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Organic Fertilizer Production and Application in Vietnam

Pham Van Toan, Ngo Duc Minh and Dao Van Thong

Abstract

Crop production is an important subsector of Vietnam's agriculture, has an impressive achievement in last 30 years and based on the intensive production with increasing use of chemical fertilizer and pesticide. Consequences are the negative effects on environment and human health and food safety. Organic agriculture has become a trend worldwide and is developing rapidly in the world. In Vietnam the certified organic farming area has expanded since 2012. Organic market revenue in Vietnam is estimated to be at \$132.15 million a year. Most Vietnamese certified organic products are exported to international markets. Organic agriculture using organic fertilizer is one of Vietnam government's priorities. Vietnam already produced organic fertilizer from different materials by using different production technologies, but the production capacity is small and does not meet the demand for organic agriculture. Vietnam government encourages, promotes the organic fertilizer production, application and has the policy to develop the organic fertilizer in Vietnam.

Keywords: Vietnam agriculture, organic agriculture, organic fertilizer

1. Introduction

Vietnam is one of the most biodiversity countries with 13,200 terrestrial plant species, around 10,000 animal species and 3000 aquatic species. The country also has an extremely long coastline extending over 3260 km, but Vietnam is the country most vulnerable to climate change and frequent natural disasters in Southeast Asia. Agriculture is the most important economic sector in the country and more than 70% of Vietnam's population is dependent on it. In the period 2000–2018, the output value of agriculture, forestry and fisheries continued to increase with the average rate of more than 4%/year. In terms of value-added of agriculture, the average growth rate of 3.7%/year of GDP in that period is relatively high and stable. The structure of agricultural production has gradually shifted to the higher efficient sector which is associated with market demand. Agricultural production has gradually improved to meet domestic needs. Despite market fluctuations, natural disasters, complicated epidemics, food production continues to grow in absolute value. Agriculture, forestry and fisheries are the only sectors of Vietnam to have consecutive trade surplus, even in the phase of difficult economic state. It shows the evident comparative advantages of Vietnam's agriculture demonstrating the important role of agriculture in the balance of payments of Vietnam's economy.

Crop production plays a very important role in Vietnam's agriculture. After more than 30 years of renovation, the crop production subsector has made an important contribution to bringing Vietnam from a food shortage and importing

food country to become one of world leading agricultural exporters. The economic value of the crop production sub-sector currently contributes over 70% of the agricultural sector's GDP and nearly 50% of the agricultural-forestry-fishery export value, contributing to hunger elimination, poverty reduction, food and social security. The crop production is now continuing to develop towards commodity production, high quality, sustainable production, climate change adaptation and export-oriented. According the report of ministry of agriculture and rural development in 2018, the export turnover of agricultural products in crop production sub-sector reached 18.9 billion USD of the total 40 billion USD of agricultural sector exporting value. Among the 10 major export commodities (over 1 billion USD) of the whole sector, there are seven commodities from crop production as rice, coffee, cashew, fruits, vegetables, rubber, cassava and pepper. Export results achieved in 2018 affirmed Vietnam's position as an exporter of agricultural products, ranked fifteenth in the world in export value and exported to 180 countries and territories around the world [1].

Crop production growth in Vietnam is based on intensive natural resource, increasing use of fertilizers, plant protection chemicals. While achieving economic targets, agricultural production causes adverse environmental effects, imbalance and depletion of natural resources. Weaknesses in the management of water resources and agricultural residues also cause increasing pollution and greenhouse gas emissions. Pollution has started to impact on soil fertility and yields, the effectiveness of chemicals in combating pests and disease, farmer health, environmental health and the safety of food. Meanwhile, the wasteful use of inputs is a drag on farm profitability. Though the incidence and impacts of agricultural pollution in Vietnam remains limited, but more has started emerging. Meanwhile, the Vietnamese has become increasingly aware of the human and environmental health problems that agricultural pollution is generating. Organic production used organic fertilizer and is one of target goal of sustainable development of crop production in Vietnam.

2. Crop production and fertilizer, pesticide consumption in Vietnam

2.1 Crop production achievement

In 2016 the total crop production area in Vietnam are 11,527,000 ha, in which rice area is 4,136,000 ha and others annual crop planting area is 2,852,000 ha. Perennial crop cultivating area is 4,539,000 ha includes the key commodity crops like rubber, coffee, cashew, pepper, tea and fruit trees [2].

In general, the yields of major crops are stable in last 5 years. The average yield of major food crops is about 5.5–5.8 tons/ha for rice, 4.4–4.8 tons/ha for maize (**Figure 1**) and industrial crops is 19–19.5 tons/ha for cassava, 2.4–2.5 tons/ha for coffee, 2.2–2.5 for rubber, 0.7–0.8 for cashew (**Figure 2**). In 2018, the vegetable and fruit production in Vietnam grow rapidly and reach the exporting value of 3.8 billion USD and increase 9.2% to year 2017. Vietnam is the biggest pepper exporter in the world with the amount of more than 200,000 tons/year. The average yield of Vietnamese pepper is 2.2–2.5 tons/ha and 2.6-fold higher as compared to average yield of pepper all over the world.

Despite some objective difficulties, key agricultural products (coffee and cashew) still maintained high export values. Export results achieved in 2018 (**Figure 3**) affirmed Vietnam's position as an exporter of agricultural products, ranked fifteenth in the world in export value and exported to 180 countries and territories around the world [1].

