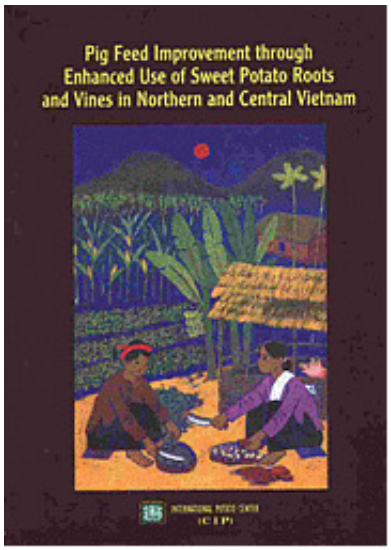

Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam

A Practical Guide for Farmers and Extensionists to Raise Pigs Efficiently with Local Feedstuffs

Dai Peters, Nguyen Thi Tinh, Thai Thi Minh, Phan Huu Ton, Nguyen The Yen and Mai Thach Hoanh. Special contribution by Danilo Pezo

INTERNATIONAL POTATO CENTER (CIP)

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Contents:

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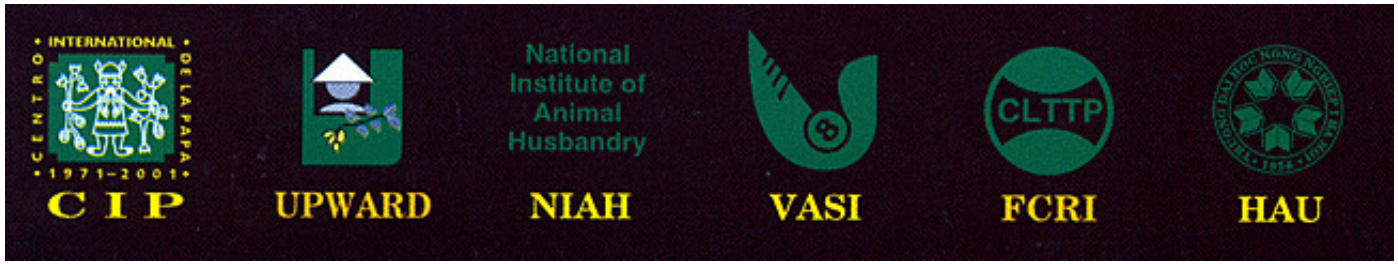

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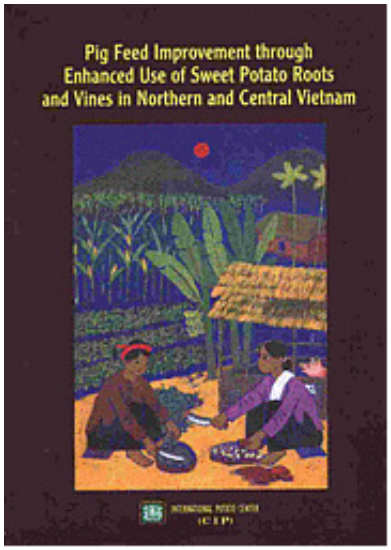


Contents:

Introduction

Scientists from the International Potato Center (CIP) and Vietnamese collaborators from various institutions and disciplines have been working together since 1997 to improve the sweetpotato-based pig feeding systems in northern and central Vietnam. The avenues for improving this system consist of three approaches:

1) sweetpotato selection for varieties most suited for pig feed,
2) sweetpotato root and vine processing to improve nutritional value, and
3) improved pig feeding and management to enhance growth efficiency.

Sweetpotato varietal selection involves conducting on-station and on-farm trials to select varieties most suitable for pigs. On-farm trials are conducted in various locations in north and central Vietnam where sweetpotato is an important crop for pig feed.

Two types of varieties are selected: 1) dual-purpose varieties, and 2) forage varieties. For dual-purpose varieties, both the vines/leaves and roots are taken into consideration because roots provide starch while leaves provide protein and soluble carbohydrates. In this case, fresh yields are not used to determine the quality of sweetpotato as a feed stuff. Instead, the starch yield (fresh yield x dry matter (DM) x percent starch in DM) in roots and the protein yield (fresh yield x dry matter (DM) x percent protein in DM) in vines and leaves are used as indicators of the nutritional value of the varieties. Dual-purpose varieties are planted in paddy fields of northern and central Vietnam as a winter-spring crop, and this is the best season for root production. During the other seasons, the growing period for sweetpotatoes is shorter, and the sweetpotatoes are also planted on uplands at these times but there is a lack of sufficient soil moisture for harvestable roots to form. Therefore, during the spring, spring-summer, summer, and summer-autumn seasons, vine and leaf production is often more important than root production. During these seasons, forage varieties, which contain abundant proteins, are the priority. For forage varietal trials, various cutting regimes (e.g., cutting intervals and cutting ratios) are also tested to determine the best cutting methods to produce the greatest amount of vine/leaf harvest. When a variety contains a high amount of total dry matter in both roots and vines, it is recommended as a dual-purpose variety. Such a variety may also contain a high amount of total protein in the leaves when vines

are cut at regular intervals of 10,15,20, or 25 days, thus it can also be recommended as a forage variety. In this case, the variety can be recommended for both dual-purpose and forage.

Farmers face three constraints after harvest of their sweetpotatoes: 1) storage, 2) high labor demand for daily processing of sweetpotato roots and/or vines for pigs, and 3) the need to cook the sweetpotato roots because they contain high levels of trypsin inhibitor. Without adequate storage facilities, farmers are often forced to feed large quantities of sweetpotato to pigs immediately after harvest in order to minimize loss during storage due to weevils, rats, rotting, or other factors. Pigs can only benefit from a certain amount of feed sources each day and over-feeding only results in wastage. Those farmers who do not over-feed during the post-harvest period, however, usually encounter loss during storage due to damaged roots or vines. Trials are conducted to find simple and low-input ensiling methods to conserve roots and vines so that farmers may process during the off-season and then feed the resulting silage during the busy field seasons reserved for rice planting and harvesting. Ensiled roots and vines can also be stored for at least five months so that farmers can ration the roots and vines based on balanced feeding formulation. Most importantly, the silage process minimizes the trypsin inhibitor in roots and eliminates the need to cook the feed. This saves two to three hours of labor per day and the fuel necessary for cooking the pig feed.

On-farm pig-feeding trials are conducted using the ensiled roots and vines in conjunction with a base feed which mainly consists of crops available on-farm to minimize additional investment. These trials have three objectives: 1) to determine the optimal proportion of each ingredient within the balanced feed, 2) to examine the best ensiling method, and 3) to examine the best proportion of sweetpotato silage in the daily diet. The results of these trials show that sweetpotato silage has three advantages: 1) improved pig growth rate, 2) reduced cost per kilo of weight gain, and 3) saved labor and fuel for cooking. The use of ensiled vines also improves growth and reduces cost while eliminating the need to chop vines daily.

Although the focus has mainly been on nutritional aspects of the pig-raising system, disease management is essential in order to take full advantage of improved nutrition. More importantly, without disease management, the results of feeding trials would be inconclusive because it would not be possible to differentiate between the effects of nutrition and illness on growth. No trials are conducted on disease management; nevertheless, participation of a veterinarian is an integral part of the project. The vet makes sure that the trial pigs are property vaccinated, looks after the pigs' general health, and treats the pigs as soon as symptoms arise in order to minimize any potential impact of illness on pig growth during the trials. At the same time, farmers are advised on general disease and illness identification, prevention, and treatment.

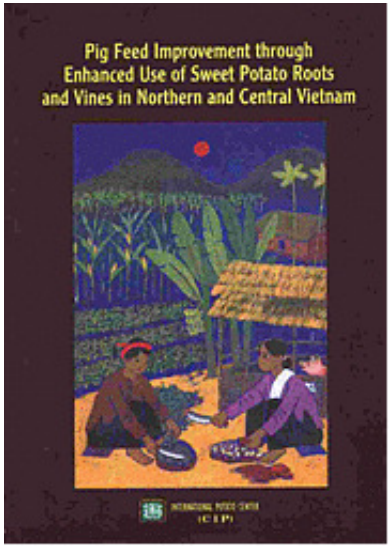
This book provides a summary of these four programs that CIP personnel and Vietnamese collaborators have been conducting since the beginning of 1997. Accordingly, the book is organized along the lines of these four programs, for each of the agro-ecological regions in northern and central Vietnam where sweetpotato serves as an important source of pig feed. Southern Vietnam is not included in the book because most pigs in this area are raised on commercial feed and sweetpotato is mainly a cash crop. The book provides information for, and will be of interest to, sweetpotato-pig farmers and agricultural extension workers who have responsibilities in rural household crop and pig production.

A Vietnamese-language version of the book is available specifically for the farmers and extensionists in northern and central Vietnam. This English-language version of the book is produced for non-Vietnamese readers, because it is expected that the integrated methods of crop and feed production and processing explored in this manual will be of interest to agriculturalists and livestock specialists in general. Some contextual information on sweetpotatoes and pigs in Vietnam is provided below to facilitate the understanding of these readers.

There are seven agro-ecological regions in Vietnam; this book targets the three major regions in northern and central Vietnam where most of the sweetpotato is grown during two or three seasons a year between rice crops. Due to climatic and soil

variations among these regions, the crops grown are somewhat different, and the requirements for each crop, particularly for sweetpotato which is highly variable also differ. Since pigs are crop-fed, the available feeds also vary among these regions. In order to provide specific, useful information for farmers in each agro-ecological region, the book is further organized by agro-ecological region. For each region, information on sweetpotato varieties is provided for each season, both for human consumption and pig feed. Each region also requires somewhat varied agronomic techniques; therefore, information on agronomic techniques is also region-specific. Likewise, information on pig-feeding rations and daily formulations are all organized according to the available feed in each region. Information on pig disease prevention, identification, and treatment, however, is not as site-specific and is presented in general for all three regions. This health section is included in the Vietnamese version as a guide for farmers; it is not included in the English version since no research was actually conducted on illnesses and diseases.

The English version was reviewed and revised based on comments provided by Dr. Danilo Pezo, animal nutritionist with the International Livestock Research Institute (ILRI), to ensure the technical quality of the book. Asection on "Some principles of pig nutrition in the tropics" was consequently supplied by Dr. Pezo to strengthen the book by providing a technical context for feeding sweetpotato to pigs in the tropics.



Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam

Contents:

PART I SELECTING AND GROWING SWEETPOTATO FOR LIVESTOCK

1 Technology for growing dual-purpose and forage purpose sweetpotato in the Northern Midlands of Vietnam

1.1 Characteristics of the Northern Midlands of Vietnam

1.1.1 Soil characteristics

The agricultural land of the Northern Midlands of Vietnam consists of the old alluvial bed area and valleys of the plain areas. Erosion- has led to soil acidity and low soil organic matter, phosphorus and nitrogen. This restricts yield potential of cultivated crops.

The plains areas of the valleys are more fertile, with soil composition from loamy to less loamy and mixed sandy soil, suitable for sweetpotato as well as for corn, beans, and groundnut. The plains areas are 30 m above sea level and the slope varies from 10-30 %. There is mainly one crop a year, and the utilisation rate of agricultural land is low.

1.1.2 Climatic conditions

Climate of the Northern Midlands of Vietnam is a monsoon tropical climate. The dry season lasts from November to April, with early north-east winds. It is considered the coldest area of the country. Therefore, winter crop sweetpotato needs to be planted early with cold-tolerant varieties.

Rainy season is from May to October, with the greatest concentration between June and September. There is potential for flood during this period. Heavy rains and floods cause serious erosion. On the other hand, dry season runs from October/November to March/April, and the drought and low

temperature tend to stunt crop growth. The most serious drought usually happens at the end of December and the beginning of January.

1.1.3 Population and density

The population density of this area is fairly low, ranging from 70 to 140 persons/km2, with Kinh people occupying more than 60% and various ethnic minority groups occupying the other 40%. The main income comes from crop production, mostly from a single food crop, yielding relatively tow living standards. The food/head/year averages between 220 kg and 302 kg. Low income leads to low investment and poor cultivation technology. Irrigation and water systems are not well developed, especially in the upland and mountainous areas. It is necessary to select varieties suitable for these conditions.

1.1.4 Crops and production systems

For crop purposes, the Northern Midlands of Vietnam is divided into two parts: upland and plain fields. The following crop rotations are recommended:

- On upland:

Sweetpotato or autumn corn
Spring sweetpotato - Winter rice (upland rice) - Winter soybean

Spring-Summer bean - Winter rice (upland rice) - Winter sweetpotato
Sweetpotato under permanent fruit trees

- On the plains:

Spring sweetpotato - Winter rice
Spring-Summer bean - Early winter rice - Winter sweetpotato
Late spring rice - Early winter rice - Winter sweetpotato
Spring sweetpotato - Early winter rice - Winter corn

1.2 Geographical location

The Northern midlands of Vietnam consist of the following provinces: Quang Ninh, Bac Giang, Bac Ninh, Vinh Phuc, Phu Tho, Thai Nguyen, Ha Tay, Hoa Binh. The following recommendations also apply to some neighbouring provinces that share similar topographical, soil and planting characteristics.

1.3 Recommended sweetpotato varieties suitable for root and vine dual-purpose and their characteristics

1.3.1 The characteristics of yield, agronomic performance, and growing period

Distinguishing characteristics	Variety

	Hoang long	KB1	K51	TQ2	KL5
Root yield (ton/ha)	21-35	13-17	14-29	11.94	20-22.5
Vine yield (ton/ha)	18-35	29-40	19-32	28.70	20-36
Root DM yield (ton/ha)*	2-7	1-2.5	1.51	2.85	1-5.2
Root starch yield (ton/ha)*	1.4-4.9	0.7-1.75	1.05	2.14	0.7-3.5
Season suited to planting	Winter	Winter	Spring	Spring	Winter,spring
Tolerance performance:					
• Drought tolerance	Good	Good	Medium	Medium	Good
• Submergence tolerance	Medium	Bad	Fair	Fair	Good
• Cold tolerance	Medium	Good	Medium	Medium	Fair
• Leaf insect tolerance	Good	Medium	Fair	Good	Medium

• **Weevil tolerance**	**Poor**	**Poor**	**Medium**	**Good**	**Medium**
Growing time (days)	**140**	**150**	**150**	**120**	**120**

***Root DM yield=Root yield x Dry Matter (DM) content in root**
*** Root starch yield=Root DM yield x starch content in DM**

1.3.2 The characteristics of utilization, vine, root and storage

Distinguishing characteristics	**Variety**				
	Hoang long	**KB1**	**K51**	**TQ2**	**KL5**
Root palatability[1]: • For human (boiled) • For pigs (cooked)	High DM Good	High DM Good	Low DM Fair	Low DM Fair	Med DM Good
Vine palatability:					

• For humans (boiled) • For pigs (fresh)	Bitter Bitter	Not sweet Not sweet (Should be cooked)	Sweet Sweet (Should be cooked)	Not sweet Not sweet	Sweet Sweet (Should be cooked)
Method of storage: • Time (month) • Way to store	3-4 Fresh, dried	3-4 Fresh, dried	3-4 Fresh,dried	3 Dried	3-4 Fresh, dried
Root morphology: • Color of skin • Color of root flesh • Shape of root	Red-pink Yellow Roundish	White White Roundish	Pink Yellow Slender	White White Slender	Light red White Slender
Vine morphology: • Shape of leaf • Color of tender leaf • Color of adult leaf	Heart shape White Dark blue Violet	Heart shape Violet Green Purple	Heart shape Violet Green Green	Saw-tooth Green Dark green	Lobe White Green Green

• Color of stem		green		Purple green	

[1] For human consumption as a staple, instead of a vegetable, in which the level of DM is important to establish palatability. Palatability for pigs, on the other hand, was established by pigs' reaction when fed with certain varieties.

1.4 Sweetpotato varieties suitable for forage purpose and their characteristics

1.4.1 The characteristics of yield[2], agronomic performance and

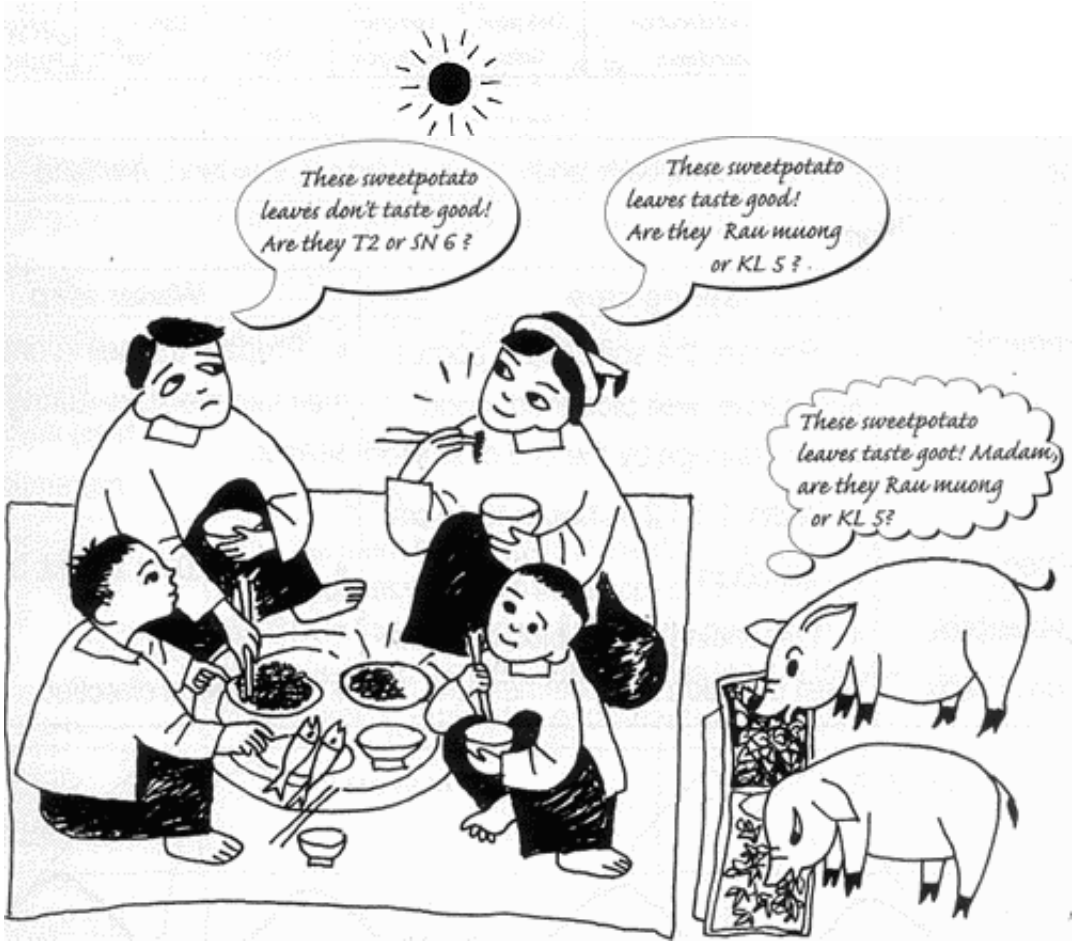
growing period

Distinguishing characteristics	Variety				
	Rau muong	**KL5**	**TQ1**	**T2**	**SN16**
Fresh vine yield (ton/ha)	42	50	37.83	63.61	47.58
Fresh leaf yield (ton/ha)	10.72	7.6-13.5	11.99	13.25	14.01
Leaf DM yield (ton/ha)*	2.48	2.99	2.22	2.74	2.59
Leaf CP yield (ton/ha)*	0.55	0.58	0.49	0.53	0.47
Season suited to planting	Spring	Winter, spring	Spring, winter	Spring	Spring
Tolerance performance:					
• Drought tolerance	Good	Good	Fair	Medium	Medium
• Submergence tolerance	Fair	Good	Fair	Fair	Fair
• Cold tolerance	Fair	Good	Fair	Medium	Medium

• Leaf insect tolerance	Good	Good	Good	Good	Fair
• Twisted leaf virus tolerance	Good	Good	Good	Fair	Fair
Branching and regrowth	Strong	Strong	Strong	Strong	Strong

**** Leaf DM yield=Fresh leaf yield x leaf DM content (excluding vines)***
**** LeafCP (crude protein) yield = Leaf DM yield x CP% in DM***

2 The vine yield of the same variety grown for forage-purpose would be higher than that which was grown for dual-purpose which was not cut frequently in order to allow for root development.



