

Production Efficiency and Quality of Mustard Greens (*Brassica juncea* (L.) Czern) Cultivated According to the Vietnamese Good Agricultural Practice (VietGAP) Guideline in Thai Nguyen City

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ABSTRACT--- *Mustard greens (Brassica juncea (L.) Czern) is one of the major vegetables produced and consumed in large volume in Thai Nguyen city. Application of advanced cultivation techniques for quality produce would contribute to improving the quality of life and sustainable production efficiency for vegetable growers. This study was carried out during August – November 2011 to evaluate the efficiency in terms of plant growth and quality of mustard greens in Thai Nguyen condition. In the experiment, two sub-plots were divided to compare growth parameters between plants grown according to the VietGAP guideline (experimental treatment) and conventional farmers' method (control treatment). Quality of the experimental plants was tested according to the current national standards. It was found that the experimental plants had significant higher growth parameters with regards to leaf number per plant and leaf areas than those of the control. Moreover, the lab tests showed the experimental plant samples met the quality standards to be certified as a clean produce. High levels of disease occurrence and damage were evident in the control sub-plot due to a number of reasons, namely, high planting density, improper manure treatment and fertilization, and overuse of chemicals. The comparative study on a home garden of a household would also improve farmers' awareness, while at the same time it would serve as a demo-plot for local farmers to have a more practical view on the improved cultivation method and thus a gradual shift in their production practices.*

Keywords – Clean vegetables, Food safety, Mustard greens, Quality, Plant growth, VietGAP.

1. INTRODUCTION

Commercial production of clean agricultural produce has recently been one of the major focuses in the agricultural development strategies of the central and local governments in Vietnam. The technical guideline of Vietnamese Good Agricultural Practice (VietGAP) for horticultural produce issued by the Ministry of Agriculture and Rural Development, dated on 28 January 2008, was formulated based on the analyses of opportunities, potentials and challenges for horticultural development in Vietnam since the country joined the World Trade Organization (WTO) on 11 January 2007 (Nguyen, 2008; Ha, 2011).

In addition, there have been increasing concerns with regard to food safety and thus increased domestic demands for clean horticultural produce, particularly vegetables. This is because the overuse of agrochemicals and its unintended consequences such as environmental contamination, human health problems and food poisoning have been evident (Jansen *et al.* 1996; Shepherd & Tam, 2007; Vinning & Nguyen, 2008).

Thai Nguyen is a Northern province of Vietnam that possesses a large area of arable agricultural land (about 82,000 ha) and favourable climatic conditions for agricultural production (Ha, 2011; Nguyen, 2010). Vegetable production has been developed into specialized intensive production areas such as Ngoc Lam, Tuc Duyen, Hung Son and Dong Tien (Do, 2010). In which, Mustard Greens (*Brassica juncea* (L.) Czern) is regarded as one of the main vegetable crops being consumed in large volume (Ha, 2011).

Application of eco-friendly practices in vegetable production would therefore contribute to improving economic efficiency, environment and health condition of the people in the research area. In accordance with a component of awareness raising for the growers and defining solutions to improving market access (Ha, 2011; Ha & Nguyen 2013), this study was conducted to evaluate the effectiveness of plant growth and quality of mustard greens in Thai Nguyen.

2. MATERIALS AND METHODS

2.1. Plant materials, research location and duration

Mustard greens (*Brassica juncea* (L.) Czern) was selected for this study since it is one of the major vegetable crops, being consumed in large volume in Thai Nguyen city (Ha, 2011; Ha & Nguyen, 2013). Seeds were purchased from a branch agent of Tre Viet JSC. – Vietnam Academy of Agricultural Sciences, Vinh Quynh, Thanh Tri, Hanoi.

Plants were grown in a plastic house at Ngoc Lam village, Linh Son commune of Dong Hy district. The study was carried out during August – November 2011.

2.2. Research contents and methods

2.2.1. Research contents

- Compare the growth parameters between experimental treatment (crops grown according to the VietGAP guideline) and control treatment (farmers' conventional practices).