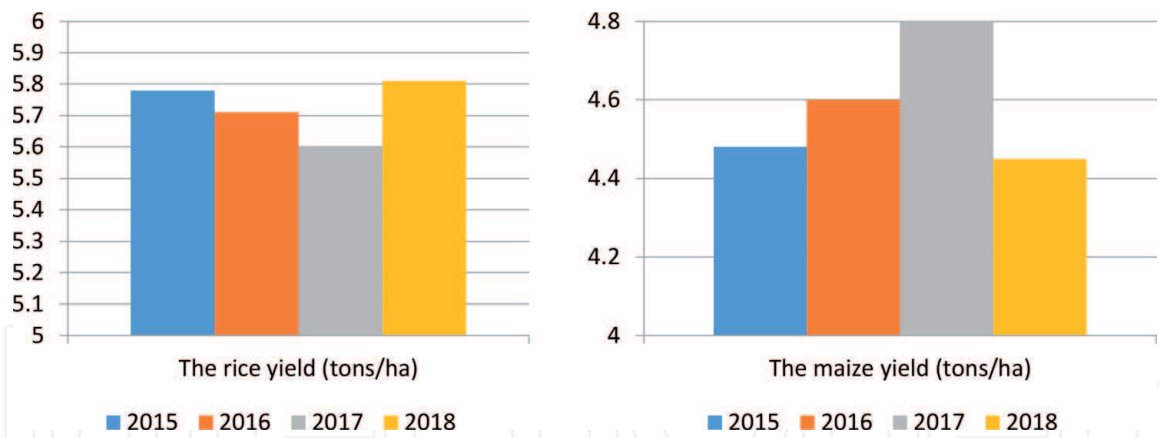


Figure 1.
 The yield of some food crops in Vietnam.

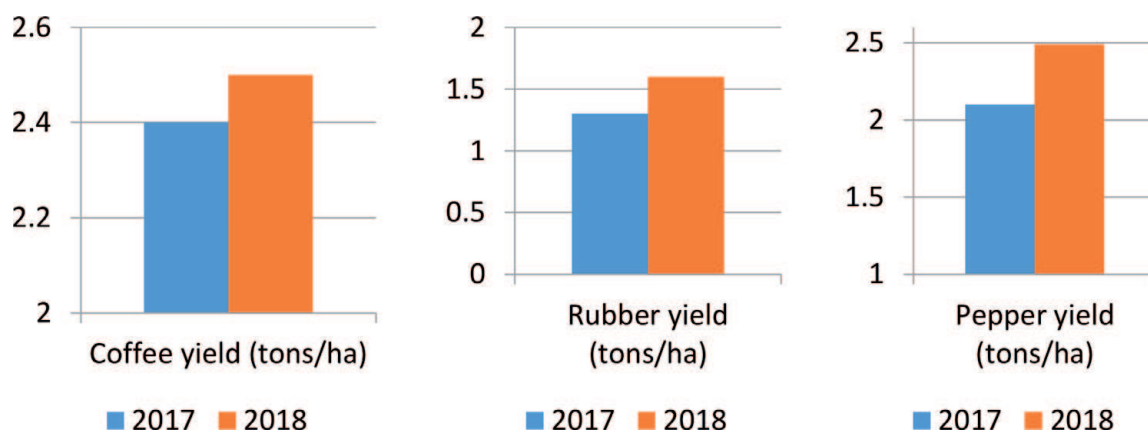


Figure 2.
 The yield of some major industrial crops.

2.2 Fertilizer and pesticide consumption

Together with the trend of agricultural intensification, the use of inputs, especially fertilizers and pesticides for crops, also increased very quickly in the past two decades. The country has imported between 3.5 million and 4.5 million tons inorganic fertilizers per year since 2000. Urea imports reached a peak in 2000–2004, before declining but amounts of imported ammonium sulfate and potassium have tended to increase since. From 1985 to 2005, the rate of fertilizer consumption of nitrogen, phosphorous, and potassium increased by about 10% per year, peaking at 25 million tons in 2005. Fertilizer use for crops has varied among and within provinces, but generally increased in volume over time. Fertilizer application rates vary greatly, depending on the types of crops, varieties, cropping seasons, locations, soil types, and forms of application. Overall, fertilizer use in crop cultivation has been increasing. In general, crop requiring the most fertilizer application is rice, accounts for approximately 65% of total fertilizer demand, followed by corn crop with 9%. Short duration growing crop such as sugarcane, peanuts, soybeans, cotton, vegetables etc. use 6% of fertilizer; the other plants including rubber, coffee, tea, pepper, cashew, fruit, etc. account for 20% (**Figure 4**).