1.5 Technologies that can be applied to increase vine and root yield

1.5.1 Selecting the appropriate variety

Growing purpose	Spring crop	Winter crop
Dual	TQ1, KF1, KLF, KB1	TQ2, KB1, Hoanglong, KLF, SN2

Dual purpose	TQ1,K51,KL5,KB1	TQ2,KB1,Hoanglong,KL5,SN3
Vine purpose	Raumuong,T2,KL5,TQ1,SW6,KB1	TQ2,SN3,KB1,KL5,Hoanglong

1.5.2 Planting season

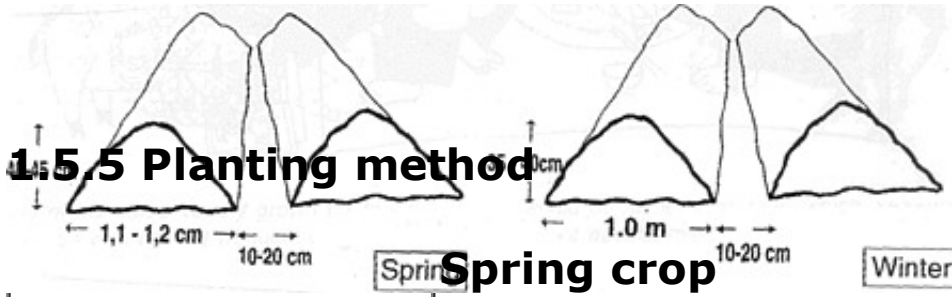
	Spring crop	**Winter crop**
Planting season	• 20 February-15 March • For vine purpose, it can be planted whenever the soil is moist.	• 20 September-5 October • For vine purpose, it can be planted whenever the soil is moist.
Favorable conditions	• From planting to harvesting the temperature and moisture is rather suitable.	• During planting time, moist soil and high temperature provide good conditions for vines to grow.
Unfavorable conditions	• Need to prevent flooding at the end of the season and too much vine growth.	• At the end of season, soils are dry and temperatures low, roots may not develop well.

1.5.3 Soil characteristics

	Spring crop	Winter crop
Proper soil type	Sandy-light loamy soil	Loamy soil, light loamy soil, sandy mixed soil
Land type	High land, upland, bedy land	Upland, low land, low land

1.5.4 Soil preparation

	Spring crop	Winter crop
Requirements	Prepare the soil deeply, porous and friable, well ploughed, good water drainage by the end of season	Prepare the soil in order to maintain moisture during growing season
Size of bed	Width: 1 .1-1 .2 m; height:40-45 cm.	Width: 1.0m; height: 35-40 cm
Distance btwn beds	10-20cm	10-20 cm
Direction of beds	Depending on the plot, but East-West direction is recommended	East-West direction



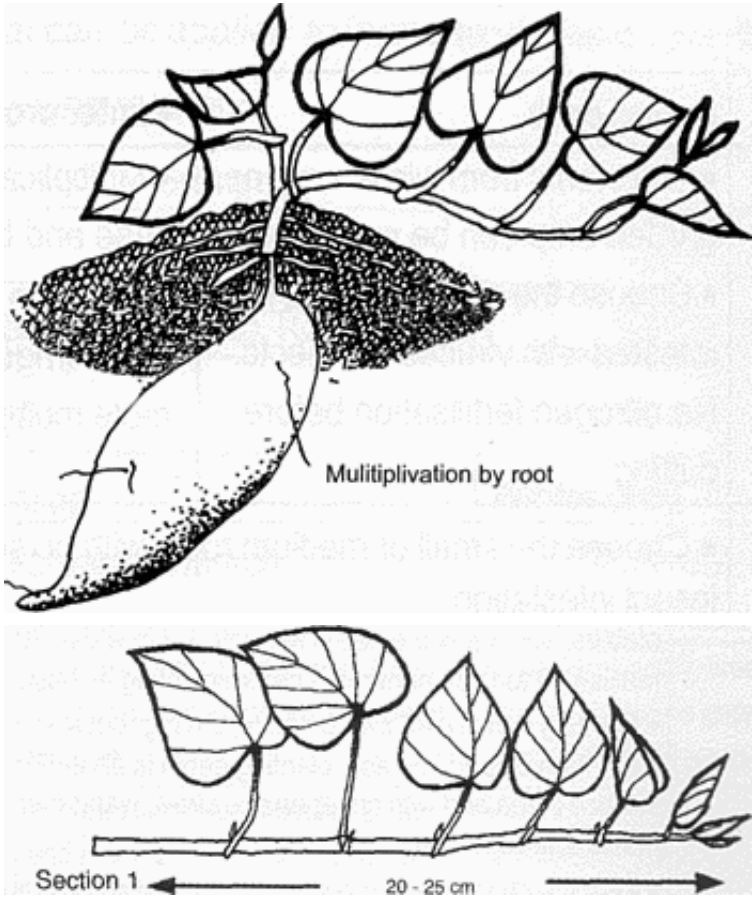
1.5.5 Planting method

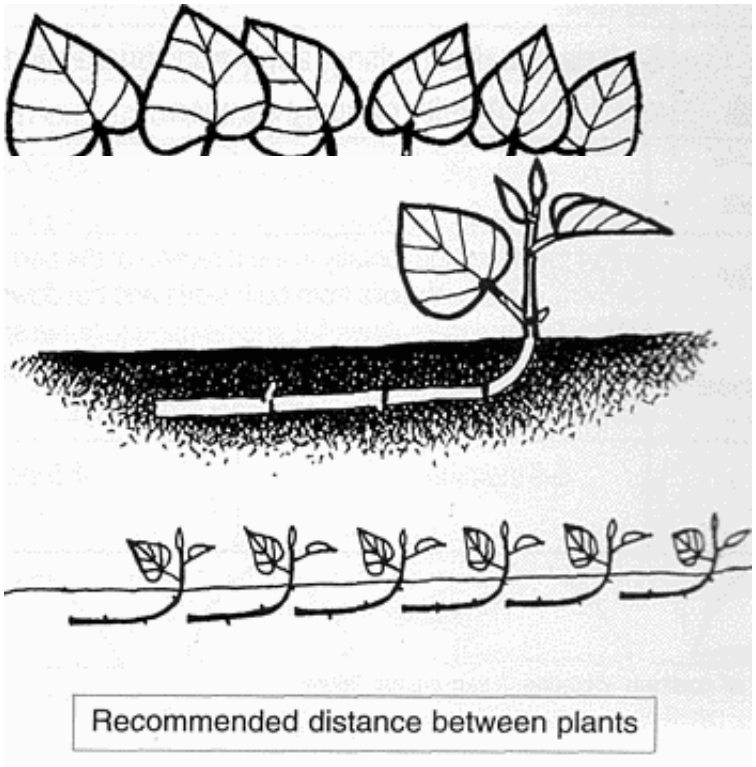
	Spring crop	Winter crop
Vegetative multiplication	• The stems from winter crop or garden crop can be multiplied. • Choose the stems that are not infested with viruses or insects. No nitrogen fertilisation before cutting	• Multiplication season is the end of June and beginning of July • Plant in mounded beds or flat beds. Irrigate, cut tops early to pro-mote multiple branches.
Multiplication method of planting material from root	• Choose the small or medium roots with no scratches, no virus, or insect infestation • Prepare the soil well, the soil clods must be as fine as for veg etables. The top of the bed is flat, with 1.2 m width, 20 cm height, fertilise 10 tons of manure/ha before planting as basic fertiliser. • Planting density: 40 x 40 cm/hole, the big root should be cut into parts then dipped into ash, planting depth is about 3 cm, cover the surface	

	of the bed with chopped rice straw, water them to keep the plants and soil moist. • After the shoots have grown out of the soil surface about 5 cm, cut off weak shoots, leave only 2-3 shoots in a hole. When the shoots are 20- 25 cm long, cut the top to allow branching, 50 - 60 days later cut the stem to plant.	
Preparation before cutting planting material	7-10 days before cutting, apply additional P and K fertiliser (1-2 kg K/ sao*), do not water or apply nitrogen	
Standards of good planting material	Adult stem, thick and hard, with no root, no virus and insect infestation	
Method of cutting planting material	Cut the 1st and the 2nd section, avoid damaging the stems and leaves	
Length of stem (cm) Node number/stem	25-30 6-8	20-25 5-7
Planting method	Put the stem horizontally in the direction of the bed, exposing the top 3-5 cm, cover with soils from both sides and pat down the soil next to the stem. Lay the stem down flat and no need to leave space between plantlets. Keep the stem fresh. Better plant in the evening. In winter, avoid planting during the north-	

	east windy days.	
Planting density (stem/m of bed)	5-6 stem/ m	4-5 stem/m

*** sao : An area unit of northern Vietnam, 1 sao equals 360m^2**



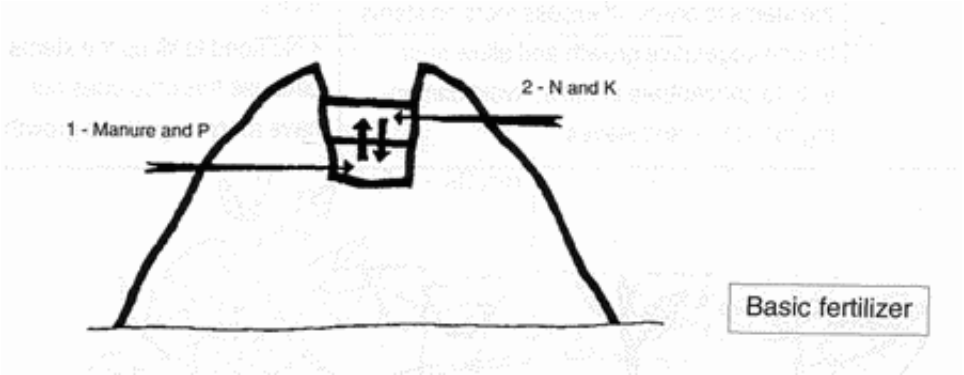


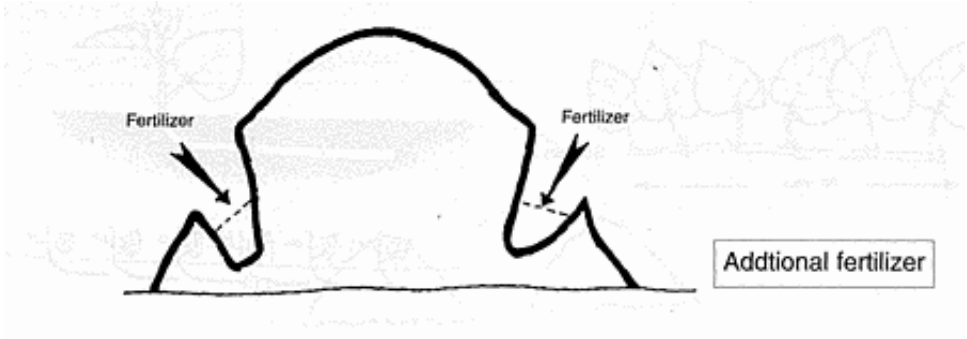
1.5.6 Fertilization

	Spring crop	**Winter crop**
Ratio and total amount of fertilizers (kg / sao*)	300 -400 kg manure 3 kg urea (N) 10 kg superphosphate(P) 6 kg potassium chloride (K)	300-400 kg manure 4-5 kg urea (N) 10 kg superphosphate (P) 4.5 kg potassium chloride (K)
Basic fertilization	All manure	All manure

	All P fertilizer 1 kg urea	All P fertilizer 1 kg urea
Frist additional fertilization Timing Amount (kg/sao)	15-20 days after planting 2 kg urea 2 kg potassium chloride	20-25 days after planting 2-2.5 kg urea 2-2.5 kg potassium chloride
Second additional fertilization Timing Amount (kg/sao)	45-60 days after planting The remaining potassium chloride (4 kg)	45-60 days after planting The remaining amount: 1-1 .5 kg urea 2-2.5 kg potassium chloride

*** sao : An area unit of northern Vietnam, 1 sao equals 360m^2**



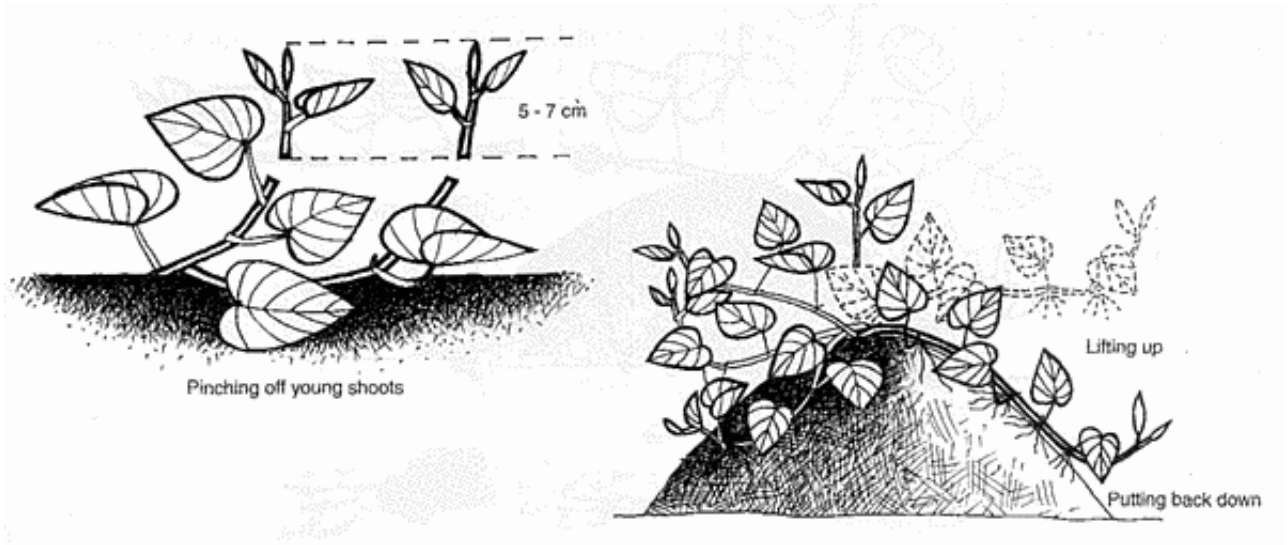


1.5.7 Cultivation technology

	Spring crop	Winter crop
Pinch off young shoots	• At 20 days after planting pinch off the tops to promote branching and optimize	• At 20 days after planting pinch off the tops to promote

	vegetative development. • At 80-90 days after planting, if vegetative development is too strong, cut 30-40 % of vine.	branching and optimize vegetative development. • No cutting
Weed control, re-mounding the bed	• Link with the 1st additional fertilization • Dig small holes on both sides of the bed, let the soils dry for 1 day. Fertilize 2 kg of potassium chloride in holes, cover fertiliser with soil. During this process, excess roots are cut off to promote better root growth.	• Mulch to protect the plants from cold and drought while keeping the soil surface moist. • Use rice straw to cover both sides of the bed when it is dry and cold.
Irrigation	• Water while applying 1st additional fertilization. Drain to avoid the crop sub merged in water.	• Water while applying 1st additional fertilization. During drought, irrigate rows between beds to keep soil moist.
Vine lifting	• When too much vegetative growth, lift up the stems to	• No need to lift up the stems because

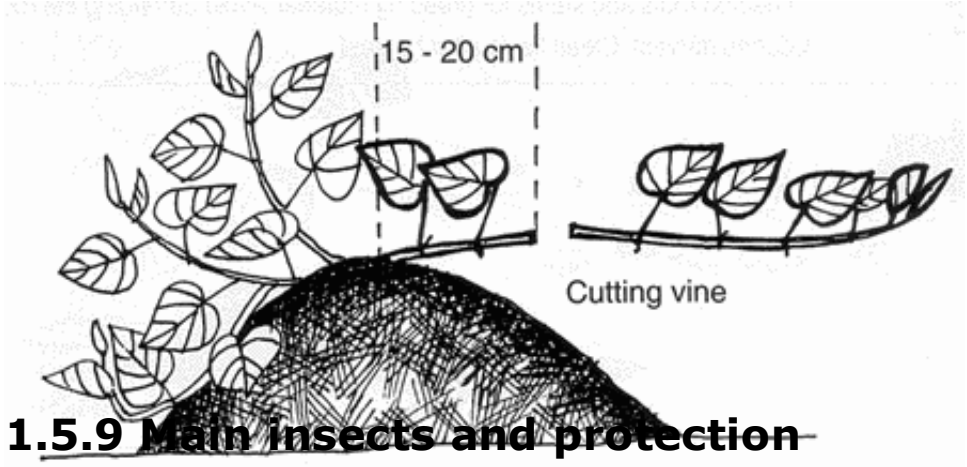
	break off excess roots on stems to limit vegetative growth and allow nutri ents to concentrate in roots. Avoid damaging the stems and leaves.	this crop does not have much vegetative growth.



1.5.8 The vine-cutting method for forage varieties

Cutting method	Spring crop	Winter crop
First vine harvest		

First vine harvest • Time to start harvest • Harvest criteria	• At 40-45 days after planting • Choose 2-3 longest stems of a plant, use a sharp knife to cut, leaving 10-1 5 cm.	• At 45-50 days after planting • Choose 1 -2 longest stems of a plant, use a sharp knife to cut, leaving 15-20cm.
Subsequent vine harvest • Harvest interval • Stems and amount to cut	• Cut stems every 10-15 days until the last harvest. • Depending on vegetative growth, cut 2-3 longest stems, up to 4 stems if much growth, leaving 1 5-20 cm. More stems can be cut near the end harvest.	• Cut stems every 10-15 days until the last harvest. • Cut 2-3 longest stems of a plant, leaving 15-20 cm. Irrigate while applying addi tional fertiliser after cutting.



1.5.9 Main insects and protection

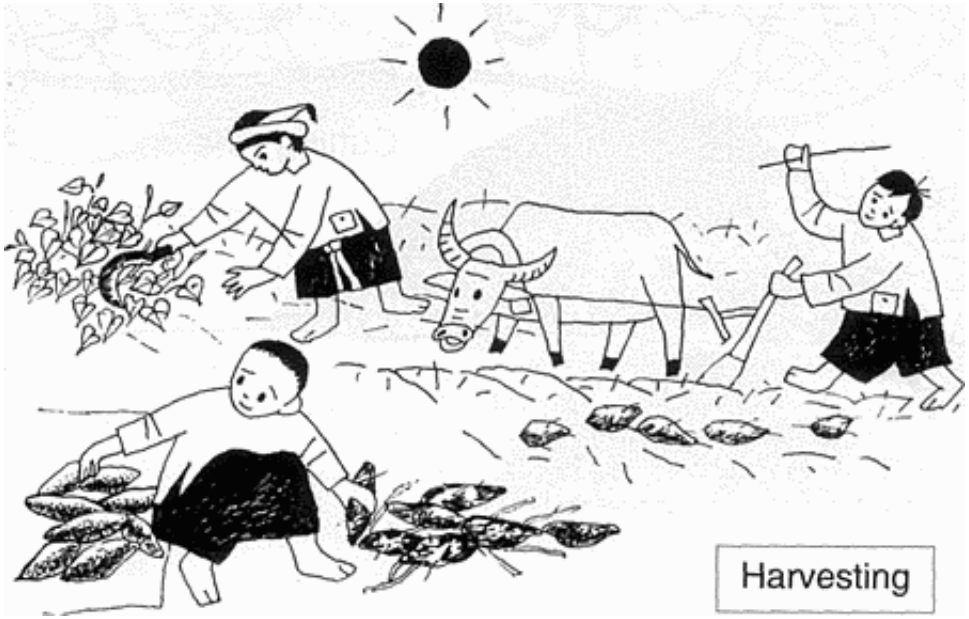
	Spring crop	Winter crop
Weevil	• The most serious for spring crop. The drier and hotter the weather is, the more weevil attack. Less serious in sandy soils than in loamy soils. Cracked soils are most susceptible to weevils. Storage roots are also often attacked, so it is necessary to cover the roots with nylon or sand. • Rotate sweetpotato with paddy rice and other crops. Use biological control such as introduction of natural enemies, manipulation of habitat, conservation of natural enemies through avoidance of pesticide use or trap weevils to eliminate them.	
Sweetpotato Hornworm	• The most serious attack is in spring when they eat all the leaves.	

