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Introduction

Before the large use of chemical fertilizers, farm-yard animal manure (FYM) has been used as the primary source of nutrients in crop production. Manure supplies nutrients to the soil, and improves soil health by increasing soil organic matter and promoting organisms. The soil structure and its water holding capacity are improved after incorporating manure into the field. Manure application rates should be specific to the cultivated crops and type of soil; applications should also be scheduled to fit the farming operation and the season. The application level must be carefully estimated; an excess of animal-waste organic matter in the parcel could pollute surface and ground water, increase the toxicity to livestock consuming the crops, and affect the plant growth. The planning of manure applications is also important; spreading during winter and early spring need to be avoided; frozen ground and rain-fall are inadequate for spreading and would lead to runoff and leaching of nutrients into water re-sources.

Whenever manure is applied on food crops, safety precautions should be taken to avoid contamination that might result to human illness. The pathogens of most concern that can be found in livestock ma-nure are Escherishia coli or Salmonella. To avoid the risk of contamination, fresh manure should not be applied within 60 days of harvesting food crops. In fact, fresh manure, especially if it is from young animals such as dairy calves, should always be used with extreme caution and should be composted at least two months to reduce potential of disease pathogens.

Fertilization in local cropping systems

In Vietnam, agriculture production facing to a problem is intensive in order to get high quantity. Amount of fertilizers has been used quite high. Average amount of inorganic fertilizers using in one hectare of agricultural land was 190 kg (N+ P_2O_5 + K_2O) in 2000 and increased year by year. Organic fertilizers using per hectare of agricultural land is 190 kg (Table 1 and Table 2).

Table 1: *Inorganic fertilizers pressure in a ha of agricultural land in Vietnam from 1996 - 2000*

Year	***1996***	***1997***	***1998***	***1999***	***2000***
N	*109.4*	*103.2*	*107.9*	*106.3*	*113.6*
P_2O_5	*51.8*	*43.4*	*49.5*	*59.9*	*54.7*
K_2O	*9.1*	*22.7*	*24.7*	*43.9*	*22.6*
Total	*184.6*	*169.3*	*182.0*	*210.1*	*190.8*
Agricultural land (1000 ha)	*7681.2*	*7843.1*	*8080.2*	*8712.8*	*9345.3*

Table 2: *Organic* fertilizers pressure in a ha of agricultural land in Vietnam from 1996 - 2000*

Year	***1996***	***1997***	***1998***	***1999***	***2000***
N	*43.2*	*43.4*	*42.9*	*40.8*	*39.2*
P_2O_5	*48.9*	*49.5*	*49.2*	*47.1*	*46.1*
K_2O	*105.3*	*105.4*	*104.2*	*98.7*	*94.0*
Total	*197.4*	*198.3*	*196.2*	*186.6*	*197.4*
Agricultural land (1000ha)	*7681.2*	*7843.1*	*8080.2*	*8712.8*	*9345.3*

** Calculation based on excreta of human, cattle, horse, pig, goat and poultry in Vietnam (1).*

In Thai Binh province, the agricultural production has obtained the achieving an all-side development with its structure converted to commercial production, serving for the provincial needs, a part of de-mand of other provinces, and for export.

With a long-term experience from history, cultivating products are plentiful and diversified; the rice productivity reaches the top figure of 8.0-10.0 ton/ha/year compared with the whole country. Area of high-quality food plants such as potato, tomato, cucumber, salad, onion, garlic is expanding. Potentials on fruit trees (orange, apple, longan, and litchi) are remarkable to cover input for fruit canning & proc-essing plants and soft drink factories. Industrial trees like mulberries, jutes, sedges show great poten-tials and strength in development.

Agricultural development strategies of Thai Binh province in the next years will focus on three main sectors: cultivation, livestock and aquaculture. Rice production is to yearly maintained to one million ton of rice and increase rice exportation of 40.000 – 50.000 ton per year up to 2010, of which Thai Binh focus on intensive rice production with high quality rice and expand it up to 6000-7000 ha of paddy rice. On the other hand, Thai Binh has expanded the winter crop area up to 40-50 % of total agricultural area, of which vegetables: 26.000-30.000 ha and root crops 10.000 ha. In livestock sector, Thai Binh has also focused on pig production to reorganize pig production system and increase the total exportation pig meat over 10.000 ton in 2010. In aquaculture, Thai Binh will improve and utilize 3.000 ha of water surface area for intensive aquaculture production.

Thus, in the next years, estimated fertilizer requirement would increase up to 1.5 – 2.0 times for both cultivation and aquaculture because, at present, winter crops just occupied 20 % of potential land area that possible to plant winter crops. However, expanding pig production would also lead to the evolu-tion of pig waste and would threaten the water environment, so that balancing between produced wastes source and absorption units should be taken a consideration in Thai Binh in 2010 (see chapter 10).

Industrialized production and intensive agriculture often lead to an inadequate nutrient supply, especially, the shortage of organic fertilizer source and the increase of chemical fertilizers are two main reasons for soil compaction, leading to soil degradation in the future, while high development of pig production in some locations has not yet created a shifting mechanism of animal waste among locations. Redundancy and mismanagement of wastes sources is a major reason for water pollution (2).

This part will be emphasized in analyzing and evaluating the reality of using the composts for agricul-tural production in Thai Binh province, as well as provide the database for simulating the future possibilities of the usage of pig effluence through provincial orientations for livestock development up to 2010 in Thai Binh province. Flow data and necessary information have been collected in the targeted districts and additional data collection has been collected from other districts and Thai Binh city thanks to District Statistical Division and Agricultural Department. Formal interview and semi-structure interview were employed in field survey. The field survey was conducted in four districts (Vu Thu, Quynh Phu, Thai Thuy and Dong Hung). In each district, 20-40 farmers were interviewed and additional data and information were collected from leaders of communes. Primary data were collected through directly farmer interviews. Interviews focused on the current production for each crop, inputs apply, outputs obtained, management techniques and farmer' orientation in the future development. Secondary data are data sources from communes, from Statistical Office and Agricultural Departments. Moreover, annual reports of agricultural production and framework of orientation development also collected. Reference data are mainly based on the previous research results of National Institute for Soils and Fertilizers (NISF), fertilizers technical guideline (3, 4, 5) etc. These reference data are basic scientific foundation for comparison and evaluation of farmer practice and calculation fertilizer demand for crops in Thai Binh province. Based on the data and information has been collected in the field survey, descriptive statistic methods were employed. The outputs of calculation estimate real farmer practices in fertilizer use and fertilizer demand for crop as database for GIS-link (see chapter 10).

The cropping system

Thai Binh province has an intensively agricultural production term from 1980s and was also the first province that achieved with completely successful in rice-based system in Vietnam. In the period of Doi Moi and movement of the marketing economy, Thai Binh continuously leads in agricultural production; the rice productivity has reached 10-12 tons per hectare. The diversity of cropping systems and high land use coefficient, such as Quynh Phu, Vu Thu and Thai Thuy dis-

tricts from 3.0 to 4.5 times per year has brought the gross revenue from 40-50 millions Vietnam Dongs per hectare per year (eq. to 2000-2500 Euros).

The cropping system in Thai Binh province is mainly divided in three crops per year with summer rice, spring rice and winter crops season. Applying new varieties with the high frequency of cropping rotation in both spatial and temporally is a driving force to increase the cropping diversity and economic value of agricultural production up to year of 2010 as policies orientation of Thai Binh was set up in 2005.

The paddy rice system in Thai Binh is divided in two crops per year: the spring rice and summer rice. The summer rice season is starting from January or February and harvest occurs in May-June and win-ter rice season from June to October. Varieties changes following season and land use type, at present, Thai Binh has been using three popular rice varieties comprise of regular rice "Local rice", hybrid and sticky rice. In the wetland areas the rice-fish system is applied to increase the land use efficiency of these areas.

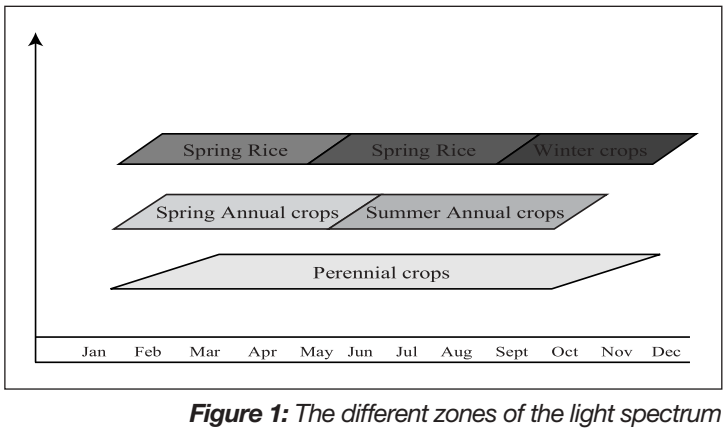

Figure 1: *The different zones of the light spectrum*

The winter crop is starting after summer rice, from October to January of next year. At present mostly winter crop is cultivated along Thai Binh River and on land parcels with light texture, i.e. sandy and loamy sand. The cropping structure is quite diversity, such as: Maize, root crops (potato and sweet potato); legume crops (Soybean, green bean etc); vegetations and some exported crops such as water-melon, cucumber; salad and chilli etc. The market demand is considered as a driving force of yearly cropping structure in the field.