There are three main cropping seasons in Vietnam: Winter-Spring from late November to March of the following year, Summer-Autumn from April to August and Autumn-Winter from late August to late November. Agricultural production mainly concentrates in the Winter-Spring season. The demand in Winter-Spring crop accounts for 49% of total fertilizer demand per year, the other two seasons have relatively equal demand of about 25% of total demand. Fertilizer demand in

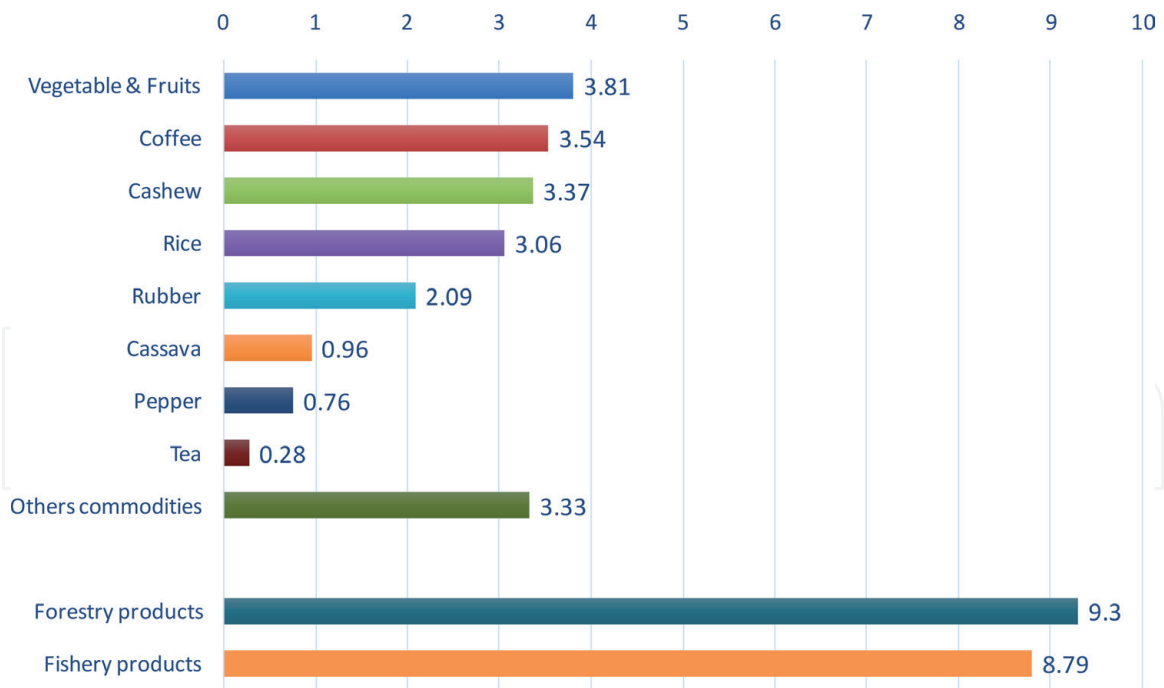


Figure 3. Export value of some agricultural commodities in 2018 (source: Vietnam Customs [3]).

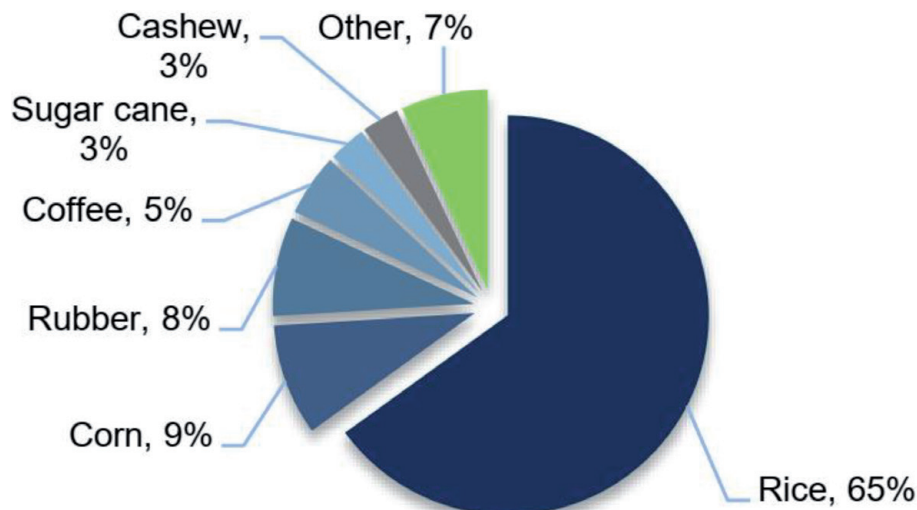


Figure 4. The fertilizer use by crop in Vietnam (source: Tin [4]).

Northern Vietnam is clearly separated by different time of a year. While Summer-Autumn season takes up only 6% of total demand that of Winter-Spring season is up to 58% of fertilizer demand. Fertilizer demand in Central Vietnam and Southern Vietnam don't have that difference and is relatively stable throughout the year. Briefly, Winter-Spring has seasonally highest fertilizer demand (**Figure 5**) [4].

Annually, Vietnamese farmers spend about VND 110.000 billion (about USD 5 billion) on fertilizers. Compared with nearby countries, Vietnam fertilizer consumption is only lower than China in terms of fertilizer use dosage. Vietnam farmer apply NPK fertilizer of dosage 297 kg/ha. The Vietnam fertilizer market was estimated at USD 228.1 million in 2017 and is expected to reach to USD 280.9 million by 2023, growing at a CAGR of 4%. Currently, the market is less regulated, less technologically, highly competitive, and has good opportunities for growth [5].