- Evaluate the quality of mustard greens grown according to the VietGAP guideline.

2.2.2. Research methods

* Experimental design:

The experiment comprised two treatments, a control and/or conventional farmers' practice (T1) and an experimental treatment (T2) that applied VietGAP guideline. To better compare growth parameters between the two treatments, the experimental plot was divided into two subplots for the control and experimental treatments, respectively. Within each subplot, 3 soil-beds were used. The Randomized Complete Block (RCB) design was applied, where each soil bed was considered as one block, to reduce the experimental errors. In each sub-plot, nine single replicate plants were chosen for measuring growth parameters (Figure 1).

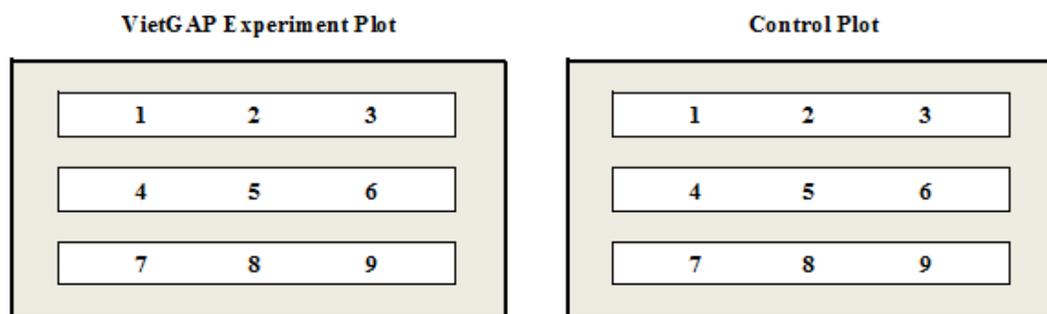


Figure 1. Experimental design for two treatments in two separate subplots. There are 3 soil-beds per each subplot. The numbers indicate the single deprecate plants selected for measuring the growth parameters.

* Production guidelines applied for each treatment:

+ Control treatment (T1): the cultivation was applied according to the local farmers' traditional practice. The researcher and farmers together took note of all details from the beginning of the whole production cycle, including fertilizer amount, types, quantity of pesticides used and cultivation techniques applied. The total amount of fertilizers calculated in one hectare is described as follow: 2.10 tons of farmyard manure (applied 100% as a basal fertilizer); 416.67 kg of N.P.K-S (5: 10: 3 - 8) (Lam Thao Superphosphate and Chemicals JSC., Lam Thao, Phu Tho province) (applied 100% as a basal fertilizer); and 154.16 kg Urea (46.0%) (Ha Bac nitrogen fertilizers and chemicals Co., Bac Giang city, Bac Giang province). The amount of urea was divided into two portions to apply as top-dressing fertilization at 18 days after sowing with 83.33 kg ha⁻¹ and 25 days after sowing with an amount of 70.83 kg ha⁻¹.

Vegetables in the control treatment were densely sown by the farmers with a purpose of harvesting twice. The first time was harvested at week 3 after sowing as a way to reduce plant density. The plants harvested at this time were sizable for sales. In the second time (one month after sowing), all the remaining plants were harvested. Watering was carried out on daily basis or every 2-3 days, depending on growth stages and weather conditions. Weeding and chipping were done regularly. Pesticides were applied when there were high occurrences of pests and diseases (types of chemicals used are described in section 3.1).

+ Experimental (VietGAP) treatment (T2): Ploughing and removal of crop residues were conducted early prior to sowing. Soil pH was initially tested with a value of 4.51 ± 0.04. The low level of pH was reported to negatively influence

the nutrient absorbability of plant roots and mobility of mineral nutrients (Cao *et al.* 2011; Tran *et al.* 2012). The formula of soil pH adjustment by Lester (2010) was applied to raise the pH value to 6.0, which is suitable for the experimental crop.

At 20 days prior to sowing, formalin solution (2.0%) was prepared and applied to the soil with an amount of 5.0 L m⁻² to saturate it up to a depth of 20 cm. The drench area was then covered by polyethylene sheets. After 15 days, the cover was removed and soil-beds were raised for sowing seeds (Tewari 2009).

