters of two tested tea varieties

Tea shoots, which are capable for harvesting, are appeared on the surface of the plucking table. Wider the plucking table is more area for tea shoots grow that means more tea yield making it to be an important criterion to assess the capacity for creating yield of a tea field. The effect of the application methods on the growth of two tested tea varieties was assessed base on the disparity between the first and the second measuring of all the growth parameters, which are shown on Table 1 and Table 2.

Table 1. Effect of the application methods on the growth parameters of PH8 tea variety

Methods	Width of plucking table (m)			Height of tea bush (m)		
	Before experiment (A)	After experiment (B)	Disparity (A-B)	Before experiment (A)	After experiment (B)	Disparity (A-B)
Control (non-treated)	1.33	1.45	0.12[bc]*	0.72	0.91	0.19[b]
Chemical	1.36	1.55	0.19[a]	0.75	1.00	0.25[ab]
GAP	1.39	1.48	0.09[c]	0.74	0.96	0.22[ab]
Organic	1.39	1.56	0.17[ab]	0.72	1.01	0.29[a]
CV%	-	-	25.65	-	-	24.67

* Mean of four replications. Mean followed by a common letter in each column were not significantly different by DMRT at P=0.05

Table 2. Effect of the application methods on the growth parameters of PH9 tea variety

Application Methods	Width of plucking table (m)			Height of tea bush (m)		
	Before experiment (A)	After experiment (B)	Disparity (A-B)	Before experiment (A)	After experiment (B)	Disparity (A-B)
Control (non-treated)	1.34	1.45	0.11[a]	0.79	0.96	0.17[b]
Chemical	1.47	1.54	0.07[a]	0.82	1.09	0.27[a]
GAP	1.41	1.48	0.07[a]	0.82	1.07	0.25[a]
Organic	1.41	1.49	0.08[a]	0.82	1.08	0.26[a]
CV%	-	-	26.51	-	-	14.20

* Mean of four replications. Mean followed by a common letter in each column were not significantly different by DMRT at P=0.05

The result showed that the chemical, GAP and organic method gave significantly better effect on the height of the tea bush than the non-treated control in case of PH9 variety, with the disparity values of 0.17, 0.27, 0.25 and 0.26 m, respectively (Table 2); on which, in case of PH8 variety, only the organic method (0.29 m) was significantly better effective than the non-treated control (0.19 m), while the chemical (0.25 m) and GAP method (0.22 m) were not (Table 1). There was non-significant difference on the width of plucking table between all the treated methods and the non-treated control in case of the PH9 experiment (Table 2); meanwhile, on which, only the chemical method was significantly better effective than the non-treated control, and the others were not in case of PH8 experiment (Table 1).

A comparison in the investigated growth parameters of two tea varieties among three treated methods showed that the chemical, GAP and organic method were not significantly different from each other, except for the width of plucking table in case of PH8, which showed the chemical and organic method, with the disparity value of 0.19 and 0.17 m, respectively, were significantly better effective than the GAP method, with the disparity value of 0.09 m (Table 1).

Effect of the application methods on the constituents of tea yield and the yield of the two tested tea varieties

The components which constitute the tea yield of a mature tea field (over 3 years-old) include number of tea bushes/area, density of tea shoots/m^2 and weight of a fresh tea shoot. The density of tea shoots, which is various and depends on tea varieties, cultivation method of the tea field, weather conditions and the level of pests and diseases on the tea field, plays an important role on the tea yield of tea plantation. The effect of the application methods on the constituents of tea yield and the yield of the application methods are shown on Table 3 and Table 4. The density of tea shoots and the tea yield of each treatment are illustrated on Fig. 1.

The result showed that in case of the two experiments, the chemicals, GAP and organic methods showed significantly higher values of the shoot length and the density of shoots than the non-treated control (Table 3, Table 4), except for the organic method of PH8 experiment, which showed non-significant difference in the length of shoot as compared to the non-treated control, with the values of 3.31 and 3.19 cm, respectively (Table 3). Regarding to the weight of tea shoot, there were not significantly difference among all the application methods in case of both the experiments, except for the weight of fresh shoot of PH8, of which showed that the chemical method gave significantly higher value (0.82 g/shoot) than the non-treated control (0.77 g/shoot), but did not give significantly higher value than GAP method (0.79 g/shoot) and organic method (0.81 g/shoot) (Table 3). However, organic method gave higher value of the dry shoot weight than chemical and GAP ones which were 0.19, 0.17 and 0.18 g/shoot, respectively in case of PH8 (Table 3), and were 0.19, 0.19 and 0.21 g/shoot, respectively in case of PH9 (Table 4).