Similar to fertilizers, the consumption of pesticides in Vietnam has increased dramatically in the 2 past decades together with the intensification of the agricultural

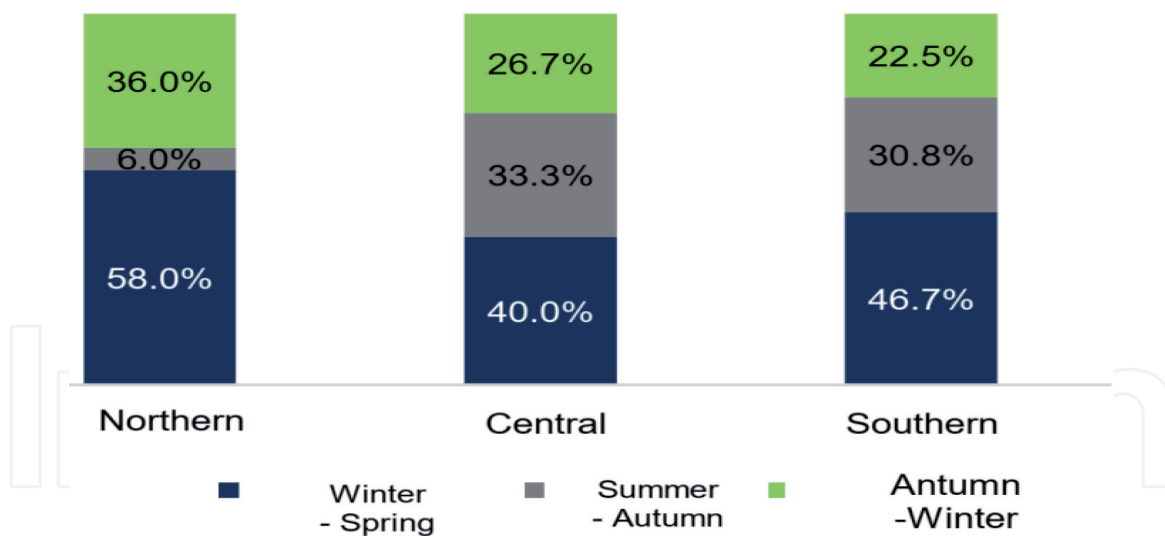


Figure 5.
 Fertilizer demand by season and region (source: Tin [4]).

sector. In 1981–1986, Vietnam imported around 6500–9000 tons of pesticide active ingredients, then increased to 13,000–15,000 tons/year in 1986–1990, to 20,000–30,000 tons/year in 1991–2000, to 33,000–75,000 tons/year in 2001–2010 and up to approximately 100,000 tons/year around 2015 [6]. Along with that trend, the import value of pesticides increased quickly from around US \$472 million in 2008 to US \$537 million in 2010 and nearly US \$700 million in recent years [2]. In 10 years (2000–2011), the number of pesticides registered and used in Vietnam has increased 10 times. In 10 years (2000–2011), the number of pesticides registered and used in Vietnam has increased 10 times. Before 2000, the number of active ingredients was around 77, corresponding to 96 trading products and increased in 2011 up to 1202, corresponding to 3108 trading products [7].

Vietnam, as previously noted, has achieved high rates of growth in agricultural output over the past decades, but this accomplishment has been at a heavy cost to the environment. The sector’s increasing use of land and synthetic inputs has accelerated deforestation, biodiversity loss, land degradation, water pollution, and greenhouse gas emissions. Saddled as it is with high expectations, Vietnamese agriculture will need to produce more from less going forward. Maintaining high output growth under changing climate and economic conditions may require a strategy of intensification, sparing not only time and labor, but also land and water, pesticides and fertilizer.

Recently, the Vietnamese government has policies to shift away from production to focus more on quality, value addition and sustainability. This strategic shift was highlighted in Decision no. 899/QĐ-TTg dated 10th June, 2013 on approving the plan of restructuring the agricultural sector towards improving added value and sustainable development. The agricultural restructuring plan (ARP) defines sector goals in terms of the triple bottom line of economically, socially, and environmentally sustainable development. It lays out expected changes in the roles and spending patterns of the government in the sector and discusses the need to work with other stakeholders, including in the private sector. There are currently many initiatives aiming in these directions. Yet achieving the shift these represent on a large, sector-wide scale, will require important changes in certain economy-wide and sector-specific policies and, over time, major changes and additions to the core institutions servicing agriculture. It calls for an ambitious and ongoing process of learning and experimentation, and several potential directions are offered below for consideration. Various programs have been initiated in Vietnam to promote sustainable production and natural resource management practices.

3. Vietnam organic agriculture

Organic agriculture has become a trend worldwide. Organic agriculture is developing rapidly in the world with 57.8 million ha and the market potential worth nearly US \$90 billion [8]. In Vietnam, organic agriculture journey ultimately led to establishment of The Vietnam Organic Agriculture Association (VOAA) within the first congress of organic agriculture development held in Hanoi in May 2012. From these important steps, the certified organic farming area has expanded during last 5 years in Vietnam. According to the Research Institute of Organic Agriculture (FiBL) and the International Federation of Organic Agriculture Movements [8], the certified area of organic agricultural production in Vietnam increased rapidly, from 43,000 ha in 2014 to 118,000 ha in 2016 [9].

Up to now, 33 of the 63 provinces and cities nationwide have developed organic farming and aquaculture models. About 60 groups, corporations and production establishments have invested in organic agriculture in Vietnam. Though organic farming area is modest as compared to the total farming area in Vietnam, businesses and organizations are applying international organic standards and certified organic products are being exported to many markets, including the US and EU. Organic market revenue in Vietnam is now estimated to be at \$132.15 million a year, with spending for such products in the north higher than that in the south. Most Vietnamese certified organic products are exported to international markets such as Taiwan, Singapore, Japan, EU countries, the United States and Australia. Nearly 80 domestic companies have been certified by the EU.