Annual crop such as soybean, peanut, tobacco and vegetations are often cultivated in spring season or summer season on the land parcel where lack of water resource in spring season and having a light texture. On these areas, the land use coefficient could obtain from 3-4.5 times/ha/year. The production value on these land area often higher compare with other land use types, which could reach from 30-40 million VND/ha/year.

Perennial crops occupy a small area and gather in our study several fruit trees, i.e. litchi, longan, guava, and medicine tree (*Sophora japonica*). These trees are mostly planted in home garden and high terrace easily drained and non-flooded during the rainy season.

The organic fertilizer is applied on rice when farmers prepare the field before sowing. For spring rice in January or February and in summer in June and July. Chemical fertilizers (N;P;K) are spread 2-3 times. The first application occurs often at the same time with transplantation. The second application is conducted after 15-20 days later and a third time occurs about 60-70 days after transplantation.

For winter crops, organic fertilizers are often applied in September and October before planting. The chemical fertilizers for winter crops such as maize, root crops are spread in several times. For vegeta-bles, of the major part of the chemical fertilizers is applied by irrigation during planting season. Nutrient flow for agricultural production in Thai Binh

The organic fertilizer use in agricultural production in Thai Binh province is generated mainly from three sources: pig production, cattle and poultries and human ejection. Of which 90-95 % of organic fertilizer used in agricultural production is produced from pig production. In general, wastes from these sources are generated in two types: solid and liquid (liquid consist of excreta residue, urine and pens washing). The quality of organic fertilizer largely varies from types of pig production and rate of straw and crop residues incorporate inside. Volume of liquid generated from pig production also varies from household to household and depends on the type of shelter and pig farm. Concreting of pig shelter and daily washing are major cause of increasing the volume of liquid waste in communities.

Requirement of organic fertilizer in agricultural production is major absorption banks of waste from livestock components and human ejection that includes rice-based system and annual crops, fruit trees and aquaculture system. The capacity of absorption of each component depends on soil characteristics, crops' demand, season cropping and farming management techniques by farmers; it will be showed more detail in next section.

Considering that nitrogen and phosphorus contents could differ dramatically depending on the kind of organic fertilizer, it permits farmers to rightly quantify the amount of fertilizers and nutrient elements use for crops in the field. The variation of nutrient content in organic fertilizers and liquid wastes can be determined by laboratory analysis or refer to the guideline book. Few results are available in chapter 7.

Fertilization recommendations and nutrient requirements

Fertilizer uses for crops is often recommended base on the publication of research institutions and fertilizer companies after experimental tested. However, in practice, it exists many sources of fertilizer recommendation are published. The discrepancy of recommendation rate for a specific crop often appears in different public sources, it could be explained by heterogeneous of soil and crop varieties in experiments. In the real production, the recommendation rate of agricultural offices or extension services often modified from publication for suitable with local natural conditions.

In this case, organic fertilizer is a compost-like pig solid waste mixed with green wastes, such as rice straw, rice husk or weed, and incubated during 3-4 month before application. The fertilization hand-book (3) recommended the rate of organic fertilizer for rice is about 14.0 ton/ha, Maize: 17.0 ton/ha, Legumes: 30.0 ton/ha (Table 4). New publications on fertiliser use for crops have modified under addition of chemical fertilizer. Quyen (2002) (6) reported that for rice in Thai Binh province, the application rate in spring season is: compost 10.0 ton/ha; N: 120.0 kg/ha; P_2O_5: 70.0 kg/ha; K_2O: 60.0 kg/ha, in summer season, the rate are: compost: 9.0 ton/ha; N: 90.0kg/ha; P_2O_5: 70 kg/ha; K_2O: 45 kg/ha. National central for testing crop varieties (1995) recommended that for hybrid rice fertilizer rate should apply: compost: 14.0 ton/ha; N: 140.0kg/ha; P_2O_5: 70 kg/ha; K_2O: 65 kg/ha; for local rice va-rieties: compost: 10.0 ton/ha; N: 110-120.0kg/ha; P_2O_5: 70.0- 80.0 kg/ha; K_2O: 60.0 kg/ha. Hung (2002) (4) indicated that for maize, the rate should apply: compost: 10.0 ton/ha; N: 150.0kg/ha; P_2O_5: 90.0 kg/ha; K_2O: 90.0 kg/ha.

For perennial crops such as longan and litchi in home gardens, fertilization is needed to improve the yield (7), and it has to be modified depending age of the trees. The average rate apply should compost: 5.0 ton/ha; N: 100.0kg/ha; P_2O_5: 90 kg/ha; K_2O: 80.0 kg/ha. However, amount of fertilizer apply in each year need to control base on the actual productivity obtain.

Table 3: *Recommendation fertilization for crops*

Crops	***Compost***	***N***	***P_2O_5***	***K_2O***	***Source***
	Ton/ha	*Kg/ha*	*Kg/ha*	*Kg/ha*	
Annual crops					
Rice	*10.0-14.0*	*10-14.0*	*110-140.0*	*60.0-65.0*	*1,2,7*
Maize	*10.0*	*150.0*	*90.0*	*90.0*	*4,5,7*
Soybean	*10.0*	*20.0*	*60.0*	*30.0*	*7*
Peanut	*7.0*	*30.0*	*60.0*	*30.0*	*7*
Potato	*20.0*	*120.0*	*60.0*	*150.0*	*3,7*
Sweet potato	*8.0*	*40.0*	*60.0*	*90.0*	*5,7*
Green bean	*5.0*	*20.0*	*50.0*	*50.0*	*7*
Cabbage	*30.0*	*200.0*	*90.0*	*120.0*	*7*
Tomato	*25.0*	*200.0*	*180.0*	*150.0*	*7*
kohlrabi	*15.0*	*240.0*	*20.0*	*30.0*	*7*
Water melon	*10.0*	*185.0*	*100.0*	*100.0*	*5,7*
Cucumber	*13.0*	*200.0*	*150.0*	*150.0*	*7*
Pumpkin	*15.0*	*90.0*	*60.0*	*60.0*	*5,7*
Chilli	*20*	*120*	*80*	*160*	*1,7*
Ion and garlic	*30.0*	*45.0*	*40.0*	*60.0*	*1,7*
Perennial crop					
Mulberry	*30.0*	*120.0*	*80.0*	*50.0*	*1*
Litchi and longan	*5.0*	*100.0*	*90.0*	*80.0*	*6*

Source: (1)- Le Van Can (1975), (2)- Mai Van Quyen (2002); (3)- Tran Khac Thi (1996); (4)- Nguyen The Hung (2002); (5)- Hoang Minh (2005); (6)- Tran The Tuc (1998); (7)- National central for testing crops varieties

Other type of organic fertilizer such as the liquid waste of pig and cattle often used fruit trees and medicinal plant in home garden and partly for annual crops in the field. Benoit Hillion (2005) (8) reported that recommended by Agricultural office of Vu Thu district on using of the liquid waste of pig for main crops, it estimated that the liquid waste used per ha for rice average: 19 ton/ha, vegetation: 23 ton/ha; Maize: 40 ton/ha; Bean and peanut: 14.0 ton/ha; and potato: 27 ton/ha.

Waste management and characteristic of organic fertilizer in Thai Binh

Organic fertilizer used for agricultural production in Thai Binh is collected from different sources: pig production, cattle and poultry. Pig manure is the major source of organic fertilizer; it is said to meet the demand of rice-based system, annual crops, fruit trees and aquaculture system.

The quality of organic fertilizer depends on many factors such as on-farm practices and proportion of crop residues incorporate during the composting process. Moreover, solid waste management tech-niques and characteristics of crop residue mixed in pig manure also affect the quality of organic fertilizer. Difference of process in managing the pig waste among farmer households has given different types of organic fertilizers before applying for crops on the field.

