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EVALUATING PRODUCTION EFFICIENCY AND QUALITY OF LEAFY RADISH CULTIVATED ACCORDING TO THE VIETNAMESE GOOD AGRICULTURAL PRACTICE (VIETGAP) GUIDELINE IN NORTHERN VIETNAM

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ABSTRACT

Eco-friendly production practices have recently embraced in various regions in Vietnam, particularly for horticultural produce, to meet the increasing demands by both domestic and overseas markets. The practices would not only bring about secure income for producers but also contribute to economic, environmental sustainability and improved human health in broad terms. Leafy radish is one of the important cash crops in the urban and outskirts of Thai Nguyen city (Northern Vietnam). Adoption of the Vietnamese Good Agricultural Practice (VietGAP) for the crop would help improve quality of life and sustainable production efficiency for local farmers. This study was conducted during August – November 2011 to evaluate the effectiveness of plant growth and quality of leaf radish in Thai Nguyen. 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. As a result, the experimental plants had significant higher growth parameters regarding leaf number and surface areas than those of the control. Lab test results showed the experimental plant samples met the quality standards to be certified as a clean produce. The comparative study on a home garden of a local farmer served as a demo-plot for awareness raising and possible adoption of local producers.

INTRODUCTION

Recent food safety, environmental and health concerns due to the overuse of agrochemicals and various unintended consequences have led to promotion of more sustainable production practices for agricultural produce in Vietnam (Ha, 2014a; Phan *et al.*, 2005; Thuy *et al.*, 2012; Van Hoi *et al.*, 2009; Veerapa & Chien, 2011; Wertheim-Heck *et al.*, 2014). The national guideline for Good Agricultural Practice (VietGAP) in agricultural production was therefore developed in early 2008 (Ha, 2011; Nguyen, 2008). This would be seen as a timely effort of the Vietnamese government to address the aforementioned issues in accordance with the recent domestic and export market demands (Dung & Ngan, 2012; Ha, 2011; Simmons & Scott, 2008; Simmons, 2008) and sustainability of agricultural production systems (Ha, 2014b). Given that many concurrent measures should be taken to realise a radical shift from conventional production practices to large-scale production and consumption of clean and/or "safe" produce.

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Those interventions include technical support (Trung, 2005; Veerapa & Chien, 2011), improving market access (Scott, 2006), enhancing "collective action" of local producer groups (Moustier *et al.*, 2010; Naziri *et al.*, 2014; Wang *et al.*, 2012), and awareness campaigns (Ha & Nguyen, 2013; Ha, 2011, 2014b, 2014c), etc.

Field trials on households' lands would be of equal importance to build local capacity, create awareness regarding the adoptability and effectiveness of the clean production practice (Ha, 2014b). Thai Nguyen is one of the major provincial cities in the northern part of Vietnam. Thanks to its preferable climatic conditions and large arable agricultural lands, many specialised vegetable production within the city and peri-urban areas have been developed (Ha & Nguyen, 2013; Ha, 2011, 2014b). The demands by domestic and overseas markets have facilitated a range of support from the local government to assist smallholder farmers to form safe vegetable production groups and/or cooperatives together with technical support, capacity building and certification of produce at the initial stage (Ha, 2011). Leafy radish (*Raphanus sativus* L.)

(Brassicaceae), a small taproot and short-duration radish group (Porcher, 2010), is among the economically important vegetable crops which is produced and consumed in large volume in Thai Nguyen city (Ha, 2011). The objective of this study was to evaluate the effectiveness of plant growth and quality of leaf radish in Thai Nguyen. Results of this study would serve as a demo-plot for raising awareness and thus wider adoption by local farmers. This, in accordance with the aforementioned measures, would contribute to improving quality of life for local vegetable producers via change of production habits, improved production efficiency, income and sustainability.

MATERIALS AND METHODS

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 the experimental leafy radish grown according to the VietGAP guidelines.

Research methods

*** Experimental design**

The experiment comprised two treatments, a control and/or conventional farmers' practice (T1) and an experimental treatment (T2) that applied the 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. A Randomized Complete Block (RCB) design was applied, where each soil bed was considered as one block, to reduce experimental errors. In each sub-plot, nine single replicate plants were chosen to measure growth parameters (Figure 1).