(Agnus convolvuli)	• Protection by planting in rotation with other crops or pick them out by hand.
Borer	• The larvae attack the main stems and petioles and decrease the vegetative growth. Vine yield is decreased. For dual-purpose varieties, in the case of too much vegetative development, borer attack is good because it limits vegetative growth, allowing the nutrients to go into roots. In this case, protection is not necessary.
Black rot	• Plant sweetpotato in rotation with other crops such as paddy rice. Clear all the remaining parts of the previous crops, do sanitation of the field. • Plant sweetpotato in rotation with other crops. Do not use black rot- infected roots and stems for breeding material. Avoid damaging the roots during harvest. Clean fields after harvest.

1.5.10 Harvest

	Spring crop	**Winter crop**
Methods of identifying the	• Most appropriate time for harvest depends on the timing of rotation with other crops.	

time for harvest	• Harvest when two thirds of the leaves have turned yellow or fallen off. Another indication is when tubers no longer have any roots attached.	
Date of harvest	From 20 June to 5 July	From 5 February to 20 February
Methods of harvest	Sunny and dry days are best for harvesting. First, dig out both sides of the bed, then hoe to pick out the roots. Avoid damaging the roots, clean soils off of the roots and store in cool place.	

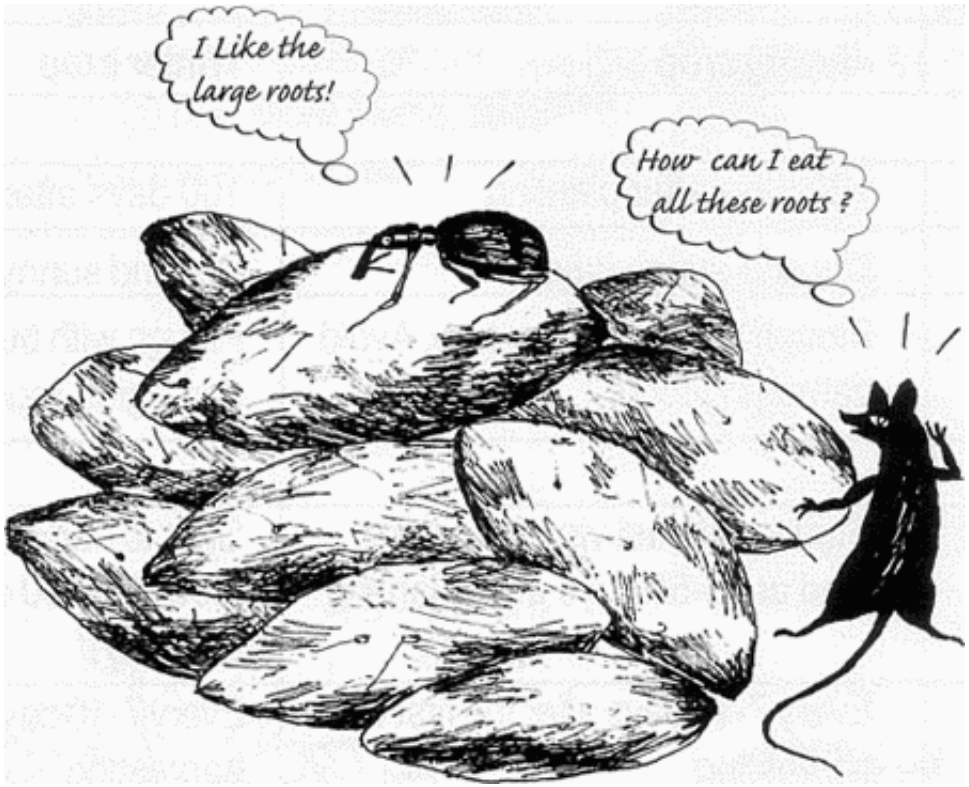


1.5.11 Storage

	Spring crop	Winter crop
Root storage Root storage Methods	• Put roots in a heap, cover the heap with a layer of sand before covering with a sheet of nylon. The roots can be stored up to 2-3 months. • Slice the roots with or without the skin to make dry chips <0.5 cm in thickness. Avoid molding. The experience of the farmers: soak slices in salt water (in concentration of 8-10% for 1 hour) before drying to avoid molding. When completely dried, put chips in nylon bags for storage.	
Storage duration	From July to February	From March to June
Remarks during storage	Susceptible to rotting or weevil attacks. Check regularly to eliminate rotting or weevils or dry the slices again.	Due to high humidity, storage roots are often molded or rot ten.
Vines storage Methods to store vines	• Chop vines into 0.5-1 cm lengths, dry thoroughly and store in nylon bags and feed them to pigs regularly.	

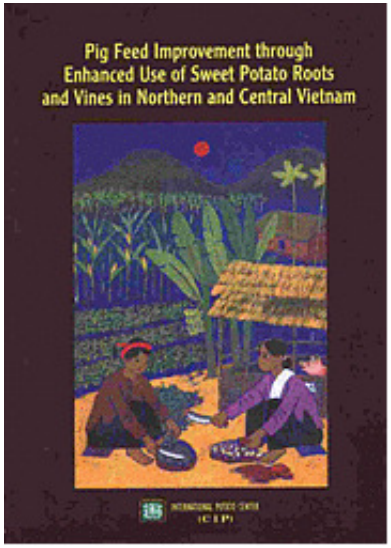
	• Chop vines into 0.5-1 cm lengths, pre-wilt, then ensile with additives*.	
Storage duration	From July to February	From March to June
Remarks during storage	Susceptible to molding.	Due to high humidity, storage roots are often molded or rotten. Bags need to be air tight.

*** Ensiling methods will be covered in Chapter 2.**



1.5.12 Recommended utilization

	Spring crop	**Winter crop**
Vine	Use dried or ensiled vine	Use fresh or ensiled vine or sell the surplus vine
Root	Big root, slice and dry to make chips or starch noodles	Small root, high moisture content, feed fresh or ensiled roots to pigs



Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam

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2 Technology for growing dual-purpose and forage-purpose sweetpotato in the Red River Delta of Vietnam

2.1 Characteristics of the Red River Delta

2.1.1 Soils

The Red River Delta was deposited by the Red River and the Thai Binh River, resulting in fertile alluvial soils. Total land area of the Red River Delta is 1,250,000 ha., of which Agricultural land occupies 721,321 ha. (57%). Of the total agricultural land, 643,021 ha is cultivated annually, leaving only 11% to fallow. Rice cultivation, as the most important crop, occupies 91% of annual crop land area.

2.1.2 Climatic conditions

The Red River Delta has a monsoon climate. The average temperature between November and April is 15-18°C, with the coldest months in January and February, when it can drop to as low as 5-9°C. There are two distinct seasons a year: dry season from November to April and rainy season from May to October. The average rainfall is 1,800-2,000 mm, mainly concentrated during the rainy season, when it usually storms and floods the delta between July and October.

2.1.3 Population and density

The small area of the Red River Delta boasts a big population of 14,800,100, with the majority (78.9 %) residing in rural areas. Due to the high population density, agricultural land per capita averages only 553 m2. The Kinh people comprise the majority of the population in the area.

2.1.4 Crops and production systems

Sweetpotato is planted in winter between two rice crops to serve a feed source for animal production in fresh and processed form. The agriculture rotation systems are as below.

- On secondary land:

Winter/Spring sweetpotato - Sesame - Autumn/Winter

sweetpotato
Spring groundnut - Sesame - Autumn/Winter sweetpotato
Winter/Spring sweetpotato - Sesame - Autumn groundnut

- One rice crop with two secondary crops:

Winter/Spring sweetpotato - Main winter rice
Spring sweetpotato - Early winter rice - Potato
Spring sweetpotato - Early winter rice - Winter sweetpotato
Spring groundnut - Early winter rice - Winter sweetpotato
Winter sweetpotato - Winter rice seedling - Late winter rice

- Two rice crops with a winter crop:

Late spring rice - Early winter rice - Winter sweetpotato

2.2 Geographical location

The Red River Delta of Vietnam consists of the following provinces: Hai Phong, Hai Duong, Hung Yen, Ha Tay, Ha Noi, Nam Dinh, Ha Nam, Thai Binh and Ninh Binh. The following recommendations also apply to some neighbouring provinces that share similar topographical and soil characteristics.

2.3 Recommended sweetpotato varieties suitable for root and vine dual-purpose and their characteristics.

2.3.1 The characteristics of yield, agronomic performance, and growing period

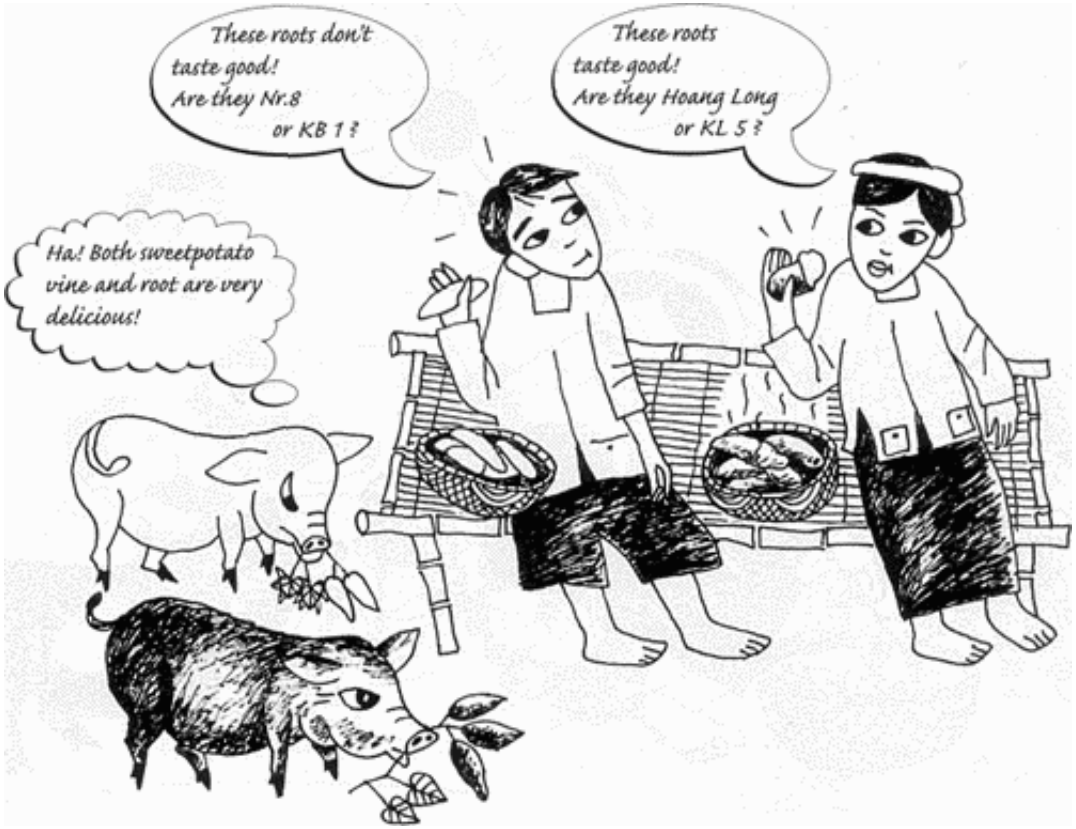
Distinguishing characteristics	Varieties				
	Hoang long	Nr.8	KL5	KL6	KB1
Root yield (ton/ha)	16-18	18-20	22-27	24-28	16-30
Vine yield (ton/ha)	17-20	18-20	20-25	21-25	18-20
Root DM yield (ton/ha)	4.59	5.65	6.25	6.35	6.46
Root starch yield (ton/ha)	3.93	4.84	5.25	5.18	5.34
Season suited to planting	Winter	Winter, spring	Winter, spring	Winter, spring	Winter, spring
Tolerance performance:					
• Drought tolerance	Fair	Fair	Good	Fair	Fair
• Submergence	Poor	Poor	Poor	Poor	Poor

tolerance					
• Cold tolerance	Medium	Fair	Good	Fair	Fair
• Leaf insect tolerance	Fair	Fair	Fair	Fair	Fair
• Weevil tolerance	Medium	Fair	Fair	Fair	Fair
Growing time (days)	100-120	100-120	100-120	100-120	100-120

2.3.2 The characteristics of utilization, vine, root and storage

Distinguishing characteristics	**Varieties**				
	Hoang long	**Nr.8**	**KL5**	**KL6**	**KB1**
Root palatability:					
For humans (boiled)	High DM	High DM	High DM	Med. DM	High DM
For pigs (cooked)	Good	Good	Good	Good	Good

Vine palatability:					
For humans (boiled)	Bitter	Med. sweet	Sweet	Sweet	Med. sweet
For pigs (fresh)	Bitter (Should be cooked)	Med. sweet (Should be cooked)	Sweet	Sweet	Med. sweet
Method of storage:					
Time (month)	3	3-4	3-4	3-4	3-4
Way to store	Dried	Dried	Dried	Dried	Dried
Roof *morphology*					
Color of skin	Light red	Red-Pink	Red-Pink	Red	White
Color of root flesh	Yellow	Ivory white	Ivory white	Ivory white	Ivory
Shape of root	Slender	Slender	Slender	Slender	Slender



2.4 Sweetpotato varieties suitable for forage purpose and their characteristics

2.4.1 The characteristics of yield, agronomic performance, and growing period

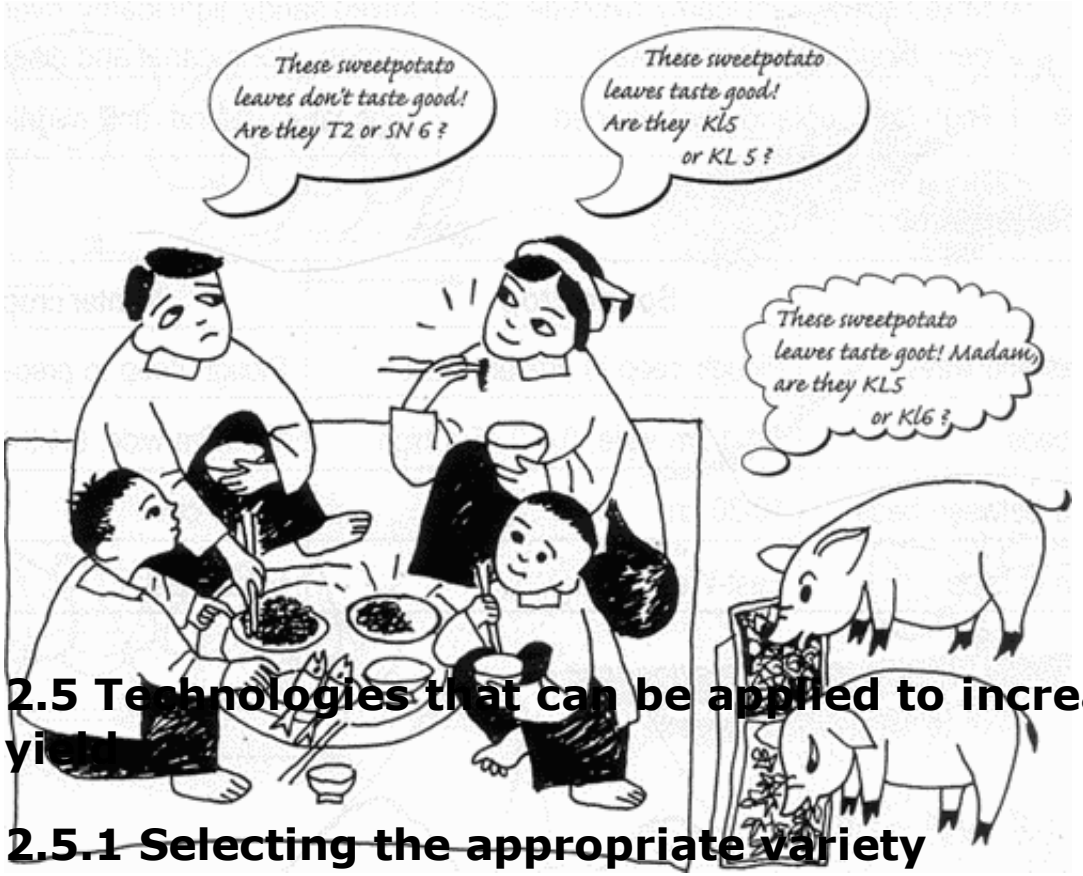
Distinguishing characteristics	Varieties				
	Hoanglong	Nr.8	KL1	KL5	KL6

	Huanglong	NK8	KL1	KL3	KL6
Fresh vine yield (ton/ha)	17-20	18-20	20-25	20-25	21-25
Fresh leaf yield (ton/ha)	11.75	12.50	14.25	13.50	13.25
Leaf DM yield (ton/ha)	2.30	3.25	3.80	3.90	3.01
Leaf CP yield (ton/ha)	0.34	0.49	0.54	0.58	0.48
Season suited for planting	Winter	Winter, spring	Winter, spring	Winter, spring	Winter, spring
Tolerance performance:					
Drought tolerance	Fair	Fair	Fair	Fair	Fair
Submergence tolerance	Poor	Poor	Poor	Poor	Poor
Cold tolerance	Medium	Fair	Fair	Fair	Fair
Leaf insect tolerance	Fair	Fair	Fair	Fair	Fair
Weevil tolerance	Medium	Fair	Fair	Fair	Fair
Branching	Strong	Strong	Strong	Strong	Strong
Re-growing	Fair	Fair	Fair	Fast	Fair

2.4.2 The characteristics of utilization, vine, root and storage

Distinguishing characteristics	Varieties				
	Hoang long	Nr.8	KL1	KL5	KL6
Vine palatability:					
For humans	Strong, a	Med.	Med.	Sweet	Sweet

For humans (boiled)	Strong, a bit sweet	Med. sweet	Med. sweet	Sweet	Sweet
For pigs (fresh)	Strong, a bit sweet (Should be cooked)	Med. sweet	Med. sweet	Sweet	Sweet
Method of storage:					
Time (month)	3-4	3-4	3-4	3-4	3-4
Way to store	Dried	Dried	Dried	Dried	Dried
Vine morphology:					
Shape of leaf	Heart shape	Dentate	Heart shape	Dentate	Elliptical
Color of tender leaf	Purple	Light green	Light green	Light green	Light green
Color of adult leaf	Green	Green	Green	Green	Green
Color of stem	Violet	Purple green	Green	Green	Green



2.5 Technologies that can be applied to increase vine and root yield

2.5.1 Selecting the appropriate variety

USE purpose	Spring crop	Winter crop
Dual purpose	Nr.8,KB1,KL5,KL6	Nr.8,KB1,KL5,KL6,Hoanglong
Forage purpose	Nr.8,KL1,KL5,KL6	Nr.8,KL1,KL5,KL6,Hoanglong

2.5.2 Planting season

	Spring crop	Winter crop
Planting season	10 February-25 February	25 September-25 October

Favorable conditions Unfavorable conditions	• From planting to harvesting the temperature and moisture are fairly suitable for growing sweetpotato. • Need to avoid plants submerged in water and over-producing vines at the end of the season	• At the start of winter high mois ture and temperature create good conditions for vine growth. • At the end of the dry season low temperature and moisture prevent good root development.

