Improved manure management in Vietnam

Pre-reading material for ToT training

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<td>Climate Change</td>
</tr>
<tr>
<td>DBSCL</td>
<td>Mekong River Delta</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<tr>
<td>KSH</td>
<td>Biogas</td>
</tr>
<tr>
<td>NN &amp; PTNT</td>
<td>Agricultural and Rural Development</td>
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<tr>
<td>SNV</td>
<td>Netherlands Development Organization</td>
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</table>
INTRODUCTION

Foreword

Viet Nam is one of the countries predicted to be among the most affected by the adverse impacts of climate change in terms of land size, number of affected people, rate of GDP decline and level of impact on agricultural production¹. However, the country is not only directly affected by climate change but also contributing to climate change by steadily increasing annual emissions from the different sectors, in which agriculture is the highest proportion with 43.1%. Together with rice production, greenhouse gas emissions in livestock production is huge, accounting for 17.2% of total greenhouse gas emissions in agriculture².

According to national statistics up to September 2014, the national herd is estimated on 26.5 million pigs, 7.7 million cattle’s and 304.5 million poultries. Annually, the livestock production emits more than 85 million tons of manure, tens of billions of cubic meter liquid waste and several hundred million tons of exhausted gas³.

For many years, livestock waste has been treated mainly by the biogas system under the project "Biogas Program for the Animal Husbandry Sector in Viet Nam" which was co-implemented by the Department of Livestock Production under the Ministry of Agriculture and Rural Development and the Netherlands Development Organization (SNV). With over 140,000 biogas plants constructed so far in 55 provinces of Viet Nam⁴, this project dramatically contributed in the minimization of environmental pollution regarding soil, water and air pollution; reduction of greenhouse gas emitted from livestock production; minimization of diseases and enhancement of community health protection in Viet Nam. Through communication and training activities the Project has efficiently supported farmers in the utilization of biogas plants, especially using gases for cooking and lighting etc. However, the number of efficient bio-slurry and surplus manure users among biogas households was lower than expected. Only 44 percent of biogas households have been using bio-slurry⁵.

Although the use of biogas has been studied since the 60s of the last century, there is lack of focus on research and education on bio slurry utilization. Currently, the extension programs and projects at both central and local levels have not supported for any concrete demonstration of bio-slurry application⁶. Therefore, a large proportion of households in the country, that fall under the project "Biogas Program for the Animal Husbandry Sector in Viet Nam", does not have adequate knowledge of bio-slurry utilization, which is easily understandable.

The Project’s survey shows that only 60 percent of the interviewed households think training on bio-slurry and manure management is helpful and necessary⁷.

Provincial and district technicians who have a lot of experience and skills to work with the community, have been chosen to directly support the provincial management board to conduct capacity building for beneficiaries. However, most of them do not have deep knowledge on soil science, efficient fertilizer utilization, manure and slurry utilization in particular (only ...% of the people have expertise in crop production )⁸. This fact is considered a major difficulty for these

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¹ ADB (2009) The economics of climate change in Southeast Asia  
² Ministry of Natural Resources and Environment. 2010. The national GHG inventory of the National notifications No. 2.  
⁴ Annually Biogas User Survey  
⁵ Report on Training Need Assessment of "Biogas Program for the Animal Husbandry Sector in Vietnam"  
⁶ Extension activities in animal waste treatment and climate change. Scientific bulletin on agricultural/aquacultural extension. No. of September 2014.  
⁷ Report on Training Need Assessment of "Biogas Program for the Animal Husbandry Sector in Vietnam"  
⁸
extension officers when they directly transfer knowledge on manure and bio-slurry utilization to farmers.

**Objectives of the training**

The training course is organized to give the provincial / district technicians of the project:

1. Basic information on manure and bio-slurry and efficient methods to use these two organic fertilizers for some major crops and freshwater fish farming;
2. Basic training skills: (i) Define training objectives and priorities; (ii) Define training content and develop training material on farm yard manure and bio-slurry utilization for farming households;
3. Basic skills for conducting an efficient training course on manure and bio-slurry utilization for project beneficiaries.

**Expected outcome**

After training, the provincial / district technicians are expected to attain and understand:

1. Basic information on manure and bio-slurry science, the scientific basis to develop effective methods for using manure and bio-slurry in the production of major crops and freshwater fish farming, which will prepare them for their extension service to people in project localities;
2. Basic training skills or improve training skills on manure and bio-slurry utilization.

**Subject of the training**

Direct beneficiaries of the training are the provincial and district technicians of the project.

**Structure and content of the training material**

**Topic 1. Manure and bio-slurry management**

1. Characteristics of manure and bio-slurry. Similarities and differences of these two organic fertilizers.
2. Benefits of the application of manure and bio-slurry on crop production and on the income of farmer households.
3. Bad effects of untreated manure and bio-slurry on environment, family health and community.
4. Methods of making compost fertilizer from manure and bio-slurry.

**Topic 2. Using manure and bio-slurry for some major crops and freshwater fish farming**

5. How to apply manure and bio-slurry efficiently (or effectively)?

1. Using manure and bio-slurry for some major crops.
2. Using bio-slurry for freshwater fish pond.

**Topic 3. Basic training skills for training on manure and bio-slurry utilization**

1. Basic training skills
2. Some basic skills that are necessary for trainers

**Training duration**
A training course lasts for four days.

**Training program**

<table>
<thead>
<tr>
<th>No.</th>
<th>Time</th>
<th>Content</th>
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<tbody>
<tr>
<td><strong>DAY 1</strong></td>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>8h 15 – 8h 30</td>
<td>Opening training course</td>
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<tr>
<td>2</td>
<td>8h 30 – 9h 00</td>
<td>Instruction and rules for training course</td>
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<tr>
<td>3</td>
<td>9h 00 – 9h 30</td>
<td>Pre-training test</td>
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<tr>
<td>4</td>
<td>9h 30 – 9h 45</td>
<td>Break</td>
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<tr>
<td><strong>Topic 1. Manure and bio-slurry management</strong></td>
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<tr>
<td>5</td>
<td>9h 45 – 10h 35</td>
<td>Characteristics of manure and bio-slurry</td>
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<tr>
<td>6</td>
<td>10h 35 – 11h 15</td>
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<tr>
<td>2</td>
<td>8h 10 – 9h 15</td>
<td>Using manure and bio-slurry for paddy rice</td>
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<td>3</td>
<td>9h 15 – 9h 30</td>
<td>Break</td>
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<tr>
<td>4</td>
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<tr>
<td>5</td>
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<td>Using manure and bio-slurry for cassava</td>
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<tr>
<td>6</td>
<td>10h 50 – 11h 30</td>
<td>Using manure and bio-slurry for peanut</td>
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<tr>
<td>7</td>
<td>11h 30 – 13h 30</td>
<td>Lunch</td>
</tr>
<tr>
<td>8</td>
<td>13h 30 – 14h 00</td>
<td>Using manure and bio-slurry for sugarcane</td>
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<tr>
<td>9</td>
<td>14h 00 – 15h 00</td>
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<td><strong>DAY 3</strong></td>
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<td>2</td>
<td>8h 20 – 9h 15</td>
<td>Using bio-slurry for freshwater fish pond</td>
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<td>3</td>
<td>9h 15 – 9h 30</td>
<td>Break</td>
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<tr>
<td><strong>Topic 3. Basic training skills for training on manure and bio-slurry utilization</strong></td>
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<tr>
<td>4</td>
<td>9h 30 – 10h 00</td>
<td>Define training objectives and set up training priorities</td>
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<td>Time</td>
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<tr>
<td>5</td>
<td>10h00 – 10h30</td>
<td>Set up training activities</td>
</tr>
<tr>
<td>6</td>
<td>10h30 – 11h30</td>
<td>Define training structure and how to develop training material for training on manure and bio-slurry utilization for project beneficiaries</td>
</tr>
<tr>
<td>7</td>
<td>11h30 – 13h30</td>
<td>Lunch</td>
</tr>
<tr>
<td>8</td>
<td>13h30 – 14h30</td>
<td>Select suitable training method</td>
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<td></td>
<td>Some basic skills that are necessary for trainers</td>
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<tr>
<td>9</td>
<td>14h30 – 15h15</td>
<td>Promoting skill (Listening skill and Questioning skill)</td>
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<tr>
<td>10</td>
<td>15h15 - 15h30</td>
<td>Break</td>
</tr>
<tr>
<td>11</td>
<td>15h30 – 15h50</td>
<td>Facilitation skills for group discussion (observation skill)</td>
</tr>
<tr>
<td>12</td>
<td>15h50 – 16h10</td>
<td>Facilitation skills for group discussion (presentation skill)</td>
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<td>13</td>
<td>16h10 – 17h00</td>
<td>Set up training plan for in the province</td>
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<td><strong>DAY 4. Set up training plan for in the province and practice developing training material</strong></td>
</tr>
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<td>Set up training plan for in the province (continue)</td>
</tr>
<tr>
<td>2</td>
<td>9h05 – 9h15</td>
<td>Divide class in groups and inform the groups about the practicing exercises</td>
</tr>
<tr>
<td>2</td>
<td>9h15 – 9h30</td>
<td>Break</td>
</tr>
<tr>
<td>3</td>
<td>9h30 – 11h30</td>
<td>Practice developing training material</td>
</tr>
<tr>
<td>4</td>
<td>11h30 – 13h30</td>
<td>Lunch</td>
</tr>
<tr>
<td>5</td>
<td>13h30 – 14h30</td>
<td>Practice developing training material (continue)</td>
</tr>
<tr>
<td>6</td>
<td>14h30 – 15h15</td>
<td>Presentation of group result</td>
</tr>
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<td>4</td>
<td>15h15 - 15h30</td>
<td>Break</td>
</tr>
<tr>
<td>5</td>
<td>15h30 – 16h00</td>
<td>Presentation of group result (continue)</td>
</tr>
<tr>
<td>6</td>
<td>16h00 – 16h30</td>
<td>Post-training test</td>
</tr>
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<td>6</td>
<td>16h15 – 16h45</td>
<td>Instruction on the financial procedure for training courses in the province</td>
</tr>
<tr>
<td>7</td>
<td>16h45 – 17h00</td>
<td>Summarize and close training course</td>
</tr>
</tbody>
</table>
PART 1. CHARACTERISTICS OF FARMYARD MANURE AND BIO-SLURRY

1. Characteristics of manure

1.1. Definition

Manure is a mixture of:

- Animal faeces
- Animal urine
- Litter used as bedding material (straw, grass, ash, green manure etc.)
- Residues from the fodder fed to the cattle

1.2. Composition and characteristics

Farmyard manure has:

- Organic matter: ranging from 18% to 20% of the total amount of fresh manure
- Macro nutrients: nitrogen, phosphorus and potassium (*table 1*)
- Micro nutrients: One ton of manure has about 30 to 50 g MnO; 4 g B; 2 g Cu and 82 to 96 g Zn.
- Manure also contains growth stimulants such as auxin, IAA (indole acetic acid) etc.

*Table 1. Amount of nitrogen, phosphorus and potassium in one ton of manure*

<table>
<thead>
<tr>
<th>Kind of animal</th>
<th>Average amount of nutrient in one ton of manure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pure nitrogen</td>
</tr>
<tr>
<td>Buffalo</td>
<td>2.5</td>
</tr>
<tr>
<td>Cattle</td>
<td>3 -5</td>
</tr>
<tr>
<td>Horse</td>
<td>5 - 6</td>
</tr>
</tbody>
</table>
## 1.3. Characteristics of farmyard manure

<table>
<thead>
<tr>
<th>No.</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Containing all nutrients necessary for crops</td>
<td>The amount of nutrients in manure is often low and unstable</td>
</tr>
<tr>
<td>2</td>
<td>Most nutrients are in organic forms and degrade gradually, so that nutrients can be slowly released into the soil without being washed away</td>
<td>The organic decomposing process in manure is slow, which makes it difficult to timely meet the nutritional needs of plants</td>
</tr>
<tr>
<td>3</td>
<td>Can be produced in households, so it's readily available for crops</td>
<td>Requires transportation costs*</td>
</tr>
<tr>
<td>4</td>
<td>This fertiliser is easily produced with manual methods</td>
<td>Has many insects, germs and weeds</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>Smelly. If applied in its fresh form it will affect the taste of the vegetables</td>
</tr>
</tbody>
</table>

**Example:** If you need 30kg pure nitrogen for basal fertilizing, farmers have to transport only 65 kg urea but more than 10 tons of fresh manure to have the equivalent amount of nitrogen.

## 2. Characteristics of bio-slurry

### 2.1. Product of biogas system

The biogas system creates two main products: biogas and bio-slurry. Bio-slurry has three forms: liquid, scum and residue.

- Liquid effluent comprises soluble and suspended matters. Due to continuous operation, most of the small scaled biogas plants often produce a small volume of liquid effluent.

- Condense effluent comprises scum and residue which is deposited at the plant’s bottom. Condense effluent is stored in the digester and is periodically removed.

### 2.2. Composition and dry matter of bio-slurry

Dry matter is ranging from 6% to 10%. In dry matter composition, there are:

- Organic matters: a ranging from 30% to 50%.
- Macronutrients, secondary nutrients and micronutrients.

### 2.3. pH and nutrient amount
pH of bio-slurry is ranging between 6.9 – 8.5

**Table 2. Amount of nitrogen, phosphorus and potassium in bio-slurry**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Liquid effluent</th>
<th>Condense effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pure nutrient (kg/m³)</td>
<td>Equivalent fertilizer* (kg)</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.37</td>
<td>0.80</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.10</td>
<td>0.63</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.50</td>
<td>0.90</td>
</tr>
</tbody>
</table>

**Source:** Pure nutrients are from the research of Nguyen Nhu Ha, 2005 [9]

Some important points to note: * Urea, Super phosphorus and Potassium Chloride

**Table 3. Nitrogen, phosphorus and potassium in bio-slurry**

<table>
<thead>
<tr>
<th>Feeding material</th>
<th>Average nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pure nitrogen (kg/m³)</td>
</tr>
<tr>
<td>Pig dung</td>
<td>0.47</td>
</tr>
<tr>
<td>Cow dung</td>
<td>0.80</td>
</tr>
<tr>
<td>Mixture of cow dung and pig dung</td>
<td>0.37</td>
</tr>
</tbody>
</table>

**Source:** Pure nutrients are from the research of Tran Thi Tam, 2004. [18]

2.4. Characteristics of bio-slurry

<table>
<thead>
<tr>
<th>No.</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Having all necessary nutrients for crops</td>
<td>Amount of nutrient is unstable</td>
</tr>
<tr>
<td>2</td>
<td>pH value is high, not increasing? the acidity of soil</td>
<td>Transportation is uneasy</td>
</tr>
<tr>
<td>3</td>
<td>Contain less infectious germs; contain no weed seed</td>
<td>Condense effluent is not always available as it is only removed periodically</td>
</tr>
<tr>
<td>4</td>
<td>Not smelly</td>
<td>Containing fairly high level of cholera</td>
</tr>
</tbody>
</table>

2.5. Factors affecting quality of bio-slurry

The quality of bio-slurry depends on:
- Kind and age of animal
- Quality of food for animal
- Urine is fed in biogas digester or not
• Latrine is connected with biogas digester or not
• Efficiency of bio-slurry storing and processing

3. Similarities and differences between manure and bio-slurry

<table>
<thead>
<tr>
<th>Similarities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Manure and bio-slurry are both organic fertilizer</td>
</tr>
<tr>
<td>• The composition contains all needed nutrients for crops</td>
</tr>
<tr>
<td>• The composition contains a high amount of organic matters that helps improving the soil</td>
</tr>
<tr>
<td>• Amount of nutrients are lower than that from inorganic fertilizers and are unstable</td>
</tr>
<tr>
<td>• Even though the composition contains the adequate nutrients, it is such a low amount that it ensures the need for quite a big volume to meet the needs of the plant, which is relatively costly to transport to the field.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Differences between manure and bio-slurry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>1. Organic matter</td>
</tr>
<tr>
<td>2. Nitrogen and phosphorus</td>
</tr>
<tr>
<td>3. Ammonium nitrogen (the nitrogen form that crops can be used directly)</td>
</tr>
<tr>
<td>4. Potassium</td>
</tr>
<tr>
<td>5. pH value</td>
</tr>
<tr>
<td>6. Weed seed</td>
</tr>
<tr>
<td>7. Ability to decompose organic matters in composition</td>
</tr>
</tbody>
</table>

4. Impacts of untreated manure and bio-slurry on the environment

4.1. Impact on soil

4.1.1. Causing nutrient deficiencies of available nitrogen and phosphorus (nutrients plants can absorb directly) in the soil at a time

When fresh manure or bio-slurry is applied in soil, soil microorganisms will focus on decomposing organic matters to create humus. Microorganisms have to use available nutrients, available nitrogen and phosphorus in the soil, to produce energy for their activities. Consequently, there is a nitrogen and phosphorus dispute between microorganisms and plants, causing a deficiency of these nutrients for plants at that time. This phenomena is detrimental for crops in case of poor soil (infertile soils, sandy soil, sea sandy soil) or in case of young plants with undeveloped roots that limit the absorption of nutrients.

4.1.2. Causing acidity of soil (in case of manure application)

The continuous application of farmyard manure, especially in saturated soil, will create acidity of soil due to the fact that, during the decomposition of manure under anaerobic condition, a lot of organic acids are released in soil.

4.2. Causing the spread of pests and weed
• As fresh manure contains many parasites, worm eggs, bugs, bacteria and pathogens, the application of fresh manure to soil creates a good condition for these germs to proliferate and spread, killing some beneficial microorganisms in soil.

• As fresh manure contains many weed seeds, insect pupae cocoons, fungal spores, actinomycetes and harmful bacteria to plants, the application of fresh manure to the soil may cause very prominent phenomena of harmful pathogens. For example:

- Rhizoctonia Solani infection in coffee
- Tomato yellow leaf curl virus
- Peanut bacterial wilt 
  \( (Pseudomonas solanacearum) \)
- Bacterial soft rots on cabbage

• Fresh manure and bio-slurry may contain pathogens, worms, salmonella and E.coli that may infect human beings.

• The application of fresh manure may increase weed in the field. In some cases, this phenomenon is due to the germination of weed seeds in manure in case the manure is mixed with soil when preparing soil beds. In some other cases, weeds are strongly growing after the application of manure/bio-slurry, because these fertilizers contain growth stimulants that increase the speed of the germination of weed seeds in the soil.

4.3. Reducing quality of crop products

During the decomposition in the soil, chemical compounds such as Skatole, Indole and Phenol compounds are released. These compounds may be absorbed by crops, causing the loss of natural flavour of crop products, especially the crops that are directly used by human beings.

Several types of manure may contain toxic residues such as stimulants, antibiotics, disease-causing bacteria and other organic disease-causing elements that decline the quality of the product.

4.4. Impact on water

Untreated farmyard manure and bio-slurry may pollute water resources through: (i) causing eutrophication (excessive nutrients in the water); (ii) increasing the growth of algae in the water; (iii) increasing the concentration of ammonium nitrogen, nitrates and heavy metal elements; Reducing water quality and affecting human health (for instance, causing Hypochromic anemia diseases in children) and agricultural production. The main causes of this phenomenon comes from the decomposition of nitrogen containing organic matters in manure and bio-slurry.
Untreated farmyard manure and bio-slurry cause serious water pollution as these fertilizers contain a large number of pathogenic microorganisms, such as E. coli, causing intestinal diseases, and other parasites such as trematode larvae, typhoid, parasitic worms, courtyard etc. In many cases, pathogens are most likely transported to water with surface runoff and erosion or by direct animal access to surface water.

5. Effects of farmyard manure and bio-slurry application

Properly treated farmyard manure and bio-slurry not only eliminates unwanted impacts but also brings about many benefits to farming households. The effects of manure and bio-slurry are listed below:

5.1. Improving crop productivity

5.1.1. Direct effect

Farmyard manure and bio-slurry (liquid effluent and condense effluent) contain all necessary nutrients for crops. When these fertilizers are applied into soil, plants can absorb nutrients from the fertilizers by two ways:

- Direct absorption of available mineral nutrients (nitrogen, phosphorus, potassium etc.) from the two types of fertilizers
- Absorb mineral nutrients that are released from the decomposition of organic matters in manure or bio-slurry.

Example: absorb NH$_4^+$ released from protein; absorb H$_2$PO$_4^-$ or HPO$_4^{2-}$ released from phosphorus containing organic matters such as phosphorus lipid etc.

Researches by the research institute, universities and field surveys on experiences of farmers in Viet Nam indicated that farmyard manure can increase crop yields from 10% to 20%. In the case of paddy rice, the increased rice yield by manure application in Viet Nam has reached 2.5 - 3 million tons / year [14]. The effects of the application of bio-slurry on crop productivity have also been confirmed by a number of authors (Table 4).

**Table 4. Examples of impact on increased yield of bio-slurry**

<table>
<thead>
<tr>
<th>Type of crop</th>
<th>Amount of application</th>
<th>Increase rate of yield (%)</th>
<th>Information source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>10 tons of condense effluent + 200 kg Urea + 560 kg Super phosphorus + 100 potassium chloride / ha</td>
<td>5.9 *</td>
<td>Nguyen Nhu Ha [ 9 ]</td>
</tr>
<tr>
<td>Maize</td>
<td>360kg Farmyard manure + 22.5m$^3$ liquid effluent / 360m$^2$</td>
<td>25.8 **</td>
<td>Institute of Energy [ 32 ]</td>
</tr>
<tr>
<td>Cabbage</td>
<td>435 kg Urea + 625 Super phosphorus + 180 kg potassium chloride + 40 – 120 m$^3$ liquid effluent / ha</td>
<td>6 - 19</td>
<td>Dinh The Loc [ 18 ]</td>
</tr>
<tr>
<td>Green cabbage</td>
<td>60 kg Urea + 12,000 litres liquid effluent/ha</td>
<td>12.6**</td>
<td>Dinh The Loc [ 18 ]</td>
</tr>
<tr>
<td>Rambutan fruit</td>
<td>18 kg condense effluent + 3.2 kg Urea + 6.3 kg Super phosphorus + 3 kg potassium chloride / plant / year</td>
<td>67.0**</td>
<td>Vo Van Binh [ 5 ]</td>
</tr>
</tbody>
</table>

Some important points to note: * Compared to the control of applying 10 tons of farmyard manure

** Compared to the control of applying inorganic fertilizers
Researches by a number of authors in vegetable production showed that the effect of effluent in increasing crop yields is higher than that of manure.