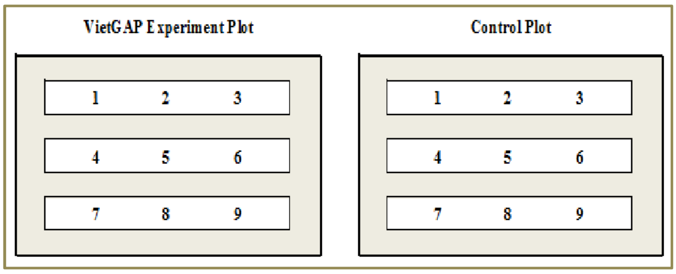

Figure 1. Experimental design for two treatments in two separate subplots. There are 3 soil-beds per each subplot. The numbers indicate the single replicate plants selected for measuring the growth parameters

*** 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); 416.67kg 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 154.16kg 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 83.33kg ha^{-1} and 25 days after sowing with an amount of 70.83kg ha^{-1}. Vegetables in the control treatment were densely sown by the farmers with a purpose of harvesting crops twice. The first time was harvested at week 3 after sowing as a way to reduce plant density. The plants harvested at this stage 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 the later section).

+ 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 leaf radish were applied according to the production guideline of Tran and Tran (2009). 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 (dm^2): measured according to the method of Holtzclaw (2007); and
- Weight per one square meter (kg m^{-2}).

***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 20cm deep. The samples were then put into plastic bags and sealed before sending for lab tests.

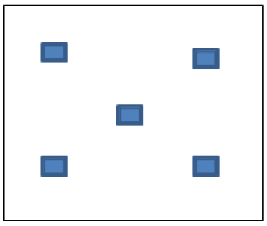

Figure 2. Five diagonal point sampling method for soil (Ha, 2014b)

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 residues at the laboratory of soil and agricultural product quality analyses, Northern Mountainous Agriculture & Forestry Science Institute.

*** 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.

RESULTS AND DISCUSSION

Evaluation of crop growth

Given the experimental cultivar is a "leafy radish" cultivar, which is mainly produced to harvest leaves for cooking and pickling purposes, not for harvesting tuber roots as other cultivars (Ha, 2011; Porcher, 2010). Thus, plant heights, leaf indexes and whole plant weight were the major parameters for analyses of plant growth and the final product evaluation. There was no significant difference in the final plant height and weight between the experimental and control plants. However, leaf number and leaf surface areas of the experimental plants (T2) achieved higher values than those of the control (T1) owing to the balanced fertilizer imputs and proper planting density (Table 1; Figure 3).These criteria are crucial for leafy vegetables as they influence consumers' preferences and "willingness-to-pay behaviour" (Bonti-Ankomah & Yiridoe, 2006; Ha, 2014b).

Table 1. Plant growth of leaf radishes

Treatment	Plant height (cm)	Leaf number	Leaf area (dm^2)	Weight (kg m^{-2})
Experimental	33.11	11.4(b)	11.74(b)	3.20
Control	31.00	08.9(a)	06.01(a)	3.32
P-value	*n.s*	**	***	*n.s*