In 2015, the Ministry of Science and Technology (MOIT) issued TCVN 11041: 2015 to guide the production, processing, labeling and marketing of food produced by organic methods. Within international collaborative projects or by private and/or foreign enterprises that based on different standards such as: The Participatory Guarantee System (for organic vegetable); EU, USDA, JAS standards (for organic tea, rice, vegetables, fruits) most of Vietnamese organic agricultural products are based on the foreign standards but not according to the TCVN 11041: 2015. In 2018, Ministry of Science and Technology (MOIT) has officially issued the first standards system for The National Organic Agriculture Standards (production, cultivation, animal husbandry, processing and labelling of organic products) putting an end to any argument related to actual criteria of organic agriculture, as well as responding to expectations of farmers and enterprises in this field. With referred to IFOAM's standards and standards of several countries with advanced organic agriculture including the U.S., EU, Japan, Thailand, and China, the new the Vietnamese Organic Agriculture Standards is in line with the current standards adopted by the ASEAN countries under the ASEAN Standard for Organic Agriculture. This is the important reference for farmers and producer to practice organic agriculture and for appropriate authorities to inspect, control the organic agricultural production. The standard is supposed to promote agricultural production in general and organic agriculture in particular, helps add more values to products improve quality of domestic and export goods.

In 2018, the government issued Degree 109/2018/ND-CP providing preferential terms for small enterprises, cooperatives, farms and farmer households engaged in organic agriculture. According to the decree, the government will fund all organic product certification costs and cost of verifying areas eligible for organic production. Farmers and cooperatives can also enjoy the government's agricultural promotion assistance in organic production training. This decree which takes effect on October 15, is actually an important legal framework for organic farming, and on that basis, mobilizes all economic sectors, enterprises, cooperatives. The Government of Vietnam always strongly supports efforts to develop a sustainable

and environmentally friendly agriculture, improving the productivity and competitiveness of products, including organic agricultural products. In recent years, Vietnam has tried to complete national organic standards, comprehensive legal framework for production, certification and quality control of organic agricultural products and support policies to promote organic agriculture development.

4. Organic fertilizer production in Vietnam

In Vietnam organic fertilizers are fertilizers produced from the main raw materials that are natural organic substances (excluding synthetic organic substances), processed through physical or biological methods. Organic fertilizer composed mainly of organic substances and nutrients derived from organic materials (Degree No 108/ND-CP). In combination with mineral nutrition elements or beneficial microorganisms, organic fertilizer can be called as organic mineral fertilizer or biological-organic fertilizer or bio-organic fertilizer. According Degree No 108/ND-CP, organic fertilizer should be free of Salmonella while the density of *E. coli* and Coliform is lower than 1.1×10^3 MPN/g. The heavy metal concentration in organic fertilizer do not exceed 10.0 ppm for as, 5.0 ppm for Cd, 200.0 ppm for Pb and 2.0 ppm for Hg. The main quality requirement of organic fertilizer is showed in Table 1.

4.1 Organic fertilizer production technology

The organic fertilizer production line is commonly used to process different fermented organic substance into biological organic fertilizer. In Vietnam, organic fertilizers are now produced domestically in two ways: traditional composting and industrial production.

Traditional composting methods are mainly used on farm scale based on waste materials or crop residues collected from livestock and household farming. The traditional composting procedures take as long as 4–8 months to produce finished compost, by which organic residues are mixed well, and mineral elements can be added, and then composted into piles.

The industrial production of organic fertilizer is production of compost in industrial scale by using the rapid composting technology. Rapid composting methods offer possibilities for reducing the processing period up to some weeks. The industrial organic fertilizer production needs to invest in infrastructure, equipment lines with the large production capacity. Currently, there are in Vietnam 180 enterprises granted licenses to produce organic fertilizers, accounting for 24.5% of the total production licenses granted by authority agency with the production facilities about 2.5 million tons/year, accounting for 8.5% of the total capacity of domestic fertilizer production [10].

In Vietnam, rapid composting methods are used in early 2000 based on guide line of FAO on the on farm composting methods [11], in which the compost is regulated at 10% of oxygen saturation, the moisture from 50 to 55%, the pH from 5.5 to 7.0, the carbon-nitrogen (C:N) ratio around 20:1, the size of the parent materials from 5 to 10 cm. As compost enrichment the biomass of decomposing bacteria, fungi added at the rate of 500–1000 g/tons of compost materials [12].

There are several composting technologies in Vietnam as following: pile composting, box chamber composting, open-furrow composting with turning and aeration and enclosed vessel composting with mechanical agitation and aeration. Generally, less capital investments in equipment mean less capacity to treat wasted organic materials. These materials also need longer composting periods to reach

Kind of organic fertilizer	Quality parameters	Measured unit	Standards
Traditional organic fertilizer	Organic matter (OM)	%	≥20.0
	C/N		≤12.0
	Moisture	%	≤30.0
	pH H ₂ O		≥5.0
Bio-organic fertilizer	Organic matter (OM)	%	≥15.0
	Density of beneficial microbes or	CFU/g	≥1.0 × 10 ⁶
	Number of infective propagules of mycorrhiza	IP/g	≥10
	Moisture	%	≤30.0
	pH H ₂ O		≥5.0
Biological organic fertilizer	Organic matter (OM)	%	≥20.0
	Humic acid, fulvic acid or	% of OC or	≥2.0
		%	≥3.5
	Other biological substances	According the standards or regulation	
	Moisture	%	≤30.0
	pH H ₂ O		≥5.0
Organic mineral fertilizer	Organic matter (OM)	%	≥15.0
	Content of total nitrogen available phosphorus and potassium	%	≥8.0 ≤ 18.0
	Content of each total nitrogen, available phosphorus and potassium	%	≥2.0
	Moisture	%	≤25.0
	pH H ₂ O		≥5.0