3.1.2. Indirect effect

Indirect effects of manure and bio-slurry in increasing crop yields is due to increased chemical fertilizers use efficiency (fresh weight or product yield per content of nutrient).

Example: Comparing to no application, the combined application of nitrogen and farmyard manure may increase nitrogen use efficiency of coffee from 37.2 % to 52.8% [4]. The application of farmyard manure for rice may increase nitrogen use efficiency of rice up to 30-40% [14].

As bio-slurry has a high pH value (> 7.5), when being applied in acid soil, the practice will have the effect of reducing the acidity of the soil and thus increasing the ability of phosphorus absorbing from inorganic phosphorus fertilizer of plants.

5.2. Improving soil properties

5.2.1. Improving the physical properties of soil

As manure and bio-slurry are organic fertilizers, containing large amounts of organic matters, they contain material to create humus. Thus when applied to soil, the two organic fertilizers will:

- Improve the stability of soil structure: farmyard manure and bio-slurry have a high ratio of cellulose (C) to nitrogen (N), which enables the creation of high humus particles to create a stable structure of soil, increase cohesion between soil particles and reduce the wettability of soil, resulting in a stable structure of soil in water.
- Making soil more porous, reducing compaction in the heavy soils such as medium and heavy loams; making soil softer (as friable soils are favourable for cultivation); Reducing erosion on sloppy soils.
- Improve water-holding capacity of soil. This effect is clearer in sandy soil than heavy and medium soils.

Example: The application of condense effluent for durian helped farmer Nguyen Van Kinh from My Thanh A hamlet, Long Tien commune, Cai Lay district, Tien Giang province save about one third of irrigation cost as the soil can retain moisture better than in the case of chemical fertilizer application [31].

5.2.2. Improving the chemical properties of soil

Farmyard manure and solid bio-slurry not only provide nutrients for crops but also bring about below benefits:
- Increasing ability to hold nutrients while limiting the leaching of soil.
- Increasing ability to transform difficultly decayed compounds into soluble elements to provide nutrients to plants, most clearly in the metabolisation of phosphorus compounds in the soil by improving soil pH (when solid bio-slurry is applied).
- Thanks to the reduction of soil acidity [5] bio-slurry has the effect of reducing the cytotoxicity of Fe, Al and Mn in soil, especially on the alkaline soil [23] and barren soil.
- The application of solid bio-slurry for saline soil can reduce the soil salinity up to 30-40% [1].

5.2.3. Improving the biological properties of soil

The application of organic fertilizers (including manure and bio-slurry) has positive effects in increasing the number of beneficial microorganisms in the soil, but at different levels. The
application of manure and bio-slurry also has benefits as the increasing number of beneficial microorganisms in the soil, such as nitrogen fixation microorganisms, phosphorus decomposition microorganisms, helps plants absorb nutrients in soil more easily.

5.3. Improving quality of crop products

The application of properly treated manure and bio-slurry not only increases crop yields and improves soil properties, but it also improves the quality of agricultural products. 

Example: The application of solid bio-slurry for fruit orchards in the districts of Cai Be, Cai Lay, Chau Thanh, Cho Gao, Go Cong Tay, Go Cong Dong of Tien Giang province had positive results. Specific results are that the plants are longer green, the harvest products have a shiny colour and the crop products have a better quality and taste, in comparison to that of control fruit orchards without using bio-slurry [31].

5.4. Reducing the spread and damage by pests and pathogens

- The application of bio-slurry may constrain green aphid that damages vegetables and cotton, such as the leaf spot disease in some plants. In many cases, the practice can limit the development of pest to 30-100%. If you put a small amount of pesticides (about 10%) into bio-slurry, the practice will increase the effectiveness of pesticides while improving the effects of pesticide (having effect only 48 hours after application). Therefore, it may reduce the amount of pesticides applied to crops, eliminating environmental pollution and saving costs [18].
- Research conducted by the National Institute of Soils and Fertilizers (2004) pointed out that the application of biogas liquid effluent as additional fertilizer for cabbage helped reducing the use of leaf bite insecticide per crop season with 50%. The farmers in Quang Dien district, Thua Thien Hue province communicated that the utilization of liquid effluent as watering water for assorted green cabbage helped reducing the rod-shaped disease in comparison to that of the control situation without using bio-slurry.
- The application of liquid bio-slurry for a paddy rice field growing Khang Dan 18 breed in Cam Giang district, Hai Duong province, showed that the phenomenon of stripe blight and bacterial spot were not detected, while they were detected in other control fields where bio-slurry was not used [18].
- The application of manure will add Trichoderma fungi source, thus reducing root rot causing pathogens on tomato and chili or preventing harmful fungi on citrus and cucurbits vegetables [30].
- The application of fully decomposed manure or bio-slurry may constrain the Rhizoctonia Solani infection in coffee in comparison to gardens using fresh manure [15].

5.5. Reducing production costs and increasing income

Table 5. Summary of demonstrations of bio-slurry application of the “Biogas Program for the Animal Husbandry sector in Viet Nam” funded by SNV in 24 provinces

<table>
<thead>
<tr>
<th>Type of crop</th>
<th>Paddy rice</th>
<th>Vegetable</th>
<th>Short day growing dry plants</th>
<th>Fruit tree</th>
<th>Industrial tree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of demonstrations</td>
<td>3</td>
<td>24</td>
<td>4</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Result</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased yield (%)</td>
<td>7</td>
<td>2 – 14</td>
<td>15 – 20</td>
<td>20 – 30</td>
<td>5 – 14</td>
</tr>
<tr>
<td>Increased income in comparison to the situation without application of bio-slurry (%)</td>
<td>25</td>
<td>10 – 63</td>
<td>0 – 5</td>
<td>98 – 130</td>
<td>87</td>
</tr>
</tbody>
</table>
PART 2. TECHNIQUE FOR COMPOSTING FARMYARD MANURE AND BIO-SLURRY

1. Why manure and bio-slurry need to be composted?

<table>
<thead>
<tr>
<th>Reasons for making compost</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most of the nutrients in manure and bio-slurry are in organic forms that plants cannot use directly</td>
<td>Composting decomposes organic matters under the activities of the different microorganisms to produce available nutrients that plants can absorb directly</td>
</tr>
<tr>
<td>High transportation costs</td>
<td>Composting reduces the volume of fertilizer to cut down transportation costs</td>
</tr>
<tr>
<td>Manure has a lot of disease causing germs, such as larvae and weed seed</td>
<td>Composting kills pests and pathogens and impairs the germination of weed seeds</td>
</tr>
<tr>
<td>Manure and bio-slurry contain some disease causing parasites for animals and human beings</td>
<td>Composting constrains the spread and affection of harmful bacteria</td>
</tr>
</tbody>
</table>

2. Technique for composting manure and bio-slurry

2.1. Technique for composting farmyard manure and condense bio-slurry

2.1.1. Hot compost

**This technique should be used in case:**
- Plant materials that need to be composted are straw, cornstalks, weed, dried leaves or fibrous materials that rot down very slowly.
- Farmers urgently need manure or compost in the form of fully or partially decomposed fertilizers to fertilize crops.

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Fast breaking up of the material into very fine compost, producing compost in a much shorter time</td>
<td>Hot composting conserves less nitrogen due to the high temperature in the hot compost pile, leading to lower – quality finished compost.</td>
</tr>
<tr>
<td>* Destroying worm eggs, courtyard, weed and pathogens as the compost temperature is maintained at more than 60 degrees Celsius, limiting the spread of these germs to the field and the surrounding environment.</td>
<td></td>
</tr>
</tbody>
</table>

**How to make the compost?**

- **Prepare compost area:** Ground should be located in areas with a high terrain and should not be submerged. The soil must be compact to ensure that it is waterproof. Recommended dimensions for a heap are 2 to 2.5 meter long by 1.5 meter wide by 1.5 meter high.
- **Prepare material and make compost:** Manure and condense bio-slurry are mixed with a phosphorus fertilizer. Use 20 kg of phosphorus fertilizer (*using Phosphate phosphorus for manure while using super phosphorus for bio-slurry*) to every one ton of manure and/or condense bio-slurry. The mixed ingredients are then laid in layers of about 50 – 70 cm thick. Wet the compost heap very well at the bottom so it is dripping water out of the bottom and is saturated. Materials can be added as they are generated or they can be stored until there is enough material available to make a good sized heap of about 1 – 1.5m high. Other folks
attempt to improve aeration in holding units by adding one or more ventilating stacks or by poking holes into the pile.

- **Covering:** It is optional whether the compost area has a roof. If not, use straw or plant stalks/leaf to lay across the pile as it is built.

**How long is the finished compost available for crops?**

- Using for paddy rice: about 30 – 40 days is needed
- Using as basal fertilizing for maize, sugar-cane and as additional fertilizing for fruit trees or perennial industrial trees: about 60 – 70 days is needed
- Using as basal fertilizing for peanut, legume crops and vegetable crops; as additional fertilizing for maize and sugar cane: about 70 - 75 days is needed

2.1.2. **Cold compost (compacted compost)**

**This technique should be used in case:**

- Plant materials that need to be composted are peanut and legume residue, or hyacinth.
- Farmers are not in urgent need or mainly need compost fertilizer for the next crop season

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold compost preserves nitrogen, ensuring the manure quality</td>
<td>Cold composting does not kill worm eggs, courtyard, weed and pathogens. These germs will probably grow when farmers put the compost into the field</td>
</tr>
<tr>
<td></td>
<td>Slow decomposition</td>
</tr>
</tbody>
</table>

**How to make the compost?**

- **Prepare compost area:** Ground should be located in areas with high terrain and should not be submerged. The soil must be compacted to ensure that it is waterproof. Recommended dimensions for a heap are 2 to 2.5 meter long by 1.5 meter wide.
- **Prepare material and steps to make compost:** Manure and condense bio-slurry are mixed with a phosphorus fertilizer. Use 20 kg of phosphorus fertilizer (*using Phosphate phosphorus for manure while using super phosphorus for bio-slurry*) to every one ton of manure and/or condense bio-slurry. The mixed ingredients are then laid in alternating thin layers of about 50 – 70 cm thick. Wet the compost heap very well so that the soil becomes compacted. Materials can be added as they are generated or they can be stored until there is enough material available to make a good sized heap of about 1 – 1.5m high by 2 meter wide.
- **Covering:** The built heap is then covered fully with mud. It is optional to cover the compost area with a roof.

**How long is the finished compost available for crops?**

This method is mainly used for preserving manure, the compost process needs 5 to 6 months.

2.1.3. **First hot then cold compost (combine compost)**
How to make the compost?

- **Prepare compost area:** Ground should be located in areas with high terrain and should not be saturated. The soil must be compacted to ensure that it is waterproof. Recommended dimensions for a heap are 2 to 2.5 meter long by 1.5 meter wide.
- **Prepare material and steps to make compost:** Manure and condense bio-slurry are mixed with a phosphorus fertilizer. Use 20 kg of phosphorus fertilizer (using Phosphate phosphorus for manure while using super phosphorus for bio-slurry) to every one ton of manure and/or condense bio-slurry. The mixed ingredients are then laid in layers of about 50 – 70 cm thick. Wet the compost heap very well at the bottom. After 5 to 6 days, wet the compost heap with water until it is soaked with water. Compact the heap and continue with other prepared materials. After 5 to 6 days, wet the compost heap with water. Compact the heap and continue with other prepared materials. Materials can be added as they are generated or they can be stored until there is enough material available to make a good sized heap of about 1.5m - 2 meter high.
- **Covering:** The built heap is then covered fully with mud. It is optional to cover the compost area with a roof.

**How long is the finished compost available for crops?**

The compost process needs 3 to 4 months.

### 2.2. Technique for composting bio-slurry

#### 2.2.1. Making compost from liquid bio-slurry and straw, leave, green manure plants

**How to make the compost?**

**Step 1:** Dig a hole or select an area on waterproof ground near a biogas digester for composting. Pile up materials (or put them into a big hole that you have dug in the ground. Materials should be broken up and dried (for speeder decomposition, materials should be dried).

**Step 2:** Put the prepared material in layers on the ground or in the dug hole with a roof. Lime powder should be used with a ratio of 0.5 - 0.7% in case compost materials are straw, cornstalk or dried leave.

**Step 3:** Wet the organic materials with liquid bio-slurry and turn them well to make proper moisture. The volume of used liquid bio-slurry is estimated to be 3 fold to the organic material. Put the prepared material in layers on the ground or in the dug hole. Recommended dimensions for a heap are 1.8 to 2.5 meter long by 1.5 meter wide by 1.5 meter high. Use straw or plant stalks/leaf or cut banana/coconut stalks to lay across the pile as it is built.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>This method preserves nitrogen better than that of hot compost, ensuring a better quality of manure.</td>
<td>Requires much more labour than hot compost and cold compost.</td>
</tr>
<tr>
<td>Most worm eggs, courtyard, weed and pathogens are nearly destroyed in the process, reducing the spread of these germs to the field and the environment.</td>
<td></td>
</tr>
</tbody>
</table>
The moisture level of the heap/pit should be maintained by watering it with liquid bio-slurry. Use 15 litres of water for 100kg of material. When the compost heap reaches 40 - 50°C, add more liquid bio-slurry and compact it well to reduce nutrient loss.

**Step 4:** Turn the compost heap to speed up the decomposition
- First turning: 2 - 3 weeks after building compost heap. Together with turning, use super phosphorus at the ratio of 2 - 5% and compact the heap well.
- Second turning: 45 – 50 days after the first turning.

**How long is the finished compost available for crops?**

- **Using as basal fertilizing for paddy rice or root crops:** the compost needs about 6 - 8 weeks. The compost fertilizer is in this form similar to that of manure.
- **Using for maize, peanut, vegetable, fruit tree and perennial industrial tree:** the compost fertilizer should be fully decomposed or rotted, commonly 15 – 16 weeks after building the compost heap/pile.

### Table 6. Macronutrients (N, P and K) in compost fertilizer

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of compost material</th>
<th>Nutrient (%)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>P₂O₅</td>
<td>K₂O</td>
</tr>
<tr>
<td>1</td>
<td>Liquid bio-slurry and straw</td>
<td>0.25</td>
<td>0.24</td>
<td>0.30</td>
</tr>
<tr>
<td>2</td>
<td>Liquid bio-slurry and green manure plant</td>
<td>0.26</td>
<td>0.21</td>
<td>0.27</td>
</tr>
<tr>
<td>3</td>
<td>Liquid bio-slurry + Super phosphorus + lime powder + cutting - in - piece straw</td>
<td>0.30</td>
<td>0.32</td>
<td>0.40</td>
</tr>
<tr>
<td>4</td>
<td>Farmyard manure</td>
<td>0.35</td>
<td>0.15</td>
<td>0.30</td>
</tr>
</tbody>
</table>

*Source: Nguyen Nhu Ha [10]*

### 2.2.2. Making compost from condense bio-slurry and straw and leave

**How to make the compost?**

**Step 1:** Lay the plant materials (straw, leave and green manure plants) in layers of 30 cm thick and then add a layer of condense bio-slurry. Continue laying until you have a good sized heap of about 1.5 meter high by 1.5 meter wide by 1.8 – 2.5 meter long (Dried condense bio-slurry does not need to be dried more).

**Step 2:** Water the compost heap with water to make proper moisture in case the dried condense bio-slurry (the slurry was removed out from the digester long before composting) is used. The heap is covered with a plastic sheet.

*Outer cover of the heap*
Step 3: Turning the heap to speed up decomposition

- First turning: 2 - 3 weeks after building the compost heap, together with turning, use super phosphorus at the ratio of 2 - 5% and compact the heap well.
- Second turning: 45 – 50 days after the first turning.

How long is the finished compost available for crops?

- Using as basal fertilizing for paddy rice or root crops: the compost needs about 1.5 - 2 months. The compost fertilizer is in this form similar to that of manure.
- Using for maize, peanut, vegetable, fruit tree and perennial industrial tree: the compost fertilizer should be fully decomposed or rotted, commonly 15 – 16 weeks after building the compost heap/pile.

Box 1. How to recognize that a compost heap is fully decomposed / rotted after a certain time?
Fine rotted compost fertilizer can be recognized by the size of the compost material. When fully decomposed, compost material does not remain in its original size and the initial ingredients are no longer recognizable, and have a dark color. Make a compost solution by putting the decomposed compost into water and then filter the solution by using blotter paper to see whether the solution has no color.
PART 1. PRINCIPLES OF EFFICIENT APPLICATION OF FARMYARD MANURE AND BIO-SLURRY IN CROP PRODUCTION

To attain efficient manure and bio-slurry use, the following 4 “musts” have to be implemented:

1. **Using the right amount of fertilizer**

   In crop production, manure and bio-slurry are commonly used for two purposes: (i) meet the nutritional needs of crops and (ii) improve soil properties. For those purposes, to have the optional effects of manure and bio-slurry, we need to determine the appropriate application formula for each crop, type of soil and the seasonal conditions.

   The application amount of manure and bio-slurry ranges from 5 tons to 30 tons, depending on:

   - **Type of soil**: The same varieties of crops but being grown on poor soil texture (clay loam soil, sandy soil and clay-sandy soil), having low porosity, poor aeration and drainage, which is not ideal for the growth of many crops, a higher amount of fertilizer should be applied, in contrast to the lower amount of fertilizer for other soils.
   - **Variety of crop**: Being grown on the same soil, root crops (sweet potato, cassava, arrowroot) and vegetable root crops (potato, carrot) require a higher amount of fertilizer than other crops. Crossbreed needs a higher amount of fertilizer than pure breed and local varieties.

2. **Using the right form of fertilizer**

   Farmyard manure and bio-slurry have different forms including fresh, partially decomposed or fully decomposed forms. Farmers determine the proper form of fertilizer based upon concrete factors and conditions.

2.1. **In what case can fresh (untreated) manure and bio-slurry be applied? And why?**
Fresh manure and bio-slurry that is just removed from the biogas digester can be applied directly to the crops in below cases as the practice has benefits on both the soil and the crops and has less negative effects on the environment.

2.1.1. Using on sandy soil or non-saturated clay-sandy soil
Sandy soil and clay-sandy soil have poor nutrients, poor water retention and fertility or humus. These types of soil have a poor water and nutrients holding capacity, resulting in water and nutrient loss. It tends to hold fewer nutrients as these are often washed away when watering or applying the fertilizer. As fresh manure and bio-slurry contain high organic matters, when applied on these soils, the fertilizers will increase the humus of soil through the decomposition of organic matters, increasing the water and nutrient holding capacity of the soils.

The application of fresh manure and bio-slurry on unsaturated sandy soil and clay-sandy soil will speed up and enhance the decomposition of the fertilizer, reducing the mineralization and nitrogen loss faster as compared to the application of rotted manure/bio-slurry.

Besides, as the temperature in sandy soil and clay-sandy soil is normally high in summer, the use of these fertilizers to the soils destroys harmful microorganisms, fungal diseases and weed, limiting the spread of those pathogens, fungal diseases and weeds significantly.

2.1.2. Using for root crops such as sweet potato, cassava, arrowroot being grown on light clay loam soil, sandy soil, clay-sandy soil
As being root crops, cassava, sweet potato and arrowroot should be grown in porous soil to facilitate the development of roots and tubers formation. The application of fresh manure and bio-slurry, which contain high organic matter, will increase soil humus. Formed humus then makes soils more granular as it creates smaller soil particles to form much larger soil particles, creating soil porosity. This improves the aggregation of soil particles, making soil more friable and easier to cultivate, facilitates tuber formation and growth and increases the productivity of these crops.

During the decaying of these untreated fertilizers, a big amount of CO$_2$ gas is formed, creating favourable conditions for the formation of starch in tubers, thus improving the quality of agricultural products.

2.2. In what case can decomposed manure and bio-slurry be applied? And why?

2.2.1. Using for crops grown on medium clay loam soil and heavy clay loam soil, especially where the soils are saturated
Medium clay loam soil and heavy clay loam soil feel lumpy and are sticky when wet and rock hard when dry. These soils are poor at draining and only have a few air spaces, creating unfavourable conditions for the activities of decomposing microbial, resulting in poor performance of the microbial and...
very slow decomposition of the organic matters in the soil. If untreated manure or bio-slurry is applied on these soils, the practice will:

- Not timely meet the nutrient requirement of crops due to the slow decomposition of the fertilizer.
- The decomposition of the fertilizer under anaerobic conditions (without oxygen) will release many organic acids, making soil acidic, creating unfavourable conditions for the growth and development of crops.
- Under anaerobic conditions, many of the disease causing bacteria and fungi (anaerobic strains) that are available in manure continue to grow and damage the crops.

The application of decomposed manure and bio-slurry will eliminate the above-mentioned negative impacts.

2.2.2. Using as basal fertilizing for crops including paddy rice, maize, legume crops, peanut, vegetable crops, fruit trees, industrial trees (coffee, rubber, pepper etc.)