Figure 2: *Characteristic of organic fertilizer*

Wastes from pig production often exists two forms: solid and liquid. Volume of solid and liquid from pig production depends on the pig heads and characteristics of pig sheds. Traditional shelter as for local pig variety, it often doesn't separates solid and liquid. Therefore the solid and liquid wastes are combined with crop residues close to the pig pen. Volume and quality of compost depend then entirely on the added crop residues.

In pens with concrete floor and model of pig enterprise, the solid phase is collected apart by farmers. The volume of liquid waste depends here on the volume of water used during the daily washing; it often varies according the season and available labour force. It presents more detail in Chapter 8, qualification of waste flows. One traditional method that is largely applied by farmer in pig manure management, solid waste was incorporated with crop residues (most is rice straw) and lime before incubating. The length time spends for incubation from 4-6 months, by this way; the harmful bacteria will be reduced due to high temperature of incubation process, and almost litter is decomposed, however nitrogen was emission and quality of organic fertilizer is reduced (3). To avoid nitrogen emission process the incubated heap is covered by mud during the incubation time.

Liquid waste management: Liquid waste management in the pig farms was done in different ways, liquid waste can collect into the tanks and latterly using for crops in the field, if farmer have available biogas tank, and liquid has been used for gas generating. In model combination between pig and fished production, liquid waste often directly goes into the fished ponds. Small part of pig farms, liquid waste was defecated freely into the canals and rivers, as result of the surface water has strongly polluted by mismanaging liquid waste.

Priority in fertilizer application for cropping patterns in Thai Binh province

On-farms interviews have highlighted on the priority of fertilizer used for crops and seasons. It stated that intensive agricultural production has often led to the scarcity of organic fertilizer; it is clearly that in lack of organic fertilizer for crop has occurs in small pig production farms, while the abundant of pig manure has appeared in some communes which have intensive pig production such as Nhat Tien commune in Vu Thu district. At the provincial level, the source of pig manure in compost form has not fully met the demand of agricultural production in present time. Thus, the redundant pig manure in locality needs to shift over to the other locations that not enough of organic fertilizer used for crops.

Farmer interviews and ranking techniques have been applied to find the priority in using organic fertil-izer for crops; surveys were conducted in four districts and 20 agricultural households with small pig herd have been interviewed. Main crops are listed out and individual farmer has put score follow the relative important in their production system. The score ranking was 1 to 10 depending on each type of crop (Table 5).

Table 4: *Factor score and relative important in organic fertilizer used for crops in Thai Binh*

No	***Crop and season***	***Point/score***	***Ranking***
1	*Rice (summer and spring)*	*180/20*	*1*
2	*Annual crops in spring season*	*110/20*	*3*
3	*Annual crops in summer season*	*96/20*	*4*
4	*Winter crops season*	*165/20*	*2*
5	*Perennial crops*	*72/20*	*5*

According to the farmer evaluation, rice was ranked at the first priority in using of organic fertilizer. Since rice is considered as a major crop and the main food source, farmers considered that pig raising is much in association with rice production. Winter crops are ranked at the second priority; therefore, farmers paid also attention on organic fertilizer for the main crop during winter, according the following order: maize, root crops, and vegetables. Annual spring crops were ranked at the third of priority because in spring season, some main industrial crops such as, peanut, soybean and vegetation could be obtained high yield and high value than other crop season in the year. While the annual crop structure in summer season is not so diversity. Therefore, it was not much paid attention as other crop per year. As perennial crops are mostly concentrated in home gardens, farmers ranked the use of organic fertilizer used for these trees (liquid or utilizing from cattle and compost) with the last priority.

Organic fertilizers in communes in Thai Binh province in produced from different sources such as pig, poultry cattle and human. Volume of waste produced depends on the production scale, pig is considered as main sour of organic fertilizer for agriculture and aquaculture. Waste of poultry and human injection often give high nutrients content, it often uses for cash crops such chilli and vegetations. However, because of limitation source so pig manure also uses for these crops. The priority of specific waste types used for different production systems in Vu Thu district is presented in Table 5.

Table 5: *Order selection of fertilizer type fore crops*

Production systems	***Priority use of waste***
Fishpond	*Duck >Pig> Chicken> cattle*
Home garden	*Pig liquid waste*
Annual crops	*Compost of human> poultry> Pig> Cattle*
Perennial crops	*Compost of Pig > Cattle*

Fish-Duck combination system often appears in farms, where large water area for fish pond is available. In these farms, the duck wastes are directly let out on the fish pond as one source of feed for fish. On the other hand, fresh manures of pig, chicken and cattle are additional feed sources for fish pond.

In home garden- non commercial production, includes mixing fruit trees, organic fertilizer type mainly is liquid of pig, it is used as utilization of washing water from pig shed. On the contrary, in fruit trees plantation is produced as commercial types, it mostly applied compost source from pig and cattle.

Compost of human and poultry contain a high concentration of nutrient elements (N:P:K) (Table 3) . These types of organic fertilizers are high appreciated by farmers and often used for cash crops such as chilli, onion, garlic and other vegetables. However, it is not enough to provide for crops that produce with large area. So that pig compost is still used as a main source of organic fertilizer in production.

Farmer practices in fertilizer application

Pig manure has been used by farmers as a traditional element in agriculture for rice, cash crops, fruit trees in long history in Vietnam. Moreover, pig waste is also used for fish feeding in intensive production farms. Field survey about farmers' fertilization practices indicated that pig manure is used for almost all crops in Thai Binh province and used to feed fish in intensive farms. Pig manure is used in compost type or fresh type that depends on type of crop and framer behaviour.

The practices we could describe here are not exhaustive, because the practices of the Vietnamese peasants are extremely variable and very dependent on the specific practices of the village or the commune. The peasants who use biogas effluents on the cultures justify it more by the advantages of biogas itself than by qualities of effluent biogas product. Indeed, the interviewed people underlined the hygienic pro-gress allowed thanks to biogas, the source of energy for the kitchen and the labour and cost reduction. However, farmers said once that corn and rice were more resist-

ant to the insects when they were fertil-ized with the biogas effluents. But for the majority, the use of a biogas involves the absence of liquid manure to be put on the cultures.

Fertilizer use for rice-based system

Long history in paddy rice production has brought to farmers the experience in managing the paddy rice system. Population has also increased and the higher food demand have made the paddy rice system changes follow the intensive trend through applying high yield varieties, therefore leading to increase the fertilization. The rice-cultivated techniques of farmers in Thai Binh have reached as the top ten compare with the other provinces in Vietnam. (9)

Therefore, fertilization techniques and pest management are also well control by rice growers. The amounts of fertilizer used for rice in districts have nearly reached the scientific recommendation (3, 6). However, the amount of fertilizers used for rice is not homogenous among districts in province. The variation amount of applied fertilizers depends on the available sources of organic fertilizer and the price fluctuation of chemical fertilizers in market and households' economy condition. The result of field survey on fertilizer used for rice is presented in Table 6:

Table 6: *Liquid flow on ten pig farms in Thai Binh*

Items	***Unit***	***V.Thu***	***Q.Phu***	***T.Thuy***	***D.Hung***	***T.Hai***	***K.Xuong***	***H.Ha***	***T.Binh***
Spring rice									
Total area	*ha*	*9,029.8*	*10,841.6*	*12,929.3*	*25,338.5*	*10,676.1*	*13,022.0*	*10,371.6*	*1,778.2*
FYM	*Ton/ha*	*8.0*	*7.6*	*8.3*	*7.8*	*7.7*	*7.8*	*8.0*	*6.9*
Nitrogen	*Kg/ha*	*112.0*	*102.0*	*105.0*	*97.7*	*106.0*	*95.0*	*106.0*	*110.0*
Phosphorus	*Kg/ha*	*66.0*	*68.0*	*80.0*	*70.6*	*66.0*	*84.0*	*65.0*	*77.0*
Potassium	*Kg/ha*	*40.0*	*35.5*	*40.0*	*39.0*	*32.0*	*38.0*	*41.0*	*35.0*
Summer rice									
Area	*ha*	*8,886.6*	*10,377.3*	*13,949.1*	*26,323.1*	*10,686.6*	*12,982.0*	*10,744.0*	*1,023.5*
FYM	*Ton/ha*	*7.7*	*7.4*	*7.7*	*7.0*	*7.5*	*7.4*	*7.0*	*6.5*
Nitrogen	*Kg/ha*	*90.0*	*85.0*	*90.0*	*90.0*	*90.0*	*80.0*	*89.0*	*85.0*
Phosphorus	*Kg/ha*	*63.0*	*63.0*	*68.0*	*66.0*	*72.0*	*77.0*	*60.0*	*69.0*
Potassium	*Kg/ha*	*35.0*	*33.0*	*36.0*	*32.0*	*36.0*	*34.0*	*33.0*	*32.0*

Note: FYM: Compost; Nitrogen- N; Phosphorus: P_2O_5 and potassium: K_2O

The use of the composted manure on the cultures is most popular and more frequently observed. The peasants underline many qualities of the compost and do not find any inconvenient with the use of this type of pig waste, contrary to the fresh scraped manure. The compost is thus appreciated: with an easy transformation, it allows a durable growth of the cultures. According to them, the quality of the compost increases with the proportion of straw, stems, and rice husks in the mixture; this transformation allows an improvement of the ground, a better absorption by cultures and a more durable growth of the crops. According to users, the use of compost allows a better development of the leaves, therefore a better absorption of the light by the cultures. A user of compost announces that the size of vegetables was more regular than with a use of other types of slurry. The use of the compost involves a better resistance to the diseases of the cultures and thus allows more limited use of chemical inputs. The reduction of the bad odour is also a quality of the compost appreciated by the farmers. The farmers underline also the decreased weight of the compost, compared to the weight of the fresh liquid manure (diminution of 65%), which involves a saving of time and labour in transport and spreading, and thus a productivity improvement (x1,5) for the fertilization work by the peasant.