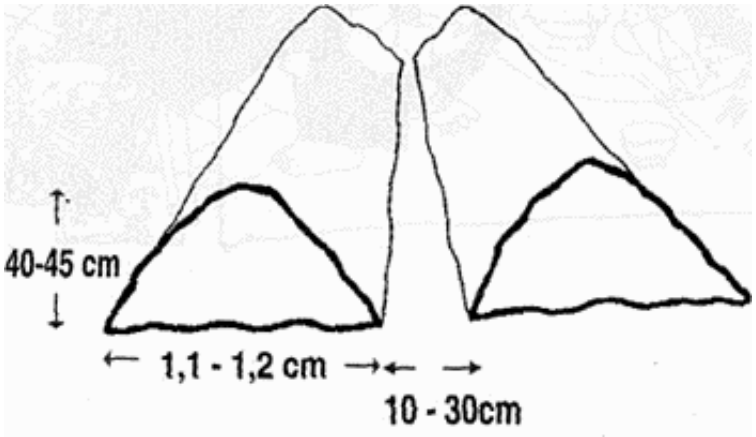
2.5.3 Soil characteristics

	Spring crop	**Winter crop**
Proper soil type	Mixed sandy, light loamy, riverside, gar den, along canals and dikes	Mixed sandy, light loamy, riverside, garden, along canal and dikes
Land type	High land, upland, well drained	High land, upland, and middleland

2.5.4 Soil preparation

	Spring crop	**Winter crop**
Requests and ways	Plough deep to prepare beds	Plough deep to prepare beds

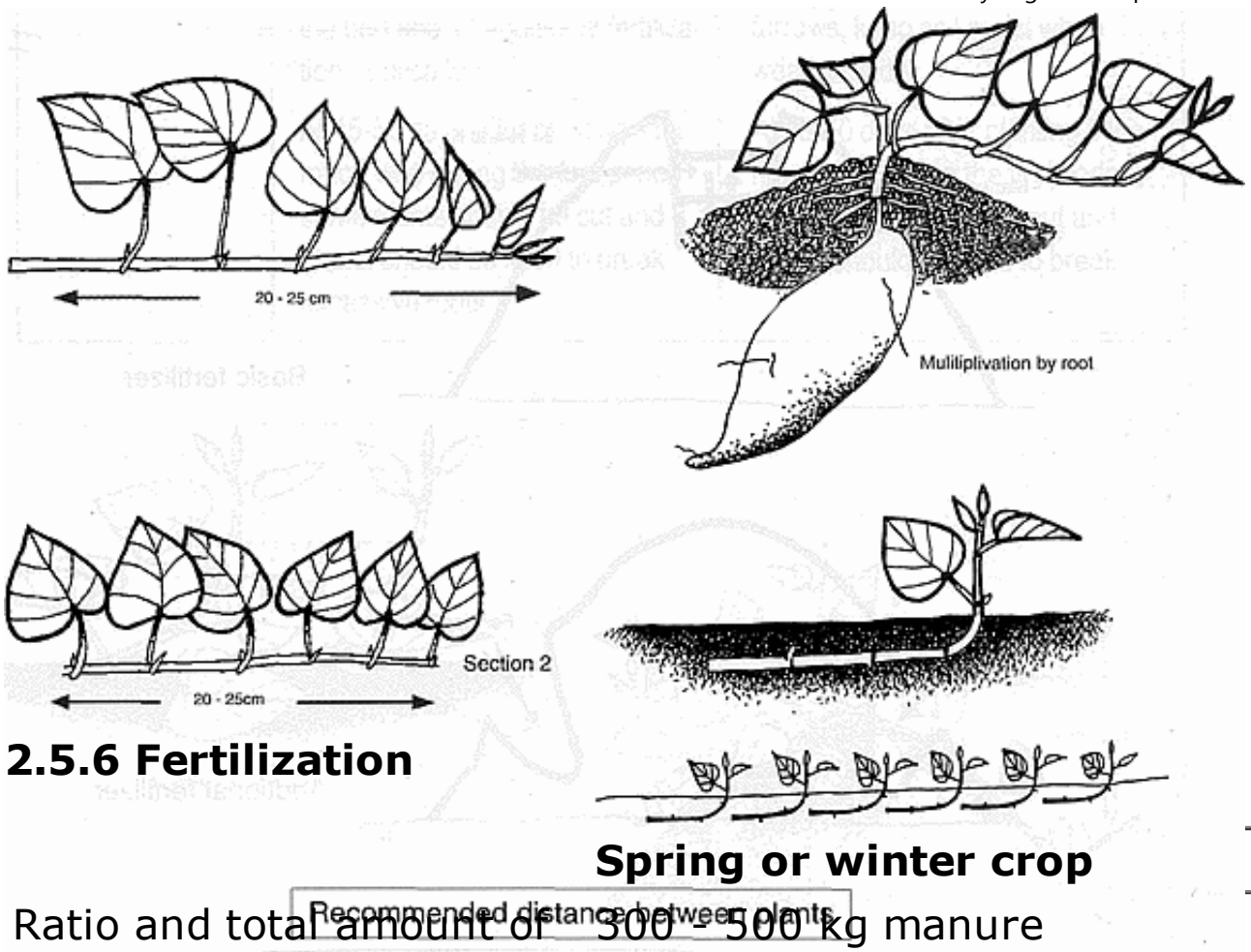
Size of beds	1.1 -1.2m wide, 0.4-0.45m high	1.1 -1.2m wide, 0.4-0.45m high
Distance between beds	10-30 cm	10-30 cm
Direction of beds	East-West	East-West



2.5.5 Planting method

	Spring or winter crops .

Vegetative multiplication	Cut 1st and 2nd sections for multiplication purpose. Plant in distance of 15x20 cm.
Multiplication method of planting material from root	Choose standard breeding roots and keep in the house. The shoots can be planted as planting material. Plant in density of 5-7 roots/m 2.
Preparation before cutting planting material	At least 45 days after multiplication, vines can be cut for planting.
Standards of good planting material	The 1st and 2nd section of an adult stem.
Method of cutting planting material	Depends on characteristics of the variety (selective cutting of vines from certain plants of each bed).
Length of stem (cm)	25-35
Number of nodes/stem	5-7
Planting method	One row in the middle of the bed
Density (stem/m of bed)	4-5

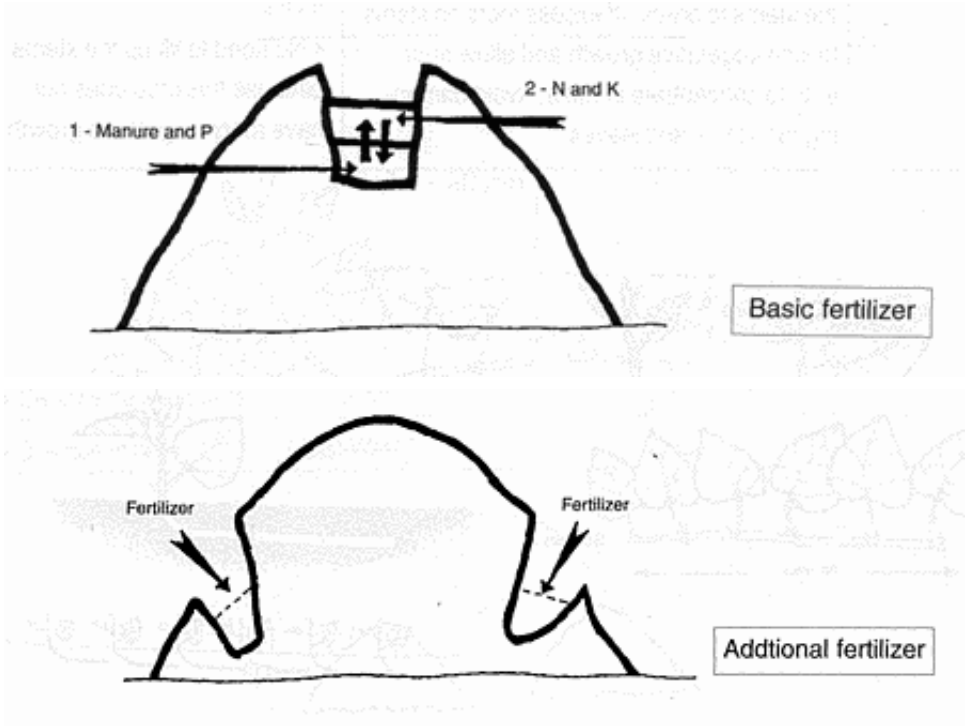


2.5.6 Fertilization

Spring or winter crop

Ratio and total amount of fertilizers (kg/sao)	300 - 500 kg manure 4 - 5 kg urea (N) 12 - 15 kg Super phosphate (P) 4 kg potassium chloride (K)
Basic fertilization	Mix manure with P, put in the furrow and cover with soil from the bed. Then, top it off with 1 kg of urea.
First additional fertilization	• At 25 - 30 days after planting

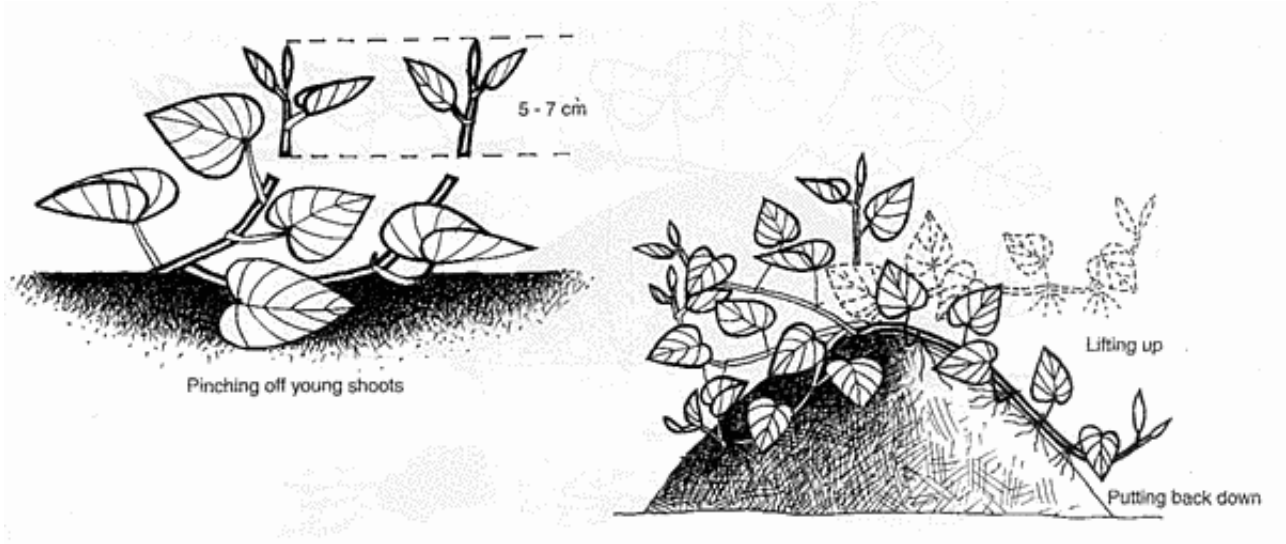
• Timing • Amount (kg/sao)	• 2-3 kg urea mixed with 3 kg potassium chloride
Second additional fertilization • Timing • Amount (kg/sao)	 • At 2-3 days after pruning the stems • 0.5-1 kg urea



2.5.7 Cultivation technology

	Spring crop	Winter crop
Pinching off young shoots	At 25-30 days after planting (several days before or after the 1 st additional fertilization) cut the tops to help branching and optimise vegetative development.	At 25 days after planting (several days before or after the 1 st additional fertilization) cut the tops to help branching and optimise vegetative development.
Re-mounding the bed for weed control	At 25-30 days after planting, hoe deeply into soil, turn up the bed slightly linking this activity with the 1 st additional fertilization. At 10-1 5 days after the 1 st addi tional fertilization, hoe, turn up soil slightly.	At 25 days after planting, hoe soil deeply, turn and earth up the bed slightly, in combination with the 1 st additional fertilization. At 10-15 days after the 1 st addi tional fertilization, hoe, turn slightly and earth up the bed highly.
Irrigation	Keep soil moist for 2-3 days after planting so that the stems can re- grow. Irrigate 2-3 days after	Keep soils moist for 2-3 days after planting so that the stems can re- grow. Irrigate, flood 1/2-1/3 of

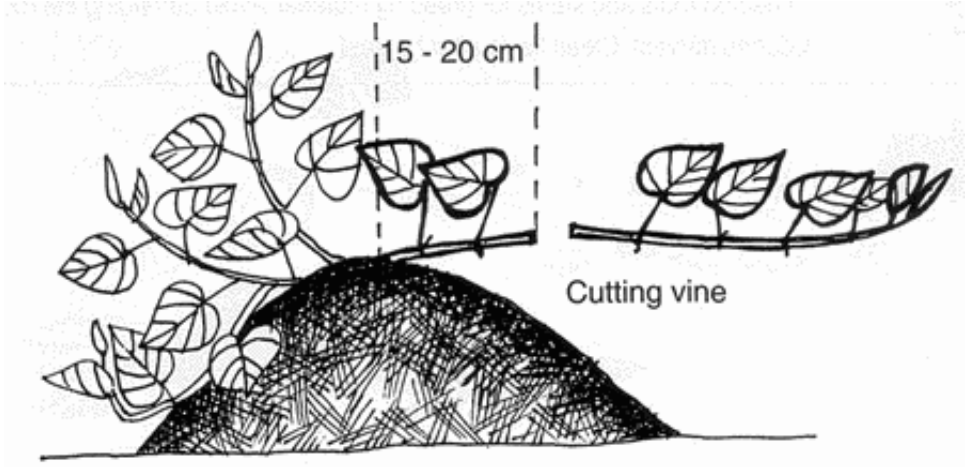
	turning up the bed and 1 st additional fertiliza tion application. At 45-50 days after planting if too much vine during the first period, some stems should be cut and stems should be lifted to break excessive roots.	the furrows, keep soil moist when weather is dry. At 45-50 days after planting if too much vine during the first period, some stems should be cut and stems should be lifted to break



2.5.8 The vine-cutting method for forage varieties

	Spring crop	**Winter crop**
First vine harvest		
• Time to start	• At 40-45 days after	• At 40-45 days after

harvest • Harvesting criteria	planting • Cut 1/3-1/4 of the length of the longest vine	planting • Cut 1/3-1/4 of the length of the longest vine
Subsequent vine harvests	Every 7-10 days after the first harvest depending on the rains.	Every 10 days after the first harvest depending on the rains.
	Cut 1/3-1/4 of the length of the longest vine.	Cut 1/3-1/4 of the length of the longest vine.
	Nitrogen should be added after each cutting (0.5 - 1.0 kg urea / sao).	Nitrogen should be added after each cutting (0.5 - 1.0 kg urea / sao).
	Cut stems every 10-15 days until the last harvest.	Cut stems every 10-15 days until the last harvest.
	Depending on vegetative growth, cut 2-3 longest stems, up to 4 stems if much growth, leaving 15-20 cm. More stems can be cut near the end harvest	Cut 2-3 longest stems of a plant, leaving 15-20 cm. Irrigate while applying additional fertilizer after cutting.



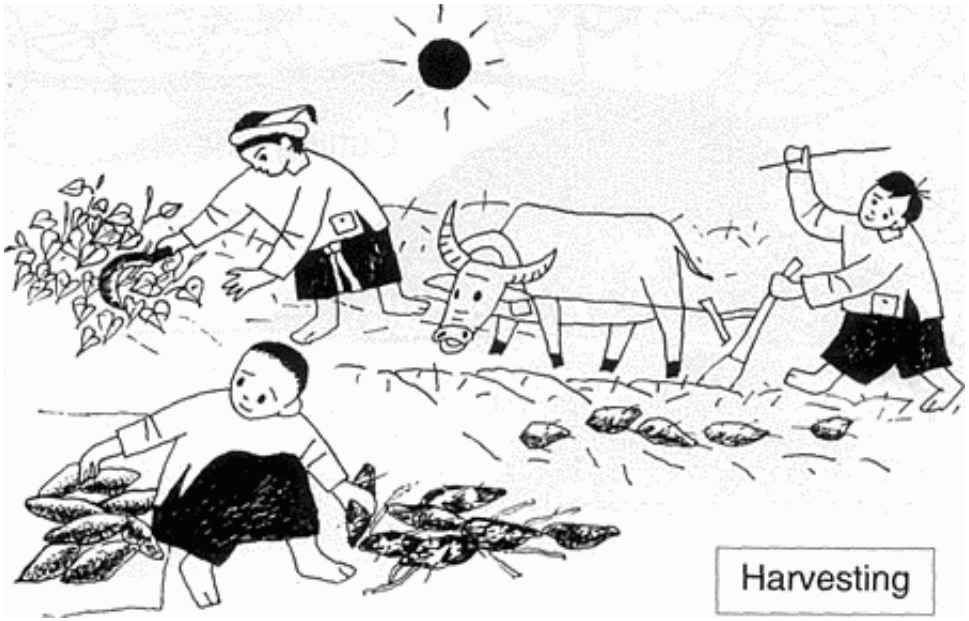
2.5.9 Main insects and protection

	Spring or winter crop
Weevil	Use traps (For example: chopped sweetpotato pieces) to lure adult weevils to come to lay eggs, then get the traps to kill larvae. Mound high beds and keep soil moist to reduce weevil damage. Use biological control such as introduction of natural enemies, manipulation of habitat, conservation of natural enemies through avoidance of pesticide use or trap weevils to eliminate them.
Sweetpotato Hornworm *(Agnus convolvuli)*	Sweetpotato rotating with paddy rice helps eliminate insects. Leaf-eating caterpillar can be caught by hand.

Scrap	Planting tolerant varieties is the best protection from scrap. Check and eliminate the attacked plants
Black rot	Restrict irrigation during the final period. Rotate sweetpotato with other crops in paddy fields, or plant on highlands.

2.5.10 Harvest

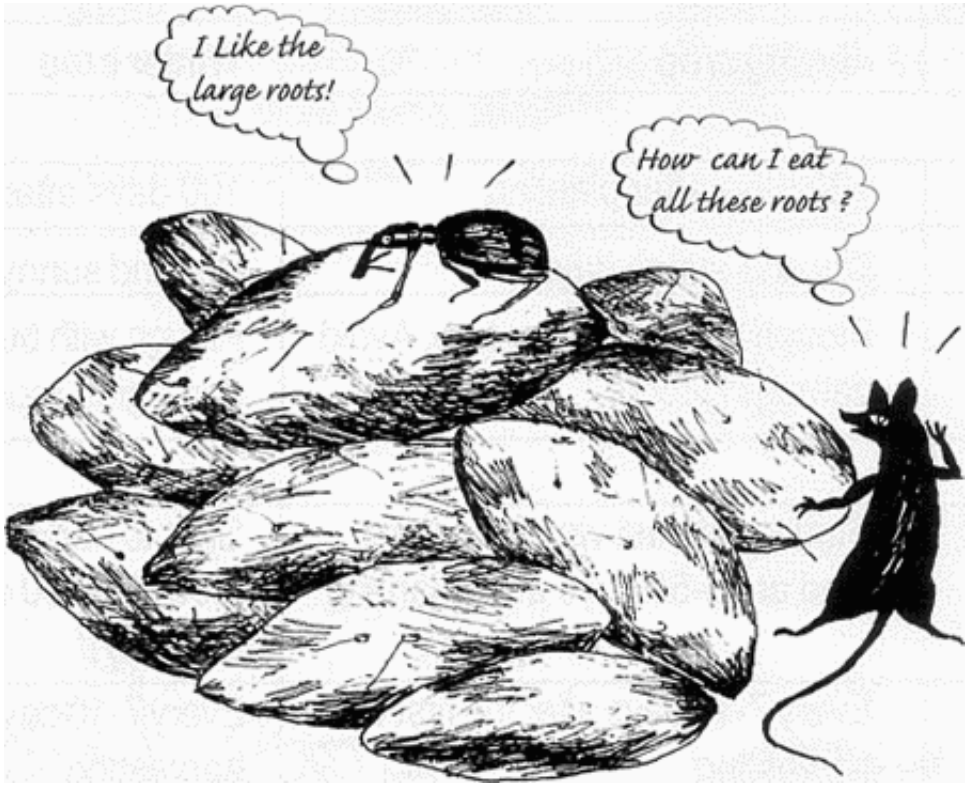
	Spring crop	**Winter crop**
Root harvest		
Time to harvest	120 days after planting	100 days after planting
Day to harvest	Dry and sunny days	Dry and sunny days
Methods to harvest	Plough with buffalo or hoe. Avoid damaging roots	Plough with buffalo or hoe. Avoid damaging roots
Vine harvesting		
Time to harvest	Start to harvest vine for animal feed at 45-50 days after planting	Start to harvest vine for animal feed at 45-50 days after planting
Day to harvest	Every 7-1 0 days after the first vine harvesting	Every 7-10 days after the first vine harvesting



2.5.11 Storage

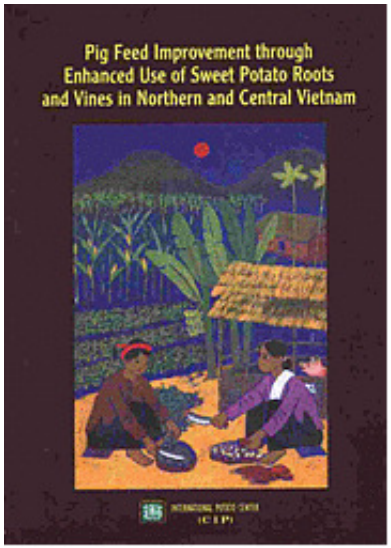
	Spring or winter crop
Storage of roots	
Methods to store roots	Clean soil or sand from roots, keep in dry, airy, and cool places
Some remarks during storage	Check regularly to eliminate rotting roots

Storage of vine	
Methods to store vine	Drying or ensiling
Storage duration	3-4 months
Some remarks during storage	After 14 days ensiled feed can be fed to pigs. It can be stored for at least 4-5 months. It has the typical smell and taste of ensiled feed. Check the bags regularly to make sure of anaerobic condition to avoid rotting and molding.