<table>
<thead>
<tr>
<th>Using treated manure and bio-slurry as basal fertilizer for the below crops will restrict the following phenomena:</th>
</tr>
</thead>
</table>
| **Paddy rice** | Nutrient dispute among soil microbial and paddy rice  
Spreading of weed, pathogens and the phenomenon of "roots stuffed" in rice |
| **Maize** | The appearance and damage of banded leaf and sheath blight disease in seedlings period |
| **Legume crops** | The appearance of wilting and green death of seedlings |
| **Vegetable crops** | Generation of cracked tubers that reduce the quality of agricultural products (kohlrabi, carrot)  
The infection of worms, helminthes and pathogens on products bad effects on the quality (taste, smell) of agricultural products due to the application of fresh manure or bio-slurry |

2.2.3. Using as additional fertilizer for paddy rice, maize, pepper, coffee and fruit trees

<table>
<thead>
<tr>
<th>Using treated manure and condense bio-slurry as additional fertilizer for the below crops will restrict the following negative phenomena, for example:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Paddy rice</strong></td>
</tr>
<tr>
<td><strong>Pepper</strong></td>
</tr>
<tr>
<td><strong>Coffee</strong></td>
</tr>
</tbody>
</table>

3. Right time application

3.1. Basal fertilizer
Commonly fresh/decomposed manure and solid bio-slurry or compost manure (produced from a composting mixture of straw, waste, green manure plants, solid/liquid bio-slurry) should be applied to the soil at the time of tillage period (last ploughing or dragging soil) or should be applied at the same time with seed sowing.

### 3.2. Additional fertilizer

Fresh manure, (fully) decomposed bio-slurry, compost manure and liquid bio-slurry can be used as additional fertilizer for crops, depending upon the stage of growth and development of plants.

### 4. Right method

#### 4.1. Right method

<table>
<thead>
<tr>
<th>Application time</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal fertilize (use decomposed manure and solid bio-slurry/compost fertilizer)</td>
<td>Spread fertilizer as even layers on the soil surface and then tilling or harrowing so that the fertilizer is buried deeply in the earth.</td>
</tr>
<tr>
<td>Basal fertilize for soil when making soil preparation:</td>
<td></td>
</tr>
<tr>
<td>Application at the time of seed sowing or growing seedlings</td>
<td>Apply the fertilizer in a row or in a hole, cover the fertilizer with a thin layer of earth and then conduct seed sowing or plant growing.</td>
</tr>
</tbody>
</table>
| Fresh manure and bio-slurry                          | Apply the fertilizer in a row or in a hole together with tillage operations for dry land crops within a short period of time  
|                                                       | - Apply the fertilizer to the tree diameter (donuts) of fruit trees and perennial industrial plants  
|                                                       | - Apply directly on paddy rice |
| Additional fertilize                                  |                                                                       |
| Liquid bio-slurry                                     | - **Diluting with water and then apply directly** on crops together with tillage operations  
|                                                       | - **Diluting with water and then apply on the leaf:**  
|                                                       |  + First take the liquid bio-slurry out of the biogas digester, then store it in slurry pit to have the separate solid part  
|                                                       |  + Filter the liquid solution. After filtering, the filtered solution should be stored for one more deposition.  
|                                                       |  + Use a sprayer to spray the soluble fertilizer on the leaf.  
|                                                       |  + The best time of the day for the application of the fertilizer is in the early morning or late afternoon.  
|                                                       |  + Do not use fertilizer if it is going to rain heavily, as the plants are unable to absorb the nutrients, causing waste of the fertilizer. |

#### 4.2. Combination with other inorganic fertilizers

The combination of manure and bio-slurry with inorganic fertilizers will enhance the efficiency of each fertilizer when they are applied in a balanced combination.
Example: The combination of manure/bio-slurry with phosphorus fertilizer will have the following benefits:
- Limits nitrogen loss during the decomposition of manure on light clay loam soil, sandy soil or clay-sandy soil for growing dry land crops.
- Reduces acidification of the soil when manure is continually applied on the same soil.
- Increase the solubility of phosphorus in phosphate fertilizers.

### Best combination of manure and bio-slurry with phosphorus fertilizers

<table>
<thead>
<tr>
<th>Combination formula</th>
<th>Benefit</th>
</tr>
</thead>
</table>
| Manure + Phosphorite phosphorus      | - Increases the solubility of phosphorus in phosphorite phosphate fertilizers, as in the following chemical reaction:  
\[
H_2SO_4 + Ca_3(PO_4)2 = Ca(HPO_4)2 + CaSO_4 
\]  
  *Insolubility Solubility*  
- Reduces the acidification ability of manure because Van Dien phosphorus fertilizer contains 30% CaO, as in the following chemical reaction:  
\[
H_2SO_4 + CaCO_3 = CaSO_4 + H_2O + CO_2 
\] |
| (Van Dien phosphorus fertilizer)     |                                                                                           |
| Bio-slurry + Super phosphorus        | H_3PO_4 + NH_4OH = (NH_4)_2H_2PO_4 + H_2O                                                |
| (Lam Thao phosphorus fertilizer)     | H_3PO_4 + NH_4OH = NH_4H_2PO_4 + H_2O                                                      |

**PART 2. HOW TO APPLY MANURE AND BIO-SLURRY EFFICIENTLY?**

**A. In agricultural production**

1. Relation of soil, crop and fertilizer – an important point to be taken into consideration

   ![Diagram](Diagram.png)

   - Soil is the habitat for plants, and it supplies and stores nutrients, air and water to plants.
   - A fertilizer provides nutrients from the outside for plants to grow and develop, forming productivity and contribute to improved soil properties.
   - Soil is the environment that can maximize the positive effects of the fertilizer (as soil provides water, air and decompose microbial to metabolize the nutrients in the fertilizer as they are applied to soil).

**Box 2. Understanding this relationship well will help farmers in selecting the proper method of using manure and bio-slurry, that is best suited to their resources (soil conditions, seasonality, the main plant structure, farming practices, market etc.)**

2. Based on soil property
2.1. Based on the mechanical composition of the soil
Farmers can select the right form of fertilizer (level of decomposition), with the best advantages, based upon the mechanical composition of the soil.

2.1.1. Agricultural soil types classified by mechanical composition

<table>
<thead>
<tr>
<th>Heavy plastic clay soil</th>
<th>Moderate plastic clay soil</th>
<th>Low plastic clay soil</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Heavy plastic clay soil" /></td>
<td><img src="image2" alt="Moderate plastic clay soil" /></td>
<td><img src="image3" alt="Low plastic clay soil" /></td>
</tr>
<tr>
<td>Clay-sandy soil</td>
<td>Sandy soil</td>
<td></td>
</tr>
<tr>
<td><img src="image4" alt="Clay-sandy soil" /></td>
<td><img src="image5" alt="Sandy soil" /></td>
<td></td>
</tr>
</tbody>
</table>

2.1.2. How to classify soils by the mechanical composition under the farmer's conditions?
In the conditions of the household (without soil analysis), the use of the following methods can quite accurately determine the soil types by its mechanical composition:

a. **Checking the size range of grain**: Use your fingers to press on the soil and rub it between your fingers, if the soil contains a lot of sand (sandy soil or clay-sandy soil), it will give a rough feeling on the fingertips.

b. **Soil moisture test**: Hold some soil in your hand and mix it with water, then toss the handful of soil from hand to hand. If the soil retains its shape and does not break, it is identified as fine grained (the soils are primarily clay), heavy mechanical property or moderate plastic clay soil.

c. **Sticky test or dilatency test**: Take a small sample of your soil and mix it with a amount of water until it is soaked. Form the sample into a cube or ball and place it in the palm of your hand, facing up. Use your thumb and index fingers to tightly press the soil sample. The more clay contained in the soil (heavy plastic clay soil or moderate plastic clay soil), the more adhesive plastic the soil has and the more elastic the soil is and vice versa.

d. **Roll the soil into a thread**: Take a small sample of soil and mix it with small amount of water until the level of moisture is 40% (feeling wet on the fingers) and work it into a thread. The more clay the soil contains, the longer “the thread” can be made and vice versa. Roll the thread until it has a diameter of about 3–4 cm and observe:
If you can roll a thread without or with a tiny crack on the thread, and you can do it easily and quickly, you have a moderately plastic soil, most likely a heavy plastic clay soil.  
If you can roll a thread with about 5 cracks or more on the thread, you have a moderately plastic soil, most likely a moderate plastic clay soil.  
If you can roll a thread but it is difficult and the soil is very stiff, you have a highly plastic soil, most likely a low plastic clay soil.  
If it is very difficult or impossible to roll a thread, you have a low plasticity soil, probably sandy soil or clay-sandy soil.

2.1.3. **Select the right form of fertilizer based upon the mechanical property? And why?**

Table 7. Physical properties of soils having different mechanical properties and the right forms of fertilizer (manure/bio-slurry)

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Physical properties</th>
<th>Right form of fertilizer (manure/bio-slurry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy plastic clay soil</td>
<td>Low porosity in the soil so organic matters are decayed slowly</td>
<td>Depending on the variety of crop and the using time, the <em>partially decomposed</em> or <em>fully decomposed</em> manure and bio-slurry are selected and utilized.</td>
</tr>
<tr>
<td>Moderate plastic clay soil</td>
<td>Higher porosity compared to heavy plastic clay soil, however organic matters are still slowly decayed, especially when the soil is saturated.</td>
<td>Depending on the variety of crop and the using time, the <em>partially decomposed</em> or <em>fully decomposed</em> manure and bio-slurry are selected and utilized.</td>
</tr>
<tr>
<td>Low plastic clay soil</td>
<td>High porosity and suitable air and water content in the soil that facilitates the speed of the decomposition of organic matters.</td>
<td>Depending on the variety of crop and the using time, the <em>fresh/untreated</em> or <em>partially decomposed</em> manure and bio-slurry are selected and utilized.</td>
</tr>
</tbody>
</table>
| Clay-sandy soil       | The soil has a big amount of oxygen, making the decomposition of organic matters easily and speedily. | *Basal fertilizer:* Use *fresh manure* or bio-slurry that is *just taken* from biogas digester.  
*Additional fertilizer:* Use *decomposed* manure and solid bio-slurry or *diluting* liquid bio-slurry. |
| Sandy soil            | The soil has a big amount of oxygen, making the decomposition of organic matters easily and speedily. | *Basal fertilizer:* Use *fresh manure* or bio-slurry that is *just taken* from biogas digester.  
*Additional fertilizer:* Use *decomposed* manure and solid bio-slurry or *diluting* liquid bio-slurry. |

2.2. **Based on the fertility of the soil**

Farmers can identify the necessity and priority of using manure or bio-slurry and right amount of these fertilizers depending on the soil fertility.

2.2.1. **Identify the necessity and priority of using manure or bio-slurry and right amount of these fertilizers depending on the soil fertility**

Depending on the fertility of cultivation soil, the producers can make their own decision on what kind of fertilizer, manure or bio-slurry, they want to use for crops as well as the suitable utilization amount.
Table 8. Necessity level of using manure/bio-slurry on types of agricultural soil

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Main characteristics</th>
<th>Level of necessity for application</th>
<th>Benefit</th>
</tr>
</thead>
</table>
| Neutral or less acidic alluvial soils | • Representative soils are found in the Northern river delta area and the Mekong River Delta area  
• Very rich in organic matters, relatively high nutrient content of nitrogen, phosphorus and potassium | Necessary to use: Application amount ranges from 5 – 15 tons per hectare | Increases the utilization coefficients of nitrogen, phosphorus and potassium, thus reducing the required amount of inorganic fertilizer |
| Acidic alluvial soils                 | • Representative soil types found in the Central provinces and some provinces in the North (inside dike area), Southern provinces and the Central Highlands  
• The soils have moderate nutrients content of nitrogen, phosphorus and potassium | Necessary to use: Application amount ranges from 10 – 20 tons per hectare | Using bio-slurry will reduce the acidity in the soil.  
• Increases the utilization coefficients of nitrogen phosphorus and potassium, thus reducing the required amount of inorganic fertilizer. |
| Gley alluvial soils                   | • Representative soil types found in areas having two seasonal rice crops with low terrain.  
• The soils are rich in organic matters, humus and nitrogen amount, but poor in phosphorus amount and slightly high in potassium amount. | Necessary to use: Application amount ranges from 5 – 10 tons per hectare | Using bio-slurry will reduce the acidity in soil.  
• Improve porosity, aeration and drainage of the soil. |
| Degraded grey soils                  | • Representative soil types found in the provinces of Thanh Hoa, Vinh Phuc, Bac Giang and Phu Tho.  
• The soils are very poor in organic matters, and nutrients including nitrogen, phosphorus and potassium. The soils are acid. | Very necessary to use: Application amount ranges from 15 – 25 tons per hectare | Increase the humus amount in soil  
• Improves porosity and aeration of the soil |
| Marine sandy soil and inland sandy soil | • Representative soil types found in the coastal provinces.  
• The soils are very poor in organic matters and nutrients, including nitrogen, phosphorus and potassium. Many areas may be saline. | Very necessary to use: Application amount ranges from 20 – 30 tons per hectare | Improves the humus amount in soil thus improving the water holding and nutrient holding capacity of the soil.  
• Increases utilization coefficients of nitrogen and potassium, thus reducing |
| Acid sulfate soils | The soils are rich in organic matters and nitrogen amount, but poor in soluble phosphorus (the form of phosphorus that plants can absorb directly) amount as the soils are very acid and saline. | Necessary to use: Application amount ranges from 5 – 10 tons per hectare | Use of bio-slurry reduces the acidity of the soil while speeding up decomposition of organic matters. Improves porosity and enhances the utilization coefficients of nitrogen and potassium, thus reducing the required amount of inorganic fertilizer. |
| Basaltic reddish brown soils, yellow reddish (ferralitic) soils | The soils are medium to rich in organic matters; relatively high in nitrogen amount; poor in soluble phosphorus and potassium amounts. The soils are acid. | Necessary to use: Application amount ranges from 15 – 20 tons per hectare | Use of bio-slurry reduces the acidity of the soil while speeding up decomposition of organic matters. Improves porosity and enhances the utilization coefficients of nitrogen and potassium, thus reducing the required amount of inorganic fertilizers. Reduces the negative impact of erosion and the wash away ability. |
2.2.2. How to identify the fertility of the soil in household’s conditions (no soil test/analysis)?

The amount of organic matters in the soil is an important indicator reflecting soil fertility. Commonly, soils with a high amount of organic matters will have a high soil fertility.

In the absence of a soil analysis, the below common sense approaches can be used to identify the level of organic matter in the soil based on sight and feel.

- **Colour of soil**: Soils that are rich in organic matters or humus normally have a darker colour.

![Neutral or less acid alluvial soils with high amount of organic matters](image1) ![Acid alluvial soil having moderate amount of organic matters](image2)

- **Growth and development of agricultural crops**

When you have the same crop varieties, the same seasonal conditions and there is equal care for the crops and you notice that some crops grow and develop better and produce a higher yield the soil probably has a higher soil fertility.

- **Ability of water retention and drainage of soil**

The soils having relatively high fertility will be permeable soil and have good drainage.

- **Temperature regime in the soil**

The soils having relatively high fertility will have a well-regulated temperature regime. In summer time, the slightly fertile soils have no significant difference in temperature between day and night as compared to the significant difference in low fertility soils (such as sandy soil or clay-sandy soil). When standing on the soil with bare feet farmers will not feel the burning feeling on their feet.

2.3. Identify proper fertilizer based on the acidity and amount of available phosphorus in the soil
Farmers can decide to use bio-slurry instead of using manure to maximize the advantages of the bio-slurry fertilizer as compared to manure based on the acidity and amount of available phosphorus in the soil.

Based on the pH value, cultivated soil can be classified as: (i) very acidic; (ii) moderate acidic; (iii) less acidic; (vi) neutral; and (v) alkaline.

2.3.1. How to identify the soil acidity in household conditions (without soil analysis)?

The below phenomena enable us to identify the soil acidity:

- **On acid soils in hilly area**: There grows a lot of Crape myrtle (Lagerstroemia indica). The more growth of these acid indicated trees, the higher the soil acidity.

- **On acid soil for saturated paddy rice field**
  (i) Many yellow flowers Tamarind (Tamarindus indica) grow on the field. When these trees grow and develop more, it indicates a higher soil acidity.
  (ii) Field water is clear. On the water surface yellow scum appears (in the valley hills).

- **On acid sulphate soil**: Many Eleocharis, sedge and narrow leaf cattail (*Typha orientalis*) grow on the soil.

- **On vegetable growing soil**
  (i) Many Wood Sorrel (*Oxalis violacea*) grow on the soil
  (ii) On the field/garden growing plants/crops that dislike soil acidity: Crops that dislike soil acidity are: cruciferous plants including cabbage, kohlrabi, mustard, lettuce etc., or allium sativum crops. When these crops are being nurtured well, as well as enjoying favourable weather conditions, with the absence of plant pests and affecting diseases, but still show poor growth and development, it clearly indicates soil acidity.
Table 9. Range of soil pH values that are most suitable for major crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Suitable pH</th>
<th>Crop</th>
<th>Suitable pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>5.7 – 7.5</td>
<td>Soybean</td>
<td>5.5 – 7.0</td>
</tr>
<tr>
<td>Cotton</td>
<td>5.0 -7.0</td>
<td>Water melon</td>
<td>5.5 – 6.5</td>
</tr>
<tr>
<td>Avocado tree</td>
<td>5.0 – 6.0</td>
<td>Peanut</td>
<td>5.3 – 6.6</td>
</tr>
<tr>
<td>Cucurbits crops</td>
<td>5.5 – 7.0</td>
<td>Allium sativum crops</td>
<td>6.0 – 7.0</td>
</tr>
<tr>
<td>Mustard, lettuce</td>
<td>6.0 – 7.0</td>
<td>Ginger</td>
<td>6.0 – 6.5</td>
</tr>
<tr>
<td>Tomato</td>
<td>6.0 – 7.0</td>
<td>Potato</td>
<td>5.0 – 6.0</td>
</tr>
<tr>
<td>Coffee</td>
<td>6.0 – 6.5</td>
<td>Sweet potato</td>
<td>5.5 – 6.8</td>
</tr>
<tr>
<td>Carrot</td>
<td>5.5 – 7.0</td>
<td>Grape</td>
<td>6.0 – 7.5</td>
</tr>
<tr>
<td>Eggplant</td>
<td>6.0 – 7.0</td>
<td>Sugarcane</td>
<td>5.0 – 8.0</td>
</tr>
<tr>
<td>Cabbage</td>
<td>6.5 – 7.0</td>
<td>Chili</td>
<td>6.0 – 7.5</td>
</tr>
<tr>
<td>Citrus trees</td>
<td>5.5 -6.0</td>
<td>Pepper</td>
<td>5.5 – 7.0</td>
</tr>
<tr>
<td>Rubber</td>
<td>5.0 – 6.8</td>
<td>Tobacco</td>
<td>5.5 – 6.5</td>
</tr>
<tr>
<td>Flower</td>
<td>5.5 – 7.5</td>
<td>Dragon fruit</td>
<td>5.0 – 7.0</td>
</tr>
<tr>
<td>Tea crop</td>
<td>4.5-5.5</td>
<td>Cassava</td>
<td>6.0 – 7.0</td>
</tr>
<tr>
<td>Banana</td>
<td>6.0-6.5</td>
<td>Cauliflower</td>
<td>5.5 – 7.0</td>
</tr>
<tr>
<td>Strawberry</td>
<td>5.5 – 6.8</td>
<td>Spices crops</td>
<td>5.5 – 7.0</td>
</tr>
</tbody>
</table>

Source: Tran Thi Thu Ha [10].

Table 10. Classification of cultivated soil based on the pH value of the soil – selection of proper forms of fertilizer, manure and bio-slurry, and benefits of the application

<table>
<thead>
<tr>
<th>Soil pH</th>
<th>Type of soil</th>
<th>Most proper fertilizer</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4.5</td>
<td>Very acid sulphate soil</td>
<td>Bio-slurry *</td>
<td>Reduces soil acidity while increasing humus amount and utilization coefficients of inorganic fertilizers</td>
</tr>
</tbody>
</table>
2.3.2. How to identify that the soil is poor in the readily available phosphorus amount (the phosphorus form that plants can directly absorb from the soil) in the absence of soil analysis?

- All acid soils have a lack of soluble phosphorus ions/form
- There is many flowering shrub (*Eupatorium Laeensis*) growing on the field
- On maize field: At the seedlings stage, in case of a lack of soluble phosphorus, the maize leaves often have purple colour on the two side edges of the leaves, appearing in older leaves first and then in the young leaves.
### 2.4. Identify proper forms of fertilizer, manure or bio-slurry, for crops based upon the characteristics of the plants and the application time

**Table 11. Proper forms of fertilizer for major crops at application time**

<table>
<thead>
<tr>
<th>Variety of crops</th>
<th>Application time</th>
<th>Form of proper fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food crop</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy rice</td>
<td>Basal fertilize when ploughing to break up soil</td>
<td>Partially decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Liquid bio-slurry</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize at the period of tillering stage</td>
<td>Fully decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Direct watering</td>
</tr>
<tr>
<td>Maize/corn</td>
<td>Basal fertilize when seed sowing</td>
<td>Partially decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize when the seedling has 7 – 9 leaves</td>
<td>Fully decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diluting with water</td>
</tr>
<tr>
<td>Cassava</td>
<td>Basal fertilize when seeding sowing</td>
<td>Fresh or untreated manure</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>Basal fertilize when growing plant</td>
<td>Fresh or untreated manure</td>
</tr>
<tr>
<td><strong>Industrial crop</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Box 3. Advantages of bio-slurry used as a fertilizer, as compared to manure, for the acid soil**

Most cultivated areas of Viet Nam are acid soils. Whereas, the vast majority of plants prefer soils less acidic to neutral to optimize their growth and development. Therefore the **decision for a proper form of bio-slurry fertilizer** is very important because this fertilizer has a pH value in the range of 7.5 to 8.0. Fertilizing this fertilizer into soil will have below benefits:

(i) Reduces soil acidity to create favorable conditions for better growth and development of crops; in the meanwhile it limits the development and spread of harmful microbials and fungi.

(ii) Increases the utilization coefficient of the fertilizer thus reducing the required amount of inorganic fertilizers, contributing to the raise of income of farm household.