Field survey and data analysis indicated that amount of organic fertilizer has been applied for rice among districts that varied from 6.9-8.3 ton/ha in spring season and in summer season amount of organic fertilizer often lesser which from 6.5-7.7 ton/ha. The hybrid rice usually applied with a rate from 9-10 tons of organic fertilizer per ha while regular rice and sticky rice has been applied at rate of 7.0-8.0 ton/ha and 4.0-6.0 ton/ha respectively. Thus, rate of organic fer-

tilizer used for rice in Thai Binh still lower than recommended rates; the scientific recommendation are 14.0 ton/ha for hybrid rice and 10.0 ton/ha for normal rice varieties (3, 6). Farmers interviewed informed that, improving of the con-creted shelter and intensively in pig production that reduced yearly amount of FYM producing as a main causing of less FYM applied. Because in the concreted pens apart of animal waste (urine and the excreta residue) is washed out by daily cleaning.

Chapter 7 highlights the quality of organic fertilizer depending on the pig production model and the proportion of crop residues incorporated into the compost. Considering the organic fertilizer in farming households, the rate of crop residues, i.e. straws, weeds, ashes or husks, incorporated into pig ef-fluents varies from 30-70 %. Laboratory analysis indicated that water fraction in organic fertilizer is about 50% (with a variation of 26.6-61.8%) and the nutrient elements in fresh organic fertilizer samples existed 17.3% of OM total (variation of 11 to 28%) and content of N, P_2O_5 and K_2O in total form are: 1.60%, 3.51%, 0.59% respectively.

Inorganic fertilizers which consist of nitrogen (Urea - 46%), phosphorus (Super phosphorus -17%) and potassium (Kalisulfat - 60%) and mixed fertilizer NPK are considered as main sources of nutrient for crops in agricultural production. From field survey, which exposed that rate of N, P and K used for rice largely varied from household to household. Besides the pedological properties, the household economy and price of N, P and K are driving factors with farmer gives a decision on the investment level. Table 7 noted that for rice, the applying rate of N from 95.0-112.0 kg/ha; P varied from 65.0-84.0 kg/ha and K varied from 32.0-41.0 kg/ha in spring season. In summer season, the rate of N, P, K applied lower corresponding rate are nitrogen: 80.0-90.0 kg/ha; P_2O_5: 60.0-77.0 kg/ha and K_2O: 32.0-35.0 kg/ha of respectively. Comparison with fertilizer recommendation for paddy rice in Thai Binh soil properties (6): organic fertilizer: 10 ton/ha ; N: 120 kg/ha; P_2O_5: 70.0 kg/ha and K_2O: 60.0 kg/ha in spring rice and organic fertilizer: 9.0 ton/ha; N: 90 kg/ha; P_2O_5: 50 kg/ha and K_2O: 45.0 kg/ha in summer season, (3). This has exposed that farmers in Thai Binh have facing with imbalance of fertilization for paddy rice in both seasons, farmer practice has underused of organic fertilizer and potassium; overused of phosphorus in summer season, while nitrogen was approximate with recommendation.

For rice, fresh pig manure was also used without incubation. Together with organic fertilizer, phosphorus also applied with 100 % by broadcasting at the same time of land preparation (basal fertilizing). Nitrogen was applied about 50 % of total; potassium (K_2O) is not applied in this time exception when temperature reduces too low. The second time, nitrogen was applied with 20 % after 15-20 days of transplanting and the third time-topdressing usually applied before flowering time from 10-20 days with 30 % of nitrogen. Potassium usually applied before flowering stage and after flowering 25-30 days (when rice is already in ear). The herbicides applying nowadays in the rice field that made a partly of farmer ignored the weeding after 15-20 days after transplanting, it means that time of fertilization reduces only two time are basal applying and topdressing.

Annual crops and fertilizer application in Thai Binh province

Although paddy rice is the dominant crop in both spring and summer season, annual crops such as peanut, soybean, watermelon, cucumber and vegetation etc have been widely planted and distributed in three crops per year: spring, summer and winter seasons. Annual crops are planted in every district. Recently, the vegetable production in the outskirt of Thai Binh City has widely expanding and intensive to serve for the domestic consumption of Thai Binh. On other district such as in Thai Thuy, Dong Hung and Kien Xuong districts, cucumber, chilli, and watermelon are cultivated for exportation and domestic consumption. However, the yearly area for exported crops is unstable and strongly depends on the exportation market.

Fertilizer used for industrial crops

Peanut and soybean are industrial crops in Thai Binh with area 2,603.0 ha and 2,514.9 ha respectively. Peanut is mainly planted in spring season; soybean is planted during summer and winter seasons and is concentrated in Vu Thu, Hung Ha and Tien Hai districts. The result of field surveys on the fertilizer application for peanut and soybean is presented in Table 7.

Table 7: *Fertilizer used for peanut and soybean*

Items	*Unit*	*V.Thu*	*Q.Phu*	*T.Thuy*	*D.Hung*	*T.Hai*	*K.Xuong*	*H.Ha*	*T.Binh*
Peanut									
Total area	*ha*	*717.0*	*61.7*	*367.3*	*4.8*	*458.7*	*197.0*	*705.0*	*91.5*
FYM	*Ton/ha*	*6.4*	*5.5*	*5.5*	*5.5*	*5.0*	*6.6*	*5.0*	*5.5*
Nitrogen	*Kg/ha*	*32.0*	*25.5*	*20.4*	*19.1*	*20.4*	*20.4*	*32.0*	*32.0*
Phosphorus	*Kg/ha*	*47.0*	*28.3*	*47.0*	*47.0*	*52.0*	*56.5*	*66.0*	*33.0*
Potassium	*Kg/ha*	*49.0*	*24.0*	*38.8*	*29.0*	*34.0*	*48.5*	*44.0*	*30.0*
Soybean									
Total area	*ha*	*949.8*		*826.9*		*510.0*	*68.0*	*151.0*	*9.2*
FYM	*Ton/ha*	*5.5*	*-*	*5.5*	*-*	*4.7*	*5.8*	*7.6*	*5.5*
Nitrogen	*Kg/ha*	*13.0*	*-*	*25.0*	*-*	*25.0*	*25.0*	*19.1*	*25.0*
Phosphorus	*Kg/ha*	*33.0*	*-*	*47.0*	*-*	*52.0*	*42.4*	*47.0*	*38.0*
Potassium	*Kg/ha*	*29.0*	*-*	*29.0*	*-*	*24.0*	*20.0*	*25.0*	*34.0*

Note: FYM: Compost; Nitrogen- N; Phosphorus: P_2O_5 and Potassium: K_2O (-) non cultivation

The rate of fertilizer used for peanut and soybean mostly is based on the combination of guideline and experience. The estimation of organic fertilizer require for those crops in whole province is about 30.795.5 ton per year. However, the farmer practices only provided 80-90 % of above requirement (Pig manure was incubated before applying, which can mix between human ejection and pig manure; length of incubation varies from 3-4 months). Compost and phosphorus are applied before planting with rate: 5.0-6.0 ton/ha and phosphorus 33.0-66.0 kg/ha. Nitrogen and potassium often separated in 3-4 times during season and was applied by irrigation, potassium often applied after flowering stage; it varies from 20.0-32.0 kg/ha for peanut and from 12.0-25.0 kg/ha for soybean. Farmers also reported that soybean and peanut are crops that can fix nitrogen. Therefore, the rate of chemical fertilizers used for peanut and soybean can change from recommendation rate and real application varied from soil fertility, crop health and farmers' economic capacity. Comparison with recommendation of Can (1975) (10) and NCTCV (10) the optimum fertilizer rate for soybean is: organic fertilizer: 10.0 ton/ha; N: 20kg/ha; P_2O_5: 60.0 kg/ha and K_2O: 30.0 kg/ha. For peanut, organic fertilizer: 7.0 ton/ha; N: 30kg/ha; P_2O_5: 60.0 kg/ha and K_2O: 40.0 kg/ha, real farmers application was underused and organic fertilizer used for both crops (Table 8) was only equal to 50-60 % and phosphorus and potassium was equal to 60-70 % of the recommendation rate.