Regarding to the tea yield, in case of both the experiments, the chemical, GAP and organic methods showed significantly higher tea yield than the non-treated control, with the percentages of yield increasing of each compared to the non-treated control were 52.86, 46.03 and 36.98 %, respectively in case of PH8 (Table 3), and were 63.96, 67.87 and 52.10 %, respectively in case of PH9 (Table 4). In the experiment of PH9, there was non-significant difference in the tea yield among the chemical, GAP and organic methods, which were 10.92, 11.18, 10.13 tons/ha, respectively (Table 4); meanwhile, in which the chemical method gave significantly higher value than the organic method, which was 9.63 and 8.63 tons/ha, respectively in case of PH8 experiment (Table 3).

Table 3. Effect of the application methods on the constituents of tea yield and the yield of PH8 tea varieties

Methods	Length of shoot (cm)	Density of shoots (shoots/ m^2)	Weight of fresh shoot (g/shoot)	Weight of dry shoot (g/shoot)	Yield of tea leaves	
					Tons/ha	Increase compared to T1 (%)
Control (non-treated)	3.19^{b*}	163.28^{b}	0.77^{b}	0.19^{a}	6.30^{c}	-
Chemical	3.48^{a}	193.12^{a}	0.82^{a}	0.17^{a}	9.63^{a}	52.86
GAP	3.49^{a}	185.77^{a}	0.79^{ab}	0.18^{a}	9.20^{ab}	46.03
Organic	3.31^{ab}	180.11^{a}	0.81^{ab}	0.19^{a}	8.63^{b}	36.98
CV%	5.12	4.97	3.10	9.51	5.72	-

* Mean of four replications. Mean followed by a common letter in each column were not significantly different by DMRT at P=0.05

Table 4. Effect of the application methods on the constituents of tea yield and the yield of PH9 tea varieties

Methods	Length of shoot (cm)	Density of shoots (shoots/ m^2)	Weight of fresh shoot (g/shoot)	Weight of dry shoot (g/shoot)	Yield of tea leaves	
					Tons/ha	Increase compared to T1 (%)
Control (non-treated)	3.38^{b}	150.80^{b}	0.75^{a}	0.18^{a}	6.66^{b}	-
Chemical	3.91^{a}	187.11^{a}	0.78^{a}	0.19^{a}	10.92^{a}	63.96
GAP	3.82^{a}	184.23^{a}	0.76^{a}	0.19^{a}	11.18^{a}	67.87
Organic	3.93^{a}	181.92^{a}	0.80^{a}	0.21^{a}	10.13^{a}	52.10
CV%	4.95	3.19	7.18	9.76	7.67	-

* Mean of four replications. Mean followed by a common letter in each column were not significantly different by DMRT at P=0.05

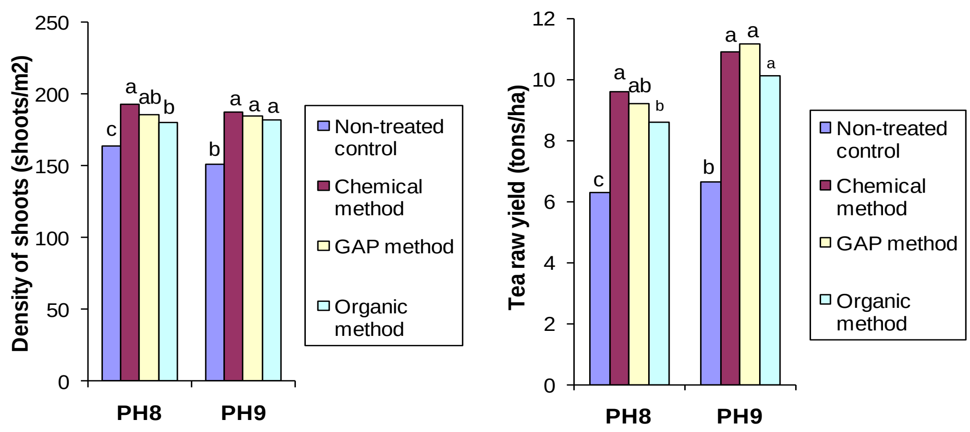

Figure 1. Effect of the application methods on the density of shoots and the yield of fresh leaves of two tested tea varieties; means followed by the same letter in columns within each tea variety were not significantly different by DMRT at P=0.05.