Besides, on acidic soils, plants cannot absorb nutrients easily because many nutrients are kept tightly in the soil. In many cases the nutrients react with some available chemical elements in the soil to form less soluble compounds, especially for the iron-rich soils like barren soil, alluvial acidic soil, alkaline soil, the sulphate paddy rice field and fruit gardens. Therefore, the **application of the bio-slurry fertilizer** (having pH in the range of 7.5 to 8.0) will have the following benefits:

(i) Releases phosphorus ions in the soil, **facilitating the absorption of phosphorus by plants more easily**. At the same time, the practice will also help plants to absorb more phosphorus ions from the super phosphorus fertilizer (Lam Thao phosphorus fertilizer), and phosphorite phosphorus fertilizer (Van Dien phosphorite phosphorus fertilizer or Ninh Binh phosphorite phosphorus fertilizer).

(ii) Reduces the required amount of inorganic fertilizers, reduces the agricultural production costs of farm households, and farmers and agricultural producers have opportunities to raise their income from agricultural production.
<table>
<thead>
<tr>
<th>Variety of crops</th>
<th>Application time</th>
<th>Form of proper fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Farmyard manure / Bio-slurry / compost fertilizer *</td>
</tr>
<tr>
<td>Peanut</td>
<td>Basal fertilize when seeding sowing</td>
<td>Fully decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize when the seedling has 2 – 3 leaves</td>
<td>Diluting with water</td>
</tr>
<tr>
<td>Soybean</td>
<td>Basal fertilize when growing plant</td>
<td>Fully decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize when the seedling has 2 – 3 leaves</td>
<td>Diluting with water</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>Basal fertilize when growing plant</td>
<td>Partially decomposed fertilizer / Fully decomposed fertilizer depending on type of soils</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize at the seasonal crops 2 and 3</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td>Coffee</td>
<td>Basal fertilize</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td>Rubber</td>
<td>Basal fertilize when growing plant</td>
<td>Partially decomposed fertilizer / Fully decomposed fertilizer depending on type of soils</td>
</tr>
<tr>
<td>Pepper</td>
<td>Basal fertilize when growing plant</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize</td>
<td>Fully decomposed fertilizer</td>
</tr>
<tr>
<td>Fruit trees</td>
<td>Basal fertilize</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Fertilize after harvesting fruit products</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td>Vegetable varieties and legume crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mustard family varieties</td>
<td>Basal fertilize when growing plant</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize</td>
<td>Diluting with water</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Basal fertilize when growing plant</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize</td>
<td>Diluting with water</td>
</tr>
<tr>
<td>Kohlrabi</td>
<td>Basal fertilize when growing plant</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td>Tomato</td>
<td>Basal fertilize when growing plant</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td>Potato</td>
<td>Basal fertilize when growing plant</td>
<td>Decomposed fertilizer</td>
</tr>
<tr>
<td>Legume varieties</td>
<td>Basal fertilize when growing plant</td>
<td>Fully decomposed fertilizer</td>
</tr>
<tr>
<td></td>
<td>Additional fertilize when the seedling has 2 – 3 leaves</td>
<td>Diluting with water</td>
</tr>
</tbody>
</table>
Important points to note: * composted fertilizer from composting liquid bio-slurry or solid bio-slurry with rice straw and plant waste.
PART 3. APPLICATION OF MANURE AND BIO-SLURRY FOR A NUMBER OF MAJOR CROPS

1. Food crops

1.1. Paddy rice

1.1.1. Popular types of soil for growing paddy rice in Viet Nam

Table 12. Popular types of soil for growing paddy rice in Viet Nam – Advantages and disadvantages of using manure and bio-slurry for paddy rice production

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of soil</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alluvial soils that are neutral or less acidic</td>
<td>The soils have very high fertility, optimum for paddy rice production</td>
<td>Heavy clay soils commonly have a poor drainage capacity</td>
</tr>
<tr>
<td>2</td>
<td>Acidic alluvial soils</td>
<td>The soils have moderate fertility</td>
<td>The soils are acidic; Heavy clay soils commonly have a poor drainage capacity.</td>
</tr>
<tr>
<td>3</td>
<td>Gley alluvial soils</td>
<td>The soils have a relatively high amount of organic matters</td>
<td>The soils have a poor drainage capacity; The soils are easily cracked and drought; poor in readily soluble phosphorus nutrient.</td>
</tr>
<tr>
<td>4</td>
<td>Gray soil with patchy ground layers (Degraded grey soils)</td>
<td>-</td>
<td>The soils have a low fertility, are acidic and have a weak textile and low porosity.</td>
</tr>
<tr>
<td>5</td>
<td>Gley gray soil</td>
<td>-</td>
<td>The soils have low fertility, are acidic, with a weak water holding capacity.</td>
</tr>
<tr>
<td>6</td>
<td>Acid sulfate soil</td>
<td>The soils have a relatively high amount of organic matters</td>
<td>The soils are both acidic and saline with poor drainage capacity and poor porosity.</td>
</tr>
<tr>
<td>7</td>
<td>Inland sandy soil</td>
<td>-</td>
<td>The soils have a low fertility, are acidic, with a weak water holding capacity and they are easily compacted when submerged under water for a long day.</td>
</tr>
<tr>
<td>8</td>
<td>Marine sandy soil</td>
<td>-</td>
<td>The soils have a low fertility. Less saline and have a weak water holding capacity and are easily compacted when submerged under water for a long day.</td>
</tr>
</tbody>
</table>

1.1.2. Fertilizer management on manure and bio-slurry utilization for paddy rice production

a. Amount of application
The amount of manure or bio-slurry fertilizer to use for paddy rice should be determined based on: (i) concentration of macro nutrients (Nitrogen, Phosphorus and Potassium) in the fertilizers; (ii) the characteristics of paddy land to ensure the balance with used inorganic fertilizers; (iii) the availability of these fertilizers at the household farm, and (iv) economic efficiency when using these organic fertilizers.

**Basal fertilizer**

It is possible to use manure, solid bio-slurry or the compost fertilizers made from composting solid / liquid bio-slurry with a mixture of straw, hyacinth for paddy rice. The main purposes of the application and practice are to improve the air regime and temperature regime in the soil while increasing the humus amount in the soil.

**Table 13. Recommended application amount of manure and bio-slurry as basal fertilizer for paddy rice (ton / hectare)**

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Spring season / Winter – spring season</th>
<th>Main season / Summer – Autumn season</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manure fertilizer</td>
<td>Solid bio-slurry fertilizer</td>
</tr>
<tr>
<td>Alluvial soils that are neutral or less acidic</td>
<td>8 - 10</td>
<td>6 - 8</td>
</tr>
<tr>
<td>Acidic alluvial soils</td>
<td>8 - 10</td>
<td>6 - 8</td>
</tr>
<tr>
<td>Gley alluvial soils</td>
<td>6 - 8</td>
<td>5 - 7</td>
</tr>
<tr>
<td>Degraded grey soils</td>
<td>12 - 15</td>
<td>7.5 - 10</td>
</tr>
<tr>
<td>Acid sulfate soil</td>
<td>6 - 7</td>
<td>6 - 8</td>
</tr>
<tr>
<td>Inland sandy soil</td>
<td>12 - 15</td>
<td>7.5 - 10</td>
</tr>
<tr>
<td>Marine sandy soil</td>
<td>10 - 12</td>
<td>7.5 - 10</td>
</tr>
</tbody>
</table>
Additional fertilizer

Purposes of additional fertilizing: the main purpose of using an additional fertilizer is to provide nutrients for plants.
- The amount of liquid bio-slurry, when used as an additional fertilizer for paddy rice, ranges from 10 – 20 \(m^3/ha\). The liquid bio-slurry should be diluted with water at the ratio of 1 volume of liquid bio-slurry to 1 volume of water (it is crucial to combine with using inorganic fertilizers as per regulated in Fertilizer management regulation for paddy rice during stages of additional fertilizing).

Box 4. Application amount of manure and bio-slurry used as basal fertilizer as recommended in the table is only for the combined application and not as a replacement for a part of the recommended inorganic fertilizers (as regulated in Technical Management of Fertilizer Utilization for paddy rice issued by local DARDs).

Box 5. An example of determining the amount of urea fertilizer when combined with liquid bio-slurry as an additional fertilizer for paddy rice

Out of three important nutritional elements N, P and K, nitrogen is the element which has direct impact and plays the most important role in the growth and development of paddy rice. Therefore, the calculation and determination of the required amount of urea fertilizer for combined application is often based on the level of pure nitrogen in liquid bio-effluent.

Example:
- The required amount of pure nitrogen for the first additional fertilizing session for paddy rice is 30 kg N per hectare;
- The (average) amount of pure nitrogen in liquid bio-slurry is 0.37 kg per cubic meter (Table 5). If you are using 10 cubic meter of liquid bio-slurry as an additional fertilizer for 1 hectare of paddy rice, the pure nitrogen is 3.7 kg. Thus, the required amount of pure nitrogen from an inorganic fertilizer is 26.3 kg (30 – 3.7), equivalent to 57.2 kg of Urea fertilizer (please refer to Annex 1 for a conversion calculator between pure nutrient and the amount of fertilizer)
**Box 6. Some important points when determining the proper amount of manure fertilizer and bio-slurry fertilizer for paddy rice**

- It is possible to use manure in combination with solid bio-slurry as basal fertilizing for paddy rice. The combined application is recommended as follows: 10 tons of farmyard manure + 0.5 tons of solid bio-slurry for soils with relatively high fertility, such as alluvial soil and sulphate soil; 10 tons of farmyard manure + 1 tons of solid bio-slurry for soils with low fertility, such as sandy soil or degraded grey soil.

- To optimize the utilization efficiency of farmyard manure and bio-slurry, these organic fertilizers should be combined with inorganic fertilizers. The amount and ration of N : P : K are regulated and recommended in the Management on Paddy rice production that is developed and issued by local authorizations.

- For soils such as alluvial neutral soil or less acidic soil, as marine sandy soil, the application of **farmyard manure** is optimum. Whereas for other soils, such as alluvial acidic soil, inland sandy soil, sulphate soil and degraded soil, the application of **bio-slurry is a more optimum choice** as compared to manure due to the high pH-level (7.2 – 7.5). If bio-slurry fertilizer is unavailable, manure can be used instead of bio-slurry, but it should be complemented by lime with the amount of 300 kg per hectare (for alluvial acidic soil, degraded soil and inland sandy soil); or with the amount of 400 – 500 kg/ha for sulphate soil.

- The application amount of farmyard manure and bio-slurry for paddy rice should be determined based on soil fertility. **Example:** the amount of manure and bio-slurry for paddy rice is **higher** when it is applied on poor soils, such as degraded soil or inland sandy soil, as compared to alluvial soil.

- The application amount of manure and bio-slurry for hybrid rice is **higher** than for pure original rice as the nutrient demand of hybrid rice is higher.

- The application amount of manure and bio-slurry for paddy rice in the main crop season/ Summer – Autumn is **higher** than that for Spring / Winter season, because the higher temperature of the soil in Summer and Autumn, results in a more speedy decomposition of nutrients in fertilizers and more speedy decaying of fertilizers. Besides, in Summer and Autumn plant roots grow and develop more strongly to absorb the nutrients from fertilizers better, which enhances the utilization coefficients of nutrients ascompared to the situation in Spring and Winter .

- The application amount of manure and bio-slurry for 2 rice cropping structures is **lower** than for 1 rice (rotating with 1 other crop) cropping structure (due to the certain available amount of straw laying on paddy fields from the previous season).
**Table 13. Proper forms of manure and bio-slurry for paddy rice**

<table>
<thead>
<tr>
<th>Application timing</th>
<th>Basal fertilizer</th>
<th>Additional fertilizer</th>
<th>Farmyard manure / solid bio-slurry / decomposed fertilizer</th>
<th>Farmyard manure / solid bio-slurry / decomposed fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy clay soil</td>
<td>Nearly fully decomposed fertilizer</td>
<td>Fully decomposed fertilizer</td>
<td></td>
<td>Diluting with a ratio of 1 volume of fertilizer : 1 volume of water</td>
</tr>
<tr>
<td>Moderate clay soil</td>
<td>Half fully decomposed fertilizer</td>
<td>Fully decomposed fertilizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slight clay soil</td>
<td>Partially decomposed fertilizer</td>
<td>Decomposed fertilizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay-sandy soil</td>
<td>Partially decomposed fertilizer</td>
<td>Decomposed fertilizer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**b. Fertilizing timing and application technique**

**Basal fertilizer**: apply the whole amount of available manure, solid bio-slurry or compost fertilizer from composting liquid bio-slurry with rice straw directly into the soil at the time of ploughing to break up the soil. When ploughing the soil, it is necessary to rake the soil up to bury the fertilizer entirely beneath the earth to minimize nitrogen loss and speed up the decomposition of the fertilizers.

**Tips**:  
- During Spring season in the North, Summer – Autumn season in the Central region or dry season in the South, it is advisable to bury manure, solid bio-slurry or bio-slurry that is composted with rice straw deeper in slightly clay and clay sandy soils than in heavy clay or moderate clay soils to avoid the nitrogen loss.

- During main season in the North, Winter – Spring season in the Central region or rainy season in the South, it is advisable not to bury manure, solid bio-slurry or bio-slurry that is composted with rice straw deeper than 15 cm into the earth (even on clay-sandy soil), as too deep application will slow down the decomposition of fertilizers, which hampers to meet the nutrient demands of plants in time. In case of manure application, the practice will increase soil acidity.

**Additional fertilizer**

- It is possible to use both partially decomposed manure and solid bio-slurry for paddy rice. However, it is more optimal to use liquid bio-slurry for the paddy field. The application amount is converted from the required amount of pure nutrients for paddy rice that is regulated and recommended in the Fertilizer Management for paddy rice production.
- Liquid bio-slurry that is taken out from a slurry pit can be used directly for paddy rice fields.
- The best time to use an additional fertilizer is at the tillering stage of rice. Liquid bio-slurry should be divided into two equal volumes. Half of the bio-slurry volume is used at the early tillering stage and the other half is used at the panicles stage.
- After fertilizing, it is advisable to work weeding and hot mud for rice field (especially when using partially decomposed farmyard manure or solid bio-slurry for rice implanting) in order to help the rice plants to absorb the nutrients in fertilizers more easily.

1.2. Maize crop

1.2.1. Popular types of soil for growing maize in Viet Nam

Table 14. Popular types of soil for growing maize in Viet Nam – Advantages and disadvantages of using manure and bio-slurry for maize production

<table>
<thead>
<tr>
<th>No.</th>
<th>Type of soil</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Neutral / less acidic alluvial soil</td>
<td>The soils have high fertility, the total amount of phosphorus ranges from moderate to relatively high, optimum for maize production.</td>
<td>Heavy clay soils commonly have a poor drainage ability and poor porosity.</td>
</tr>
<tr>
<td>2</td>
<td>Acidic alluvial soil</td>
<td>The soils have moderate fertility, the total amount of phosphorus ranges from moderate to relatively high.</td>
<td>The soils are acidic; Heavy clay soils commonly have a poor drainage ability and poor porosity, low amount of readily soluble phosphorus.</td>
</tr>
<tr>
<td>5</td>
<td>Degraded grey soil</td>
<td>-</td>
<td>The soils have low fertility and a low amount of readily soluble phosphorus; The soils are acidic, having a poor drainage ability and poor porosity (in case of heavy clay soil or moderate clay soil).</td>
</tr>
<tr>
<td>6</td>
<td>Basaltic reddish brown soils, yellow reddish soils</td>
<td>The fertility of the soils ranges from moderate to relatively high.</td>
<td>The soils are acidic; Many soil areas have a poor porosity (in case of heavy clay soil). The amount of readily soluble phosphorus is low.</td>
</tr>
</tbody>
</table>

Maize (especially hybrids) is a crop that not only requires high soil fertility, but also has quite strict requirements on the porosity of the soil. In reality, maize is grown on many soils having different...
mechanical compositions and levels of porosity, varying from heavy clay soil, moderate clay soil, clay-sandy soil to sandy soil. Hence, the determination and selection of proper manure or bio-slurry fertilizers for each type of soil is very important and needs to be followed strictly.

1.2.2. **Fertilizer management on manure and bio-slurry utilization for maize production**

a. **Amount of application**

- Maize prefers a porous soil and good drainage. Hence, using manure or bio-slurry for maize not only supplies nutrients, but more importantly increases soil porosity, helping roots to grow well, particularly for soils with low porosity such as degraded soils or inland sandy soils.

**Basal fertilizer**: The following fertilizers are advisable as basal fertilizers for maize: decomposed manure, solid bio-slurry or compost fertilizer that is produced from composting liquid bio-slurry / solid bio-slurry with a mixture of rice straw and water hyacinth. The main purpose of the practice is to improve the soil porosity, air regime and temperature regime of the soil as well as to increase the amount of humus in the soil.

**Table 15. Recommended application amount of manure and bio-slurry as basal fertilizer for maize (ton / hectare)**

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Alluvial soil</th>
<th>Degraded grey soil</th>
<th>Inland sandy soil</th>
<th>Basaltic reddish brown soils</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spring season / Winter – spring season</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure</td>
<td>8 - 10</td>
<td>12 - 15</td>
<td>12 - 15</td>
<td>7 - 10</td>
</tr>
<tr>
<td>Solid bio-slurry</td>
<td>6 - 8</td>
<td>10 - 15</td>
<td>10 - 15</td>
<td>5 - 7</td>
</tr>
<tr>
<td>Compost of liquid bio-slurry and rice</td>
<td>6 - 8</td>
<td>10 - 12</td>
<td>10 - 12</td>
<td>6 - 8</td>
</tr>
<tr>
<td><strong>Summer – Autumn season</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure</td>
<td>8 - 10</td>
<td>15 - 20</td>
<td>15 - 20</td>
<td>8 - 10</td>
</tr>
<tr>
<td>Solid bio-slurry</td>
<td>7 - 9</td>
<td>12 - 18</td>
<td>12 - 18</td>
<td>7 - 9</td>
</tr>
<tr>
<td>Compost of liquid bio-slurry and rice</td>
<td>8 - 10</td>
<td>15 - 20</td>
<td>15 - 20</td>
<td>8 - 10</td>
</tr>
<tr>
<td><strong>Autumn – Winter season</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure</td>
<td>8 - 10</td>
<td>15 - 20</td>
<td>15 - 20</td>
<td>8 - 10</td>
</tr>
<tr>
<td>Solid bio-slurry</td>
<td>7 - 9</td>
<td>12 - 18</td>
<td>12 - 18</td>
<td>7 - 9</td>
</tr>
<tr>
<td>Compost of liquid bio-slurry and rice</td>
<td>8 - 10</td>
<td>15 - 20</td>
<td>15 - 20</td>
<td>8 - 10</td>
</tr>
</tbody>
</table>
Autumn – Winter season / Winter season

<table>
<thead>
<tr>
<th></th>
<th>8 - 10</th>
<th>12 - 15</th>
<th>12 - 15</th>
<th>7 – 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid bio-slurry</td>
<td>6 - 8</td>
<td>10 - 15</td>
<td>10 - 15</td>
<td>5–7</td>
</tr>
<tr>
<td>Compost of liquid bio-slurry and rice</td>
<td>6 - 8</td>
<td>10 - 12</td>
<td>10 - 12</td>
<td>6 – 8</td>
</tr>
</tbody>
</table>

Source: Singh [22]; Ngo Huu Tinh [25], Lavina [17] and results and outcomes from researches under the framework of the “Biogas Program for Husbandry Sector in Viet Nam”.

**Box 7.** The application amount of inorganic fertilizers for maize is concretely regulated and recommended in the “Technical Management Guideline for maize”, which is developed and issued by local authorizations. It displays the application amount for specific varieties (short day / medium-day / long day; hybrids / pure original varieties), for each seasonal crop and for each major type of soil. The application amount of manure and bio-slurry used as basal fertilizer, as recommended in the table, only serves for the combined application and is not a replacement for a part of the recommended inorganic fertilizers (as regulated in Technical Management of Fertilizer Utilization for maize issued by local authorities).

**Additional fertilizer:** It is optimal to use liquid bio-slurry as basal fertilizer for maize. The application amount ranges from 40 cubic meters to 60 cubic meters per one hectare [33], in combination with inorganic fertilizers (at this stage) as regulated and recommended in the “Technical Management guideline for Maize production”.

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50
Box 8. Determining the amount of urea fertilizer that can be used together with liquid bio-slurry as an additional fertilizer for maize

Out of the three important nutritional elements N, P and K, nitrogen is the element that has direct impact and it plays the most important role for the growth and development of paddy rice. Therefore, the calculation and determination of the required amount of urea fertilizer for combined application is often based on the level of pure nitrogen in liquid bio-effluent. Example:

- The required amount of pure nitrogen for the first additional fertilizing session for maize is 40 kg N per hectare;
- The (average) amount of pure nitrogen in liquid bio-slurry is 0.37 kg per cubic meter (Table 3). If you are using 10 cubic meter of liquid bio-slurry as an additional fertilizer for 1 hectare of maize, the pure nitrogen is 3.7 kg. Thus, the required amount of pure nitrogen from an inorganic fertilizer is 36.3 kg, equivalent to 78.9 kg of Urea fertilizer (please refer to Annex 1 for a conversion calculator between pure nutrient and the amount of fertilizer).
b. Forms of fertilizer to be applied for maize

To avoid impossible risks that may happen when using improper manure or bio-slurry fertilizers, the recommendations for proper forms of fertilizers as presented below should be strictly followed by farmers / agricultural producers.