*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.*

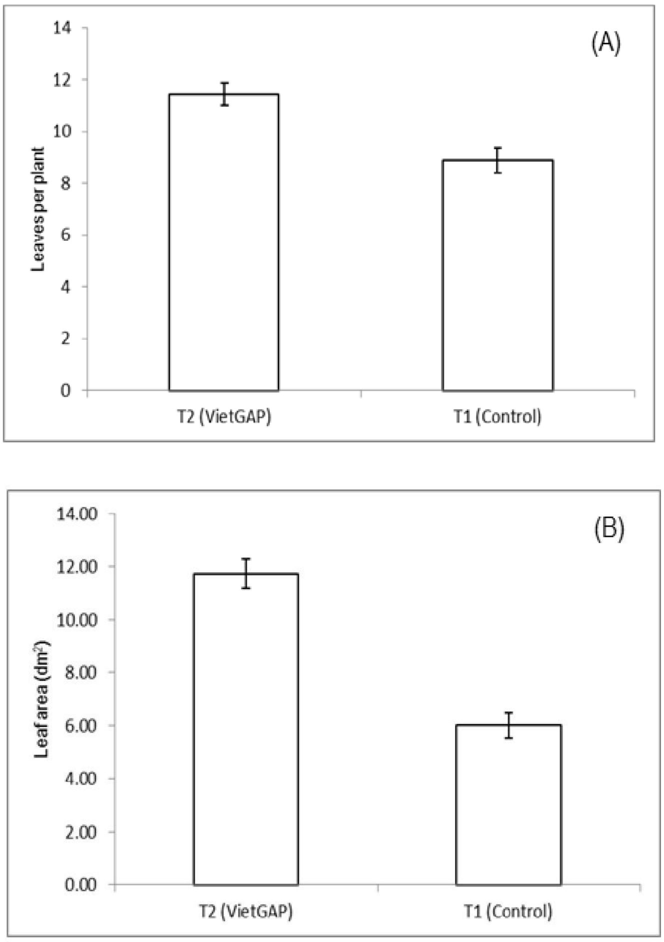

Figure 3. Differences in leaf number (A) and leaf areas (B) between the two treatments. Vertical bars represent Standard Errors (SE)

Figure 4. Difference in plant density between EP (top photo) and CP (bottomphoto)

Figure 4. Rottenness symptoms of leafy radish in the control plot. Photo taken at day 30 after sowing

Due to the high density and possibly the short composting period (about 1 weeks after purchasing chicken manure), on average 1.7 and 7.7 plants of the control treatment were, respectively, affected by rootrot and leaf-rot though the Duo Xiao Meisu (active ingredient: Validamycin A 5%) was applied by the farmers on day 11 after sowing to prevent rottenness (Figure 4). In terms of pest occurrence and damage levels, four types of pests were identified during the monitoring and plant tending, which are Leaf miner (*Liriomyzasativae* Blanchard), Green peach aphid (*Myzus persicae* Sulzer), Black cutworm (*Agrotisipsilon* (Hufnagel) and Diamondback moth (*Plutellaxylostella* Linnaeus) (Figure 5). In the experimental treatment, since after the pests were identified, they were killed manually except for the flea beetles as they were difficult to be caught, the pest number and/or pest damage levels were smaller than those in the control plot though the pesticide BP Dygan 3.6 EC (active element: Abamectin 3.6%) was applied at the 11^{th} day after sowing). As the pest occurrences were much fewer than the Action thresholds[1] in the experimental plot, no bio-pesticide was needed during the production period.

Evaluation of product quality of leafy radish grown according to the VietGAP guideline

The quality parameters according to VietGAP standards include Nitrate (NO_3-) 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.