Table 1.
Quality requirements of organic fertilizer in Vietnam.

maturity. In contrast, more capital investments in equipment mean more capacity and efficiency for composting organic materials. In general, domestic organic fertilizer production facilities now invest in simpler production technologies. Basic organic fertilizer production line equipment including excavators; turning machine; crusher and screen; drying system; additive pumping system, microbial spray; weighing and packaging system of finished products. Most equipment lines are created in the country. Some organic fertilizer production facilities from waste, livestock waste, and crop residues have invested in the installation of advanced equipment lines from developed countries like Germany, Belgium, Netherlands, and Japan. Advanced production technologies allow to shorten the composting processing time by precisely adjusting the composting temperature, moisture, pH combined with the use of cellulolytic microorganism to create high quality organic fertilizer products. In addition to the mechanization and automation of the process of collecting, treating, supplying, crushing and sifting materials; the process of drying, granulating and bagging in modern production lines allows increasing labor productivity, production capacity and reducing production costs.

4.2 Materials for organic fertilizer production

The raw material of organic fertilizer can be used as agricultural waste, animal waste, industrial waste, household waste, municipal sludge and peat after

safety disposal and fermentation, these materials are made into organic fertilizer. Thus, organic fertilizer contains a variety of organic acids, peptides, and rich nutrients including nitrogen, phosphorus and potassium. Not only provide comprehensive nutrition for crops, also with long fertilizer effect, which can increase and update the soil organic matter and promote microbial breeding, improve soil physical and chemical properties and biological activity [13]. The sources of materials for organic fertilizer production in Vietnam are now diverse and abundant, including waste from animal husbandry, aquaculture, agricultural product processing, crop residues, peat, and domestic waste. Microbial inoculants, mineral elements, biological supplements to improve the quality and efficiency of fertilizer can be used [14].

According Vietnam General Statistic Office in 2015, Vietnam produced 45.22 million tons of rice, 5.28 million tons of maize, 10.67 million tons of cassava, 1.445 million tons of coffee and 18.320 million tons of sugar cane. Based on crop biomass and product, (Trinh) [15] calculated the agricultural waste approximate 76 million tons including 45.22 million tons of rice straw, 8.73 million tons of rice husk, 4.04 million tons of sugarcane bagasse (SCB), 6.33 million tons of maize by-products, 1 million tons of coffee shell and 10 million tons of vegetable by-products [15]. Agricultural waste contained not only the carbohydrate composition and plant essential nutrition like NPK and microelement [14] (**Table 2**).

As of April 2017, Vietnam has 2,519,411 buffaloes; 5,496,557 cows; 28,312,083 pigs and 341,892,000 poultry and estimated to release about 85 million tons of solid waste [1]. Animal waste has organic content; elements plurality of minerals is quite high and contains almost medium micro nutrients which help soil fertility [14], **Table 3**.

Vietnam exported every year more than 7 million tons of seafood products and made more than 5 million tons of seafood by-products that can be used as raw material for organic fertilizer production [15]. Seafood processing by product is protein, lipid and micro element (**Table 4**).

At present Vietnam has no standard for raw materials of organic fertilizers in regulations regarding fertilizer production, distribution, and use [16]. Varied raw materials and poorly controlled manufacturing could cause a wider range of nutrient content of domestic “organic fertilizers” compared with that of the imported ones.

According Hien [14], Vietnam has about 7.1 billion cubic meters of peat, many mines are concentrated in the Mekong Delta with average concentration of C at 17.29% N at 1.2%, P₂O₅ at 0.16%; K₂O at 0.3%; pH: 4.5 and humic acid at 12.8% (**Table 5**). This is a great source of raw materials to supply organic matter to produce organic fertilizer. In addition, seaweed around the coast of Vietnam is a rich source of potassium, micro nutrients or phosphorite ore in many Northern

	C:N ratio	OM	C	N	P ₂ O ₅	K ₂ O	CaO	MgO	SiO ₂ (%)
Rice straw	78-88		54-56	0.64-0.69	0.05-0.11	2.0-2.1	0.42-1.2	0.3-0.52	4.9*
Rice hull	70-106		39-52	0.48-0.70	0.11-0.46	0.28-1.3	0.21-0.34	0.09-0.4	12.7
Rice bran	18-22	67-78	50-55	2.0-2.4	3.60-4.47	1.43-2.45	0.13-0.35	1.11-1.78	
Corn stalks	68		55	0.81	0.37	1.61	0.35	0.48	4.1
Sorghum stalks	73		53	0.73	0.25	1.94	0.60	0.62	3.9
Soybean stems	40		51	1.28	0.14	1.63	0.18	0.15	2.9
Peanut stems	30		42	1.30	0.37	1.31	1.97	1.15	2.5
Peanut hull	28		49	1.73	0.37	1.27	1.96	0.77	1.8
Coconut shell	37	96	53	1.43	0.18	0.50	0.36	0.20	

Table 2.
 Composition of some crop residue (source: Wang et al. [13]).