Fertilizer used for maize

In Thai Binh, maize is planted during spring, summer and winter season with total area 6,747.8 ha. In which 95 % of maize area is planted in winter season and mostly concentrated in Vu Thu, Quynh Phu and Hung Ha districts (Table 9). Hybrid maize (DK 888 and Bioseed 9898) have been widely used by farmer in winter. Hybrid varieties usually require high nutrient applied, fertilizers should be applied on maize as following (4): organic fertilizer: 10 ton/ha; N: 150-160 kg/ha; P_2O_5: 90.0 kg/ha and K_2O: 90.0 kg/ha. Field survey in fertilizer applies for maize in winter season in Thai Binh province was present in table 4.

Table 8: *Fertilizer used for maize in winter season*

Items	*Unit*	*V.Thu*	*Q.Phu*	*T.Thuy*	*D.Hung*	*T.Hai*	*K.Xuong*	*H.Ha*	*T.Binh*
Maize									
Total area	*ha*	*1737.8*	*2087.0*	*717.8*	*330.7*	*191.5*	*294.0*	*1341.5*	*47.5*
FYM	*Ton/ha*	*9.7*	*8.3*	*9.4*	*7.8*	*9.7*	*10.0*	*5.6*	*8.0*
Nitrogen	*Kg/ha*	*140.0*	*115.0*	*128.0*	*133.0*	*140.0*	*127.0*	*120.0*	*120.0*
Phosphorus	*Kg/ha*	*90.0*	*85.0*	*80.0*	*70.0*	*90.0*	*80.0*	*70.0*	*72.0*
Potassium	*Kg/ha*	*49.0*	*30*	*50*	*55.0*	*49.0*	*49.0*	*44.0*	*40.0*

Note: FYM: Compost; Nitrogen- N; Phosphorus: P_2O_5 and Potassium: K_2O (-) non cultivation

Although the fertilizer rate required for maize is widely promoted by seeding companies and local extension service, farmers applied less OM than recommendation. Data in Table 9 indicate that organic fertilizer is used for maize according only 80 % of the recommended rate, except Hung Ha district (55%, equivalent to 5.6 tons/ha).

Organic fertilizers applied for maize could be compost or liquid type. Compost often applied at planting time with or without incubation. Few farmers used the liquid manure for maize and liquid manure often apply from 3-4 times after planting 15-20 days until before flowering stage.

Used nitrogen varies from 120.0-140.0 kg/ha and separates into 4 times with interval 15 days after planting time and finish before flowering time. Phosphorus application varies from 70.0-90.0 kg/ha, of which 50 % was applied at planting time and the rest of phosphorus was separated into 2 times of application by irrigation when maize obtains 10-15 cm and 80-120 cm of height. The amount of potassium used for maize by farmer from 40.0-50.0 kg/ha by irrigation and potassium mostly applied after flowering time. Thus, nitrogen and phosphorus applied by farmers have reached 80-90% of recommendation rate, while potassium in farmer practice only equal 50 % of the recommended rate.

Fertilize use for cucumber, watermelon and pumpkin
Cucumber is the main exported crop in Thai Thuy district, which occupies 31 % total area of cucumber area in Thai Binh under the contract of company so that growers has obtained a full support from company including varieties, fertilizers and training, by this way, fertilizers used for cucumber is quite homogenously amount in each farmer household. Besides that cucumber is planted in some other districts such as Thai Thuy, Dong Hung, and Kien Xuong (Table 10).

In Thai Thuy district, fertilizer used for cucumber per hectare has reached 12.0 ton of organic fertilizer and 200 kg of N; 140 kg of P_2O_5 and 90 kg of K_2O. Organic fertilizer applied for cucumber has been used by compost at planting time and liquid by irrigation and chemical fertilizers mostly applied by irrigation. Compare with recommendation rate of fertilizer used for cucumber (organic fertilizer: 9.0-13.0 ton/ha; N: 200kg/ha; P_2O_5: 150.0 kg/ha and K_2O: 150.0 kg/ha), fertilizers used for cucumber in Thai Thuy are nearly get optimum rate; exception potassium was only reached 75 % of requirement. In the other districts, both organic fertilizers and chemical fertilizers are under-applied: organic fertilizer from 8-9.0 ton/ha; nitrogen 80-190.0 kg/ha, phosphorus from 75.0-95.0 kg/ha and potassium 55.0-80.0 kg/ha (Table 9).

Table 9: *Rate of fertilizer used for cucumber and watermelon*

Items	***Unit***	***V.Thu***	***Q.Phu***	***T.Thuy***	***D.Hung***	***T.Hai***	***K.Xuong***	***H.Ha***	***T.Binh***
Cucumber									
Total area	*ha*	*9.6*	*42.8*	*111.0*	*49.9*	*73.84*	*62.0*	*0*	*0*
FYM	*Ton/ha*	*8.0*	*8.5*	*12.0*	*7.0*	*9.0*	*9.0*	*-*	*-*
Nitrogen	*Kg/ha*	*150.0*	*165.0*	*200*	*80.0*	*190.0*	*180.0*	*-*	*-*
Phosphorus	*Kg/ha*	*75.0*	*85.0*	*140.0*	*118.0*	*95.0*	*85.0*	*-*	*-*
Potassium	*Kg/ha*	*55.0*	*70.0*	*90.0*	*75.0*	*80.0*	*72.0*	*-*	*-*
Watermelon									
Total area	*ha*	*38.7*	*24.3*	*484.7*	*0*	*0*	*17.0*	*244.0*	*0*
FYM	*Ton/ha*	*8.0*	*8.0*	*9.0*	*-*	*-*	*7.0*	*8.8*	*-*
Nitrogen	*Kg/ha*	*120.0*	*80.0*	*150.0*	*-*	*-*	*90.0*	*150.0*	*-*
Phosphorus	*Kg/ha*	*60.0*	*80.0*	*60.0*	*-*	*-*	*40.0*	*60.0*	*-*
Potassium	*Kg/ha*	*40.0*	*60.0*	*80.0*	*-*	*-*	*40.0*	*60.0*	*-*
Pumpkin									
Total area	*ha*	*94.9*	*160.2*	*99.5*	*0*	*0*	*5.0*	*1124.6*	*0*
FYM	*Ton/ha*	*13.0*	*8.0*	*11.0*	*-*	*-*	*12.0*	*7.0*	*-*
Nitrogen	*Kg/ha*	*75.0*	*75.0*	*100.0*	*-*	*-*	*75.0*	*90.0*	*-*
Phosphorus	*Kg/ha*	*55.0*	*50.0*	*55.0*	*-*	*-*	*47.0*	*50.0*	*-*
Potassium	*Kg/ha*	*40.0*	*30.0*	*30.0*	*-*	*-*	*34.0*	*30.0*	*-*

Note: FYM: Compost; Nitrogen- N; Phosphorus: P_2O_5 and potassium: K_2O

Watermelon is considered as a cash crop and planted in both spring and summer. The total area of watermelon is about 808.7 ha, of which, watermelon is mostly planted in Thai Thuy and Hung Ha districts in spring or winter season. Fertilizer applied for watermelon also largely varied among farmer households; organic fertilizer varies from 7.0-9.0 ton/ha; chemical fertilizers: nitrogen: 80.0-150.0 kg/ha; phosphorus: 40.0-80.0 kg/ha and potassium varied from 40.0-80.0 kg/ha. Thus, chemical fertilizers such as nitrogen and organic fertilizer used for watermelon in farmer practice has underused, it has reached from 40-75 % of requirement (as the recommendation rate: organic fertilizer: 10 ton/ha; N: 185.0 kg/ha; P_2O_5: 100.0 kg/ha and K_2O: 100.0 kg/ha).