2.5.12 Recommended utilization

	Spring or winter crop
Vine	The soft and sweet vine can be used as vegetable for humans or forage for animals
Root	Roots can be boiled or dried for human consumption or animal feed



Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam

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3. Technology for growing dual-purpose and forage-purpose sweetpotato in North-Central Vietnam

3.1 Characteristics of North-Central Vietnam

3.1.1 Soils

North-Central Vietnam was deposited by the Ma River and the Huong River, resulting in infertile coastal-sandy soils with some alluvial characteristics.

3.1.2 Climatic conditions

North-Central Vietnam is commonly hit by storms from the east sea and by hot wind currents from the west part of the Truong Son mountains. It is, therefore, often plagued by floods and drought. During the heavy rainy season, the whole rainfall comes down from the east side of the Truong Son mountains and creates floods immediately. The two distinct seasons are the rainy season from May to October when the average temperature hovers around 25-35 °C, and the dry season from November to April. The average rainfall is 264.7 mm/month, mainly concentrated in three months during the rainy season (September to November), with common flooding between June and October every year.

3.13 Population and density

Population of North-Central Vietnam is 10,007,200, of which 87.7 % reside in rural areas. Average agricultural land per capita is higher than that of the Red River Delta, averaging 910.3 m2, of which rice cultivation area occupies 75%.

3.14 Crops and production systems

In North-Central Vietnam main rotation formulas between sweetpotato and other crops are as below:

- Only subsidiary crops:

Winter/Spring sweetpotato - Rice - Bean
Soybean - Sesame or autumn ground nut - Winter/Spring sweetpotato

- One rice crop with two subsidiary crops:

Winter/Spring sweetpotato - Main winter rice
Spring sweetpotato - Early winter rice - Potato
Spring sweetpotato - Early winter rice - Winter sweetpotato
Spring groundnut - Early winter rice - Winter sweetpotato

- Two rice crops with a winter crop:

Late spring rice - Early winter rice - Winter sweetpotato

3.2 Geographical location

North-Central Vietnam consists of the following provinces: Thanh Hoa, Nghe An, Ha Tinh, Quang Tri, Quang Binh, Thua Thien Hue. The following recommendations also apply to some neighbouring provinces that share similar topographical, soil, and cropping characteristics.

3.3 Recommended sweetpotato varieties suitable for root and vine dual-purpose and their characteristics

3.3.1 The characteristics of yield, agronomic performance, and growing period

Distinguishing characteristics	Varieties				
	K51	K4	KL5	Cuc nhanh	Chiem dau
Root yield (ton/ha)	20-30	15-20	13-20	12-15	8-12
Vine yield (ton/ha)	15-20	17-22	15-25	15-20	10-15
Root DM yield (ton/ha)	3.15-4.25	5.6-7.3	3.8-6.5	4.8-6.4	3.3-5.0
Root starch yield (ton/ha)	1.2-2.3	3.5-5.0	3.0-5.5	3.5-4.0	2.0-3.0
Season suited to planting	Winter, spring	Winter, summer	Winter, spring	Winter, spring	Winter, spring
Tolerance performance:					
Drought tolerance	Good	Good	Medium	Medium	Fair
Submergence	Fair	Fair	Fair	Medium	Medium

tolerance					
Cold tolerance	Good	Good	Fair	Fair	Fair
Leaf insect tolerance	Good	Good	Medium	Fair	Medium
Weevil tolerance	Good	Fair	Medium	Medium	Fair
Growing time (days)	80-90	90-120	90-120	120-180	120-180

3.3.2 The characteristics of utilization, vine, root and storage

Distinguishing characteristics	**Varieties**				
	K51	**K4**	**KL5**	**Cuc nhanh**	**Chiem dau**
Root palatability					
• For humans (boiled)	Low DM	High DM	High DM	High DM	High DM
• For pigs (cooked)	Good	Acceptable	Fairly good	Fairly good	Good
Vine palatability					
• For humans	Sweet	Bitter	Sweet	Acceptable	Bitter

(boiled)					
• For pigs (fresh)	Sweet	Bitter (Should be cooked)	Sweet	Acceptable	Bitter (Should be cooked)
Method of root storage					
• Time (months)	*3-4*	2-3	3-4	4-5	2-3
• Way to store	Fresh, dried	Fresh, dried	Fresh, dried	Fresh, dried	Dried
Root morphobgy					
• Color of skin	Light yellow	Yellowish	Red	Red	Yellow
• Color of root flesh	Red	White,yellow	White,yellow	White,yellow	White-yellow
• Shape of root	Elliptical	Roundish	Slender	Slender	Elliptical
Vine					

morphology					
• Shape of leaf	Round heart	Long heart	Dentate	Serrated	Round heart
• Color of tender leaf	Green	Violet	Green	Green	Light green
• Color of adult leaf	Dark green	Light green	Green	Dark green	Light green
• Color of stem	Green	Purple green	Green	Green	Purple green

3.4 Sweetpotato varieties suitable for forage purpose and their characteristics

3.4.1 The characteristics of yield, agronomic performance, and growing period

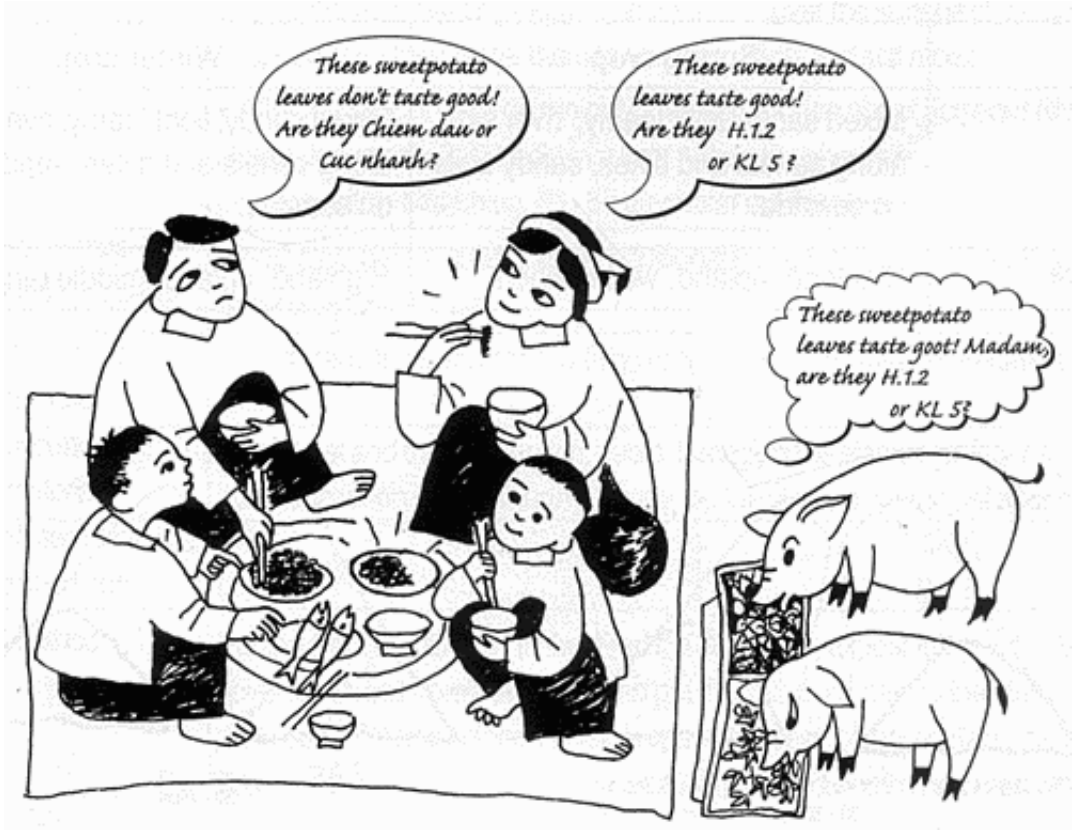
Distinguishing characteristics	Varieties				
	K51	KL1	KL5	H 1-2	Cuc nhanh

	K31	K21	K25	H.1.2	Cuc mam
Fresh vine yield (ton/ha)	6-8.7	6.3-11.34	7.2-12	8.4-13	6.8-10.2
Vine DM yield (ton/ha)	1.93	2.20	2.69	2.78	2.30
Leaf protein yield (ton/ha)	0.39	0.40	0.51	0.56	0.41
Season suited to planting	Winter, spring	Winter, spring	Winter, spring	Winter, spring	Winter, spring
Tolerance performance:					
Drought tolerance	Good	Good	Medium	Medium	Fair
Submergence tolerance	Fair	Fair	Fair	Medium	Medium
Cold tolerance	Good	Good	Fair	Fair	Fair
Leaf insect tolerance	Good	Good	Medium	Fair	Medium
Weevil tolerance	Good	Fair	Medium	Medium	Fair
Branching re-growing	Strong	Strong	Strong	Strong	Strong

3.4.2 The characteristics of utilization, vine, root and storage

Distinguishing characteristics	**Varieties**				
	K51	**KL1**	**KL5**	**H.1.2**	**Cuc nhanh**
Vine palatability					
• For humans (boiled to eat)	Sweet	Sweet	Sweet	Sweet	Sweet
• For pigs (fresh)	Sweet	Sweet	Sweet	Sweet	Sweet
Method of vine storage					
• Time (months)	34	2-3	34	4-5	4-5
• Way to store	Dried	Dried	Dried	Dried	Dried

Vine morphology					
• Shape of leaf	Long heart	Round heart	Dentate	Round heart	Serrated heart
• Color of tender leaf	Light green	Light green	Green	Green	Light green
• Color of adult leaf	Dark green	Light green	Green	Dark green	Green



3.5 Technologies that can be applied to increase vine and root yield

3.5.1 Selecting the appropriate variety

Using purpose	Spring crop	Winter crop
Dual purpose	K51.K4.KL5	K51.K4.KL5
Forage purpose	K51,KL5,KL1	K51,H.1.2,KL5

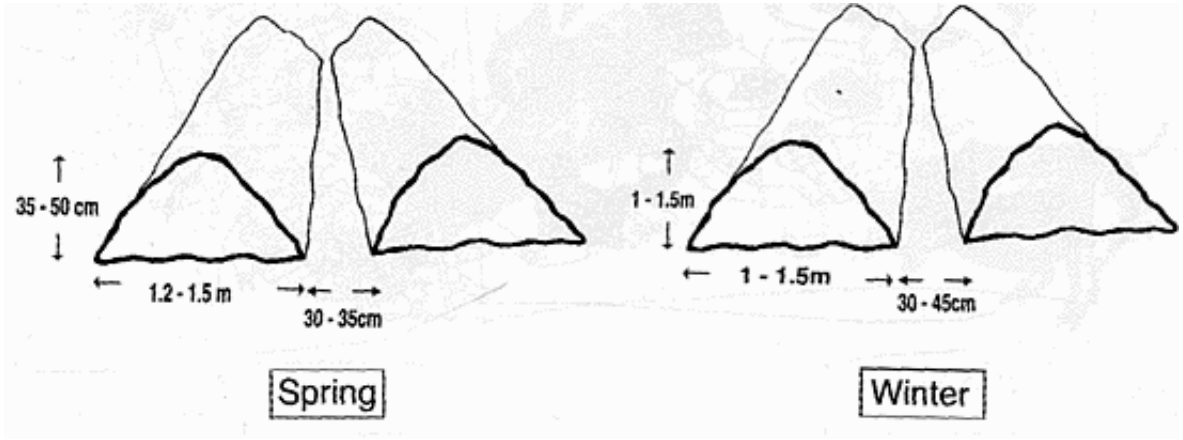
3.5.2 Planting season

	Spring crop	Winter crop
Planting season	15 February- 30 March	15 September-30 October
Favorable conditions Unfavorable conditions	• Due to low moisture require ment, sweetpotato can grow where groundnut and sesame cannot. • There usually are early rains. It has negative impact on root growth.	• Sweetpotato is planted between crops to increase land use efficiency. • The cold in the beginning and drought at the end of season both have adverse

		effects on root growth.

3.5.3 Soil characteristics

	Spring crop	Winter crop
Proper soil type	Mixed sandy, light loamy, river side, along canals and dikes, sandy soils on seaside.	Mixed sandy, light loamy, river side, along canals and dikes, sandy soils on seaside.
Land type	Highland, upland, well drained	Highland, upland, middle land.



3.5.4 Soil preparation

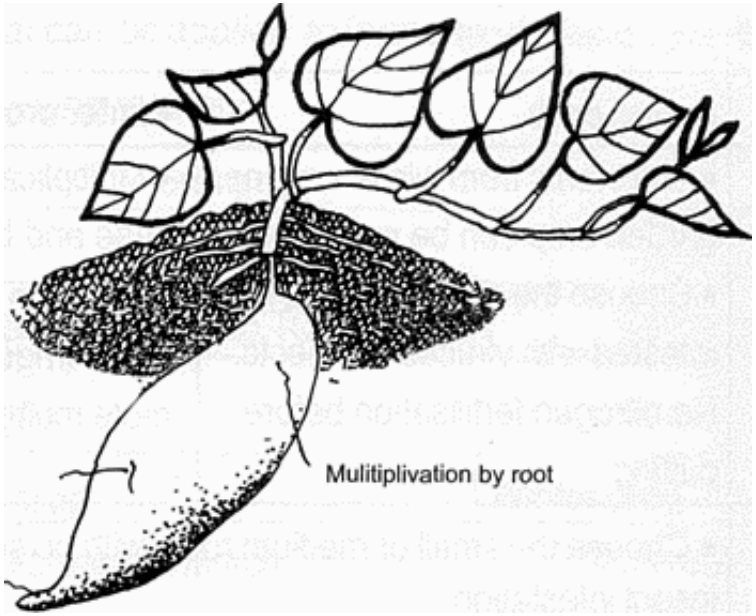
	Spring crop	Winter crop
Requirements	Dry, airy, deeply ploughed.	Deeply ploughed for moisture retention.
Size of beds	1.2 - 1.5m wide, 0.35-0.5m high	1 - 1.5m wide, 0.3 - 0.45m high
Distance between beds	30-35 cm	25-30 cm
Direction of beds	West- East	West - East

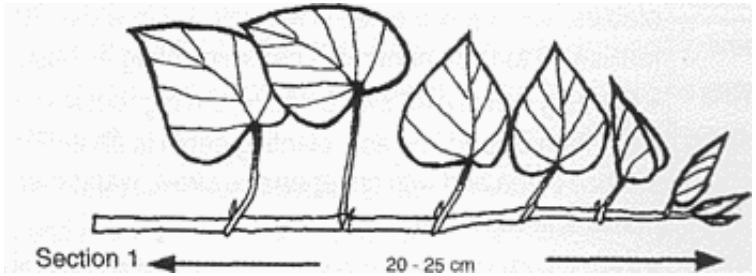
3.5.5 Planting method

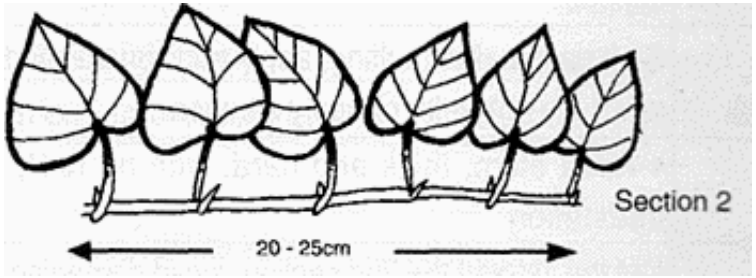
	Spring crop	Winter crop
Vegetative multiplication	• The stems from winter crop or garden crop can be multiplied. • Choose the stems that are not infested with viruses or insects. No nitrogen fertilization	• Multiplication season is the end of June and beginning of July • Plant in mounded beds or flat beds. Irrigate, cut tops early to promote multiple branches.