Table 16. Proper forms of manure and bio-slurry for maize

<table>
<thead>
<tr>
<th>Application timing</th>
<th>Basal fertilizer</th>
<th>Additional fertilizer</th>
<th>Liquid bio-slurry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy clay soil</td>
<td>Decomposed fertilizer</td>
<td>Farmyard manure / solid bio-slurry / decomposed fertilizer</td>
<td>Diluting with ratio of 1</td>
</tr>
<tr>
<td>Moderate clay soil</td>
<td>Decomposed fertilizer</td>
<td>Fully decomposed fertilizer</td>
<td></td>
</tr>
</tbody>
</table>
In order to have decomposed or fully decomposed fertilizers, it is advisable to use the whole amount of inorganic phosphorus fertilizer (recommended as basal fertilizing for maize) for composting manure or bio-slurry. The main purpose and benefits of this combined practice has been presented in item 4.2 on page 32 of this training material.

c.  **Fertilizing timing and application technique**

**Basal fertilizer**: The main purpose is to improve the porosity, moisture regime and temperature regime of the soil and increase the amount of humus in the soil.

Decomposed fertilizers can be applied by two methods as described below:

<table>
<thead>
<tr>
<th>No.</th>
<th>Application method</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Evenly spray on the field</em>: <strong>Whole amount</strong> of decomposed fertilizer is evenly spread on field, then plough the earth well, and finally place the seedbed or dig holes.</td>
<td>Saves time and labour</td>
<td>When the fertilizer is added far from the plants, the plants cannot absorb nutrients immediately.</td>
</tr>
<tr>
<td>2</td>
<td><em>Add fertilizer by row</em>: after finishing the soil preparation, the <strong>whole amount</strong> of fertilizer is put on the bottom of the prepared groove or hole. Add a thin layer of earth, and put the seeds on top.</td>
<td>Fertilizers are added closely to the plants to speed up the nutrient absorption of the plants</td>
<td>Needs more time and labour as compared to the above method.</td>
</tr>
</tbody>
</table>

**Additional fertilizer**: The main purpose is to add more nutrients for maize. Only fully decomposed manure and/or bio-slurry fertilizers can be used as additional fertilizers for maize. Besides, it is possible to use liquid bio-slurry as an additional fertilizer, especially for acidic soils.

- Application method

<table>
<thead>
<tr>
<th>Slight clay soil</th>
<th>Decomposed fertilizer</th>
<th>Fully decomposed fertilizer</th>
<th>Volume of fertilizer: 1 volume of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay-sandy soil</td>
<td>Decomposed fertilizer</td>
<td>Fully decomposed fertilizer</td>
<td>volume of water</td>
</tr>
</tbody>
</table>
Decomposed manure and solid bio-slurry: Adding fertilizers by row or hole, following by tillering and watering.

Liquid bio-slurry: Take the liquid bio-slurry directly from the slurry pit and dilute it with water at a ratio of 1:1 and irrigate it on the maize stool (the diluting ratio is already presented at page 42). The practice of fertilizing should be combined with tillering to bury all fertilizer into the earth, minimizing fertilizer loss and reducing the pollution of the surrounding environment.

- **Best timing for using an additional fertilizer**: Ideally, the additional fertilizer is applied at 3 important periods, as described below. It is necessary to combine it with the use of inorganic fertilizers at these stages (*for the amount of inorganic fertilizers please refer to box 8 on page 43*).
  - Vegetative stages with 3 – 4 leaves: using about one fourth of the total amount of fertilizer / liquid bio-slurry
  - Vegetative stages with 7 – 9 leaves: using about two forth of the total amount of fertilizer / liquid bio-slurry
  - Vegetative stages with 7 – 9 leaves: using about one fourth of the total amount of fertilizer / liquid bio-slurry

### 1.3. Cassava

#### 1.3.1. Popular types of soil for growing cassava in Viet Nam

**Table 17. Popular types of soil for growing cassava in Viet Nam – Advantages and disadvantages of using manure and bio-slurry for cassava production**

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degraded grey soils</td>
<td>-</td>
<td>Poor soil structure. Easily compacted when raining. The soils are acidic with low fertility.</td>
</tr>
<tr>
<td>Basaltic reddish brown soils, yellow reddish soils</td>
<td>The soils have relatively high fertility and soil porosity</td>
<td>The soils are acidic and easily eroded.</td>
</tr>
<tr>
<td>Inland sandy soil, marine sandy soil</td>
<td>-</td>
<td>Poor soil structure. Easily compacted when raining. The soils are acidic with low fertility.</td>
</tr>
</tbody>
</table>

#### 1.3.2. Fertilizer management on manure and bio-slurry utilization for cassava production

a. Amount of application
In most areas where cassava is cultivated in Viet Nam, the soils (including degraded grey soil, inland sandy soil, marine sandy soil or acidic soil) have many disadvantages such as low fertility, low soil porosity, and a weak water/nutrient holding capacity. Besides, many large cassava growing areas are located in a hilly topography, where they often experience the impacts of soil erosion. As organic fertilizers, manure and bio-slurry limit and reduce those negative characteristics of the soils when they are used for the crops.

The application amount of manure for high yielding cassava varieties ranges from 15 tons to 20 tons per one hectare for degraded grey soil and marine sandy soil; 10 tons to 15 tons per one hectare for Basaltic reddish brown soils (also take into account the economic effect of the utilization); and 10 tons to 13 tons per one hectare and from 6 tons to 8 tons per one hectare for local cassava varieties respectively.

Currently, there are only a few studies on using bio-slurry for cassava. According to the author of one of these studies, Le Ha Chau [6], the production yield and protein amount of experiments using solid bio-slurry are higher than that of controls using a similar amount of manure. The application amount of fertilizer for cassava can be in the range of 10 tons to 40 tons per one hectare, depending on the types of soil.

However, in the experience of the authors of this document, to ensure the economic efficiency of cassava production, the application amount should be in the range of 10 tons to 20 tons per hectare, depending on the types of soil and cassava varieties. It is optimal to combine it with the use of inorganic fertilizers for cassava, as regulated and recommended in the “Technical Fertilizer Management for cassava production” by the local Department of Agriculture and Rural Development.

**Box 10.** The application amount of inorganic fertilizers for cassava is specifically regulated and recommended in the “Technical Management Guideline for cassava”, which is developed and issued by local authorizations. It displays the application amount for specific varieties (high yielding varieties / local varieties), for each seasonal crop and for each major type of soil. The application amount of manure and bio-slurry, used as basal fertilizer, as recommended in the table only serves for a combined application, but not as a replacement of a part of the recommended inorganic fertilizer (as regulated in the “Technical Management of Fertilizer Utilization for maize”, issued by local authorities).
b. Forms of fertilizer for cassava crops

It is advisable to use fresh (untreated) manure or bio-slurry for cassava, especially for poor texture soils, such as degraded grey soil, inland sandy soil, and marine sandy soil.

If possible and convenient, in case the biogas slurry pit is not far away from the cassava cultivating area, liquid bio-slurry can be used directly for cassava.

c. Fertilizing timing and application technique

Manure and bio-slurry can be used for cassava at planting stage.

It is optimal to add the fertilizer into holes. The best time for applying fresh (untreated) fertilizers is 10 to 15 days before planting the crops. If partially / fully decomposed fertilizers are used, the best time for application is at planting stage. The fertilizers should be added deeply into the holes. Then cover the fertilizer with a layer of earth and place the cassava stems in the holes.

If liquid bio-slurry is used for cassava, it is better to use the fertilizer 15 to 20 days after planting stage.
2. Short day industrial crops

2.1. Peanut

2.1.1. Popular types of soil for growing peanut in Viet Nam

Table 18. Popular types of soil for growing peanut in Viet Nam – Advantages and disadvantages for peanut production

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvial soils that are neutral or less acidic</td>
<td>The soils have a very high fertility, a neutral pH value, and are less acidic. Optimum for peanut production.</td>
<td>Some moderate clay loam soils have relatively low soil porosity.</td>
</tr>
<tr>
<td>Acidic alluvial soils</td>
<td>The soils have a moderate to relatively high fertility.</td>
<td>The soils are acidic and some moderate clay loam soils have relatively low soil porosity.</td>
</tr>
<tr>
<td>Degraded grey soils</td>
<td>-</td>
<td>The soils have low fertility, are acidic, have a poor texture and are easy to be compacted tightly when it is rainy.</td>
</tr>
<tr>
<td>Inland sandy soil</td>
<td>-</td>
<td>The soils have low fertility, are acidic, have a poor texture and are easy to be compacted tightly when it is rainy, like degraded grey soil.</td>
</tr>
<tr>
<td>Marine sandy soil</td>
<td>-</td>
<td>The soils have low fertility, are acidic, have a poor texture and are easy to be compacted tightly when it is rainy, like degraded grey soil.</td>
</tr>
<tr>
<td>Feralit soils that are developed on ancient alluvial soil</td>
<td>-</td>
<td>The soils have low fertility, a light mechanical composition and poor texture; the topsoil is susceptible to leaching or erosion and the soils are acidic.</td>
</tr>
</tbody>
</table>

2.1.2. Fertilizer management on manure and bio-slurry utilization for peanut production

a. Amount of application

Peanuts like loose or porous soils with good permeability (it does not retain water). On high porous soils, with a good air regime, the nitrogen fixing microbials will work actively to multiply and stimulate
the formation of root nodules better. Within the nodules the bacteria convert free nitrogen to ammonia, which the host plant utilizes for its development and hence, may reduce the inorganic nitrogen amount that is required from outside resources. The application of manure and bio-slurry for peanut not only provides nutrients for the plants, but also has an important beneficial effect of improving soil porosity.

Thanks to the high pH level, compost fertilizers, from composting solid bio-slurry or liquid bio-slurry with rice straw, have advantages over the use of farmyard manure, like:

- Reducing soil acidity to improve the nitrogenous absorbing ability (especially phosphorus elements from both soil and inorganic phosphorus fertilizers);
- Enhancing the production yield;
- Enhancing product quality.

**Table 19. Recommended application amount of manure and bio-slurry as basal fertilizer for peanut production (ton / hectare)**

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Manure fertilizer</th>
<th>Solid bio-slurry fertilizer</th>
<th>Compost fertilizer from composting liquid bio-slurry and rice straw</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spring season / Winter – spring season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alluvial soils</td>
<td>6 - 8</td>
<td>5 - 7</td>
<td>6 - 8</td>
</tr>
<tr>
<td>Degraded grey soils</td>
<td>10 - 12</td>
<td>8 - 10</td>
<td>10 - 12</td>
</tr>
<tr>
<td>Inland sandy soil / Marine sandy soil</td>
<td>10 - 12</td>
<td>8 - 10</td>
<td>10 - 12</td>
</tr>
<tr>
<td>Feralit soils developed on ancient alluvial soil</td>
<td>10 - 12</td>
<td>8 - 10</td>
<td>10 - 12</td>
</tr>
<tr>
<td><strong>Summer – Autumn season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alluvial soils</td>
<td>8 - 10</td>
<td>7 - 9</td>
<td>8 - 10</td>
</tr>
<tr>
<td>Degraded grey soils</td>
<td>12 - 15</td>
<td>10 - 12</td>
<td>12 - 15</td>
</tr>
<tr>
<td>Inland sandy soil / Marine sandy soil</td>
<td>12 - 15</td>
<td>10 - 12</td>
<td>12 - 15</td>
</tr>
<tr>
<td>Feralit soils developed on ancient alluvial soil</td>
<td>12 - 15</td>
<td>10 - 12</td>
<td>12 - 15</td>
</tr>
<tr>
<td><strong>Autumn – Winter season / Winter season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alluvial soils</td>
<td>8 - 10</td>
<td>7 - 9</td>
<td>8 - 10</td>
</tr>
<tr>
<td>Degraded grey soils</td>
<td>12 - 15</td>
<td>10 - 12</td>
<td>12 - 15</td>
</tr>
<tr>
<td>Inland sandy soil / Marine sandy soil</td>
<td>12 - 15</td>
<td>10 - 12</td>
<td>12 - 15</td>
</tr>
<tr>
<td>Feralit soils developed on ancient alluvial soil</td>
<td>12 - 15</td>
<td>10 - 12</td>
<td>12 - 15</td>
</tr>
</tbody>
</table>
Additional fertilizer: The application amount of liquid bio-slurry as basal fertilizer for peanut ranges from 20 cubic meters to 40 cubic meters per one hectare, depending upon the soil fertility and growth and development of the peanut plants [8]. Bio-slurry should be applied in combination with inorganic fertilizers at this stage.

First basal fertilizer: when plants have 2-3 double pinnately (bipinnately) compound leaves, use half of the liquid bio-slurry volume. Second basal fertilizer: when peanut plants begin to produce flowers, use the other half of the liquid bio-slurry volume.

<table>
<thead>
<tr>
<th>Box 12. Determining the amount of urea fertilizer that can be used together with liquid bio-slurry as additional fertilizer for peanut crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Out of the three most important nutritional elements, N, P, and K, nitrogen is not the most important elemental nutrient for the growth and development of this crop. However, using too much nitrogen for peanut crops will increase the development and growth of leaves, which results in a decline of crop yield. Therefore, the calculation and determination of the required amount of urea fertilizer for a combined application is often based on the level of pure nitrogen in liquid bio-effluent.</td>
</tr>
<tr>
<td>Example: - The amount of pure nitrogen required for the first additional fertilizing session for maize is 10 kg N per hectare:</td>
</tr>
<tr>
<td>- The (average) amount of pure nitrogen in liquid bio-slurry is 0.37 kg per cubic meter (Table 3). When using 10 cubic meter of liquid bio-slurry as additional fertilizer for 1 hectare of peanut, the amount of pure nitrogen is 3.7 kg. Thus, the additional amount of pure nitrogen from a commercial fertilizer is 6.7 kg, equivalent to 14.5 kg of Urea fertilizer (please refer to Annex 1 for a conversion calculator between pure nutrient and the amount of fertilizer).</td>
</tr>
</tbody>
</table>
b. Forms of fertilizer for peanut crops

It is optimum to use decomposed or fully decomposed manure and bio-slurry as both basal and additional fertilizing for peanut. It is more beneficial to compost with lime and a phosphorus fertilizer.
- If using manure for peanut: It is optimum to use lime and a super phosphorus fertilizer at the ratio of 1 – 2 percent lime and 2 – 3 percent super phosphorus (i.e. to compost one ton of manure you have to use 20 kg of lime powder and 20 – 30 kg of super phosphorus fertilizer).
- If manure contains bedding material such as rice straw and chopped corn stalks, the adding ratio of lime powder and phosphorus is normally 2% and 3% respectively.
- If manure contains bedding material such as water hyacinth, the adding rate of lime powder can be lower, reducing to 1%. Manure can also be composted with 2 – 3% of phosphorus fertilizer without using lime powder.
- If composting bio-slurry: only use super phosphorus at the rate of 2 – 3%, no lime, because of the high pH value of these composting materials.
- It is possible to use all required phosphorus amount for peanut to make compost fertilizers from manure and bio-slurry. The composting should be conducted 2 – 3 months prior to the planting stage. The decomposed compost fertilizer can be used for peanut crop.

c. Fertilizing timing and application technique

**Basal fertilize**

<table>
<thead>
<tr>
<th>Application method</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Evenly spray on the field:</em> Apply manure or bio-slurry on a seedbed and plough to bury the fertilizer into the soil. After ploughing, dig trenches for planting.*</td>
<td>Saves time and labour</td>
<td>If using a partially decomposed fertilizer, the seeds may probably be rotted in the places where it contacts the fertilizer.</td>
</tr>
<tr>
<td><em>Apply fertilizer by row:</em> After making a bed, dig trenches about 8 – 10 cm deep. Apply the entire amount of decomposed manure or bio-slurry on the seedbed and cover it with 3 – 4 cm of soil before seed sowing.</td>
<td>Able to avoid the risk of rotten peanut grains in places where it contacts the fertilizer.</td>
<td>Need more time and labour as compared to the above method.</td>
</tr>
</tbody>
</table>

**Additional fertilize**

It is possible to use liquid bio-slurry as an additional fertilizer for peanut. The liquid bio-slurry is taken out of the biogas slurry pit directly and diluted with water at a diluting ratio of 1:1 for irrigating
the peanut. Ideally, application is irrigating between peanut drenches. The proper application amount of liquid bio-slurry, when used as an additional fertilizer, is calculated and determined by converting the level of pure nitrogen for an additional fertilizer, as recommended in the “Peanut fertilizer management” of local authorities.

- First additional fertilizing session when the peanut plants have 2 – 3 real leaves: Use the amount of liquid bio-slurry that is equivalent to one third of the amount of pure nitrogen in the technical guideline.
- Second additional fertilizing session when the peanut plants begin to produce flowers: Use the amount of liquid bio-slurry that is equivalent to one third of the amount of pure nitrogen in the technical guideline.

### 2.2. Sugarcane

#### 2.2.1. Popular types of soil for growing sugarcane in Viet Nam

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvial acidic soils</td>
<td>The soils have moderate to slightly high fertility.</td>
<td>The soils are acidic; Some moderate clay loam soils have relatively low soil porosity.</td>
</tr>
<tr>
<td>Acid sulphate soils</td>
<td>The soils have moderate to slightly high fertility</td>
<td>The soils are both acidic and saline. Many soil areas have poor drainage capacity.</td>
</tr>
<tr>
<td>Degraded grey soils</td>
<td>-</td>
<td>The soils have low fertility. The soils are acidic with poor soil texture. Easily compacted when raining.</td>
</tr>
<tr>
<td>Feralit soils developed on ancient alluvial soil</td>
<td>-</td>
<td>The soils have low fertility; light mechanical composition; poor texture soil; the topsoil is susceptible to leaching or erosion; the soils are acidic.</td>
</tr>
</tbody>
</table>
2.2.2. Fertilizer management on manure and bio-slurry utilization for sugarcane

a. Amount of application

Table 21. Recommended application amount of manure and bio-slurry as basal fertilizer for sugarcane production (ton / hectare) at the time of planting (young plant)

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Manure fertilizer</th>
<th>Solid bio-slurry fertilizer</th>
<th>Compost fertilizer from composting liquid bio-slurry and rice straw</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvial acidic soil</td>
<td>10 - 15</td>
<td>7 - 10</td>
<td>10 - 15</td>
</tr>
<tr>
<td>Acid sulfate soil</td>
<td>10 - 15</td>
<td>7 - 10</td>
<td>10 - 15</td>
</tr>
<tr>
<td>Degraded grey soils</td>
<td>15 - 20</td>
<td>10 - 15</td>
<td>15 - 20</td>
</tr>
<tr>
<td>Feralit soils developed on ancient alluvial soil</td>
<td>15 - 18</td>
<td>10 - 15</td>
<td>15 - 18</td>
</tr>
</tbody>
</table>

Source: Singh [22]; Nguyen Bao Ve [30]. Cao Ky Son [28].

b. Forms of manure and bio-slurry for sugarcane

Manure and solid bio-slurry should be partially decayed before using for sugarcane. It is possible to use the whole amount of required basal phosphorus fertilizer for composting manure or solid bio-slurry for the first seasonal crop (young plant or cut cane stalk), as regulated in the technical fertilizer management for sugarcane. The main benefit of this practice is to speed up the decomposition of composting materials.

c. Fertilizing timing and application technique

Apply to young plants

- **If using manure as basal fertilizer:** Spray a thin layer of lime powder on the field before the last ploughing and harrowing session. Dig trenches and apply the whole amount of decayed compost fertilizer by trenches before planting. Cover the compost fertilizer with a layer of soil to prevent that the sugarcane stalks are directly adjacent to the fertilizer. Finally put the cut cane stalks in the trenches.

- **If using bio-slurry as basal fertilizer:** Before planting, compost the bio-slurry with the phosphorus fertilizer. Dig trenches and apply the whole amount of decayed compost fertilizer in the trenches before planting. Cover the compost fertilizer with a layer of soil to prevent that the sugarcane stalks are directly adjacent to the fertilizer. Finally put the cut cane stalks in the trenches.
Apply to sugarcane roots or ratoon (from the roots of the predecessor)

- Use cattle power or machines to plow horizontally to get deep furrows or trenches on both sides along the length of each row of sugar cane in order to cut out the old roots or eliminate any plant that is out of line. Apply manure or bio-slurry fertilizer by row, use the plow to fill up the fertilizer, lightly moisten the furrows to make the plant regrow.
- Wait until rainy season in case there are no available water resources. At this time, the cane ratoons grow 2 – 3 plants; plow horizontally to get deep furrows or trenches on both sides along the length of each row of sugar cane; Apply the fertilizers in furrows or trenches and cover with soil for regrow of sugarcane.

Box 14. Some important points when using manure fertilizer or bio-slurry fertilizer for sugarcane

- Sugarcanes dislike acidic soils, hence it is better to use bio-slurry than manure for this crop. If bio-slurry is unavailable, manure should be applied in combination with lime. Depending on soil acidity, lime powder can be added ranging from 0.5 – 1 ton of lime powder per one hectare.
- It is a priority to use manure and solid bio-slurry for sugarcane that is being grown on soils having low fertility, such as degraded grey soil and feralite soils developed on ancient alluvial soil.
- The application amount of manure and solid bio-slurry for ratoon cane (the roots of the predecessor) is only 70 – 75% of the application amount for young plants.

3. Perenial industrial crops

3.1. Coffee

3.1.1. Popular types of soil for growing coffee in Viet Nam

Table 22. Popular types of soil for growing coffee in Viet Nam – Advantages and disadvantages of using manure and bio-slurry for coffee production

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basaltic reddish brown soils</td>
<td>The soils have thick and very thick layers without great slop. Slope not greater. Humus in the soil ranges from medium to slightly high.</td>
<td>The soils are acidic and very acidic, poor in soluble phosphorus; very easy to be draught in dry season.</td>
</tr>
</tbody>
</table>
3.1.2. **Fertilizer management on manure and bio-slurry utilization for coffee production**

a. **Amount of application**

Coffee is a perennial industrial plant, often grown on soils of barren soil (reddish brown soil). Coffee plants are vulnerable during dry season. In addition, the majority of the coffee growing area is distributed on slopping soils, making it more susceptible to extreme conditions such as erosion and runoff or even drought in the dry season. Hence, the application of manure and bio-slurry does not only supply additional nutrients for coffee plants, but also ensures the organic and inorganic balance as well as increases the organic matter in the soil and increases the moisture holding capacity of the soil, while it limits the impact of erosion and runoff during the rainy season. The application of bio-slurry on coffee plantations (often acidic or very acidic soil) also works to increase the amount of soluble phosphorus in the soil and increases the utilization coefficient of phosphorus in commercial phosphate fertilizers when it is applied to the soil.