Fertilization and tending of mustard greens was applied according to the production guideline of the National Agricultural Extension Centre (NAEC 2008). Plants were watered on daily basis or every 2-3 days, depending on growth stages and weather conditions. Pest scouting was regularly carried out and damage levels were evaluated according to the national technical regulation on surveillance methods of plant pests (MARD 2010) to make decisions.

After basal fertilizers were applied according to the guideline, soil samples were collected for electrical conductivity (EC) test. The EC value was 1.06 ± 0.07 mS cm⁻², which is regarded as suitable for the experimental crop (Lester 2010).

* Data collection:

The following parameters at harvest time were recorded to compare between growth parameters of experimental and control treatments:

- Plant height (taken from the stem base to the highest point);
- Leaf number; damaged leaves caused by pests and diseases and levels of damage were evaluated according to the national technical regulation (MARD 2010);
- Leave surface area: measured according to the method of Pearson (2011); and
- Weight per one square meter.

* Soil, water and vegetable sample tests:

Soil sampling was carried out at the beginning of land selection to check the contents of heavy metals. Since the experiment plot was small and flat, soil sampling was conducted by selecting five diagonal points (Modified from Le 2011; MOST 2005; Peters *et al.* 2007). At each point, a soil sample was taken from surface to 20 cm deep. The samples were then put into plastic bags and sealed before sending for lab tests.

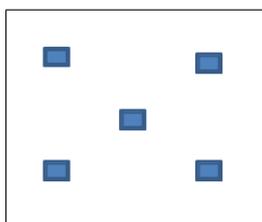


Figure 2. Five diagonal point sampling method for soil.

Since the well water was used for irrigation, three random samples were selected to test heavy metal contents.

For plant samples, three samples were selected randomly from each subplot for quality test in terms of nitrate, heavy metal contents, microbial and pesticide residue at the laboratory of soil and agricultural product quality analyses, Northern Mountainous Agriculture & Forestry Science Institute (NOMAFSI).

* Data analysis:

Data obtained were subjected to analysis of variance using General Linear Model procedure in Minitab[®] statistical package (Release 15; Minitab[®] Inc., PA, USA) with the least significant differences (LSD) calculated at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. Evaluation of crop growth

Thanks to the standard VietGAP production guideline and advanced techniques applied in the experimental plot (T2), plants had higher number of leaves (8.0 leaves per plant) at harvest compared to the control (6.3 leaves per plant) (P <

0.05). In addition, its leaf area (18.03 dm²) was almost 3 times larger than that of plants in the control treatment (6.49 dm²) (P< 0.001) (Table 1 and Figure 3).

Table 1. Comparing plant growth parameters of mustard greens between the two treatments

Treatment	Plant height (cm)	Leaf number	Leaf area (dm ²)	Weight (kg/m ²)
T2 (VietGAP)	38.56	8.0 (a)	18.03 (a)	3.05
T1 (Control)	35.67	6.3 (b)	06.49 (b)	3.07
<i>P</i> -value	<i>n.s</i>	*	***	<i>n.s</i>

Notes: The growth parameters were measured upon harvest (30 days from planting). Values followed by different letters within a column are significantly different according to Tukey test. *n.s.*: not significant, * *P*<0.05, ***P*<0.01, ****P*<0.001.