	C:N ratio	C (%)	N (%)	P ₂ O ₅ (%)	K ₂ O (%)	CaO (%)	MgO (%)	Cu ---mg/kg---	Zn
Cattle	19-28	25-40	0.89-2.1	0.55-4.81	1.6-3.5	0.20-2.0	0.83-2.1	20	122
Goat	16-21	36-48	1.6-2.4	1.5-5.27	1.9-4.0	1.3-5.4	0.7-1.40		
Swine	17-31	4-54	1.6-2.9	1.0-7.1	0.16-1.93	0.8-9.0	0.15-1.7	510	624
Egg chicken	9-14	27-32	0.6-2.9	1.4-6.8	0.77-3.8	0.73-8.2	0.3-1.8		
Meat chicken	11-28	25-47	1.8-2.5	2.11-6.6	1.41-3.6	1.57-21	0.5-1.5	80	724

Table 3.
Composition of some animal waste (source: Wang et al. [13]).

Concentration (%)	Head	Backbone	Tail	Oar
Protein	42.68	37.91	30.36	37.23
Lipid	28.79	37.91	45.10	41.57
Ash	23.13	20.11	15.24	18.47
Carbohydrate	5.4	4.57	2.76	3.70

Table 4.
Chemical composition of catfish processing byproduct (source: Trinh [15]).

provinces such as Thanh Hoa, Hoa Binh, Thai Nguyen, Bac Can, Lang Son and Cao Bang is an additional source of phosphorus and nutrient elements in the organic fertilizer production process.

4.3 Organic fertilizer production and state management

According to the Department of Plant Protection of MARD, until December 2017, in Vietnam the number of organic fertilizers including organic mineral fertilizer and bio-organic fertilizer produced and traded were 713, accounting for 5% of the total fertilizer products. There were 180 companies permitted for producing organic fertilizer in Vietnam with the total production capacity of 2.5 million tons/year, accounting for 8.5% of total fertilizer production capacity in whole country. The demand of organic fertilizer is approximately 6 million tons/year and will be increase in the future [10]. In the period 2015–2017, Vietnam exported organic fertilizer to 34 different countries with the export volume in 2017 approximately 76,000 tons, up more than six times compared to 2015 (12,000 tons). In 2015, there were 17 organic fertilizer products exported, in 2016 increased to 56 products and in 2017 there were a total of 75 organic fertilizer products exported abroad. In 2015, there were only two organic fertilizer exporters, in 2016 there were 12 enterprises, by 2017 there were 19 enterprises participating in exporting organic fertilizers.

By the end of 2016, there were 24 Vietnamese standards (TCVN) issued related to organic fertilizer, which focused mainly on testing methods to determine the density and biological activity of microorganisms in the compost enrichment inoculants and content of limiting factors in organic fertilizer. Basically, the standard system of fertilizers in general and organic fertilizer in particular has been built since the 1990s of the previous century, but still lacks in quantity, quality and unresponsive practical requirements. Some additional biological substances in fertilizers such as amino acids, vitamins, plant growth regulators, etc. do not have standard methods for testing and controlling fertilizer quality. Some standards, especially standards related to bio-organic fertilizer have not been reviewed,

Parameters	Mining area			
	North Vietnam	Central South Vietnam	Cuulong delta	Average
pH KCl	3.47 (2.40–6.40)	4.12 (3.74–4.58)	3.95 (3.18–4.78)	3.97 (2.40–6.40)
OC (%)	19.80 (8.58–43.08)	21.81 (16.45–26.54)	29.75 (10.71–40.69)	22.55 (8.58–43.08)
OM (%)	43.56	47.98	65.45	49.61
Total N (%)	0.45 (0.20–0.72)	1.35 (0.88–1.91)	0.96 (0.34–1.54)	1.12 (0.20–1.91)
Total P ₂ O ₅ (%)	0.054 (0.03–0.09)	0.162 (0.08–1.50)	0.062 (0.02–0.13)	0.141 (0.02–1.50)
Total K ₂ O (%)	0.039 (0.02–0.06)	0.136 (0.10–0.20)	0.652 (0.33–2.26)	0.191 (0.02–2.26)

Table 5.
Composition of peat in Vietnam (source: Hien [14]).

updated, modified to suit the reality and development of production and use of organic fertilizers.

Currently in Vietnam, there are 12 permitted laboratories for testing of quality criteria, limiting factors in organic fertilizers and compost enrichment inoculant. In general, the testing laboratories have met the quality control requirements for general fertilizers and organic fertilizers in particular. However, there are still many issues that need to be considered to improve the effectiveness of fertilizer quality control.

Over the years, Vietnam has achieved certain results in the development of production and use of organic fertilizers. Besides the achieved results, the organic fertilizer industry still faces many difficulties and limitations to be able to develop effectively and sustainably, namely:

- a. Farmers are now using inorganic fertilizers because of effectiveness, but not paying attention on the long-term harms of inorganic fertilizer abuse such as soil degradation, environmental pollution, toxic residues in agricultural products, etc.
- b. The number of producer of inorganic fertilizer at the present is many times higher than organic fertilizers, which is one of the causes of serious imbalance in production and use of fertilizers.
- c. Production technology of organic fertilizer is low with simple and old equipment resulting in low performance and efficiency.
- d. There are no specific policies to encourage production and use of organic fertilizers.
- e. Agricultural extension programs to introduce and promote the use of organic fertilizers have not been given adequate attention. There are no specific programs of the state or enterprises to support farmer to use organic fertilizers.
- f. The set of standards for fertilizer quality control is still incomplete, so it still faces many difficulties in the quality management and registration of organic fertilizer.