These denoted that there was non-significant difference in the effect of chemical, GAP and organic method on most of the observed parameters related to the constituent of tea yield. However, these methods were significantly higher effective on the tea yield than the non-treated control. The chemical method was seen to give significantly higher effect on the tea yield as compared to the organic method in case of PH8, which was seen not significantly higher in case of PH9. The percentage of yield increase in compared to the non-treated control given by the chemical and GAP method were higher than that given by the organic method in case of both the experiment. The chemical method had tendency to give higher number of the density of shoots, followed by the GAP method as compared to the organic method.

Effect of the application methods on some main kinds of insects and diseases in the two tea varieties

There were three types of insect including green leafhopper, red spider mite and thrips which appeared in the experiments, meanwhile only leaf spot disease was observed. An example for the insects and disease observed in the experiments is shown in Fig. 2.

The symptom of leaf spot disease **The leaf symptom caused by thrips**

Fig. 2. The insect and disease appeared in the experiment

The investigated result showed that in case of PH8, the chemical method gave significantly lower number of observed green leafhoppers, red spider mites and thrips than the non-treated control and the organic method, but of which it did not give significantly lower number than the GAP method (Table 5). The GAP method gave significantly lower observed number of red-spider mites and thrips as compared to the organic method, but it showed similar observed number of green leafhoppers when compared between them (Table 5). Observation of leaf spot disease showed that there was non-significant difference among all the applications of the PH8 experiment as seen in Table 5. In case of PH9 experiment, all the treated methods were significantly effective on the control of thrips and leaf spot disease than the non-treated control, but in which they showed non-significant difference when compared among them (Table 6). Regarding to the green leafhopper and the red spider mite, the chemical method showed significantly effectiveness than the other methods, and there was non-significant difference among the GAP, organic method and non-treated control (Table 6).

These demonstrated that the chemical method was significantly effective or tended to give higher effectiveness on the control of the investigated insects and disease than the organic method, and in which there was non-significant difference between the chemical and GAP methods. In most the cases, the organic method was not significantly effective than the non-treated control, except for on leaf spot disease and thrips, which showed opposite results, however, the organic method tended to give lower number of the other observed insects than those of the non-treated control.

Table. 5. Effect of the treated methods on some kinds of main insects and diseases in PH8 variety

Methods	Green leafhopper (N^o per a tray)	Red spider mite (N^o per a leaf)	Leaf spot disease (%)	Thrips (N^o per a shoot)
Control (non-treated)	8.59^{a}*	12.14^{a}	0.040^{a}	0.035^{b}
Chemical	6.19^{b}	9.07^{b}	0.032^{a}	0.020^{c}
GAP	7.23^{ab}	9.08^{b}	0.032^{a}	0.025^{bc}
Organic	8.38^{a}	11.90^{a}	0.037^{a}	0.050^{a}
CV%	12.90	14.37	21.05	24.05

* Mean of four replications. Mean followed by a common letter in each column were not significantly different by DMRT at P=0.05

Table. 6. Effect of the treated methods on some kinds of main insects and diseases in PH9 variety

Treatments	Green leafhopper (N^o per a tray)	Red spider mite (N^o per a leaf)	Leaf spot disease (%)	Thrips (N^o per a shoot)
Control (non-treated)	11.88^{a}	9.50^{a}	0.032^{a}	0.037^{a}
Chemical	7.66^{b}	5.66^{b}	0.020^{b}	0.000^{b}
GAP	10.24^{a}	8.43^{ab}	0.017^{b}	0.000^{b}
Organic	10.91^{a}	8.93^{ab}	0.012^{b}	0.000^{b}
CV%	12.74	26.07	25.87	26.67

* Mean of four replications. Mean followed by a common letter in each column were not significantly different by DMRT at P=0.05