Pumpkin is planted mostly in Hung Ha district with 1124.6 ha; it equal to 75 % of total area of pump-kin in Thai Binh (1484 ha). The optimum fertilizer rate used for pumpkin are: organic fertilizer (5): 15 ton/ha; N: 90 kg/ha; P_2O_5: 60.0 kg/ha and K_2O: 60.0kg/ha. According farmers' practices, fertilizers are under-applied (table 10): organic fertilizers from 8.0-13.0 ton/ha by both compost and liquid irriga-tion; chemical fertilizers (mostly applied by irrigation with rate of nitrogen) from 75.0-100.0kg/ha; Phosphorus from 47-55.0 kg/ha and potassium from 30.0-40.0 kg/ha.

Fertilizer used for root crops (potato and sweet potato) Potatoes and sweet potatoes are cultivated in the paddy field during winter season. These root crops often planted in light texture soil with good irrigation and drainage. The cultivated area for potato is about 5,193.0 ha and 3510.0 ha for sweet potato (Table 10).

Potato is considered as a cash crop, while sweet potato is planted to serve for livestock development. Potato often requires high fertilizer investment, the recommendation of fertilizer used for potato: organic fertilizer: 20.0 ton/ha; N: 120 kg/ha; P_2O_5: 60.0 kg/ha and K_2O: 150.0 kg/ha. While the require-ment of sweet potato only: organic fertilizer: 8.0 ton/ha; N: 40.0 kg/ha; P_2O_5: 60.0 kg/ha and K_2O: 90.0 kg/ha (5). The fertilizer use for potato and sweet potato is presented in Table 10.

Data in Table 10 indicated that organic fertilizer used for potato in farmer practice largely varied among districts, of which at Vu Thu and Quynh Phu organic fertilizer has applied upon 17.0 ton/ha, it equals to 85 % of requirement. In the other districts, organic fertilizer only reached the 10.0-15.0 ton/ha equivalent to 50-75 % of requirement; this lower rate of application results from a lack of organic fertilizer source. Organic fertilizer for potato is applied in compost form without incubation; 100 % of compost is then applied at the planting time.

The imbalance of chemical fertilizers has clearly exposed with potassium element. While nitrogen and phosphorus was applied from 100-120 kg/ha and 40-50 kg/ha respectively that has nearly reached optimum rate, while the amount of potassium applied was only reached 30 % compare with recommendation rate

Table 10: *Rate of fertilizers used root crops in winter season*

Items	***Unit***	***V.Thu***	***Q.Phu***	***T.Thuy***	***D.Hung***	***T.Hai***	***K.Xuong***	***H.Ha***	***T.Binh***
Potato									
Total area	*ha*	*703.1*	*958.4*	*521.0*	*966.8*	*414.1*	*828.0*	*588.9*	*213.2*
FYM	*Ton/ha*	*17.0*	*17.0*	*14.0*	*10.0*	*15.0*	*14.0*	*12.0*	*15.0*
Nitrogen	*Kg/ha*	*100.0*	*120.0*	*110.0*	*110.0*	*100.0*	*120.0*	*115.0*	*100.0*
Phosphorus	*Kg/ha*	*50.0*	*45.0*	*47.0*	*50.0*	*40.0*	*47.0*	*55.0*	*60.0*
Potassium	*Kg/ha*	*60.0*	*80.0*	*50.0*	*55.0*	*50.0*	*55.0*	*68.0*	*48.0*
Sweet potato									
Total area	*ha*	*771.5*	*275.5*	*926.0*	*259.5*	*254.6*	*385.0*	*614.2*	*23.8*
FYM	*Ton/ha*	*7.8*	*5.5*	*7.0*	*7.7*	*5.5*	*6.6*	*5.7*	*7.0*
Nitrogen	*Kg/ha*	*38.0*	*30.0*	*35.0*	*30.0*	*25.0*	*38.0*	*35.0*	*20.0*
Phosphorus	*Kg/ha*	*30.0*	*50.0*	*47.0*	*50.0*	*47.0*	*40.0*	*50.0*	*45.0*
Potassium	*Kg/ha*	*50.0*	*30.0*	*30.0*	*45.0*	*20.0*	*30.0*	*35.0*	*30.0*

Note: FYM: Compost; Nitrogen- N; Phosphorus: P_2O_5 and potassium: K_2O - E3P project

Sweet potato requires less fertilizer than potatoes, but the rate of fertilizers has been used for sweet potato still lower compare with its' requirement. Amount of organic fertilizer was applied from 5.5-7.8 ton/ha and mostly pig manure without incubation. Nitrogen applied varies 20.0-38.0 kg/ha; phospho-rus varies from 30.0- 50.0 kg/ha and potassium varies from 30.0-50.0 kg/ha. Thus, compare with rec-ommendation, organic fertilizers, nitrogen and phosphorus are applied for sweet potato equal to 70-90 % of requirement, while potassium applied only reach 30-40 % of requirement.

Fertilizer used in vegetable production

Vegetables in Thai Binh are planted three times per year: spring; summer and winter; in some area, vegetables are cultivated continuously with a 4-5 rotations per year. However, vegetables are widely grown from September-October, after summer rice harvesting. We can set apart vegetables into two main groups: leaf vegetables (cabbage and kohlrabi) and fruit and root vegetables (tomato, chili and onion and garlic). In winter season, area dedicated to cabbage and Kohlrabi is about 778 ha and 592.0 ha respectively. These areas have often changed depending on the market's demand and the price of chemical fertilizer.

Table 11: *Average fertilizer use for cabbage and Kohlrabi in winter season*

Items	***Unit***	***V.Thu***	***Q.Phu***	***T.Thuy***	***D.Hung***	***T.Hai***	***K.Xuong***	***H.Ha***	***T.Binh***
Cabbage									
Total area	*ha*	*111.8*	*44.5*	*103.2*	*0*	*169.8*	*38.0*	*205.9*	*104.8*
FYM	*Ton/ha*	*12.0*	*8.5*	*7.5*	*-*	*10.0*	*12.0*	*8.0*	*7.0*
Nitrogen	*Kg/ha*	*203.0*	*102.0*	*230.0*	*-*	*190.0*	*204.0*	*106.0*	*190.0*
Phosphorus	*Kg/ha*	*85.0*	*66.0*	*80.0*	*-*	*90.0*	*80.0*	*75.0*	*70.0*
Potassium	*Kg/ha*	*44.0*	*30.0*	*54.0*	*-*	*60.0*	*44.0*	*50.0*	*40.0*
Kohlrabi									
Total area	*ha*	*108.8*	*0*	*38.9*	*0*	*149.9*	*0*	*178.3*	*116.3*
FYM	*Ton/ha*	*7.5*	*-*	*6.6*	*-*	*7.0*	*-*	*5.5*	*7.0*
Nitrogen	*Kg/ha*	*150.0*	*-*	*127.0*	*-*	*102.0*	*-*	*115.0*	*150.0*
Phosphorus	*Kg/ha*	*45.0*	*-*	*36.0*	*-*	*55.0*	*-*	*47.0*	*55.0*
Potassium	*Kg/ha*	*30.0*	*-*	*20.0*	*-*	*40.0*	*-*	*40.0*	*30.0*

Note: FYM: organic-compost; Nitrogen- N; Phosphorus: P_2O_5 and potassium: K_2O; (-) non cultivated

Farmers have reported that organic fertilizers are used for cabbage and kohlrabi in both solid type (pig manure without incubation) and liquid type (7.0-12.0 ton/ha for cabbage). Compost is generally applied at planting time representing 60-70% of total organic fertilizer; 30-40 % of organic fertilizer is applied in liquid form during planting season. The organic fertilizer's requirement for cabbages is 30.0 ton/ha, but farmers provide only 30 % of it.

The amount of nitrogen used cabbage and indicated by farmers is included in an interval from 106.0 –230.0 kg/ha. Nitrogen is mostly applied by irrigation with time interval 7-10 days and fertilization starting for cabbage. The rate of nitrogen applied for cabbage in Quynh Phu and Hung Ha districts is only equal to 50 % of the recommendation rate is 200 kg/ha (Table 12), while in other districts, nitrogen has applied approximately of 200 kg/ha, exceptional in Thai Thuy district, the rate of nitrogen used for cabbage has overused 229.4 kg/ha. Different with nitrogen, 80 % of phosphorus is applied at planting time and the other 20 % are applied by irrigation along the cropping season.

In farmer practice, cabbage has applied from 66.0-90.0 kg/ha of phosphorus, and it is about 80 % of phosphorus is applied at planting time and the rest of 20 % are applied by irrigation along the cropping season. Thus compare with requirement of phosphorus for cabbage is 90.0 kg/ha, farmer practice has applied from 75 %- 90 % of requirement. Similarly to nitrogen, potassium used for cabbage was applied by

irrigation during planting season, for cabbage, farmer has applied from 30.0-60.0 kg/ha (Ta-ble 12), it is equal to 40-50 % of recommendation rate is 120.0 kg/ha.