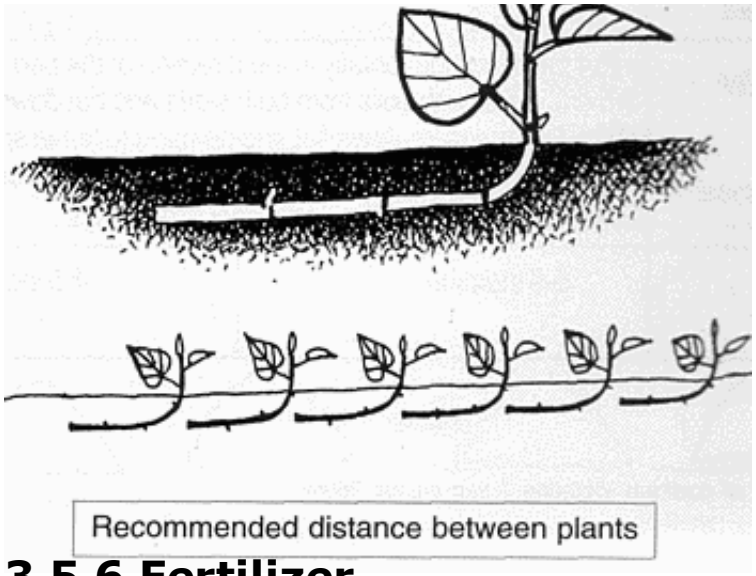
	before cutting	
Multiplication method of planting material from root	• Choose the small or medium roots with no scratches, no virus, or insect infestation • Prepare the soil well, the soil clods must be as fine as for vegetables. The top of the bed is flat, with 1 .2 m width, 20 cm height, fertilize 10 tons of manure/ha before planting as basic fertilizer. • Planting density: 40 x 40 cm/hole, the big root should be cut into parts then dipped into ash, planting depth is about 3 cm, cover the surface of the bed with chopped rice straw, water them to keep the plants and soil moist. • After the shoots have grown out of the soil surface about 5cm, cut off weak shoots, leave only 2-3 shoots in a hole. When the shoots are 20-25 cm long, cut the top to allow branching, 50 - 60 days later cut the stem to plant.	
Preparation before cutting planting material	7-10 days before cutting, apply additional P and K fertilizer (1 -2 kg K/sao), do not water or apply nitrogen	
Standards of good planting material	Adult stem, thick and hard, with no root, no virus and insect infestation	
Method of	Cut the Island the 2nd section, avoid damaging the stems	

Method of cutting planting material	Cut the stem and the end section, avoid damaging the stems and leaves. In late afternoon when it is less sunny. Do not dip the stems in water just after cutting	
Length of stem (cm) Node number/stem	25-30 6-8	20-25 5-7
Planting method	Put the stem horizontally in the direction of the bed, exposing the top 3-5 cm, cover it with soil from both sides and pat down the soil next to the stem. Lay the stem down flat and no need to leave space between plantlets. Keep the stem fresh. Better plant in the evening. In winter, avoid planting during the northeast windy days.	
Direction of beds	North east-South west	North east-South west
Density (stem/m of bed)	5 stem/m	4-5 stem/m


Mulitiplivation by root


Section 1
20 - 25 cm

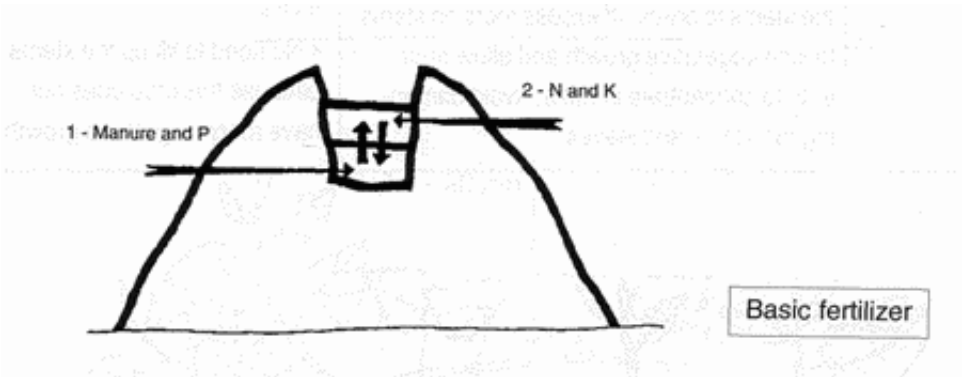

Section 2
20 - 25cm

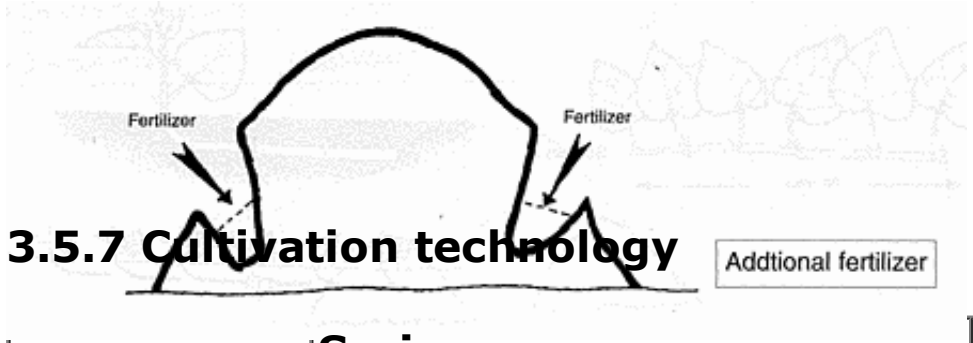


3.5.6 Fertilizer

	Spring crop	**Winter crop**
Ratio and amount of fertilizers (kg/sao)	300-400 kg manure 2-4 kg urea (N) 12-14 kg phosphate (P) 2-4 kg potassium chloride (K)	300-400 kg manure 3-5 kg urea (N) 12 -14 kg phosphate (P) 2-4 kg potassium chloride (K)
Basic fertilization	Mix manure with P, put in the furrow and cover with soil from the bed. Apply additional 1-1.5 kg urea and 1-1.5 kg potassium chloride, cover with soil. Avoid stems touching fertilizer.	Mix manure with P, put in the furrow and cover with soil from the bed. Apply additional 1-1.5 kg urea and 1-1.5 kg potassium chloride, cover with soil. Avoid stems touching fertilizer.

First additional fertilization • Timing • Amount (kg/sao)	• At 15-25 days after planting • 1-1.5 kg urea mixed with 1-1.5 kg potassium chloride	• At 10-20 days after planting • 1-1.5 kg urea mixed with 1-1.5 kg potassium chloride
First additional fertilization • Timing • Amount (kg/sao)	• At 30-35 days after planting • 1-1 .5 kg urea 1-1.5 kg potassium chloride	• 25-30 days after planting • 1-1.5 urea 1-1.5 potassium chloride

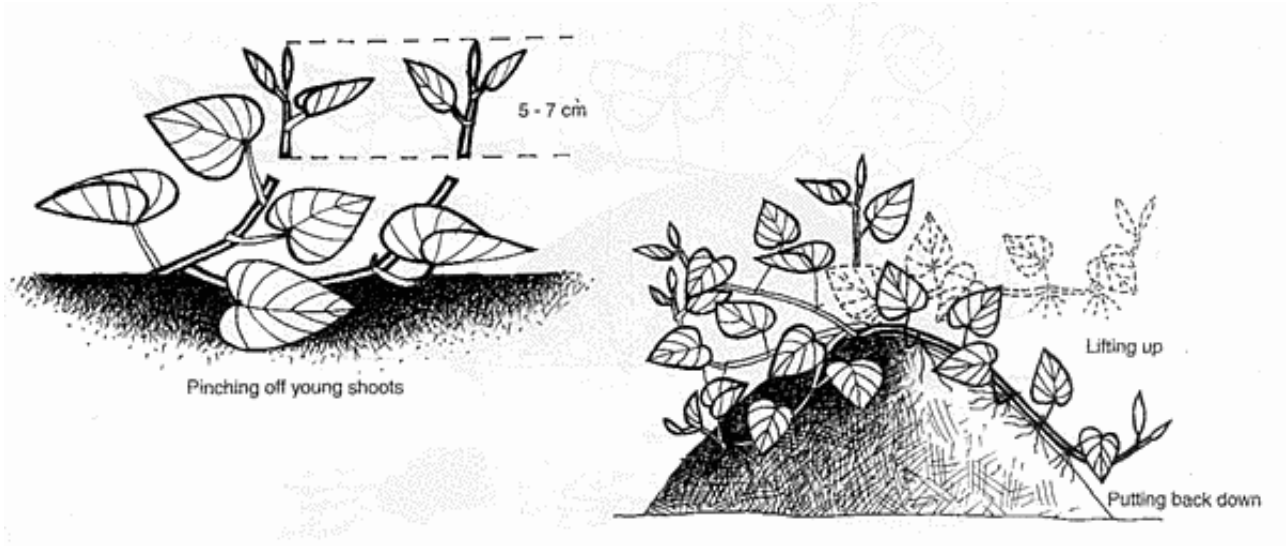




3.5.7 Cultivation technology

	Spring crop	Winter crop
Pinching off young shoots	At 25-30 days after planting (several days before or after the 1 st additional fertilization) cut the tops to help branching and optimize vegetative development.	At 25 days after planting (several days before or after the 1 st additional fertilization) cut the tops to help branching and optimize vegetative development.
Re-mount the bed for weed control	At 25-30 days after planting, hoe deeply into soil, turn up the bed slightly linking this activity with the 1 st additional fertilization. At 10-15 days after the 1 st additional fertilization, hoe, turn up soil slightly. Keep soil moist for 2-3 days after planting so that the stems can re-grow.	At 25 days after planting, hoe soil deeply, turn and earth up the bed slightly, in combination with the 1 st additional fertilization. At 10 - 15 days after the 1 st additional fertilization, hoe, turn slightly and earth up the bed highly. Keep soils moist for 2-3 days after planting so that the stems can re-grow.
Irrigation	Irrigate 2-3 days after	Irrigate, flood 1/2-1/3 of the

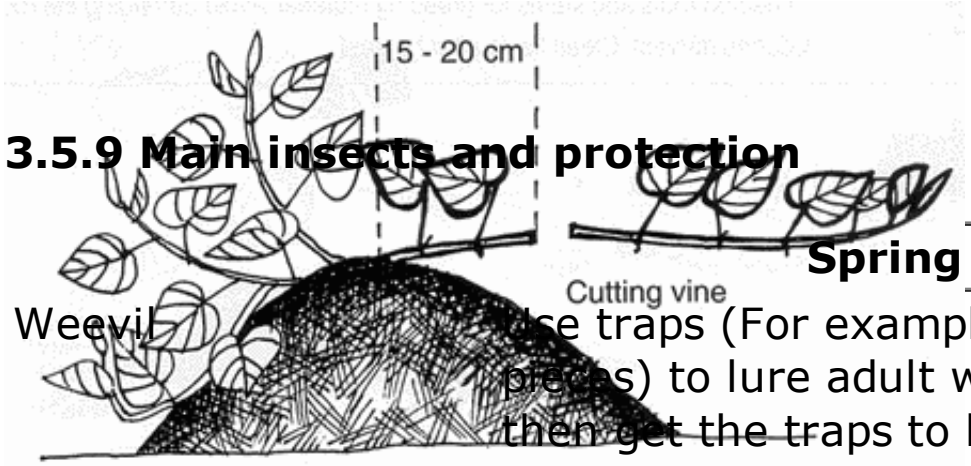
	turning up the bed and additional fertilization application.	furrows, keep soil moist when weather is dry.
Vine lifting	At 45-50 days after planting if too much vine during the first period, some stems should be cut and stems should be lifted to break excessive roots.	At 45-50 days after planting if too much vine during the first period, some stems should be cut and stems should be lifted to break excessive roots.



3.5.8 The vine-cutting method for forage varieties

	Spring crop	Winter crop
First vine		

harvest Time to start harvest	At 30-40 days after planting when the bed is covered by vine	At 35-45 days after planting when the bed is covered by vine
Harvesting criteria	Leave a section of 10-15 cm on the bottom.	Leave a section of 10-15 cm on the bottom.
Subsequent vine harvests	Nitrogen should be added after each harvest (0.5 - 1.0 kg/sao urea). Cut stems every 10-15 days until the last harvest. Depending on vegetative growth, cut 2-3 longest stems, up to 4 stems if much growth, leaving 15-20cm. More stems can be cut near the end harvest	Nitrogen should be added after each harvest (0.5 -1.0 kg/sao urea). Cut stems every 10-15 days until the last harvest. Cut 2-3 longest stems of a plant, leaving 15-20 cm. Irrigate while applying additional fertilizer after cutting.



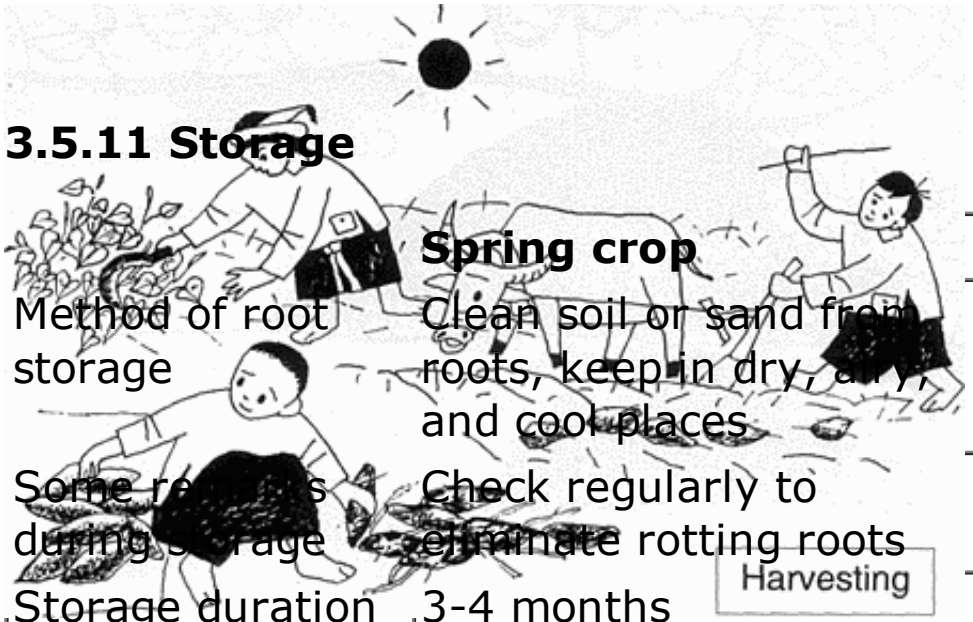
3.5.9 Main insects and protection

	Spring or winter crop
Weevil	Use traps (For example: chopped sweetpotato pieces) to lure adult weevils to come to lay eggs, then get the traps to kill larvae. Mound high beds and keep soil moist to reduce weevil damage. Use biological control such as introduction of natural enemies, manipulation of habitat, conservation of natural enemies through avoidance of pesticide use or trap weevils to eliminate them.
Sweetpotato Hornworm *(Agriusconvolvuli)*	Sweetpotato rotating with paddy rice helps eliminate insects. Leaf-eating caterpillar can be caught by hand
Scrap	Planting tolerant varieties is the best protection from scrap. Check and eliminate the attacked plants.
Black rot	Restrict irrigation during the final period. Rotate sweetpotato with other crops in paddy fields, or plant on highlands.

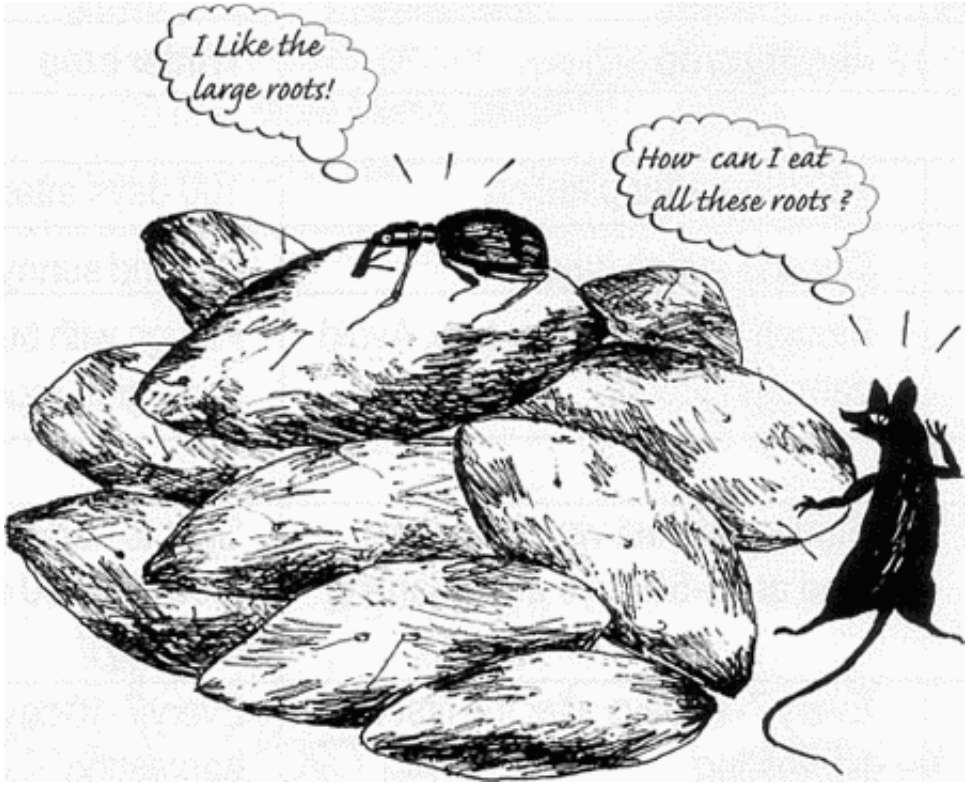
3.5.10 Harvest

	Spring crop	**Winter crop**
Root harvesting Time to harvest Date of harvest Method of harvest	105-120 days after planting End of May-Start of June -Avoid damaging roots - Process, store vine, make dried chips	80-90 days after planting End of January-Start of February - Avoid damaging roots - Process, store vine, make dried chips
Vine harvesting Time to harvest	Vines can be harvested 45-50 days after planting.	Vines can be harvested 45-50 days after planting.
Subsequent harvests	Every 10-15 days after the first vine harvest.	Every 10-15 days after the first vine harvest.

3.5.11 Storage

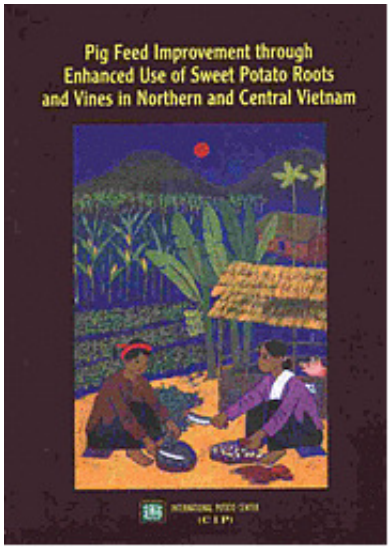


	Spring crop	Winter crop
Method of root storage	Clean soil or sand from roots, keep in dry, airy, and cool places	Clean soil or sand from roots, keep in dry, airy, and cool places
Some remarks during storage	Check regularly to eliminate rotting roots	Check regularly to eliminate rotting roots
Storage duration	3-4 months	3-4 months
Method of vine torage	Drying or ensiling	Drying or ensiling
Storage duration	3-4 months	3-4 months
Some remarks during storage	After 14 days ensiled feed can be fed to pigs. It can be stored for at least 4-5 months. It has the typical smell and taste of ensiled feed. Check the bags regularly to make sure of anaerobic condition to avoid rot and mould	After 14 days ensiled feed can be fed to pigs. It can be stored for at least 4-5 months. It has the typical smell and taste of ensiled feed. Check the bags regularly to make sure of anaerobic condition to avoid rot and mould


I Like the large roots!
How can I eat all these roots ?

3.5.12 Recommended utilization

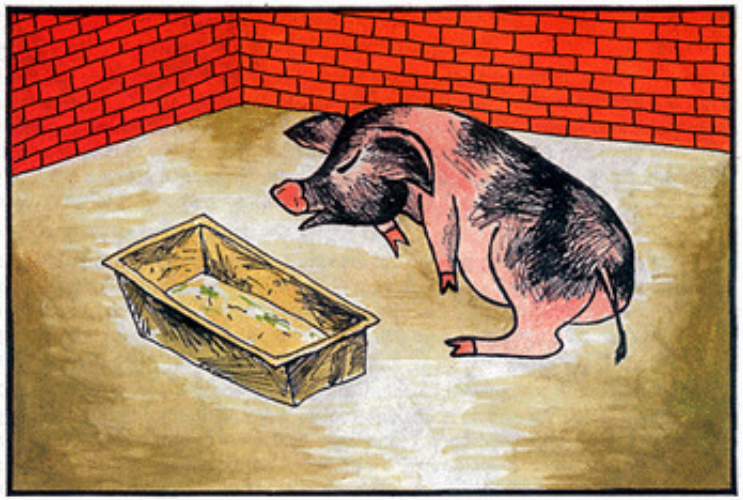
	Spring crop
Vine	The soft and sweet vine can be used as vegetable for humans or forage for animals
Root	Roots can be boiled or dried for human consumption or animal feed



Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam

Contents:

PART II
SWEETPOTATO ROOT AND VINE PROCESSING AND FEEDING TO PIGS



1 Sweetpotato vine and root ensiling methods and use of silage as pig feed

1.1 Method

1.1.1 Principles

Silage fermentation requires an anaerobic environment. So the pre-requisite condition for fermentation is to eliminate as much as possible the air from the fermenting material. Chopping the material ensiled, and the pressure exerted on the chopped material inside the containers where silage fermentation will occur, favor the elimination of most of the air present between the plant particles. Under these circumstances it is expected that anaerobic fermentation will start a few hours after the silage has been sealed; therefore losses due to transpiration and the activity

of non-desirable aerobic microorganisms (e.g. enterobacteria, molds) will be minimal.

Ensilage should take place in completely air-tight nylon or plastic bags to make sure that no air can enter and spoil the silage.The exposure of the silage to air is unavoidable once the bag is opened for feeding animals, and it results in deterioration of the product. One way to reduce those losses is to use a high feed-out rate of the silage, which is obtained by working in relatively small batches, which can be completely consumed at most in 7-10 days after opening the silage. In small-scale exploitations, the use of bags for ensiling is quite adequate for this purpose, as silage contents can be consumed almost the same day, and then this type of loss is minimized.