Table.7. The results of sensory evaluation of PH8 experiment

Methods	Appearance		Color of liquor		Smell of liquor		Taste of liquor		Total score	Rank
	Descriptions	**Score**	**Descriptions**	**Score**	**Descriptions**	**Score**	**Descriptions**	**Score**		
Control (non-treated)	Curly, green, silver-white hairy	4.38	Greenish yellow, a little dull	3.95	Typically aroma	4.03	Heavily tart, slightly astringent	4.03	16.42^{b}*	Fairly good
Chemical	Curly, green, silver-white hairy, a little crumbs	4.41	Greenish yellow	3.94	Typically aroma	4.19	Heavily tart, slightly astringent	4.02	16.62^{a}	Fairly good
GAP	Tightly curly, green, containing a little crumbs	4.46	Brightly yellowish green	3.96	Typically aroma	4.16	Softly tart	4.07	16.71^{a}	Fairly good
Organic	Tightly curly, uniform shape of rolled leaves, appearing yellow rolled leaves	4.48	Brightly yellowish green	4.10	Slightly aroma	4.02	Heavily tart, slight astringent	4.05	16.63^{a}	Fairly good

* Means of four replications, Means followed by a common letter in each column were not significantly different by DMRT at P=0.05

Table.8. The results of sensory evaluation of PH9 experiment

Application methods	Appearance		Color of liquor		Smell of liquor		Taste of liquor		Total score	Rank
	Descriptions	**Score**	**Descriptions**	**Score**	**Descriptions**	**Score**	**Descriptions**	**Score**		
Control (non-treated)	Curly, a little yellow, slightly silver-white hairy	4.32	Yellowish green, moderately viscous	4.07	Slightly typical aroma	4.06	Softly tart	3.95	16.38 [b*]	Fairly good
Chemical	Tightly curly, green, silver-white hairy	4.47	Brightly yellowish green	4.14	Slightly aroma	4.01	Softly tart	3.99	16.55 [a]	Fairly good
GAP	Tightly curly, green, silver-white hairy	4.45	Brightly yellowish green	4.18	Slightly typical aroma	4.10	Softly tart	4.01	16.69 [a]	Fairly good
Organic	Tightly curly, green, silver-white hairy	4.40	Yellowish green, moderately viscous	4.05	Slightly aroma	3.96	Softly tart	3.98	16.35 [b]	Fairly good

* Means of four replications, Means followed by a common letter in each column were not significantly different by DMRT at P=0.05

Effect of the application methods on the sensory quality of green tea processed from the leaves of two tested tea varieties

The tea leaves from each treatment of the two tested varieties were picked up and separately processed to make respective green tea products. These products were evaluated using sensory method following the Vietnamese Standard of TCVN 3218-1993. The result showed that almost the treated methods gave significantly higher total sensory score as compared to the non-treated control, except for the organic method (16.35 marks) which was not significantly different compared to non-treated control (16.38 marks) in case of PH9 (Table 8). There was non-significant difference in the score among the chemical, GAP and organic metthod, which were 16.62, 16.71 and 16.63 marks, respectively in case of PH8 (Table 7), and were 16.55, 16.69 and 16.35 marks, respectively in case of PH9 (Table 8). However, the GAP method, which made the tea products with tightly curly, green in its appeareance, brightly yellowish green color of its liquor, typically aroma and softly tart of its taste, tended to give higher score when compared to the score given by the chemical and organic method.

Discussion

The results of the present study indicated that the efficiency of the chemical, GAP and organic method depended not only on themselves but also on the tested tea varieties. In case of PH9, three treatments of chemical, GAP and organic method were significantly better effective on the height of tea bush as compared to the non-treated control, on which only the organic method showed to be significantly better effective, meanwhile the other were not with the same comparison in case of PH8. However, the effect of the chemical, GAP and organic method on the height of tea bush were not significantly different as compared among them. This result is similar to the report of Sibounnavong *et al.* (2012) who conducted a test for efficiency comparison of chemical, GAP, PFP and organic method in three tomato varieties namely Cherry, Loukthor and Sida. The report of these authors showed that at 70 days after planting, the chemical, organic and PFP method gave significantly better effect on the height of Cherry variety as compared to GAP method and the non-treated control, which showed not significant different from each other. Meanwhile, there were non-significantly differences in the height of Loukthor and Sida variety among the four treated application methods (chemical, GAP, organic and PFP), and in which only the chemical method in case of Loukthor and organic method in case of Sida was significantly better than the non-treated control. Tann *et al.* (2011) also reported that the organic and chemical method were not significantly different from each other, but they were significantly better than the non-treated control and GAP method when compared the effect between them on the height growth of rice at 45 days after transplanting in case of Neang Kong variety. Meanwhile, in case of Kea rice variety, the chemical method was significantly better than the organic method and the non-treated control, but not significantly better than the GAP method; and the GAP method was significantly better than control (which showed an opposite result in Neang Kong variety), but not significantly better than the organic method.