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Newly planted</th>
<th>Trade stage (apply every two years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manure</td>
<td>Solid bio-slurry</td>
</tr>
<tr>
<td>Basaltic reddish brown soils</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Lime reddish brown soils</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Brownish yellow on ancient alluvial soil</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Reddish brown on clayish rock and metamorphic soils</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

*Source: Lavina [16]; Truong Hong [14].*
b. Forms of manure and bio-slurry for coffee

It is compulsory to use decomposed or fully decomposed fertilizers for coffee trees. Do not use fresh (untreated) manure, especially the manure having much rice straw bedding material. The reason for this is that when adding fresh manure to the soil, decaying microbials will work extremely actively to decompose organic matters, leading to a nutrient dispute between microbials and crops. More seriously, the disputing for nitrogen may probably cause yellow leaf disease or even death of coffee due to rotten roots, because of the high temperature created during the decomposition of organic matters.

In Viet Nam there is no research or study available at trade stage on using liquid bio-slurry for fertilizing coffee. However, according to Gonzale from [ ] Uganda, the application amount of 20 litres liquid bio-slurry per tree per year will increase the coffee yield and enhance the resistance to disease of this crop.

Apply fertilizer to nursery garden

Before irrigating a nursery garden, manure should be soaked with other organic material for at least one month. When irrigating, it is better to dilute the composted manure with water at the ratio of 1:5 or 1:3 respectively, depending on the growth and development of the seedling plants.

Apply fertilizer to newly planted coffee trees: Dig the holes one to two months before planting the coffee trees. Put the whole amount of compost fertilizer (fresh manure is composted with
phosphorus fertilizer) into the prepared holes and cover the fertilizer with a thin layer of earth and let the composting happen.

**Apply fertilizer to trade stage plantation**

If using partially decomposed manure or solid bio-slurry for coffee, the practice can be conducted every 2 – 3 years. The best application time is early rainy season (when the distribution of rainfall is evenly).

- **For coffee trees without contacting branches**: Dig ring trenches outside the edge of the tree’s branch of 30 – 40 cm wide and 30 – 40 cm deep. Put the fertilizer in the trenches, cover with soil and compact tightly.
- **For trading coffee trees with contacting branches**: Dig trenches between two rows of coffee trees. If this year the digging is horizontal then the next year the digging is vertical and vice versa.

If you use diluted liquid bio-slurry for coffee, it is possible to apply it directly on the roots.

3.2. **Tea crop**

3.2.1. **Popular types of soil for growing tea crops in Viet Nam**

Tea growing areas distributed in the Midlands are commonly feralit reddish yellow soils that are developed on granite, clay and mica schist. In the mountainous areas, the tea growing areas are mostly feralit reddish yellow soils developed on clay schist rocks.

Generally, these above soils are ideal for the growth and development of tea crops as they have a suitable pH value ranging between 4 – 5, deep soil layers of more than 1 meter and relatively high soil porosity. However, the disadvantages of these soils are that they contain less organic matter, especially in high sloppy soils or long year tea growing areas without annual organic fertilizing.

3.2.2. **Fertilizer management on manure and bio-slurry utilization for tea crops**

a. **Amount of application**

- **Farmyard manure**
  - Primarily establishing stage: 20 – 30 tons of fertilizer
  - Trade stage: 25 – 35 ton/ hectare, apply every three years
• **Bio-slurry**: In Viet Nam, there is no research or study available on using solid bio-slurry for tea crops. In the world, a number of authors made their statements on the recommended application amount of solid bio-slurry in their researches, which ranges from 10 tons to 20 tons per one hectare for tea [25], to increase the tea production yield.

Besides, a number of researches and experiments on using liquid bio-slurry for tea were conducted by the Provincial Extension Centre and Agricultural and Rural Development Bureau of Dong Hy district. The two offices communicated and recommended that liquid bio-slurry can be used for tea crops with an application amount of 2 cubic meters of liquid bio-slurry combined with 4 kg urea fertilizer and 20 kg Song Gianh microbial fertilizer as basal fertilizing for 1 Northern Sao area (equivalent to 360 m2); using 4m³ liquid bio-slurry + 2m³ fresh water as additional fertilizing for tea, application times are 3 days and 15 days respectively after the first harvesting for 1 Northern Sao area.

**b. Forms of manure and bio-slurry for tea crops**

It is possible to use partially decayed manure or solid bio-slurry that is composted with a phosphorus fertilizer as basal fertilizers. For the additional fertilizer, use fully decomposed manure or solid bio-slurry or liquid bio-slurry that is diluted with water with the recommended ratio of liquid bio-slurry and water.

**c. Fertilizing timing and application technique**

**Primary establishing stage**

**Basal fertilize**

2 – 4 weeks before planting, plow the soils until you reach the depth of 40 – 45 cm, harrow the soils and dig trenches of 15 - 20 cm deep and 20 - 25 cm wide along the rows. When deep ploughing is impossible, dig trenches of 40 - 45 cm deep.

Basal fertilizer: 20 – 30 tons of manure or 10 – 20 tons of solid bio-slurry and 100 kg for 1 hectare of tea plantation.
**Additional fertilizer:** Apply 10 tons of manure or 7 tons of solid bio-slurry for one hectare of tea annually.

- **Trade stage**

  Apply manure or solid bio-slurry with an application amount of 10 – 15 tons per hectare for tea once every three years, right after heavy pruning.

  *Application technique:* Broadcast the fertilizer by ring with a distance of 10 – 15 cm from the roots. Combine with tillering to bury the fertilizer entirely in the soil. Irrigate with adequate water and maintain proper moisture after applying the fertilizer.

  If using liquid bio-slurry for tea, the fertilizer can be applied on the roots. Additional fertilizing can take place 3 days after the first harvesting and 15 days after first time of additional fertilizing.

---

**Box 16. Some important points when using manure fertilizer or bio-slurry fertilizer for a tea plantation**

- It is possible to combine the use of manure or solid bio-slurry with commercial fertilizers with the recommended amount of the regulated fertilizer management for tea production.
- If solid bio-slurry is used for tea, it is **compulsory** to combine it with ammonium sulphate \((\text{NH}_4)_2\text{SO}_4\), and **not** with urea fertilizer, because tea likes acidic soils while solid bio-slurry has a rather high pH value; using ammonium sulphate \((\text{NH}_4)_2\text{SO}_4\) will create soil acidity hence eliminates the limitations caused by the application of bio-slurry to tea.

---

**4. Vegetable crops**

**4.1. Some ecological requirements of vegetable crops**

- Vegetables only grow and develop well and produce a high crop yield with a good product quality on light mechanical composition soils, such as light clay loam soils and clay-sandy soils, which are very porous, have rich humus and other nutrients especially nitrogen and phosphorus, and have a pH value in the range of 6.0 – 6.5.
- Vegetables dislike saturated soils and draught as they cannot grow and develop well in these conditions. Therefore, conservation and supplementation of soil moisture by irrigation becomes necessary to improve the moisture regime of soil as it plays a remarkably important role to ensure good growth and development of vegetables.
- Most vegetables, especially cabbage require a relatively high level of nitrogen (with a production yield of 30 tons / ha cabbage takes 125 kg N from soils). On the other hand, if nitrogen is
excessively absorbed by the plants (in case inorganic fertilizers are excessively applied) this will cause nitrate accumulation and residues in vegetables, which has long-term effects on the health of human beings.

- Leaf vegetables are sensitive to some physiological diseases such as yellow leaf, dry leaf edge, leaf albino, and curly tops etc., which depletes growth, development and yield producing ability of vegetables, leading to the requirement of strong pesticide utilization. The main reason for these phenomena is the fact that vegetable growers only use single chemical fertilizers, such as urea fertilizer and super phosphorus fertilizer, while neglecting the application of organic fertilizers, which causes the absence of micro trace elements, such as Fe, Mn, Zn, Cu etc. in vegetables.

- Regarding production yield, fruit vegetables have a yield that is 2-3 times higher than that of leaf vegetables. Therefore, they need a higher level of nutrients. Leaf vegetables have the highest demand for nitrogen, then potassium and phosphate. In the meanwhile, fruit vegetables have a high demand for all 3 macro elements: nitrogen, potassium and phosphate. Because fruit vegetables have the characteristic of continuous flowering and fruiting, they also have a high demand for medium- and micro-elements, of which calcium (Ca) and Bo (B) are the most important elements.

4.2. Popular types of soil for growing vegetables in Viet Nam

Table 24. Popular types of soil for growing vegetables in Viet Nam – Advantages and disadvantages of using manure and bio-slurry for vegetable production

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvial soils that are neutral or less acidic</td>
<td>The soils have very high fertility; most areas have rather high soil porosity with a good water holding capacity.</td>
<td>-</td>
</tr>
<tr>
<td>Acidic alluvial soils</td>
<td>The soils have fairly high fertility with a good water holding capacity</td>
<td>Some heavy clay soils have a poor drainage capacity.</td>
</tr>
<tr>
<td>Inland sandy soil</td>
<td>The soil have light mechanical composition, hence it saves labour for soil preparation or taking care of the plantation.</td>
<td>The soils have low soil fertility with a poor water holding capacity and are rather acidic.</td>
</tr>
<tr>
<td>Marine sandy soil</td>
<td>The soil have light mechanical composition, hence it saves labour for soil preparation or taking care of the plantation.</td>
<td>The soils have low soil fertility with a poor water holding capacity and are rather acidic.</td>
</tr>
</tbody>
</table>

4.3. Roles of organic fertilizer in vegetable production
Organic fertilizers play a significant important role in vegetable cultivation. Organic fertilizers not only provide macronutrients (N, P and K), but also provide medium and micro trace elements, including Bo, Manganese, Basic, Zinc, Molybdenum etc. It is impossible to provide these elements to crops, in the same time, by any inorganic fertilizer.

Organic fertilizers also have the beneficial effect of improving soil properties, such as increasing soil porosity and humus, enhancing the moist retaining ability as well as increasing the nutrient holding capacity of the soil. Organic fertilizers also have the positive effect of improving the nutritious utilization coefficient of inorganic fertilizers, when these fertilizers are applied to the soil, because the increased humus in the soil results in a reduction of input costs for vegetable production as you save on the required application amount of inorganic fertilizers.

As leaf vegetables have a high demand for nitrogen, it is necessary to apply a relative large amount of this nutrient fertilizer to these crops. Besides the positive effects of helping plants grow better with a high crop yield, the improper application of extremely exceeded nitrogen may be of risk for underground water contamination. The application of manure or bio-slurry in combination with inorganic fertilizers will contribute to the depletion of nitrogen leaching, while limiting the nitrate accumulation in soil and groundwater, and eliminating the adverse impacts of water eutrophication, which may adversely affect health of the community.

### 4.4. Fertilizer management on manure and bio-slurry utilization for vegetable production

#### 4.4.1. Cabbage

a. **Amount of application**

Table 25. Recommended application amount of manure and bio-slurry as basal fertilizer for cabbage production

<table>
<thead>
<tr>
<th>Type of soil</th>
<th>Application time</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basal fertilizer</td>
<td>Pre-cupping stage</td>
<td>Cupping stage</td>
<td>Mature stage</td>
</tr>
<tr>
<td>Manure (ton / ha)</td>
<td>12 – 15</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Solid bio-slurry (ton / ha)</td>
<td>8 - 10</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Liquid bio-slurry (m$^3$/ha) | - | 13 - 20 | 13 - 20 | 13 - 20

**Tips:** Farmyard manure should be combined with lime powder with an application amount in the range of 300 – 500 kg/ha, as cabbage is moderately sensitive to soil acidity.

* The recommended application amount of farmyard manure and solid bio-slurry for mustard family in the above Table are based on researches by Ta Thi Thu Cuc [7] and Karki [13]; The recommended application amount of liquid bio-slurry is based on researched results by the National Institute of Soils and Fertilizers [18].

* If you apply the recommended amount of liquid bio-slurry as mentioned in the above table, it is advisable to cut down 10 - 28 kg N; 3 - 11kg P$_2$O$_5$ and 10 - 25 kg K$_2$O from the total required application amount of those N, P and K fertilizers, as regulated and recommended in the technical fertilizer management for cabbage.

b. **Forms of manure and bio-slurry for cabbage**
- Manure and solid bio-slurry: use fully decomposed fertilizers as basal fertilizer
- Liquid bio-slurry: dilute liquid bio-slurry with water at a ratio of 1 : 1 and use it as additional fertilizer

c. **Fertilizing timing and application technique**

**Basal fertilize:** Conduct basal fertilizing at the soil preparation stage. Broadcast the fertilizers evenly on the seedbeds and mix the fertilizers and soil well; take earth from the trenches to place the seedbed 1.5 – 2 cm deep and plant the cabbage crop.

**Additional fertilize:** Apply the fertilizers at three important stages: (i) pre-cupping stage; (ii) cupping stage and, (iii) 70 days after planting (mature stage). Liquid bio-slurry can be applied directly on the roots.

**Tips:** 3 – 4 weeks before harvesting, it is compulsory to stop the application (irrigation) of liquid bio-slurry for cabbage to avoid nitrate accumulation in cabbage leaves that causes the reduction of the product quality (as cabbage heads are susceptible to cracks and leaves have a bitter taste).

4.4.2. **Mustard family (Brassicaceae) and lettuce crops**

a. **Amount of application**
Table 26. Recommended application amount of manure and bio-slurry as basal fertilizer for the production of mustard varieties

Source: Ta Thi Thu Cuc [7], Tran Thi Ba [2], Ngo Quang Vinh [29]

Tips: * Farmyard manure should be combined with lime powder with an amount of 300 – 500 kg per hectare when it is applied to mustard crops, as these vegetable crops are susceptible to acidic soils.

* The application amount of liquid bio-slurry, as mentioned in the above table, can replace 10% of the inorganic fertilizers, as recommended in the fertilizer management for mustard and lettuce crops, when using liquid bio-slurry based on 20 tons of decomposed manure per hectare (if using solid bio-slurry as a replacement of decomposed manure, the application amount of solid bio-slurry is about 18 ton per hectare).

b. Forms of manure and bio-slurry for mustard vegetable crops
- Manure and solid bio-slurry: use fully decomposed fertilizers as basal fertilizer;
- Liquid bio-slurry: dilute liquid bio-slurry with water at a ratio of 1 : 1 and use it as additional fertilizer

c. Fertilizing timing and application technique

**Basal fertilize:** Conduct basal fertilize at the soil preparation stage. Broadcast the fertilizers evenly on the seedbeds and mix the fertilizers and soil well; take earth from the trenches to make a seedbed of 1.5 – 2 cm deep and plant the seedlings.

**Additional fertilize:** Apply fertilizers at two important stages:
- First fertilize timing: 7 days after planting – ½ of the total amount of liquid bio-slurry;
- Second fertilize timing: 15 days after planting – ½ of the total amount of liquid bio-slurry.

<table>
<thead>
<tr>
<th>Variety of mustard and lettuce crops</th>
<th>Basal fertilize (ton / ha)</th>
<th>Additional fertilize (m³ / ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Manure</td>
<td>Solid bio-slurry</td>
</tr>
<tr>
<td>Napa cabbage</td>
<td>18 - 25</td>
<td>15 - 18</td>
</tr>
<tr>
<td>Chinese cabbage</td>
<td>12 - 20</td>
<td>-</td>
</tr>
<tr>
<td>Mustard greens</td>
<td>15 – 20</td>
<td>-</td>
</tr>
<tr>
<td>Broccoli</td>
<td>5 - 10</td>
<td>-</td>
</tr>
<tr>
<td>Lettuce</td>
<td>15 - 20</td>
<td>12 - 15</td>
</tr>
</tbody>
</table>
4.4.3. Other vegetable crops

a. Amount of application

Table 27. Recommended application amount of manure and bio-slurry as basal fertilizer for the production of other vegetables (tons / ha)

<table>
<thead>
<tr>
<th>Variety of vegetables</th>
<th>Type of fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Farmyard manure</td>
</tr>
<tr>
<td>Tomato</td>
<td>30 - 40</td>
</tr>
<tr>
<td>Potato</td>
<td>10 – 25</td>
</tr>
<tr>
<td>Chili</td>
<td>10 - 15</td>
</tr>
<tr>
<td>Carrot</td>
<td>10 – 15</td>
</tr>
<tr>
<td>Kohlrabi</td>
<td>20 - 25</td>
</tr>
<tr>
<td>Bitter melon</td>
<td>15 - 20</td>
</tr>
</tbody>
</table>

Source: Gurung [8]; Islam. [ ]; Tran Thi Ba [2]; Jeptoo [12].

b. Forms of manure and bio-slurry for mustard family crops

Box 17. Some important points when using manure fertilizer or bio-slurry fertilizer for mustard family crops

- Phosphorus and potassium: mustard family crops are short day growing crops, with less demand for phosphorus and potassium as compared to nitrogen. Therefore, when growing mustard family crops on soils with a fairly high level of phosphorus and potassium, such as alluvial soils, it is possible to solely use solid bio-slurry (already composted with phosphate fertilizers) as basal fertilizer and liquid bio-slurry as additional fertilizer without adding phosphorus and potassium.
- The application amount of manure or bio-slurry should be higher for mustard family crops grown on soils having low fertility than the application amount on alluvial soils.
- It is advisable to apply bio-slurry for mustard family crops that grow on alluvial acidic soils, because this fertilizer has a high pH value and does not create soil acidity, which is more proper for these crops which prefer neutral soils.
- It is compulsory not to use undiluted liquid bio-slurry for mustard family crops, as the practice may probably cause wilted plants due to the higher level of inorganic salts in liquid bio-slurry, as compared to the levels of these substances in the roots. When liquid bio-slurry is applied directly on the roots, this may cause dehydration of the plants.
- Liquid bio-slurry can be diluted with water by a ratio of 1:1 or 1:2 before using it as an additional fertilizer for mustard family crops. However, the former ratio is recommended as this ratio creates higher revenues for vegetable growers.
- The number of liquid bio-slurry irrigation can be increased depending growth and development.
It is compulsory to use fully decomposed manure or solid bio-slurry for mustard family crops, instead of using fresh (untreated) fertilizers, as the application of these fertilizers to the soil may probably create favourable conditions for the growth and development of disease causing fungi, especially collar rot fungi. This disease restricts the growth and development of plants significantly, which results in a dramatic reduction of the crop yield as well as the product quality.

c. Fertilizing timing and application technique

**Basal fertilizer**: Manure or solid bio-slurry are used as a fertilizer for mustard family crops at the final soil preparation stage (for carrots) or put in trenches or holes (for crops such as tomato, potato and chili).

**Additional fertilizer**: Liquid bio-slurry should be diluted with fresh water with a diluting ratio of 1:1 before additional fertilizing.

5. Fruit trees

5.1. **Popular types of soil for growing fruit trees in Viet Nam - Advantages and disadvantages of using manure and bio-slurry for fruit trees production**

Table 28. Characteristics of fruit tree growing soil; requirements of fruit crops growing soil - Advantages and disadvantages of using manure and bio-slurry for fruit crops production

<table>
<thead>
<tr>
<th>Primary requirements</th>
<th>Major characteristics of current fruit tree growing soils</th>
<th>Benefits of using manure and bio-slurry for fruit crops production</th>
</tr>
</thead>
<tbody>
<tr>
<td>The soils have an earth layer of at least 1 m thick (for perennial fruit crops).</td>
<td>Topsoil layers are easily eroded or leached away (in case fruit crops are grown on raised beds or sloppy soils).</td>
<td>Increases the humus amount and adhesion of soil particles / grains, while it eliminates soil erosion or leaching.</td>
</tr>
<tr>
<td>Soils must have a high porosity and good drainage capacity.</td>
<td>Soils are compacted tightly as they are often irrigated or due to rain.</td>
<td>Increases the humus amount, improves the soil texture and porosity and increases drainage capacity of the soil.</td>
</tr>
<tr>
<td>Proper pH value falls within the range of 5.5 – 7.0, depending on the variety of fruit crops.</td>
<td>Many fruit crop growing areas have alluvial acidic soils or ancient alluvial soils, with a low pH value.</td>
<td>Application of a decomposed solid bio-slurry or a compost fertilizer from bio-slurry (pH &gt;7) may probably neutralize soil acidity.</td>
</tr>
</tbody>
</table>
Table 29. Recommended application amount of manure and solid bio-slurry for the production of some fruit crops

<table>
<thead>
<tr>
<th>Variety of crop</th>
<th>Recommended application amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Farmyard manure</td>
</tr>
<tr>
<td><strong>Rambutan</strong> (kg/tree/year)</td>
<td></td>
</tr>
<tr>
<td>Apply before planting</td>
<td>15 – 20</td>
</tr>
<tr>
<td>Apply when plants produce fruits</td>
<td>5 - 10</td>
</tr>
<tr>
<td><strong>Mango</strong> (kg/tree/year)</td>
<td></td>
</tr>
<tr>
<td>Apply before planting</td>
<td>30 – 50</td>
</tr>
<tr>
<td>Apply when plants produce fruits</td>
<td>10 - 15</td>
</tr>
<tr>
<td><strong>Mangosteen</strong> (kg/tree/year)</td>
<td></td>
</tr>
<tr>
<td>Apply before planting</td>
<td>10 – 20</td>
</tr>
<tr>
<td>Apply when plants produce fruits</td>
<td>10 – 20</td>
</tr>
<tr>
<td><strong>Citrus tree</strong> (kg/tree)</td>
<td></td>
</tr>
<tr>
<td>1 – 2 years stage</td>
<td>25 - 30</td>
</tr>
<tr>
<td>4 – 5 years stage</td>
<td>35 - 40</td>
</tr>
<tr>
<td>6 – 7 years stage</td>
<td>45 - 50</td>
</tr>
<tr>
<td><strong>Papaya</strong> (kg/ha)</td>
<td>10 – 20</td>
</tr>
<tr>
<td><strong>Banana</strong> (Basal fertilize when planting)</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Vo Van Binh [5]; Lavina [17]; Nguyen Dang Nghia [21]

Tips: * Should be combined with 3.3 kg Urea + 6.25 kg super phosphorus + 3 kg KCl / tree / year.