The same application method with cabbage, organic fertilizer was applied for kohlrabi varied from 5.5-7.5 ton/ha. This amount equals only 30-50 % of recommended rate (15.0 ton/ha). For kohlrabi, Nitrogen application is 100-150.0 kg/ha; this amount is only equal to 50-60 % of the recommended 240 kg/ha (Table 12). Nitrogen is mostly applied by irrigation with time interval 7-10 days and fertilization starting for from 7 days after planting extending until 5-10 days before harvesting, the demand of phosphorus and potassium for kohlrabi is quite small, which is about 20 kg/ha and 30 kg/ha respectively. The rate of application phosphorus and potassium for kohlrabi from 36.0-55.0 kg/ha and 20-40.0 kg/ha respectively that noted that farmer practice have overused for kohlrabi as comparison with recommendation rate.

Table 12: *Fertilizer use for tomato, chilli and onion and garlic*

Items	***Unit***	***V.Thu***	***Q.Phu***	***T.Thuy***	***D.Hung***	***T.Hai***	***K.Xuong***	***H.Ha***	***T.Binh***
Tomato									
Total area	*ha*	*703.4*	*74.6*	*43.4*	*28.30*	*49.0*	*24.0*	*425.0*	*6.3*
FYM	*Ton/ha*	*8.0*	*8.5*	*9.0*	*8.0*	*10.0*	*9.5*	*12.0*	*9.5*
Nitrogen	*Kg/ha*	*100.0*	*120.0*	*110.0*	*85.0*	*90.0*	*115.0*	*120.0*	*100.0*
Phosphorus	*Kg/ha*	*75.0*	*80.0*	*65.0*	*55.0*	*70.0*	*66.0*	*80.0*	*55.0*
Potassium	*Kg/ha*	*30.0*	*45.0*	*50.0*	*40.0*	*30.0*	*35.0*	*60.0*	*30.0*
Chili									
Total area	*ha*	*0*	*367.5*	*108.0*	*13.3*	*0*	*0*	*14.7*	*0*
FYM	*Ton/ha*	*-*	*8.0*	*10.0*	*7.0*	*-*	*-*	*8.0*	*-*
Nitrogen	*Kg/ha*	*-*	*100.0*	*75.0.*	*90.0*	*-*	*-*	*65.0*	*-*
Phosphorus	*Kg/ha*	*-*	*60.0*	*60.0*	*50.0*	*-*	*-*	*50.0*	*-*
Potassium	*Kg/ha*	*-*	*50.0*	*50.0*	*45.0*	*-*	*-*	*40.0*	*-*
Onion and garlic									
Total area	*ha*	*12.7*	*85.6*	*493.9*	*0*	*51.7*	*0*	*56.7*	*38.2*
FYM	*Ton/ha*	*8.0*	*9.0*	*14.0*	*-*	*7.0*	*-*	*7.0*	*7.0*
Nitrogen	*Kg/ha*	*40.0*	*50.0*	*35.0*	*-*	*20.0*	*-*	*30.0*	*40.0*
Phosphorus	*Kg/ha*	*30.0*	*30.0*	*33.0*	*-*	*30.0*	*-*	*40.0*	*35.0*
Potassium	*Kg/ha*	*30.0*	*30.0*	*30.0*	*-*	*40.0*	*-*	*50.0*	*40.0*

Note: FYM: Compost; Nitrogen- N; Phosphorus: P_2O5 and potassium: K_2O

The second group of vegetables includes tomato, chilli and ion and garlic. Tomato is mostly planted in winter season with total area 1354.0 ha, in which tomato was planted in Vu Thu: 703.4 ha (52.0 %) of total area and 425.0 ha is planted in Hung Ha district 31.3 % of total area and in other district. Chilli is planted in both spring and winter season with total area 503.5 ha and it was planted in Quynh Phu: 367.5 ha (73.0 % of total area) and Thai Thuy was 108.0 ha (21.0 % of total area), other districts (Table 12).

Onion and garlic is mostly planted in winter season with total area is about 739.0 ha, in which chilli planted in Thai Thuy 493.9 ha (67 % of total area), Quynh Phu 85.6 ha (11.6 %) and other districts area of 12.7-56.7 ha) as data in Table 12.

Difference with other crops, organic fertilizer used for tomato, chilli and onion and garlic is combined of poultry manure, pig manure and human ejection as mixed compost type. These manures often incu-bated from 5-6 months before applying.

Compost is usually applied 100% at basal application at planting time; additional application occurs in liquid form during the season. According farmers' practice, total organic fertilizer has used for tomato from 8.0-12.0 ton/ha, it is equal to 30-50 % of its demand of 25 ton/ha. Chemical fertilizers were ap-plied at rate of nitrogen from 85.0-120.0 kg/ha; phosphorus from 55-80.0 kg/ha and potassium from 30.0-60.0 kg/ha. Thus, for tomato nitrogen potassium and phosphorus have reached 40-50 % of re-quirement, compare with re-

commendation rate are: nitrogen 200.0 kg/ha; phosphorus 180.0 kg/ha; and potassium: 150.0 kg/ha.

For chilli organic fertilizer was applied from 7.0-10.0 ton/ha, while the demand of chilli is about 20 ton/ha. Chemical fertilizers were applied at rate of nitrogen from 65.0-100.0 kg/ha; phosphorus from 50.0- 60.0 kg/ha and potassium from 45.0-60.0 kg/ha, while the recommendation rate for chilli: or-ganic fertilizer: 20 ton/ha; nitrogen: 120.0 kg/ha; phosphorus: 80.0 kg/ha; and potassium: 160.0 kg/ha. Thus, both organic fertilizer and chemical fertilizers were undersupplied for chilli in framer practice.

Onion and garlic requires large amount of organic fertilizer, it is about 30 ton/ha (10). Farmer has applied organic fertilizer for onion and garlic from 8.0-14.0 ton/ha, it approximates 30-50% of requirement. In contrast with organic fertilizer, onion and garlic require chemical fertilizers with average level: 45 kg of N: 40 kg of P_2O_5; 60 kg of K_2O per ha. Thus, in farmer practice (table 13), chemical fertilizer used for onion and garlic have reached nearly optimum rate.

Perennial crops

Perennial crops in Thai Binh mostly planted in home garden with three main trees are litchi, longan, hoe and mulberry is planted in near river banks and high land terrace. Of which litchi and longan exist with total area 1885.0 ha and Hoe is a medicinal tree with 274.8 ha and mulberry 262.3 ha. The area of Hoe and mulberry are mainly concentrated in Thai Thuy, Kien Xuong, Quynh Phu, and Hung Ha districts.

Concerning fruit trees, there are differences with other crops; fertilizers are often applied for individual fruit tree; the amount of fertilizer used per ha depends on the density of tree per ha. In farmer practices, the density of fruit tree per ha largely varies depending on farmer households. The density of fruit tree per ha is assumed to follow the guideline of fruit tree technical manual of extension office with an average density of 180 trees/ha.

The use of urines on the cultures is rarely used at field. On one hand, the farmers appreciate his convenience of use in the garden, where spreading in liquid form is easy: the farmers who use the urines in their garden underline a better and faster absorption by the plants; this type of liquid manure is well appropriate for trees and crops few days after the sowing; when urines are mixed with washing water, they are very good for rice, allowing less chemical fertilizers. On the other hand, this type of liquid manure is more complicated to transport, and is not applicable at the beginning of the cultures.