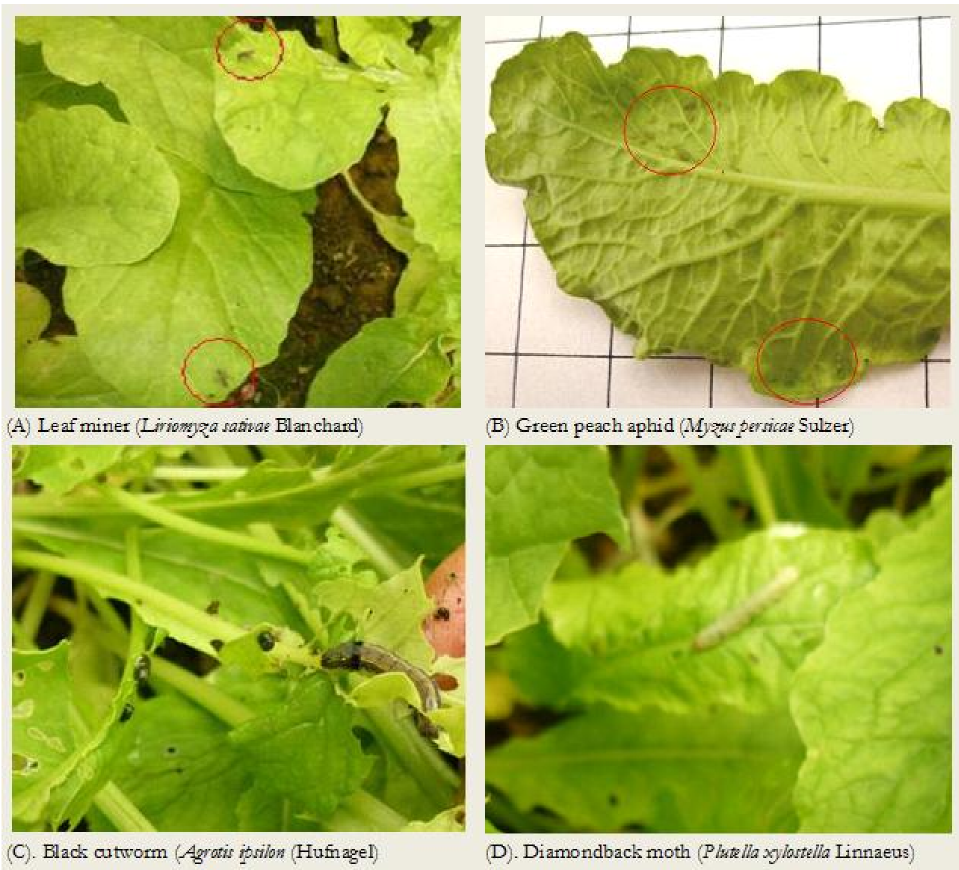

Figure 5. Pest occurrence on leafy radish

[(1)]Action thresholds: Leafminer: 30% leaves affected; Green peach aphid: 30% plants affected; Black cutworm: 5 wormsm^{-2}; Diamondback moth: 30 mothsm^{-2} (MARD, 2010)

Table 2. Analyses of Nitrate, microbial and heavy metal contents in leaf radish samples

Parameters	NO_3- (mg/kg)	Microbial content (CFU/g)			Heavy metal content (mg/kg)			
		Salmonella	Coliforms	Escherichia coli	As	Pb	Hg	Cd
Average value	266.14	0	98.67	2.33	0.090	0.017	< 0.0001	0.007
S.E	0.38	0.00	1.20	0.88	0.012	0.003	-	0.000

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.

The results in Table 2 show that the contents of nitrate, microorganisms and heavy metals were in the safe thresholds.

Table 3. Test results for pesticide residues in leaf radish samples

Parameters	Residue contents in plant samples (mg/kg)			Average (mg/kg)
	Sample 1	Sample 2	Sample 3	
Methyl Parathion	0.016	0.016	0.014	0.015 ± 0.0007
Fenvalerate	< 0.001	0.001	< 0.001	-
Imidacloprid	0.001	0.002	< 0.001	-
Diazinon	0.032	0.035	0.034	0.033 ± 0.0009
Cypermethrin	0.008	0.010	0.012	0.010 ± 0.0012

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

Conclusions

Leafy radish grown according to the VietGAP guideline clearly showed increased growth parameters regarding leaf number and leaf surface area compared to those of the conventional production practice of local farmers. As a leafy vegetable, these are important criteria of consumers' choices. Though plants in the control treatment were grown with high density and were harvested twice, the final average weight per one square meter showed no significant difference with that of the experimental treatment. In addition, due to the high plant density, inappropriate treatment of farmyard manure, imbalanced fertilization and overuse of chemical fertilizers in the control plot, significant ratios of shoot and root rot occurred. Application of the VietGAP guideline for leafy radish in Thai Nguyen city met the national quality standards to be certified as a clean produce. As discussed above, technical support for promoting safe vegetable production would not be sufficient. Rather, simultaneous interventions at different levels with relevant stakeholders (i.e. local government, entrepreneurs, NGOs, farmers, cooperatives, local authorities and relevant government agencies) should be executed to ensure widespread adoption of the eco-friendly production practices and thereby sustainability of the production systems, long-term benefits for local farmers and improved rural lives. Moreover, various bottlenecks have been reported by Ha (2011), Ha and Nguyen (2013) and Ha (2014b). Those include fragmented production, lack of shared vision among individual farmers, shortage of transparency by the local government, poor control of false clean produce in supermarkets, costly and complicated procedures by third party certification, poor market actor linkages, and limited awareness of both producers and consumers, etc. These certainly cannot be addressed at local level by the individual farmers. Therefore, multi-stakeholder collaboration at different levels in promoting clean vegetable production and sales in the research area is required.

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