5. Vietnam policy on the organic fertilizer production and application

In 2018 ministry of agriculture and development setting up the program to encourage the organic fertilizer production and application with the aim to develop the organic fertilizer contributing to promoting crop production in the direction of enhancing added value and protecting the environment. It concentrates on the followings:

- Effective using the agricultural by-products to produce organic fertilizer for domestic consumption and export;
- Increasing the organic fertilizer at least 3 million tons/year for domestic consumption and export of 0.5 million tons/year;
- Selection and adoption of advanced technology of organic fertilizers production in accordance with the Vietnam conditions;
- Increase the ratio of organic fertilizer products to total fertilizer products from 5% currently to 10% in the near future;
- Encouraging and mobilizing to ensure at least 50% of the fertilizer producer in the country commit to invest in the development of organic fertilizer production and complete the standards, the testing laboratory in service of state management on the organic fertilizer quality control and insurance.

The solution to carry out the program of encouragement of the organic fertilizer production and application is determined as follows:

1. The government should review the legal documents on fertilizer and organic fertilizer to create a suitable legal system for state management of organic fertilizer, including specific contents on further encouraging the production and use of organic fertilizer in the Law on crops production and supporting policies on land use, taxes, credit as well as promotion of application new technologies. In the long term, it is necessary to setting up the priority policies to encourage the production and use of organic fertilizers using available materials from crop production, animal husbandry, food processing waste and other natural material like peat, seaweed etc.
2. The government will develop a national plan on fertilizer production based on the balance between inorganic and organic fertilizers to pushing the gradually increase of proportion of production and use of organic fertilizers. In nearly future it needs to implement a survey projects on the production and use of organic fertilizers for each region in whole country, with special emphasis on local available materials, the feasibility of transferring advanced production technologies, practices of using organic fertilizers, etc. to have a scientific basis to develop a strategy for developing organic fertilizer.
3. Based on the results of reviewing the system of standards of fertilizer, the responsible ministries should speeding up the amendment, supplement and completion of standards for organic fertilizer supporting the quality control and quality assurance (QC&QA) of organic fertilizer. In addition, the testing laboratory system should be reviewed, evaluated and step by step upgraded to

meet the requirement as prescribed by law. The government will invest for the fertilizer testing laboratories in the North, Central and South regions for the quality control and quality ensurance of fertilizer and organic fertilizer.

4. Building up and implementation of new policies to encourage and develop the link chain in crop production and organic fertilizer production, application as well as encourage the organizations and individuals to invest in research, technology transfer, mastering and application of advanced technologies for organic fertilizer production based on Vietnam's available raw materials.
5. Vietnam will promote the research, transfer and application of advanced technologies for organic fertilizer production with priority on environmentally friendly technologies and technologies using locally available materials and tools as well as technology increasing the efficiency use of organic fertilizer, etc. contributing to increase sustainable crop productivity.
6. Regarding inspection and state management of fertilizers quality control and quality assurance (QA&QC), the government will innovating the inspection, examination and compliance with regulations on fertilizer management in all stages from laboratory testing, field trial, production, trading and using fertilizers. The Ministry of Agriculture and Rural Development will organize an specialized inspection forces to check the quality of fertilizers produced and commercialized, thoroughly handling fertilizer producer that fail to meet the conditions for fertilizer production or that have the products not been permitted for the commercialization. The responsible local authorities should be strengthened in the inspection, supervision of production, business and fertilizer use.
7. The government will develop the training materials for management agencies, organizations and individuals producing, trading organic fertilizers as well as organize the training course on the implementation of legal documents and management skills for responsible local authorities. The agricultural extension will innovate the guide on using organic fertilizer through practical models and field days in coordinating local authorities, fertilizer producer to guide the farmer to use organic fertilizer.
8. Regarding the communication, the mass media will coordinate with fertilizer associations, Farmers' Association, Gardening Association, universities, research institutes, etc. propagating and guiding the farmer to produce traditional organic fertilizers based on reuse of agricultural byproducts, animal manure and household waste as well as propagating and replicating advanced models in production, business and use of organic fertilizer. The farmer should understand the role and long-term effects of the use of organic fertilizers via communication.
9. Vietnam government encourages and promotes the international cooperation on organic fertilizer development in Vietnam and will actively participate in the international organic fertilizer market. The international cooperation in the technology transfer in organic fertilizer production from oversee will be strengthened. Vietnam will participate in international treaties and agreements on organic agriculture and organic fertilizer, both multilateral and bilateral with countries and organizations in the region and the world.

6. Conclusion

Vietnam is a tropical country and has enormous progress and remarkable growth in agriculture contributing actively in poverty reduction, national food security, and social stability in last 30 year. Vietnam faces bright opportunities in both domestic and international markets; yet effectively competing in these will depend upon the ability of farmers and firms to deliver products with reliability, and with assurances relating to quality, safety, and sustainability. Organic agriculture using organic fertilizer is one of Vietnam government priority. Vietnam has good condition for organic fertilizer production and application, but the production capacity is small not meet the demand for organic agriculture. Vietnam government promotes the organic fertilizer production and application and has the policy to develop the organic fertilizer in Vietnam.

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