The results of the present study also showed that all the treated applications of chemical, GAP and organic method were significantly higher effective on the tea yield as compared to the non-treated control. The chemical method gave significantly higher result than the organic method in case of PH8, which showed not significantly different in case of PH9. The percentages of yield increase in compared to the non-treated control given by the chemical and GAP method were higher than organic method in case of both the experiment, which ranged of 52.86 - 63.96, 46.03 - 67.87 and 36.98 - 52.10 %, respectively. The chemical method tended to give higher value of the density of shoots, followed by the GAP method as compared to the organic method. This result was similar to the report of Tann *et al*. (2011) which showed that the chemical, GAP and organic method (with applications of Ketomium as a fungicide and

Beauveria and *Metarhizium* as a bio-insectide), gave significantly higher yield of rice as compared to the non-treated control, with the percentage of yield increasing ranged from 49.15 to 76.76 %. However, Sibounnavong *et al.* (2006) also reported that the yield of Kangkong given by the organic method increased by 45.83% as compared to the natural control.

The present study denoted that in most the cases, all the treated application method were significantly effective or tended to give higher efficiency on the insect and disease control than the non-treated control. On which, the chemical method was significantly effective or tended to give higher efficiency than the organic method, and there was non-significant difference between the chemical and GAP method. The insect-bio-control agent of *Metarhizium* and *Beauveria*, and the disease-bio-control agent of *Chaetomium* might play an important role for insect and disease control in these experiments. Mamun and Ahmed (2011) said that *Metarhizium anisopliae* was the commonest entomopathogenic fungi that reduced the population of red spider mites, thrips in tea. Soytong *et al*. (2001) stated that Ketomium, which was formulated from *Ch.globosum* and *Ch.cupreum*, has been successfully applied to infested field-soils integrated with cultural control measures and organic amendments for the long-term protection of durian and black pepper caused by *Phytophthora palmivora*, tangerine caused by *Phytophthora parasitica*, strawberry caused by *Phytophthora cactorum*, wilt of tomato caused by *Fusarium oxysporum* f.sp. *Iycopersici* and basal rot of corn caused by *Sclerotium rolfsi*. This product also has been registered as a biological biofertilizer for degrading organic matter and for inducing plant immunity and stimulating growth of tomato, corn, rice, pepper, citrus, durian (Soytong *et al*., 2001). This suggests that Ketomium® product might play a real role in promoting the growth of tea shoots in the application of GAP and organic method. This result is in accordance with the report of Kean *et al.* (2010) who noticed that the chemical fungicide-metalaxyl was not different in disease reduction when compared to GAP, Ketomium and Trichderma biological fungicides, and that biological fungicides expressed a curative effect to control diseases plant. Nguyen *et al.* (2014a, b) reported that *Ch.cupreum* and *Ch.globosum* were successfully used to control *Pestalotia* spp. causing leaf spot disease of tea *in vitro* test.

In conclusion, the GAP method could be better used for safe tea production than the chemical and organic method because it promoted tea shoots grow and gave the tea yield that was though lower but not significantly different as compared to the chemical one and tended to be higher than organic one. Furthermore, the efficiency for insect and disease control of the GAP method was not significantly different from the chemical and organic method.

It seems that the GAP method is more friendly and safe to the environment and the consumer's health than the chemical method due to its reducing of chemical inputs as compared to the chemical one. Haggag and Mohamed (2007) said that mycofungicides and fungal biofertilizers help to minimize the use of synthetic chemical fungicides and chemical fertilizers. On the other hand, the GAP method tended to give higher score when compared to the score given by the chemical and organic method.

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