- **Reducing the moisture content of the ensiling material**

Because sweetpotato vines have high moisture content (up to 90% water), it is necessary to pre-wilt them before fermenting. Otherwise there is not only the risk of loosing nutrients by excessive effluents coming out from the silage or the loss of all silage soaked in water when drainage is impeded, but also the possibility of Clostridia development in the silage, resulting in poor quality silage (high in butyric acid, most of the protein degraded to ammonia).

- **Using additives for ensiling**

Several additives can be used to improve the ensiling process, but those can be classified as fermentation stimulants (e.g., inoculants, molasses), fermentation inhibitors (e.g., formic acid, mineral acids, salt), aerobic deterioration inhibitors (e.g. propionic acid), nutrients (e.g., urea, minerals) and absorbents (e.g., straw, dried sugar beet pulp).

Sweet potato vines practically contain all nutrients required for a good fermentation process, except for its high moisture content, which can be controlled by pre-wilting. However, in many practical experiences good results have been obtained using corn meal, cassava meal, rice bran, chicken manure and salt. The main effect of the first four could be as absorbents, given their high dry matter content, whereas salt restricts fermentation, preventing a large proportion of available non-structural carbohydrates from fermenting. In the case of chicken manure, the ammonia released during fermentation may also help to improve the aerobic stability of the silage, once the silage is opened.

For ensiling sweet-potato roots, it is even more necessary to use additives with high dry matter content, as roots cannot be pre-wilted. Also, the low protein content of sweet-potato roots may limit the growth of fermenting microbes; therefore the use of protein rich additives (e.g., chicken manure or even urea) may help. The use of salt as an additive is particularly relevant in the case of roots, as it could help to save some of the starch and sugars from being fermented in the silage. The quality of the

fermented sweet-potato vines and tubers can be kept stable for a long time if processed properly.

1.1.2 Ensiling sweetpotato vines

Sweetpotato vines are converted to silage by the following procedure:

- **Chopping sweetpotato vine**

Chop SP vine to 0.5-1 cm length, remove the old, yellow and rotted leaves and stems.

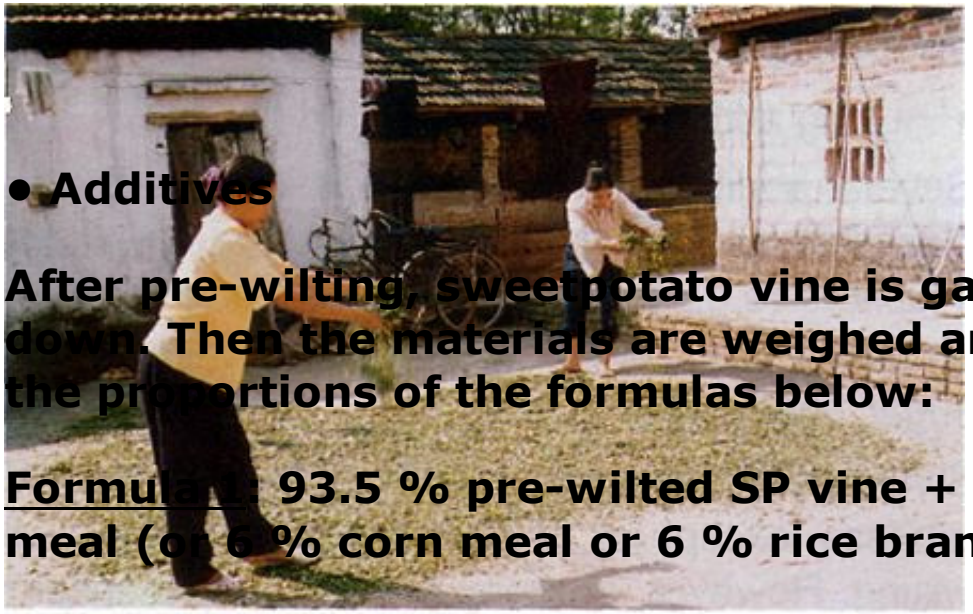
- **Pre-wilting**

Pre-wilting is a very important step to reduce moisture content of fermenting material.

After chopping it needs to be partially wilted immediately in the sun until the water loss is about 40-45 %. For example: if you have 100 kg of fresh SP vine, after pre-wilting the water loss is 40-45 kg remaining pre-wilted SP vine is about 55-60 kg.

Try the following: hold the wilted SP vine in your hand then open the hand. If the SP vine keeps the * initial shape, the wilting is enough. Pre-wilting can take about 2-4 hours in dry, sunny weather. During pre-wilting the vines should be turned over regularly to allow rapid and uniform wilting.

You should harvest the amount of SP vine that is just enough to chop, pre-wilt and ferment on the same day to minimize nutritive loss.



- **Additives**

After pre-wilting, sweetpotato vine is gathered and left to cool down. Then the materials are weighed and combined based on the proportions of the formulas below:

<u>Formula 1</u>: 93.5 % pre-wilted SP vine + 0.5 % salt + 6 % cassava meal (or 6 % corn meal or 6 % rice bran)

If you have chicken manure, use the following proportion:

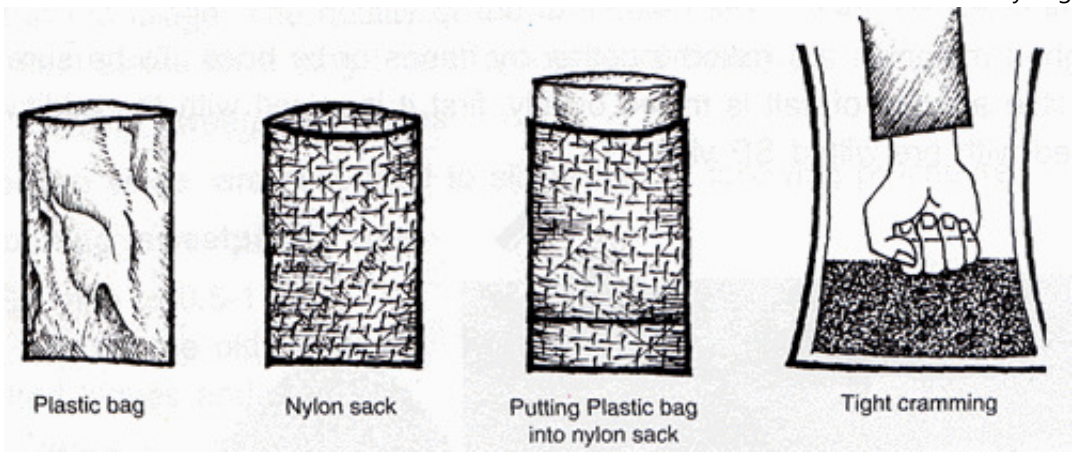
<u>Formula 2</u>: (83.5 % prewilted SP vine + 0.5 % salt + 6 % cassava meal (or 6 % corn meal or 6 % rice bran) + 10 % dried and ground chicken manure

- **Mixing and ensiling**

Rice bran or chicken manure **Sweetpotato vine**

The weighed materials are mixed together by hands or by hoes. To be sure that the very little amount of salt is mixed evenly, first it is mixed with the additive(s) then mixed with pre-wilted SP vine.

The mixture can be put into containers or nylon bags but it is best to put it in two layers of nylon bags (nylon bag inside and one sack outside). Hence, it is more convenient to feed pigs and keep the bags anaerobic during feeding. This mixture should be put in layers of about 15-20 cm. After each layer, press own hard to remove air from the materials. Close your hand as a fist and press it down hard layer by layer. Avoid scratching the bags. Immediately after finishing this work the bags are tightly closed. Remember the air must come out of the bag before closing.



- **Packing the bags**

The bags containing the fermented feed need to be kept in a dry, cool place and avoid mice and insects. The bags would become aerobic when bit or scratched by them; consequently, the feed would mold or rot.

Remark: Check the bags during the first and second day after fermenting. If there is air in the bags, open the bag to let the air out then close tightly again. This air is generated by the transpiration of SP vine or roots.

1.1.3 Ensiling sweetpotato roots

The procedure of ensiling sweetpotato roots is as follows:

- **Grating, chopping or slicing sweetpotato root**

Grate, chop or slice SP root as small as possible. Remove the

rotted or weevil-attacked parts of the roots, or discard the whole root if well damaged. Ensiling should be done as soon as enough sweetpotato roots have been grated.

- **Weighing ingredients**

Weigh the grated or chopped SP root and the additives according to the proportion of the formulas below:

Formula 3: 79.5 % SP root + 0.5 % salt + 20 % rice bran (or cassava leaf meal)

If you have chicken manure, use the formula below:

Formula 4: 79.5 % SP root + 0.5 % salt + 20 % dried, ground chicken manure.

- **Mixing and ensiling**

Mix the same way as fermenting SP vine but pack the ferment in 3 layers of bags (2 nylon bags inside and 1 sack outside) to avoid aerobic conditions or leaking. If there are lumps among the grated SP root, it is necessary to break them so that SP root particles can adhere to salt and the other additive particles.

• Packing the bags (refer to methods for packing fermenting SP vine).

1.2 Using sweetpotato vine and root silage to feed pigs

• How many days after ensiling can we start using ensiled sweetpotato vine and root to feed pigs?

If sweetpotato vines are ensiled according to formula 1 (with rice bran or com meal or cassava meal and salt), it can be fed to pigs

at 14 days after ensiling. If sweetpotato vines are ensiled according to formula 2 (with rice bran or com meal or cassava meal and salt and chicken manure), it should wait until 21 days after ensiling.

If sweetpotato roots are ensiled according to formula 3 (with rice bran or cassava leaf meal and salt), it can be fed to pigs at 14 days after ensiling. If sweeetpotato roots are ensiled according to formula 4 (with chicken manure and salt), it should wait until 30 days after ensiling.

The proposed period of time is needed for the pH value to become stable. Under this management, the quality of the ensiled feed is good and stable and there is no risk associated with pathogens.

• Which pigs can be fed with silage made of sweetpotato vines and roots?

Fattening pigs from 18-20 kg live weight (or after the age of 2-2.5 months) can be fed with SP vine and root silage because by this time the physiology and functions of the digestive tract have been completed and become stable, so there would not be disturbances from eating fermented feeds.

Besides this, sows, including nursing sows, can be fed with sweetpotato vine and root silage but small piglets under the age

of 2-2.5 months should not be fed sweetpotato vine and root silage.

• How long can fermented SP vine and root silage be stored?

It depends on anaerobic conditions. If it is the most anaerobic (well pressed, air tight closed, no hole, no scratches), it can be stored for at least 4.5-5 months with no significant nutritive value reduction.

• Method of feeding sweetpotato vines and roots silage to pigs

Sweetpotato vine and root silages are mixed with concentrates according to Section 3 of this chapter.

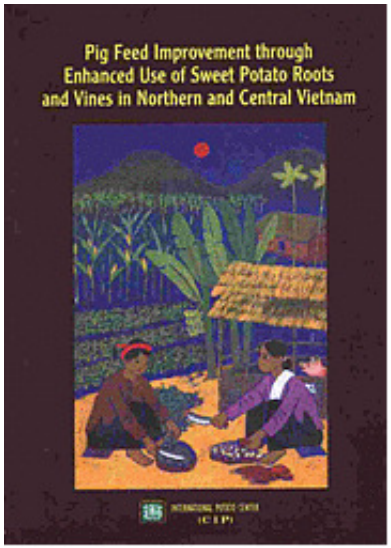
When sweetpotato vine and root silage are offered the first time, animals must learn to adapt to these new diets including the

silage.

- **How to adapt**

For the first 2-3 days feed pigs only twice per day (early evening and late morning), and reduce the amount of feed so that pigs are hungry. This way they will have to eat new feeds and get acquainted with the new diet faster, and this helps to reduce the adaptation period. The amount of new feed should be increased gradually, so this can take one week. One should be strict in getting pigs acquainted with the new diet.

The silage made of sweetpotato vines or roots, fresh chopped SP vine and the base feed (commercial concentrates) are weighed or estimated according to the rations for each growing stage (i.e., live weight categories) of pigs. The daily ration formulas are provided later in the chapter. Feeds are mixed together with some water and fed uncooked (raw) to pigs. In winter, water should be heated. The daily feed ration should be divided into three meals to feed pigs in the morning, in the afternoon and in the evening. Feeding in this way is simple, convenient and economical because no fuel, time, or labor is needed to cook the feed.



Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam

Contents:

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2. Feed crops and their processing and storage methods

Main available feeds include rice bran, corn, and sweetpotato (SP)

vine; in addition, SP root, cassava roots, and cassava leaf are also very important feed resources for pigs.

2.1 Energy sources

2.1.1 Sweetpotato (SP) root

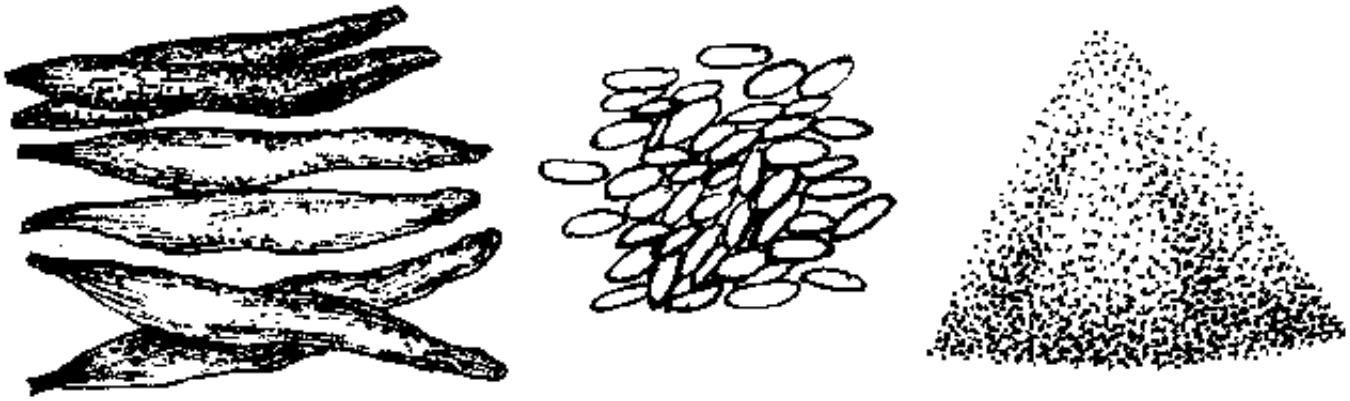
Like com meal and cassava meal, sweetpotato is also a readily available starch feed with high energy content in northern and central Vietnam. Similar to cassava meal, it has very low protein content. One major constraint of feeding sweetpotato roots as pig feed is the trypsin inhibitor which needs to be eliminated by bringing the feed to boil. Therefore, protein supplementation is also needed for sweetpotato root-based diet. SP root is very difficult to store for long because of its perishability and weevil attack. Hence, there is a need to process, such as ensiling, not only to reduce losses but also to improve quality by increasing nutritional level and decreasing trypsin inhibitor level, during long storage and use.

2.1.2 Dried cassava slices (chips) and cassava meal

Cassava root is also an available, common and cheap starch feed with high energy but low protein content. So protein supplementation is needed for the diets including cassava root meal. Fresh cassava roots contain high levels of hydrocyanic acid (HCN), which is toxic to animals, and cassava root cannot be stored in fresh form for a long time. It is better to store in form of dried chips or

slices for later use.

To make chips or cassava meal, wash roots after harvesting. Then slice them (it is better when the brown peel is eliminated before slicing) and dry naturally in the sun on concrete floor until they become crispy dried and the moisture content gets below 14%. Drying time should not exceed 2 days. When it exceeds 3 days, quality may deteriorate. Put the dried slices in completely tight nylon bags for storage. The bags should be kept in a high, dry and cool place. They are milled only before feeding to pigs and they should be ground on a 1 mm sieve. Cassava meal prepared in this way has little risk of poisoning with hydrocyanic acid.

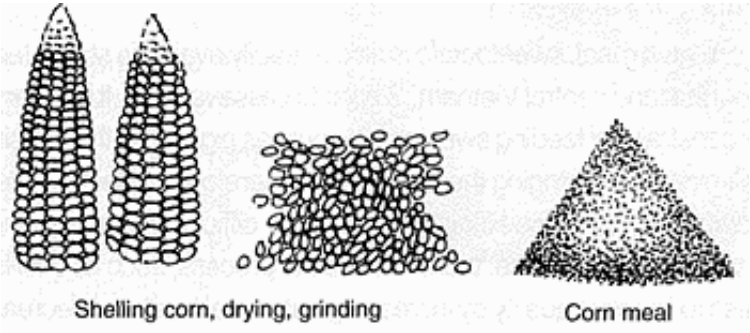


Chipping, drying, grinding **Cassava meal**

2.1.3 Corn meal

This is the most common and most available starch feed with high

energy content. After harvesting, eliminating hairs, and shelling, the seeds are dried naturally in the sun on concrete floor and turned over regularly until reaching the moisture content of 14 % or below. The seeds are stored in a container to protect them from insects and rats. Before feeding to pigs they are ground to 1 mm.



2.2 Protein sources

2.2.1 Rice bran

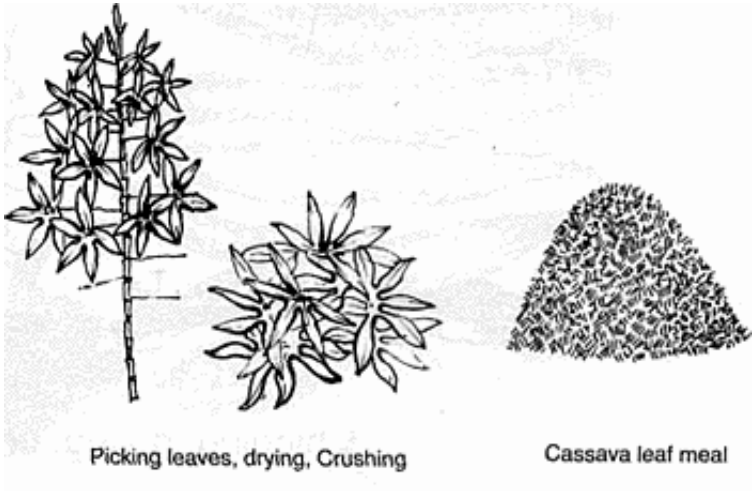
This is the by-product of the milling industry. It is a good source of protein, fat, minerals and vitamin (B1). For pigs, rice bran Class 1 should be used because of its higher protein, fat and low fibre content.

2.2.2 Cassava leaf meal

Cassava leaf meal is a good feed source for animals because of its high protein, carotene and ash content. Fresh cassava leaves contain

high HCN which can be eliminated by processing such as drying or ensiling.

After harvest, cassava leaves should be chopped not only because it helps to reduce cyanide, but also it shortens the drying time. Simple sun drying alone eliminates almost 90 % of the initial cyanide content. When combined with chopping, cyanide in the dried meal is reduced to levels which are safer for monogastric animals. They are then naturally dried in the sun by uniform distribution on concrete floor and turned over regularly as necessary. Once the moisture content reaches 14 % or lower, they become crispy and



become easier to break by hand. Drying takes two days in sunny and dry weather. After that they can be preserved in completely tight nylon bags for later use. The bags can be kept in the kitchen under

the roof or in a high, dry and cool place. This procedure of preservation risks little chance of molding and insect infestation. Dried cassava leaves need to be ground on 1 mm sieve before feeding to pigs.