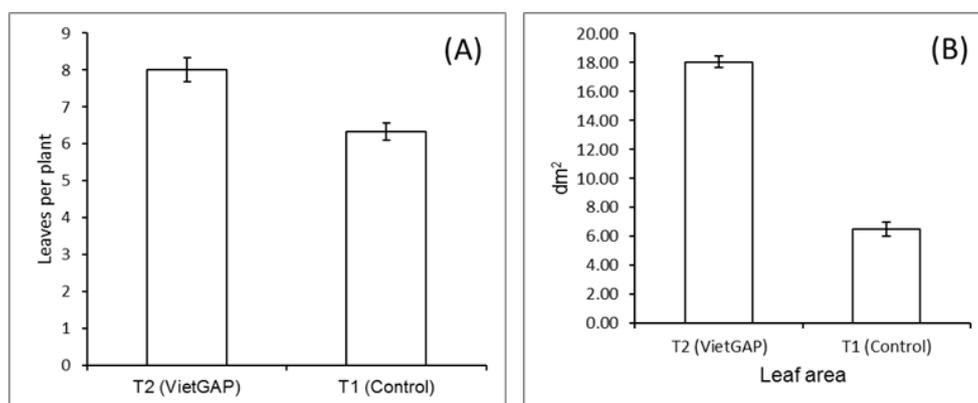


Figure 3. Differences in leaf number (A) and leaf areas (B) between the two treatments.

Vertical bars represent Standard Errors (SE).

Although plants of the control treatment (T1) were densely sown (Figure 4-B) and were harvested twice (the first time was at week three after sowing), there was no significant difference in total weight per one square meter between the two treatments. This, together with the increased leaf number and area, implied that the plants of T2 had larger sizes. For a leafy vegetable, in addition to the quality concern, size and appearance are important factors that influence willingness-to-pay behavior of customers (Bonti-Ankomah & Yiridoe, 2006).



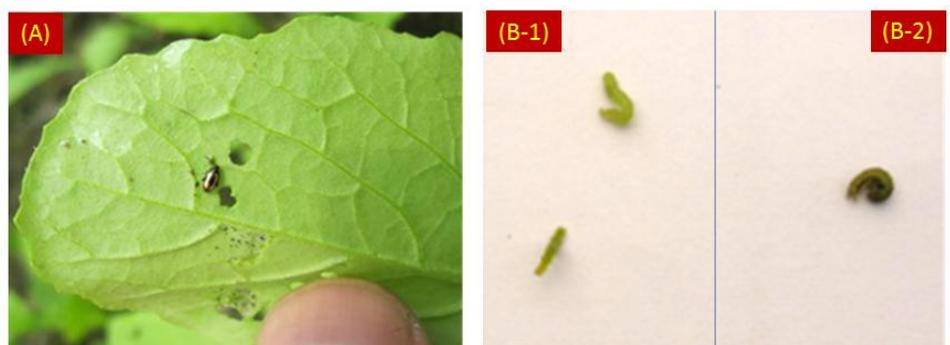
Figure 4. Planting distance of experimental plot (A) and control plot (B) at week 3 after sowing.

On average there were 5.7 ± 1.20 plants per square meter (ranging from 4 - 8) affected with root rot in T1 (Figure 5-A). This might be due to the fact that the farmers did not treat the soil before planting, while in T2, soil was ploughed loose and a disinfectant (formalin) was applied prior to sowing. Therefore, no disease symptom occurred. Besides, high density planting in the control plot resulted in an average of 9.7 ± 1.76 rotten plants (ranging from 7 – 13) per one square meter at the time of harvest (30 days after sowing) (Figure 5-B).



Hình 5. Rotten plants (A) and white mould occurred on the bed surface (B) of mustard greens in T1 at the time of harvest (30 days after sowing).

In terms of pests and damage levels, there were on average 3.3 ± 0.33 plants where only 1-2 leaves had noticeable damages by the diamondback moth (*Plutella maculipennis* Curtis), since monitoring of the pests showed that their occurrence levels were less than the prescribed thresholds¹ where intervention needs to be taken (According to the national technical regulation on surveillance methods for plant pests by MARD 2010, pp.16-17)



(A). Flea beetle (*Phyllotreta* spp.) on a leaf of mustard greens. (B). Diamondback moth (*P. maculipennis* Curtis) (B-1) & Black cutworm (*Agrotis ipsilon* (Hufnagel)) (B-2)

Figure 6. Pest damages on mustards greens.

In the control plot, since pesticides were applied during plant growth, damage showed from no to little damage on plant leaves, only spotted leaves were evident due to flea beetles. The chemicals used included BP Dygan 3.6 EC (active element: Abamectin 3.6%) (applied at day 11 after sowing). Even though the Duo Xiao Meisu (active ingredient: Validamycin A 5%) was applied on the same day to prevent rottenness, high level of rotten plants were however still observed at the time of harvest as shown in Figure 5.