Table 13: *Fertilizer used for fruit trees*

Items	***Unit***	***V.Thu***	***Q.Phu***	***T.Thuy***	***D.Hung***	***T.Hai***	***K.Xuong***	***H.Ha***	***T.Binh***
Litchi and Longan									
Total area	*ha*	*250.0*	*459.3*	*186.0*	*283.1*	*47.0*	*413.0*	*181.5*	*65.0*
FYM	*Ton/ha*	*4.0*	*5.5*	*5.0*	*6.0*	*4.5*	*5.0*	*4.0*	*4.8*
Nitrogen	*Kg/ha*	*80.0*	*75.0*	*90.0*	*90.0*	*76.0*	*90.0*	*80.0*	*70.0*
Phosphorus	*Kg/ha*	*90.0*	*85.0*	*80.0*	*70.0*	*84.0*	*80.0*	*70.0*	*70.0*
Potassium	*Kg/ha*	*50.0*	*60.0*	*60.0*	*50.0*	*60.0*	*60.0*	*60.0*	*60.0*

Note: FYM: Compost; Nitrogen- N; Phosphorus: P_2O_5 and potassium: K_2O

Organic fertilizer from cattle and pig manures are usually used for litchi and longan and often incubated during 4-6 months. Amount of organic fertilizer varies following the age of tree and the previous yearly yield. Compost is yearly applied after harvesting season from June-July with amount of 25-30 kg/tree it equal to 4.5-5.5 ton/ha and 100 % of phosphorus also applied in this time with amount of 2.5-3.0 kg superphosphat (17 % of P_2O_5) per tree that equal to 75.0-90.0 kg/ha. Nitrogen and potassium also applied in this time with 50 % of total application: 0.5 kg of urea (46% of N) and 0.3 kg of Kalisulfat (60% of K_2O) per tree that equal to 40 kg of N/ha and 32.0 kg of K_2O per hectare respectively. The rest of nitrogen and potassium were applied before flowering stage and young fruit stage. Farmers are said to underuse mineral fertilizer for litchi and longan during of the first 7-8 years (Table 13): organic fertilizer: 5 ton/ha and N: 100 kg/ha; P_2O_5 90 kg/ha and K_2O: 80 kg/ha (7).

Mulberry and hoe

The area of mulberry in Thai Binh has rapidly decreased in recently; it exists 263.3 ha and more than 50 % of mulberry area of Thai Binh is planted in Hung Ha district. According to extension staffs, fer-tilizers used for mulberry are only organic fertilizer and nitrogen, potassium doesn't apply for mulberry. Estimation of amount of organic fertilizer used for mulberry in farmer practice is about 15 ton/ha and nitrogen varied from 60.0-80.0 kg/ha. Thus, compare with the recommendation rate (3), mulberry demands organic fertilizer: 30.0 ton/ha; nitrogen: 100.0 kg/ha; phosphorus: 80.0 kg/ha and potassium: 50 kg/ha, in farmer practice only provided 50 % of organic fertilizer and 60-80 % of nitrogen and 0 % of potassium.

Hoe (Sophora japonica) is a medicinal tree, which can give high economic value for farmer household. It doesn't completely organize as farm model, hoe planted in home garden or along the road and marginal land area. At present, hoe is concentrated in Quynh Phu and Thai Thuy district with total area: 273.8 ha. Fertilizer used for hoe was not much paid attention as other crops. According to farmer, hoe is annually fertilized from 1-2 times including liquid of pig production and composition fertilizer NPK -5:10:3. Estimation of organic fertilizer used for hoe 7-10.0 ton/ha and inorganic fertil-izer: nitrogen: 40.0 kg/ha; Phosphorus: 80.0 kg/ha and potassium: 24.0 kg/ha.

Global estimation of the evolution of organic fertilizer during the year

Thai Binh is agricultural province with two rice crops per year and annual crops have been planted in three crops per year. As this intensive agriculture leads to a very high demand of organic fertilizer, it is clear that the shortage of organic fertilizer has widely appeared in all of districts. This phenomenon is also to be considered at the international level where prices of nitrogen on the international market are increasing dramatically (11). Although livestock development has highly developed in some communes under enterprise production as well as households scale and the redundant of pig manure has become great attention by local government, the organic fertilizer is still not enough provided for crop in yearly cropping season. Therefore, in farmer practice, the under applying of organic fertilizer for crop is popularly in the field. The result of estimation is presented in Table 14:

Global estimation of organic fertilizer used in farmer practice within seasons indicated that organic fertilizer mostly used for rice. Volume of organic fertilizer applied for rice depends on the total rice area is cultivated as data in table 14. Amount of organic fertilizer was used in spring season was higher than compare to the summer season. Estimated amount of organic fertilizer has used for spring rice in Thai Binh 578,473.8 ton and for summer rice is about 573,947.0 ton.

Table 14: *Estimation of the evolution of organic fertilizer during the year*

Items	***Unit***	***V.Thu***	***Q.Phu***	***T.Thuy***	***D.Hung***	***T.Hai***	***K.Xuong***	***H.Ha***	***T.Binh***
Spring rice									
Rice	*Ton*	*72,238.4*	*82,396.2*	*107,313.19*	*197,640.3*	*82,205.97*	*101,571.6*	*82,972.8*	*12,269.6*
Annual crop	*Ton*	*23,084.3*	*4,148.0*	*12,728.9*	*10,618.5*	*7,923.2*	*18,182.8*	*4,586.9*	*2,193.4*
Summer season									
Rice	*Ton*	*68,426.8*	*76,792.0*	*107,408.0*	*184,261.7*	*80,149.5*	*96,066.8*	*75,208.0*	*6,652.7*
Annual crop	*Ton*	*13,161.7*	*2,856.8*	*8,900.9*	*11,216.1*	*9,624.8*	*5,840.5*	*1,760.6*	*2,401.3*
Winter season									
Annual crop	*Ton*	*51,681.9*	*87,630*	*36,244.2*	*27,839.1*	*11,192.0*	*103,944.6*	*44,363.0*	*5,556.7*
Preniel crops									
Fruit trees	*Ton*	*1,200.0*	*9,526.0*	*1,318.8*	*1,133.2*	*211.5*	*2,265.0*	*1,471.5*	*512.0*

Estimation for winter season with diversity of crops, in the whole province, the organic fertilizer has used of 386,451.0 tons, of which Kien Xuong district has largest winter crop area and amount of organic fertilizer used 103,944.6 ton. In the other districts, this amount varied from 11,192.0 ton in Tien Hai to 51,682.0 ton in Vu Thu district. Because of limitation of cultivated land area, amount of organic fertilizer has used in Thai Binh city in winter season only 5,556.7 ton.

Data in table 15 also indicated that amount of organic fertilizer used for annual crops in spring season is often

higher than compare with summer season and it depends on the total land area and area annual crop were planted in these districts. Estimation of organic fertilizer used for annual crops in whole province, it is about 83,466.0 ton for spring season and 55,762 ton for annual crops in summer season. The highest in Vu Thu, amount of organic fertilizer has applied for spring annual crops was 23,084.3 ton and in summer season was 13,161.7 tons and the amount of organic fertilizer has applied for an-nual crop in other districts (table 14).

For perennial crops in Thai Binh consists of litchi, longan, mulberry and hoe tree, it is quite difficult to estimate exactly because according to Statistical Office in Thai Binh, land area planted for Hoe is not complete estimation.

Based on 2004 census database, the total volume of organic fertilizer applied on agricultural produc-tion in Thai Binh province is 1,958,891.7 tons per year, of which annually organic fertilizer applica-tion in Vu Thu: 229,793 tons, Quynh Phu: 263,349 tons; Thai Thuy: 273,914 tons; Dong Hung: 432,708.9 tons; Tien Hai: 191,307 tons; Kien Xuong: 327,871.3 tons; Hung Ha: 210,362.8 tons and Thai Binh city: 29,585.7 tons per year.

Conclusion

Thai Binh's agricultural productivity has reached to high productivity level compare with the other provinces in both rice and annual crops productivity. Intensive agricultural has exposed the high re-quirement of input uses in both organic and inorganic fertilizer. Result of field survey clearly indicated that agriculture in Thai Binh has facing with the shortage of organic fertilizer and imbalance nutrient in production. In farmer practices, organic fertilizer was applied for crops in two types are compost (but without incubation) and liquid type. Organic fertilizer uses has been stetting priority for crop (rice > annual crops in winter season > annual crop in spring season > annual crop in summer season > fruit trees). High quality waste such as poultry manures and human injection often prioritise for cash crops such as chilli and vegetations. However, the rate of organic fertilizer applied for crops often less than crop requirement as compare with recommendation rate, even using for rice, which was set up in the first priority.

Sources of organic fertilizer mainly from pig production, and the quality of organic fertilizer supplying for crops largely changed from household to household. The high rate of crop residues incorporated inside is main cause of the low quality of organic fertilizer that popularly occurred in farmer households who having small pig farm.

Increasing chemical fertilizers application in agricultural production due to shortage of organic fertil-izer has widely done by farmers. However, the more chemical fertilizers are applied the more soil will be degraded because of less contain soil organic matter in one hand, and another hand because of increasing of price of chemical fertilizer and lack of credit source that leaded to the popular underused of chemical fertilizer for crop. As the consequence that nutrient imbalance has occurred in production with all of crops in Thai Binh province.

Heterogeneous livestock development among households, communities and districts has led to the imbalance in using the waste. The redundant of pig manure and mismanagement of liquid waste in some communes that made the pollution occurred in locality while the shortage of organic fertilizer in other communities has become major limitation for agricultural production.

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