Commercial inorganic fertilizers should be divided into 4 applications.

** Mixing well with earth
b. **Forms of manure and bio-slurry for fruit crops**

Before application to fruits crops, it is compulsory to compost manure or solid bio-slurry with a phosphate fertilizer (with a rate of 1 – 2%) until it reaches the fully decayed form.

c. **Fertilizing timing and application technique**

**Fertilize before planting:** Use topsoil to mix it well with fully decomposed manure or solid bio-slurry. Put the mixed compound into dug holes and compact the mixed compound firmly. Place the gourd seedling plants into the prepared holes. Use more mixed compound and topsoil to make beds.

**Fertilize after harvesting:**

*For general fruit trees:* If fully decomposed fertilizers are readily available at the early rainy season, it is advisable to dig trenches (20 cm deep and 2 cm wide) around the tree’s shading ring, add fertilizers on the trenches and fill back with soil. It is better to use a knife to carefully dig trenches to avoid cutting off or damaging the roots.

*For rambutan crop:* Application timing commences from finishing harvest until tree rehabilitation. Dig trenches around the tree’s shading ring, mix fertilizers and soil well and add it evenly to the soil. Water the plants well to stop the roots from drying out and further settle the grass around, if possible, to keep the trees warm.

*For mango crop:* Fertilizers are added after harvesting. Dig trenches around the tree’s shading ring, mix the fertilizers and soil well and add it evenly to the soil. Water the plants well to stop the roots from drying out and further settle the grass around, if possible, to keep the trees warm.

B. **Using bio-slurry for fresh water fish pond cultivation**

1. **Foundation of using bio-slurry as feeding for fish pond cultivation**

1.1. **Quality of fish pond water**

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter</th>
<th>Pond recirculating systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum concentrations (mg/l)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Carbon dioxide - CO₂</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>NH₃</td>
<td>0.02 – 0.5</td>
</tr>
<tr>
<td>3</td>
<td>NO₂</td>
<td>0.5 – 5.0</td>
</tr>
<tr>
<td></td>
<td>NO₃</td>
<td>1000</td>
</tr>
<tr>
<td><strong>Optimum ranges</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>pH</td>
<td>6 - 9</td>
</tr>
<tr>
<td>2</td>
<td>Dissolved oxygen (mg/l)</td>
<td>&gt;6</td>
</tr>
</tbody>
</table>

- At high levels, NH₃ is toxic to fish (for channel catfish LD₅₀=3.10 mg/l). At lower concentrations (0.05-0.2 mg/l) it causes a significant reduction in growth. In water, the NH₃ concentrations are
dependent on the NH$_4$ concentrations, pH and temperature. NH$_3$ concentration will increase with a higher level of NH$_4$, pH and temperature.

- Nitrite (NO$_2$-) is an intermediate during the biological oxidation of ammonium (NH$_4$+) to nitrate (NO$_3$-). The toxicity of nitrite depends on the concentration of Ca- and Cl-ions in water; an increase in these ions can increase the tolerance to nitrite.

1.2. **Negative effects of directly using fresh (untreated) manure for a fish pond**

For a very long time, manure has been used in fish farming in many households, primarily in households with extensive farming methods. The reality has shown that: the direct use of manure in a fish pond provides a significant source of food for the fish. However, the practice of using fresh farmyard manure, including cattle dung, pig dung and poultry droppings directly on fish ponds causes some negative affects, including:

- Spreading harmful bacteria and parasite eggs, which easily infect fish.
- The inefficient decomposition of fresh manure in a fish pond may cause oxygen depletion, leading to the "dead fish floating" phenomenon in fish ponds or even causes fish suffocation due to depletion of dissolved oxygen in the pond if excessive fresh manure is applied.

1.3. **Using liquid bio-slurry as a fertilizer for commercial fish pond cultivation** [21]

1.3.1. **Pond preparation**

The fish pond needs to be cleared of bushes. Then pump the water out of the pond and dry the pond bottom for at least three days. The next step is to disinfect or treat the pond with lime powder with an amount of 7 – 10 kg for 100 square meters. Put water in the pond. The water source should be clean and safe. It is better to filter the water with a sieve with a mesh size of 1mm x 1mm to remove all various predators and juvenile catfishes inside the pond.

1.3.2. **Fish stocking**

- Select healthy juveniles / fingerlings, without disfigurement or disease, for stocking.
- As a source of rich nutrients to create abundant phytoplankton and zooplankton (phytoplankton and zooplankton bloom) in the pond, as a preferred food source for fish, liquid bio-slurry is ideal for fishes such as the silver carp and the bighead carp. As liquid bio-slurry is produced from anaerobic digestion, it has a better quality and it contains less disease bacteria and pathogens. Therefore, it is suitable for fishes that like a fresh water environment, such as grass carps and black carps.
- Integrating stocking rate of ponds enjoying with commercial industrial feedstock supplement and qualified water resource is 40% Nile tilapia, 15% grass carp, 5% bighead carp and 10% for each rests including common carp, Indian carp, silver carp, black carp
- For single stocking, the common stocking rate for a black carp is 2 – 3 fish / m$^2$. If the fish ponds enjoy abundant fresh and clean water and when it is dug till a depth of 1.5 – 2 m, the stocking rate of 2 – 3 fish / m$^2$ can be applied to the pond. Before stocking, the fish should be soaked into a diluted salt solution with a concentration of 2 – 3% (using 2 – 3 kg salt for 100 litres water)
for 10 minutes. The stocking should be implemented at cool weather. During stocking, the balance between the pond water temperature and the water temperature of the transported plastic bags is very important to be taken into consideration. If stocking is implemented in sunny weather, it is advisable to find a shady place (for example below trees) and to stir the water upwards to avoid a temperature shock for the fish (a sudden change of the water temperature), as this can be fatal to fish, especially small fish or fry.

1.3.3. Preparation of liquid bio-slurry (taken from biogas digester)
- With an application amount of 20 litres liquid bio-slurry for 100 m$^2$ fish pond per week, the proper size of a digester that can supply liquid bio-slurry for 5,000 m$^2$ is 8 - 10 m$^3$ if the biogas digester enjoys a normal and continuous operation.
- Liquid bio-slurry is taken directly from the slurry pit (s) that is connected with the compensation tank of the bio-digester. Strictly ensure the water level of the slurry pit is higher than the flowing level of the compensation tank. Before fertilizing, liquid bio-slurry should be disposed to eliminate and remove contaminants or refuse. The liquid bio-slurry should be exposed to air to reduce and limit the quantity of harmful anaerobic microbials that harm fish.

1.3.4. Application methods for liquid bio-slurry from biogas digesters for fish ponds
- Mix liquid bio-slurry and commercial feedstuff well with a mixing ratio of 1 litre liquid bio-slurry to 1 kg commercial foodstuff and wait for at least 10 – 15 minutes until the food is fully soaked with liquid bio-slurry before applying it to the fish pond.
- Second method: Distribute (pump) liquid bio-slurry directly with an application amount of 10 litres for a 100m$^2$ fish pond. Apply twice every week. If using a pump, the pumping capacity (m$^3$/h or litre/h) should be checked to identify the proper timing for pumping the adequate amount of liquid bio-slurry in the fish pond.

The activities, such as food management, cultivating environment control and fish health management, should strictly follow the fish pond cultivating procedures as issued by the provincial Department of Agriculture and Rural Development.
A. Basic knowledge for training

1. Study characteristics of training participants

All trainees participating in the trainings under the project "Biogas Program for the Animal Husbandry Sector in Viet Nam" are defined as adults. Therefore, understanding the characteristics of these trainees well will help the trainer to select the appropriate training methods to best convey information on using manure and bio-slurry to them.

Main characteristics of adult trainees include:

- Adults often have more experience and knowledge in production and life;
- They often come to the training with the set aim to learn the missing knowledge or the knowledge they do not have up to date;
- Adult trainees are only interested in the knowledge / skills that are really helpful or directly related to their production or business and really want to receive the knowledge / skills.

Box 18. Some important points to note to organize and conduct an efficient training for adults

1. Adult trainees will receive information more efficiently if:
   - The training is focused on the issues that they are currently interested in;
   - The training content matches with their qualifications;
   - Trainees can make comments and share their thoughts;
   - Trainees feel comfortable and respected;
   - The trainer(s) uses training methods that are appropriate to the trainees.

2. A number of factors that prevent or limit the acquisition of knowledge for trainees:
   - Conservativeness and inflexibleness;
   - Education and awareness of trainees in a training is inequivalent;
   - Lack of time;
   - The issues of gender and ethnicity;
Identifying training objectives is clearly defining the possibilities of skills or experiences that trainees can attain by the end of the training. Clearly defining training goals will help trainers to select suitable content and appropriate methods for the training in order to achieve the expected objectives.

When building objectives of a class / training, trainers should adhere to the following principles:

- The objectives are constructed based on the student centred learning principle, i.e. a process of learning that puts the needs of the students over the conveniences of content, to create a curriculum framework that centres the authentic needs of each student makes sense after attending classes / a training;
- Factual observation indicates that evaluation of training effectiveness through objective evaluation is the most accurate. Thus, using active verbs to write training objectives is essential. Suggested verbs like solve, realize, identify, select etc. are an example;
- Define conditions and limitations that specifies the behaviours or action expected to occur.

Training objectives should be:

(i) **Concrete**

*Example:* To contribute to changed perceptions of trainees on the negative effects of the utilization of untreated manure and bio-slurry on soil, water and air.

(ii) **Achievable**

*Example:* To provide instructions on effective utilization of manure and bio-slurry based on the characteristics of the household resources (soil conditions, capital and production).

(iii) **Measurable**:

*Example:* About 80-90% of participants would use manure and bio-slurry to fertilize their crops after training.

---

**Box 19. Some notes for identifying training objectives**

- Trainees always want to receive practical knowledge that is applicable to their actual production.
- Test the set targets of training courses based on the characteristics of the trainees and competencies of trainers. Do objectives meet the expectations of trainees? Can the trainer, through the training activities, achieve the targeted goals?
- *Establish training priorities:* Decentralize training objectives based on importance and allowable timing conditions. Trainers do not have enough time to transfer all the content in one day training.

---

3. **Develop a content outline for the training**

The outline of content for the training covers the important activities that are planned to be done in the training course.

A training course should have three main parts:

- Introduction and getting acquainted among trainees and between trainees and trainers (facilitators):
- What is the proper training method? It must depend on the characteristics of the trainees, especially age, culture, custom;
- Estimated duration of a training?

- Conducting course content:
  - Designed course content is planned to be conveyed to the trainees;
  - Training methods and estimated duration of each part;
  - Questions to be used; designed group discussions and solutions.
- Wrapping up and training evaluation: this part articulates the conveyed information and knowledge and the possibilities of applying these to their actual production and work.

4. Identify training course content and develop a method for training materials on utilization of manure and bio-slurry for beneficial households

Identify training course content

- Goal: Identifying training course content to achieve the designed objectives.
- Identify training course content: Identify content for the whole duration / whole training and content of each topic. Order of appearance of the content in each section / subsection and topic.
- Select content for the training: it depends on the requirements of perception, knowledge and skills that trainees would gain by the training.
  - Perception: how to change perception?
  - Knowledge: what for?
  - Knowledge that they need to know
  - Knowledge that they should know
  - Knowledge if known, it would help in the future
  - Skills: how to do? What skills are necessary for trainees? It is necessary to take the characteristics and job requirements of the trainees into account to build appropriate skills for the training.

Box 20. Example of knowledge to be conveyed during a training on utilization of farmyard manure and bio-slurry

a.  *Knowledge that they need to know*: Characteristics of manure and bio-slurry. Advantages and disadvantages, similarities and difference of these fertilizers.
b.  *Knowledge that they should know*: Benefits of manure and bio-slurry for agricultural production.
c.  *Knowledge if known, it would help in the future*: Identify acidic soils with the absence of soil

4.1. Compiling and developing training material for the trainer
4.1.1. **Develop content outline**

**Goals**

(i) To make the compiling more easily  
(ii) To avoid repetition of information in training materials  
(iii) Ensure the logic between the parts / chapters / sections / subsections of the document  
(iv) Save time for compiling and developing training material

**Process of outline development**

1. **Study training subject carefully**

   Thoroughly studying the training subject ensures that the most concise content will be presented and mentioned in the training material. Therefore, studying and identifying the training subject carefully is essential to ensure that the compiled content is adhered to the subject of the training and plays as the basis for determining the amount of content to be conveyed as well as the level of detail in the training content (*i.e.* the amount of chapters / parts / sections and subsections).

   **Example**: The training subject is defined as “Using farmyard manure and bio-slurry for crop production”. In this case, the content of the training material should cover information related to utilization of the two organic fertilizers such as: (i) characteristics and the positive effects of manure and bio-slurry utilization for crop production; (ii) negative impacts of using fresh (untreated) manure on soil and water; (iii) using manure and bio-slurry for some major crops etc.

2. **Identify chapters / parts / sections / subsections**

   • List the chapters / parts / sections / subsections according to the training subject
   • Carefully review the list of chapters / parts / sections / subsections to make sure that:
     - No chapter / part / section / subsection is missing or repeated;
     - The level of detail in the training material meets the requirements on the amount of information to be conveyed to trainees.

3. **Identify the order of appearance of the chapters / parts / sections / subsections**
Collocate the list of chapters / parts / sections / subsections. In reality, the collocation of chapters / parts / sections / subsections may be conducted several times, depending on the level of knowledge of the trainers on the related training subject and his/her content building ability.

d. Identify the logical order of appearance of chapters / parts / sections / subsections

This is the most important step in the process of compiling training materials, deciding the quality of training materials and having direct influence on the effectiveness of informative conveyance of the trainer. It is really necessary to spend adequate time as well as special attention to this step to ensure the **consistency** of the content to be presented and conveyed.

Logically presented content not only helps the trainer to easily convey information but also helps trainees in acquiring the necessary information more efficiently. Training content which is logically compiled with scientific sequences will be more attractive than content which is fragmentarily, messily and confusedly compiled.

Logically constructed content also helps the trainer to build the most proper methods to convey relevant information on each specific subject and to avoid repetition of the used method, which could cause boredom during the training.

<table>
<thead>
<tr>
<th>Examples of a logical order of items in training materials on the use of manure and bio-slurry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOPIC 1. Management on manure and bio-slurry</strong></td>
</tr>
<tr>
<td>Part 1. Characteristics of farmyard manure and bio-slurry</td>
</tr>
<tr>
<td>Part 2. Positive effects of farmyard manure and bio-slurry</td>
</tr>
<tr>
<td>Part 3. Negative impacts of using fresh (untreated) farmyard manure and bio-slurry on the environment</td>
</tr>
<tr>
<td>Part 4. Methods to compost farmyard manure and bio-slurry</td>
</tr>
<tr>
<td><strong>TOPIC 1. Management on manure and bio-slurry</strong></td>
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<tr>
<td>Part 3. Positive effects of farmyard manure and bio-slurry</td>
</tr>
<tr>
<td>Part 4. Methods to compost farmyard manure and bio-slurry</td>
</tr>
<tr>
<td>Sections are presented in a logical flow of information</td>
</tr>
<tr>
<td>The flow of information is not really logical</td>
</tr>
</tbody>
</table>

As mentioned in the example above, in order to help trainees to acquire knowledge on the use of manure and bio-slurry, firstly trainers should help trainees to review / remind the characteristics of manure and bio-slurry, including the advantages and disadvantages of these two fertilizers to guide them in distinguishing the similarities and differences between the two types of organic fertilizers, so that they are able to identify the proper fertilizers for their future production; as well as to manage the harmful effects of the two organic fertilizers if they are not properly managed; and how to store manure and bio-slurry.
In this case, the information is always logically presented and the training content will be more attractive, even to the older, female ethnic minority trainees or the trainees with limited education.

e. Identify reference sources

There are plenty available resources where trainers may refer to for the compilation of training materials. However, it is necessary to determine the reference sources to ensure the legality, accuracy and consistency of the training content even though it is the final step for the compilation. Determining the reference sources before the compilation of the document helps trainers save their time for compiling.

- **How to gather reference sources:**
  - *For information relating to agricultural engineering:* the formal information sources are available at:
    (i) Data sources (syllabus, lecture) from agricultural / agroforestry universities; research institutes of the Ministry of Agriculture and Rural Development. It is possible to visit websites of universities and institutes or directly contact the authors to collect materials.
    (ii) Specialized journals, such as the journal of agriculture and rural development; the Journal of Soil Science under the Viet Nam Soil Science Association etc. Magazines and journals can be found at the library of Agricultural and forestry vocational schools / colleges or universities, provincial agricultural and forestry extension centres.
  - *For information relating to policies, law, decrees, regulations, national standards, sector standards, agricultural market etc.,* it is possible to visit the following websites: 
    www.vanban.chinhphu.vn; 
    www.thuvienphapluat.vn; 
    www.mard.gov.vn; 
    www.agroviet.com.vn

- **Some important points to note when gathering and citing reference sources**
  - The materials that are used for citing information must have a clear origin, including: (i) Name of author; (ii) title of the document or article. If cited from journal articles, also collect the issue number of the journal, date of publication, and page numbers of the article; (iii) publisher's name, and the year of publication; (iv) page number of the cited information.
  - If cited information is taken from various official sources, it is necessary to specify all sources.
  - For information related to crop production, for example information such as the recommendation on the "application amount of fertilizer for maize," you should include information on what type of maize? on what type of soil? For what crop season? And whether it is locally appropriate.

### 4.1.2. Establish the structure of the document content

The structural content of the training material for trainers should be developed as follows:

© Table of content
Abbreviation

Introduction

Purpose: List the purposes of the document such as Raise awareness? Provide knowledge? Provide skills?

Expected result: List the expected results of the training (what will trainees acquire after the training?)

Subject: what is the subject of the training?

Scope of material: The training material is used under the framework of the project "Biogas Program for the Animal Husbandry Sector in Viet Nam"

Main content of training material: including the chapters / parts / sections / subsections that have been built in the content outline, but are presented in detail.

Chapter / part A (or 1)

Objective: the content of the chapter / part / section will provide what information to the trainees?

Expected result: what will trainees acquire from this chapter / part?

Specific content of the chapter / part A includes:

- Content of Chapter / Part A (divided in subsections)
- Methods to convey the information
- Duration
- Necessary equipments or stationary for performing and presenting the content (such as a projector, markers, A0 paper etc.).

Chapter / part B (or 2)

Objective: the content of the chapter / part / section will provide what information to the trainees?

Expected result: what will trainees acquire from this chapter / part?

Specific content of the chapter / part B includes:

- Content of Chapter / Part B (divided in subsections)
- Methods to convey the information

If the use of the method "group discussion" is planned in a subsection of the chapter / section, it is necessary to provide questions / topics for a group discussion in this subsection.

- Duration
- Necessary equipments or stationary for performing and presenting the content (such as a projector, markers, A0 paper etc.).

Chapter / part C (or 3)

Objective: the content of the chapter / part / section will provide what information to the trainees?
Expected result: what will trainees acquire from this chapter / part?

Specific content of the chapter / part C includes:
- Content of Chapter / Part C (divided in subsections)
- Methods to convey the information

If the use of the method "group exercise" is planned in a subsection of the chapter / section, it is necessary to provide practical exercises with solutions from the trainer in this subsection.
- Duration
- Necessary equipments or stationary for performing and presenting the content (such as a projector, markers, A0 paper etc.).

Practice part

4.1.3. Detailing the content of the chapter / part / section that is already built in the document outline (theoretical part)

The content of each chapter / part / section that has been listed in the document outline should be specified in detail in the chapter / part / section / subsection and should be logically and appropriately developed and presented.

Each chapter / part / section must include the following three elements:

(i) Main ideas
(ii) Explain / analyze main ideas
(iii) Present conclusion / finishing chapters / parts / sections and switch to another chapter / part / section.


- Main ideas (purpose to be achieved when conveying this part): present composition, amount of nutrients; advantages and disadvantages of these two organic fertilizers.
- Explain / analyze those ideas by subsections
  1.1. Characteristics of farmyard manure
  1.2. Characteristics of bio-slurry
  1.3. Similarities and differences of these two organic fertilizers

Conclusion: Farmyard manure and bio-slurry are considered as potent organic fertilizers that are usually recommended for application to crop production. However, besides advantages, they also have certain restrictions. Therefore, it is necessary to understand their characteristics well to make use of their positive effects while eliminating their negative impacts.

4.1.4. Develop questions and topics for group discussions and case studies
The quality and attractiveness of a training course partly depends on the number and quality of questions, topics for group discussions and situations/practical exercises that trainers use in the training.

Use questions, topics for group discussions and case studies that are appropriate to the level that trainee's can understand and that are closely related to the conditions of their actual production and lives. This will have a great effect on encouraging the participation of trainees in the training and sometimes helps trainers gather more local knowledge from trainees to supplement more content to the training materials.

However, trainers should determine in advance what cases he/she wants to use for questions, discussions and situations / practical exercises and the trainer should specify this in each chapter / part / section / subsection of the training materials.

Box 22. Some important points to note for trainers when compiling training material:

1. Always present information accurately
2. Present brief but concise information
3. Make sure the information is conveyed clearly
4. Make sure that the depth / detail or overview of information is consistent with the targeted trainees
5. Ensure logic of content
6. Ensure the authentic of reference sources

Design questions

- The questions used in the “Maieutic method” should be short, specific, easily understandable, and matching the level of the trainees. Do not use questions that are too difficult with cumbersome content.

Example: How many tons (or cubic meters or carts or carries) farmyard manure do you often use for 1 sao of rice? (take into account the discrimination of unit "sao" in each region: equal to 360 m² in the northern provinces while 500 m² in the central provinces and 1,000 m² in the Highlands and the Southern provinces respectively).