3.2. Evaluation of product quality of mustard greens grown according to the VietGAP guideline

The quality parameters according to VietGAP standards include Nitrate (NO₃⁻) level, microbial content (*Salmonella*, *Coliforms*, *Escherichia coli*), heavy metals (As, Pb, Hg and Cd) and pesticide residues in plant samples. Results of quality analyses were compared with the current national standards. The results in Table 2 show that the contents of nitrate, microorganisms and heavy metals were in the safe thresholds.

Table 2. Analyses of Nitrate, microbial and heavy metal contents in mustard greens samples.

Parameters	NO ₃ ⁻ (mg/kg)	Microbial content (CFU/g)			Heavy metal content (mg/kg)			
		<i>Salmonella</i>	<i>Coliforms</i>	<i>Escherichia coli</i>	As	Pb	Hg	Cd
Average value	278.15	0	107	2	0.117	0.013	< 0.0001	0.004
S.E	0.47	0.00	2.52	0.58	0.018	0.003	-	0.00

Note: National standards applied for each parameter: TCVN 5247:1990 for Nitrate; TCVN 4829:2005 for *Salmonella*; TCVN 6848:2007 for *Coliforms*; TCVN 6846:2007 for *Escherichia coli*; TCVN 7601:2007 for As.; TCVN 7602:2007 for Pb.; TCVN 7604:2007 for Hg; and TCVN 7603:2007 for Cd. S.E - Standard Errors. CFU – Colony Forming Units.

¹ Thresholds of pest occurrence to apply pesticides: Diamondback moth: 30 moths/m²; Black cutworm: 5 worms/m²; and Flea beetle: 20 beetles/m² (According to MARD 2010, pp. 16-7).

The test results of pesticide residues in plant samples were compared with the maximum residue limits (MRLs) as stipulated in by the Ministry of Health (Decision No. 46/2007/QD-BYT, dated on 19 December 2007). The results in Table 3 show that the levels of chemical residues are below the MRLs.

Table 3. Test results for pesticide residues in mustard greens samples

Parameters	Residue contents in plant samples (mg/kg)			Average (mg/kg)
	Sample 1	Sample 2	Sample 3	
<i>Methyl Parathion</i>	0.024	0.023	0.026	0.024 ± 0.0009
<i>Fenvalerate</i>	< 0.001	0.001	< 0.001	-
<i>Imidacloprid</i>	0.002	< 0.001	0.001	-
<i>Diazinon</i>	0.043	0.040	0.045	0.043 ± 0.0015
<i>Tebufenozide</i>	0.075	0.080	0.078	0.078 ± 0.0015

Based on the above quality test results, mustard greens grown according to the VietGAP guideline in Thai Nguyen met the quality standards as a clean produce.

4. CONCLUSION

Mustard greens grown according to the VietGAP protocol showed increased growth parameters with regards to number of leaves and leaf area compared to the conventional production practice of local farmers. Even though plants in the control treatment were grown with high density, its overall plant weight per one square meter was not significantly different with plants of the experimental treatment (T2). Moreover, the high plant density, inadequate treatment of farmyard manure, improper fertilization and overuse of chemical fertilizers caused significant ratios of shoot and root rot. Application of the VietGAP guideline in production of mustard greens in Thai Nguyen city met the national quality standards to be certified as a clean produce.

To promote the application of clean vegetable production techniques in a large scale, there should be adequate support from the local government and technical assistances by relevant departments and the extension network. Besides, for sustainable production of clean produce, it is necessary to enhance market access for the growers via market actor linkages and contract farming. Likewise, awareness raising for both producers and consumers towards long term multiple benefits of the eco-friendly practices is needed to ensure stable market outlets and thus more secure margin for the growers.

5. ACKNOWLEDGEMENT

This study was funded by the Australia Award Alumni Program – Small Grant Scheme. The author would like to thank Mr. Nguyen Cao Hoang for his support in the lab tests.

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