Should not ask the question: How many tons of farmyard manure do you often apply for rice?

For the questions used in the “Maieutic method” you often do not need much information from the trainees. Questions are often indirect or closed questions.
•  **The questions used in the "group discussions" method:** this is the type of question to be answered with abundant information. Therefore, open questions, leading or "loaded" questions, probing questions, or questions that are situation based are proper questions.

**Example:**

+ Please tell me what you need to do to limit the environmental pollution caused by the flow of bio-slurry from biogas plants?
+ Please tell me what you need to do to prevent the dead peanut wilt when using solid bio-slurry for peanut?

**Do not ask the following questions:**

+ Please tell me what are common measures to eliminate the environmental pollution caused by the flow of bio-slurry from biogas plants? (*Many people may not understand the word “measures” so they may not have the correct answer*).
+ Please tell me how to prevent the dead peanut wilt when using solid bio-slurry for peanut? (*"How" is a broad question so many trainees can hardly have the right answer*).

**Box 23. When using the “group discussion” method?**

The "Group discussion" method is often used to encourage all trainees to participate in the training and increase opportunities for trainees to share their knowledge and skills. However, if the method is continuously repeated in one or two chapters / parts / sections, it might become stressful for trainees. Therefore, this method is merely used when trainers can anticipate that the majority of trainees can participate in sharing information on the topic for group discussion to be conducted.

In case it is impossible to predict whether trainees may or may not have the knowledge to share in group activities, trainers should make the topics of group discussions highly practical. For example, the experience of trainees in the utilization of manure as basal fertilize for rice; use decomposed manure as additional fertilize for maize or using nitrogen for peanut will have adverse effects on yield creation of peanuts etc.

**Design a situation based excercise**
A situation based exercise or case study is a training method that is often used in training courses with trainees having experience that is more or less relevant to the training topics. To apply this method well, trainers also need to have in-depth knowledge related to the training content. To ensure effective implementation of this method, it is extremely essential to have the answers or solutions of the exercises carefully prepared and reflected in the content of training materials for trainers.

Box 24. Examples of a situation based exercise or case study for the training course on the use of manure and bio-slurry

Farmer Bui Van Cuong raises three buffalos and 5 fattening pigs. His family also has 2000 m$^2$ of paddy rice with two cultivation seasons and 7,000 m$^2$ of maize, that planted in spring - summer crop season.

Please elaborate the most appropriate method for composting farmyard manure? Please explain the reasons why you select that method?

4.1.5. Develop and construct the practice part

- Practical content (example: practice in identifying pests on maize crops)
- Duration: How many sessions / hours for the practice?
- Location: define a tentative location for the practice?
- Steps for implementation: define the work or skill that trainees have to practice at every step
- How to proceed: divide into groups or not? How many groups are divided? What assignment for each group?
- Plan for necessary materials / equipments

Points to note: In order to compile a specific document as in the above presented example, trainers have to invest a lot of time and effort. However, if the training material has been prepared this way, trainers can use it for many different audiences and in different times and can still ensure the suitability of the training content. Adjustments (if any) are easily done. The only things trainers need to do is regularly updating the information and being flexible in using the method to convey the information.

4.2. Methods to compile hand-outs for the trainees (if required)

4.2.1. Some requirements to be complied with when compiling hand-outs for trainees

Trainees of the training courses under the project are adults, many of whom have limited education, and do not speak fluent Vietnamese. Therefore, in order to have good quality handouts so that trainees can read the information, understand the information, remember the information and are able to
apply the information from the training course, trainers need to follow a number of guidelines, as presented below:

- Only introduce basic information related to the training topic that is highly practical and most necessary to the trainees in the hand-outs;
- Regarding to the training content in agriculture, the information presented in training materials are highly in compliance with the specific conditions of the local resources (such as soil conditions, weather conditions and production customs etc.)
- Information must be presented clearly and briefly and must be easily understandable; Do not use or limit using academic and unfamiliar languages to trainees (for example: words such as protein, glycerol, unicellular, tonicity, humid content, hydrolysis, carbohydrate etc.).
- Use as much examples as possible to illustrate the presented content. The examples must be highly locally appropriate. Do not use or limit using examples that are not locally available (example: when presenting about the phenomenon of climate change in training courses for trainees from the northern mountainous provinces, trainers take the illustrated examples of climate change on phenomena such as a tsunami or salinization).
- Use as much images/photos as possible to illustrate the presented content. The illustrations and presented content need to be highly interactive and related.

4.2.2. Compile content of hand-outs

Build handout structure

The content of handouts for trainees should be constructed as follows:
© Table of contents
© Introduction

Purpose: List the purposes of the handout, such as Raise awareness? Provide knowledge? Provide skills?

Targeted subject: what targeted subject does the training serve?

© Main content of handouts: including the chapters / parts / sections / subsections that have been built in the content outline, but are presented in detail.

Chapter / part A (or 1)
♦ Content of subsection 1
♦ Content of subsection 2

...........

Chapter / part B (or 2)
♦ Content of subsection 1
♦ Content of subsection 2
Detailed content of handouts

Like the training material for trainers, the content of each chapter / part / section that has been listed in the document outline should be specified in detail in the chapter / part / section / subsection and should be logically and appropriately developed and presented.

Each chapter / part / section must include the following three elements:

(i) Main ideas
(ii) Explain / analyze main ideas
(iii) Examples or illustrations for the explanation / analyzation.

Box 25. Regarding the level of detail of material content, the differences between trainer’s material and trainee’s handouts are described bellow:

Compared with the length of the content in the trainer’s material, the length of the explanation / analysis in trainee’s handouts is often shorter but must be very clear and easily understandable. Examples for every training must be locally appropriate and practical to the actual production of trainees.

When finishing each chapter / part / section, the most important thing that trainers have to do is making conclusions to help trainees with grasping the conveyed information well.

Presentation Mode

Presentation mode of the content of a sub-section.

Split sub-sections into paragraphs
Trainees are often older people who do not want to read too long wordings. Therefore, in order to enhance the attractiveness of the information to be conveyed, the content of training materials should be divided into subsections. The content of the subsections is then divided into paragraphs. However, it is compulsory to ensure a rational and logical relation between paragraphs in a subsection.

Use the bullets or dotpoints (*; #) in bulleted paragraphs in training material
Using bullets or dots in bulleted paragraphs may help readers recognize important information. However, it is better not to use the bulleted paragraph style too much in one chapter / part / section in the training material.
Illustration mode for the material content

To enable trainees to read, understand and remember the information that has been trained, it is advisable to use pictures to illustrate the content of the training material.

Use words in content presentation

Trainers should use simple and easily understandable words without distorting the meaning of the words to enable trainees in easily understanding the training content.

For example:

Box 26. Example of presenting a subsection
Section 2.3. Factors affecting the quality of bio-slurry

Quality of bio-slurry depends on:
- Types and age of animals;
- Quality of feedstuff for animals;
- Animal urine is implemented into biogas digesters or not;
- Biogas digester is or is not connected with latrine;
- Efficiency of treating and storing bio-slurry.

Illustration 1 for the steps of implementing the compost process for bio-slurry

Picture 2 to illustrate the covering compost heap with waste plant leaves in the hot composting method

However, trainers should carefully select images/photos to illustrate material content. Otherwise the effects of the illustration are not/less gained.
"Protein" should be replaced by "nitrogen"
"Lipid" should be replaced by "fat"
"Diets" should be replaced by "feed amount"
"Syndrome of livestock diseases" should be replaced by "Symptom of disease on animals" etc.
"Moisture" should be replaced by "water amount"
If possible, trainers should learn a few local words or words that people often use by heart (for clarification)

**Example:** “darnel grass” is also locally called “ryegrass” or “ray-grass”; “super phosphate” is also named “Lam Thao phosphate”; “phosphorite phosphate” is also called “Van Dien phosphate” etc.

5. **Select training method**

5.1. **Factors to be considered when selecting training methods:**
- Characteristics of adult trainees;
- Size of the training course;
- Type of information that is planned to be transferred and conveyed;
- Skills of trainers.

<table>
<thead>
<tr>
<th>Box 27. Questions to be answered when selecting training methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Is the method implemented effectively? How?</td>
</tr>
<tr>
<td>- Knowledge or skills that the trainees need to have to be able to participate in the training activities if trainers apply this method?</td>
</tr>
<tr>
<td>- Does this method cause any difficulties for students if it is used? Degree of difficulty?</td>
</tr>
<tr>
<td>- Does the condition of time and space allow the application of this method?</td>
</tr>
</tbody>
</table>

5.2. **Recommended methods to use in training courses on utilization of manure and bio-slurry**

No training method is absolutely perfect. Content or information of the subject / part / chapter / section in the training and characteristics of trainers are primarily used to select training methods.
Table 31. Recommended methods to use in training courses on utilization of farmyard manure and bio-slurry

<table>
<thead>
<tr>
<th>Method</th>
<th>Description of method</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
</table>
| Presentation          | Trainers directly convey information to trainees, by using or not using a projector and/or A0 paper | - It is possible to convey information to many trainees at the same time;  
- Does not require equipment or a machine                                      | - Trainees can easily become passive  
- Trainees acquire only partial information due to the limited duration of the training  
- It is rather difficult for trainees who have a low ability to acquire knowledge |
| Maieutic method       | Trainers convey information by questioning trainees                                      | - Encourages the participation of trainees  
- Trainers control the content and duration of the training well                  | Trainers are required to have good questioning skills (using diversified types of questions and content of questions)                                                                            |
| Group discussion      | Trainees are divided into groups to conduct discussions on specific topics given by the trainers. Trainers only have a promoting role | - It promotes the initiatives of trainees  
- Experience and knowledge of the students are effectively exploited  
- The trainees can learn from many different views on an issue                     | - Time consuming  
- If trainers manage the discussion poorly, it could happen that some of the trainees talk too much and dominate others, which could discourage people with a low self-esteem to participate in the discussion |
| Situation based exercise / case study | Situations or case studies are raised by trainers after the trainees have acquired a certain training content and initially have gained knowledge (along with their experience) to solve the situations | - Creates excitement for trainees  
- Trainees acquire the transferred content easily and are able to apply the knowledge to actual production in the future  
- Experience and knowledge of students is effectively exploited                         | - Trainers master the knowledge related to the raised situation to be resolved  
- Trainers need more time to prepare the content and answers / solutions of the exercises  
- Takes much time of the total amount of time for the training |
<table>
<thead>
<tr>
<th>Method</th>
<th>Description of method</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factual visiting</strong></td>
<td>Creates conditions for trainees to observe and reference to the knowledge that has been conveyed in the training</td>
<td>- Highly practical</td>
<td>- Much time is needed to prepare the plan (budget, visiting location, time etc.)</td>
</tr>
</tbody>
</table>
| **Modelling Method** | Demonstrate the skills needed to operate a certain activity that trainees are able to perform at the end of the training in conditions of farming household production | - Helps trainees to understand and remember the information that has been conveyed in the theoretical part of training course more easily  
- Trainees can apply the knowledge in their actual production  
- Trainees have opportunities to comment on each other during the practice  
- Promotes active participation of trainees | - Much time is needed for trainees to practice  
- Trainers must understand the content of the practice well and must have prior experiences in conducting the operations  
- It can be less efficient if too many trainees are involved as it limits the observation of the trainees |
6. Design of a presentation when using a projector (power point) (if required)

6.1. Benefits of using Power Point software to deliver information in a training course

According to Rob Tongue, a training expert of the University of Sydney, Australia, the method "hear and see" of receiving information, will help participants to collect the most information (65%) compared with the methods "only hear" (10%) and "only see" (35%). Hence, training lectures presented with power point software, in combination with the analysis and explanation, will help trainers to convey training content more effectively to trainees.

6.2. A number of necessary provisions when presenting the training content on slides

- Quality of lines on one slide: no more than 8 lines
- Font size: not larger than 32 and not smaller than 20
- The space between the lines (paragraph): at least 30 pt
- Only display the main content, avoid to copy and paste the entire content of the document on one slide
- Illustrated images should match the content

6.3. Taboos to avoid

- Use too much and continuous effects
- Excessive use of colour for words on a slide
- Select cumbersome background (birds, flowers etc.) for slides

B. Basic training skills

1. Promoting skill
1.1. Listening skill

1.1.1. What is the listening skill?
- Listening is the ability to accurately receive and interpret messages in the communication process.
- Effective listening does not only mean empathy, but also means understanding and sharing with the speaker.
- Listening requires active participation in the position of the speaker and the effort to understand their situation.

1.1.2. Principles of the listening skill
- A good listener will not only listen to what is being said, but also to what is left unsaid or only partially said.
- Effective listening involves observing body language and noticing inconsistencies between verbal and non-verbal messages.

For example: if someone tells you that they are happy with their life but through gritted teeth or with tears filling their eyes, you should consider that the verbal and non-verbal messages are in conflict, and they may not mean what they say.

Why good listening skills are needed?
- Limit misunderstanding
- Avoid disappointment from 2 sides (speaker and listener)
- In order to understand the issue more clearly
- Make others become more open with you
- To have more information

1.1.3. Principles of effective listening
- Stop talking: When somebody else is talking listen to what they are saying, do not interrupt, talk over them or finish their sentences for them. When the other person has finished talking you may need to clarify to ensure you have received their message accurately.
- Prepare yourself to listen: Focus on the speaker. Put other things out of your mind.
- Put the speaker at ease: Help the speaker to feel free to speak. Remember their needs and concerns. Nod or use other gestures or words to encourage them to continue.
- Remove Distractions: (i) Focus on what is being said; (ii) Don’t doodle, shuffle papers, look out the window, pick your fingernails or similar; (iii) Avoid unnecessary interruptions.
- Empathise: Try to understand the other person’s point of view. Look at issues from their perspective.
- **Be Patient:** Be patient and let the speaker continue in their own time. Take notes for main ideas.
- **Avoid Personal Prejudice:** (i) Try to be impartial; (ii) Don't become irritated and don't let the person's habits or mannerisms distract you from what the speaker is really saying;
- **Listen for Ideas – Not Just Words:** You need to get the whole picture, not just isolated bits and pieces.
- **Ask questions:** Ask questions to clarify what is being said or to help listeners to better understand what is being said, and at the same time, to let the speakers know the audience is listening very attentive. Obviously, do not speak too much.

2. **Questioning skill**

2.1. **Why asking questions?**
- Questioning is a common form of communication
- Questioning for information
- Questioning to learn from each other

2.2. **Some points to note when questioning**

- Questioners need to be clear of the need for information when asking questions (is the information necessary?)
- Questioners need to clarify what information (information needed for what purpose?) should be collected or gathered.
- Questioners need to understand the words or terms well when questioning the content and issues.

**Do not ask:** Please tell me how the village uses farmyard manure?

**Do ask:** Please tell me how the village's people use farmyard manure?

- Questioners should choose the appropriate questions (difficulty of the question, type of questions) with the object to be asked.

**Example:** In case the people to be asked are rural villagers who have limited education.

**Instead of asking:** Which crops are you currently cultivating?

**Do ask:** Which crops are you currently growing?
• Questioners should be persistent to achieve reasonable responses. If necessary, questions can be adjusted to gain as much information as possible.

**Example:** **Question 1:** How should the project help you in improving the efficiency of bio-slurry utilization? – no response is made

**Then continue with Question 2:** if the project wants to help you to better know how to use bio-slurry, do you need more guidance on the use of bio-slurry or do you need to go sightseeing and learn from families who efficiently use bio-slurry, or any other way?

### 2.3. Types of questions and how to use them

**Table 32. Types of questions and how to use them**

<table>
<thead>
<tr>
<th>No.</th>
<th>Types of question</th>
<th>Example</th>
</tr>
</thead>
</table>
| 1   | **Closed Questions:** are questions that simply require a ‘Yes’ or ‘No’ answer (without information) | - Have you ever participated in any training on bio-slurry utilization?  
- Is there any female extension worker in the commune? |
| 2   | **Open Questions:** are questions where the answer depends on the actual situation, from thoughts and perceptions of the information providers | - Have you ever used any method to limit the pollution of the surrounding environment caused by flow of liquid bio-slurry? |
| 3   | **Leading or loaded questions:** are questions that have suggested answers. A leading question, usually subtly, points the respondent’s answer in a certain direction. People are suggested to choose the answer (from some suggested information) | - Which fish, hybrid catfish or grass carp, do people usually cultivate in this pond area?  
- Do you often directly use manure or liquid bio-slurry for the fish pond? |
| 4   | **Situation based questions:** are questions for a particular situation (or assumed situation) | - If you do not have enough money to buy inorganic fertilizer, will you use liquid bio-slurry for vegetables? |
| 5   | **Importance Questions:** are questions of which the answer is often based on a comparison | - If your cultivation soils are acidic, do you select manure or bio-slurry for fertilizing crops? |
2.4. Effective questioning skills

- **Limit** to ask questions that have a simple answer or result in gaining less information - type of closed questions
  
  **Example:**
  - Do you know benefits of using bio-slurry?
  - Do you want to be financially provided by the project?

- **Do ask questions that** begin with "What?" "When?" and "Where?"
  
  **Example:** How can the project help your family to know how to best use bio-slurry for crop production?

- **Limit** the use of leading questions as these questions direct respondents to a conclusion that is predetermined or foreseen. This kind of question can be answered with "yes" or "no".
  
  **Example:** If biogas technicians ask questions:
  - Have you used bio-slurry as guided? The answer may be “have used” or “have not used”
  - Or question: Do you agree with our instructions? - The answer may be "yes" or "no".

- **Limit** to ask questions beginning with "Why?" as this type of question can make the other person feel defensive, while they're providing information for you. This feeling may damage the friendliness between the two sides.
  
- **Limit** to ask and answer questions by yourself
  
  **Example:** How do you observe the rainfall in the region? Is it unevenly distributed in months, right?

- **Do not ask** too many questions at once. Give the respondents time to understand your question.
  
  **Example:** Do you often use bio-slurry for maize? If yes, please tell me when you apply? And how much you apply for one sao?

If possible, **increase** the use of the type of questions that have beginnings and endings as these questions stimulate thinking and response from the respondents. These questions also ensure that the respondents are focusing on the issue you're asking about.
Example:

- What makes you use liquid bio-slurry for vegetable?
- How to raise pig to have a high income, but not affect the environment of the village?

- Listen to the tone. Volume and tone both add to what someone is saying.

- Keep a friendly face even if you are very anxious to solve an issue and the respondents are making you unhappy

3. Observation skill

3.1. Definition of observation skills

- The ability to see beyond the limits of your vision
- The ability to feel or grasp the feelings of others when things are happening towards a positive or negative feeling for them.

3.2. Period of observation

3.3. Observation skills in group discussions

- Watching what is happening but do not make any assessment
- Understand the situation of the problem
- Oversee the operation of the groups objectively
- Cross-check the information
3.4. **Observe what?**

- Discussion method of groups?
- Who said what?
- Who did what?
- Who said too much, dominating others?
- Who kept silent throughout the discussion?
- What type of communication is used when the group presents the results? (Presentation, ask question, gestures)
- Overall level of positivity among the trainees?
- Overall level of interest of the trainees?

---

**Box 28. With good observation skills, you can:**

- Assess the feelings of trainees
- Supervise dynamism of the group
- Assess the equal involvement of participants?
- Make timely adjustments to the methods of the group discussion
- Encourage unconfident trainees to participate in discussions
- Restrict the ones who said too much
- Promptly respond to questions

---

4. **Presentation skill**

4.1. **How to convey information in the most efficient way?**

- Try to bring a positive impression and goodwill towards the listeners from the beginning to the end of the presentation
- Pay attention to the points of special interest
- Provide an overview of the content before presenting details
- Encourage the use of multiple senses such as the combination of speaking and interacting with your eyes
- Try to grasp the issues and requirements of the listeners
- Use both oral presentation and visual illustrations
- Encourage people to share their experiences
- Do not present too long
- Manage time well (ending on time)
- Use appropriate body language
- Have respect for the listeners

4.2. Factors limiting effective presentation
Weak observation and poor timing management         Non-humble attitude and gesture

Monologue                                           Immodest attitude with the opposite sex

Box 30. What is a skillful facilitator for group discussions?
A good facilitator for group discussions is the person who has the following skills:
- Makes people feel comfortable and respected
- Encourages the participation of all people effectively
- Limits and manages debates and conflicts well (if it occurs)
- Has good listening and observation skills
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Box 31. Method to convert/calculate nutrients in organic fertilizers when combining with farmyard manure or bio-slurry

1. Convert from pure nutrients to fertilizer amount

\[
\text{Amount of inorganic fertilizer (kg/ha)} = \frac{100 \times \text{Amount of pure nutrients in regulated management}}{\text{Amount of pure nutrients in manure or bio-slurry}}
\]

- Amount of pure nitrogen (N) in Urea fertilizer: 46%;
- Amount of pure nitrogen (N) in Ammonium sulfate fertilizer: 20.5 - 21%;
- Amount of pure phosphorus (P_2O_5) in super phosphate fertilizer and phosphorite phosphate fertilizer: 16%;
- Amount of pure potassium (K_2O) in potassium chloride fertilizer: 56 - 60%;
- Amount of pure potassium (K_2O) in potassium sulfate fertilizer: 46 - 52%;

**Example:** as recommended in the fertilizer management for paddy rice, when the total N is 90 kg/ha, the amount of urea fertilizer is calculated as follows:

\[
\frac{100 \times 90}{46} = 196.5
\]

2. Convert from fertilizer amount to pure nutrients

\[
\text{Amount of pure nutrients (kg/ha)} = \frac{\text{Amount of inorganic fertilizer x amount of pure nutrients in inorganic fertilizer}}{100}
\]

**Example:** the amount of super phosphate, as stated in the fertilizer management, is 300 kg/ha, hence, the amount of pure nutrients to apply to crops is

\[
\frac{300 \times 16}{100} = 48
\]