2.2.3 Sweetpotato vine

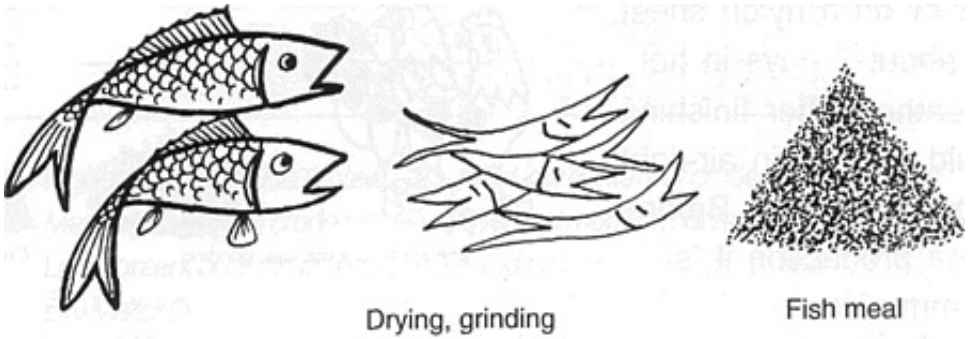
Sweetpotato vine is a good source of protein, ash and vitamins but rotting often develops, especially during the winter when it is cold and humid. Hence, it needs to be processed to improve quality, particularly increasing CP, and for prolonged use. Ensiling is a good method to process and store sweetpotato vine. For dual-purpose SP, vines are harvested in one cutting, which makes it convenient to irrigate, fertilise, and manage ensiling. The methods of ensiling sweetpotato vine and root have been discussed in an earlier section.

2.2.4 Fish meal

Fish meal contains high protein, fat, and ash content, and the animal protein source with high biological value makes it a particularly good feed.

Fish can be dried naturally in the sun or artificially in an oven. The dried whole fish can be preserved in completely air-tight nylon bags. Before feeding to pigs they should be ground. Fish is difficult to grind alone because of its high fat level, so they should be ground with dried com or soybean. For example, fish can comprise 10% of

100 kg of mixed concentrate feed. Or, 10 kg of fish can be mixed with 44 kg of com seeds and 10 kg of roasted soybean seeds before grinding them together.



2.2.5 Roasted ground soybean

Soybean is also a protein- and fat-rich feed. It provides plant protein with high biological value. Together with fish meal, roasted ground soybean is a good protein supplement for pigs when they are fed with cassava meal and sweetpotato root.

After harvest, soybean can be dried naturally in the sun as with corn. When drying is completed soybeans should be preserved in a container to protect from insects. Before grinding to feed to pigs, soybeans should be well roasted to eliminate trypsin inhibitor and to improve flavour.

2.2.6 Chicken manure

Although chicken manure is a waste product of chicken production, it is a very cheap source of protein and minerals. After drying it can be an additive for making silage of sweetpotato vines and roots. Ensiling has the effect of eliminating pathogens potentially present in chicken manure.

Two sources of chicken manure are available; The first source is from industrial chicken production including broiler and laying chickens, fed on balanced commercial feeds (feeds from the joint-venture companies or self making). The second source is from Free-ranging chicken raising, manure can be collected only when the chickens are inside the pen during the night. Industrial chicken manure has highest N content than Free-ranging one with, and the

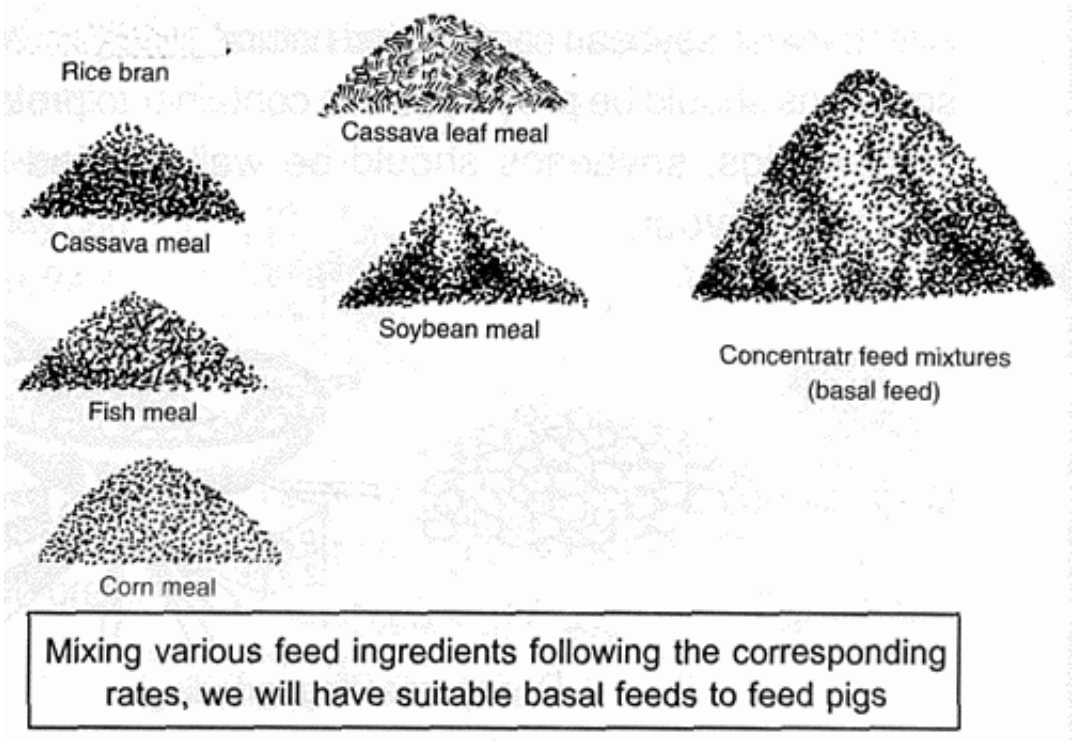
quality of boiler chicken manure is higher than the one from laying hens.

The chicken manure used for animal feed could come from broiler's manure cage floor system caught on a nylon sheet since its protein content is high while fibre and ash contents are lower. On the other hand, it is not contaminated with soil. It can be collected every 5-7 days before drying in the sun on concrete floor or on a nylon sheet. Drying takes about 2 days in hot and sunny weather. After finishing drying it should be kept in air-tight nylon bags for longer use. Before using for silage production it is ground on 1 mm sieve.

2.3 Concentrate feed mixtures (basal feed)

Concentrate feed mixture is a compound from various feed ingredients: from starch, energy source (com meal, cassava meal), protein and fat sources (rice bran, cassava leaf meal, soybean, fish meal) and mineral sources (mineral premix or dicalcium phosphate) to supply the basic requirement of the pigs diet.

After grinding on 1 mm sieve, the feed materials (com meal, cassava meal, cassava leaf meal, fish meal, soybean, rice bran) are mixed together according to the proportion shown in a later section. The ingredients can be mixed manually (by hand or by hoes) or by means of a mechanical mixer. If mixed manually it should be mixed and turned over 3-5 times until the mixture becomes well integrated.



2.4 Chemical composition and nutritive value of main feeds for pigs in Vietnam

Feed	DM	CP	TP	EE	CF	NFE	T.ash	Ca	P	ME
Rice bran 1	87.58	13.00		12.03	7.77	46.41	8.37	0.17	1.65	2553
Rice bran II	90.27	9.76		6.76	18.57	40.09	15.09	0.32	0.54	1803
Rice bran III	89.70	7.60		5.00	23.30	38.90	14.90	0.34	0.65	1308
Red corn	88.11	9.27		4.21	3.05	70.08	1.50	0.09	0.15	3265
White corn	86.71	8.88		4.20	2.32	70.00	1.31	0.14	0.30	3235
Yellow corn	87.30	8.90		4.40	2.70	69.90	1.40	0.22	0.30	3248
Dried cassava with hull	89.10	2.94		1.89	3.14	79.41	1.72	0.14	0.14	3145
Dried cassava without hull	87.41	2.87		1.68	2.95	77.73	2.18	0.23	0.15	3138
Cassava leaf meal	84.91	21.74		4.50	14.53	38.23	5.91	1.10	0.63	234S
SP root	18.64	0.81		0.19	0.87	16.02	0.75	0.07	0.03	957
SP vine	9.21	1.42		0.25	1.92	4.50	1.13	0.14	0.06	303
Ch.manureCP1	91.04	24.81	4.16	2.02	10.80	30.23	23.19			
Ch.manureCP2	85.40	22.60	11.54	2.27	14.91	16.84	28.77	2.22	1.42	
Ch.manure CG	89.72	17.26	19.39	1.14	19.71	28.80	18.83	3.13	2.33	

Ch. manure KB	88.06	23.29	15.60	1.14	15.31	28.80	19.52			
Ch.manure TH	89.10	13.80	7.85	1.12	18.26	26.43	29.49			

Rice bran I: *High content of crude protein (13%) and low content of crude fiber (7.8%)*

Rice bran II: ***Medium content of crude protein (9.8%) and medium content of crude fiber (18.6%)***

Ricebran III: ***Low content of crude protein (7.6%) and high content of crude fiber(23.3%)***

DM. ***Dry Matter(%)***

CP. ***Crude Protein (%)***

TP. ***True Protein (%)***

EE. ***Ether Extract(%)***

CR. ***Crude Fibre(%)***

NFE. ***Nitrogen Free Extract (%)***

T.ash: ***Total ash (%)***

Ca: ***Calcium (%)***

P. ***Phosphorus (%)***

ME. ***Metabolisable Energy (kcal/kg).***

Ch.manure CP1: ***Meat purpose broiler chickens' manure from cage floor system caught on a nylon sheet, fed with CP***

group's feed.

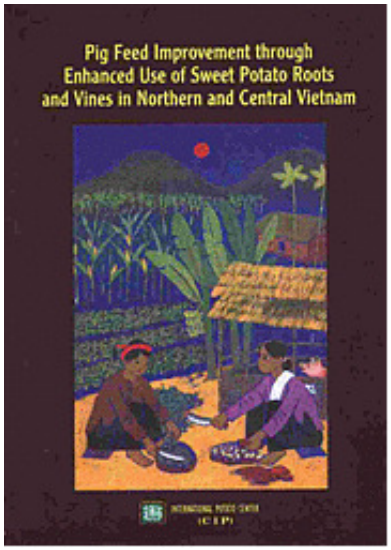
Ch.manure CP2:	***Meat purpose broiler chickens' manure from cage floor system caught on ground, fed with CP group's feed.***
Ch.manure CG:	***Meat purpose broiler chickens' manure from cage floor system caught on a nylon sheet, fed with Cargill's feed***
Ch.manure KB:	***Kabir dual purpose (a Chinese breed) broiler chickens' litter caught from deep litter system with rice husk bedding material, sieved to eliminate rice husk.***
Ch.manure TH:	***Tam Hoangdual purpose (a Chinese breed) broiler chickens' litter caught from deep litter system with rice husk bedding material, sieved to eliminate rice husk***


Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam

Contents:

INTRODUCTION

PART I -SELECTING AND GROWING



Technical supplement: Some principles of pig nutrition in the tropics

3 Composition of concentrate feed mixtures (basal feed) and the rations for pigs for various weight categories

3.1 Summary of various types of feed

Type	Available feeds	Basal feed composition (See section 3.2)	Daily feed ration (See section 3.3)	SP vine silage formula (See section 3.4)
1	Rice bran, corn meal, cassava meal, cassava leaf meal, soybean, fish meal, SP vine and root, chicken manure	Table 1	Table A and B	Formula 2 and 4
2	Rice bran, corn meal, soy bean, fish meal, SP vine and root, chicken manure	Table 2	Table A and B	Formula 2 and 4
3	Rice bran, corn meal,	Table 3	Table C	Formula 2

	cassava meal, soybean, fish meal, SP vine, chicken manure			
4	Rice bran, corn meal, SP vine, chicken manure	Table 4	Table C	Formula 2

3.2 Composition of four types of basal feed and corresponding rations

3.2.1 Basal feed type 1 and corresponding ration

If the feed available at your location includes *rice bran, corn meal, cassava meal, cassava leaf meal, soybean, fish meal, SP vine and root, chicken manure,* but no mineral supplements, use the basal feed formulation in Table 1. SP vine and root are to be ensiled according to Formula 2 and 4, respectively.

Table 1. Composition of basal feed type 1.

Material	**Composition (%)**		
	For pig: 20-30 kg	**For pig: 30-60**	**For pig: >60**

Cassava meal	13	18 kg	25 kg
Cassava leaf meal	8	10	12
Rice bran	15	13	10
Com meal	44	39	35
Fish meal	10	10	10
Soybean	10	10	10
CP(%)	15.55	15.32	15.19
ME (kcal/kg)	2,916	2,927	2,947
	12-15	16-20	18-23

***If the chicken manure is not available, farmers may supplement diet with 2% premix mineral and 1% Dicalcium Phosphate.**

When base feed type 1 is used, either the daily feed ration in Table A (feeding fermented SP root with fresh SP vine) or Table B (feeding both SP root and vine silage) can be use to feed pigs.

3.2.2 Basal feed type 2 and corresponding ration

If the locally available feed includes *rice bran, corn meal, soybean, fish meal, SP vine and root, chicken manure* but no mineral supplements, use the base feed formulation in table 2. SP vine and root are to be ensiled according to Formula 2 and 4, respectively.

When base feed type 2 is used, the daily feed ration in Table A (feeding SP root silage with fresh SP vine) or Table B (feeding both SP root and vine silage) can be used to feed pigs.

Table 2. Composition of basal feed type 2

Material	Composition (%)		
	For pig: 20-30 kg	For pig: 30-60 kg	For pig:>60kg
Rice bran	25	26	27
Corn meal	56	56	56
Fish meal	9	9	9
Soybean	10	9	8
CP(%)	15.35	15.09	14.82
ME(kcal/kg)	3,304	3,021	3,009
Weigh gain (kg/month)	12-14	16-17	17-20

*** If the chicken manure is not available, farmers may supplement diet with 2% premix mineral 3.2.3 Basal feed type 3 and corresponding ration**

If the local available feed materials are rice bran, corn meal, cassava meal, soybean, fish meal, SP vine, chicken manure but no mineral supplements, use the basal feed formulation in Table 3. SP vines are to be ensiled according to Formula 2. When basal feed type 3 is used, use the daily feed ration in Table C.

Table 3. Composition of basal feed type 3

Material	Composition (%)		
	For pig: 20-30 kg	For pig: 30-60 kg	For pig:>60kg
Cassava meal	13	18	25
Rice bran	30	28	25
Corn meal	40	39	36
Fish meal	9	8	7
Soybean	8	7	7
CP(%)	14.45	13.48	12.64
ME(kcal/kg)	3,040	3,046	3,065
Weigh gain (kg/month)	12-15	16-18	17-20

***If the chicken manure is not available, farmers may supplement diet with 2% premix mineral and 1% Dicalcium Phosphate.**

3.2.4 Basal feed type 4 and corresponding ration

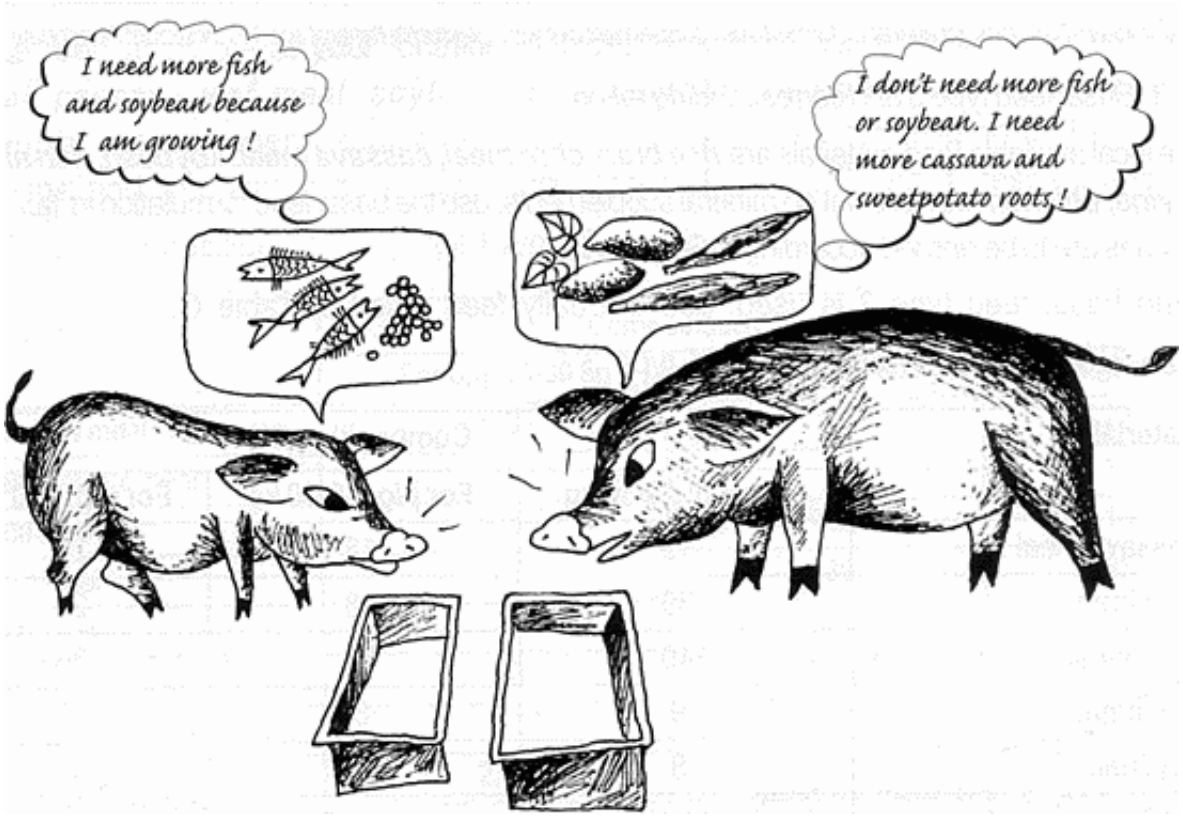
If the locally available feed includes *rice bran, corn meal, SP vine, chicken manure* but no mineral supplements, use the basal feed formulation in Table 4. SP vines are to be ensiled according to Formula 2.

When basal feed type 4 is used, use the daily feed ration in Table C.

Table 4. Composition of basal feed type 4

Material	Composition (%)		
	For pig: 20-30 kg	For pig: 30-60 kg	For pig:>60kg
Rice bran	35	32	30
Corn meal	65	68	70
CP(%)	10.00	9.94	9.90
ME(kcal/kg)	3,096	3,037	3,051
Weigh gain (kg/month)	10-12	12-15	14- 17

***If the chicken manure is not available, farmers may supplement diet with 2% premix mineral and 1% Dicalcium Phosphate.**



3.3 Daily feed ration

Table A. Recommended daily feed ration (feeding SP root silage with fresh SP vine).

Feed	Feed amount (kg/head/day)

	For pig: 20-30 kg	For pig: 30-40 kg	For pig: 40-50 kg	For pig: 50-60 kg	For pig: >60kg
Basal feed	1.0-1.4	1.4-1.7	1.7-1.9	1.9-2.2	2.2-3.0
SP root silage	0.7-1.0	1.0-1.2	1.2-1.5	1.2-1.6	1.6-1.8
Fresh SP vine	0.5	0.5	0.5	0.5	0.5

Table B. Recommended daily feed ration (feeding both SP root and vine silage).

Feed	Feed amount (kg/head/day)				
	For pig: 20-30 kg	For pig: 30-40 kg	For pig: 40-50 kg	For pig: 50-60 kg	For pig: >60kg
Basal feed	1.0-1.5	1.5-1.8	1.8-2.0	2.0-2.3	2.3-3.0
SP root silage	0.3-0.5	0.5-0.6	0.6-0.8	0.8-0.9	0.9-1.0
SP vine silage	0.3-0.5	0.5-0.6	0.6-0.8	0.8-0.9	0.9-1.0

Table C: Recommended daily feed ration (feeding SP vine silage)

Feed	Feed amount (kg/head/day)				
	For pig: 20-30 kg	For pig: 30-40 kg	For pig: 40-50 kg	For pig: 50-60 kg	For pig: >60kg
Basal feed	1.0-1.5	1.5-1.8	1.8-2.0	2.0-2.3	2.3-3.0
SP vine silage	0.7-1.0	1.0-1.2	1.2-1.5	1.2-1.6	1.6-1.8

3.4 Vine and root sweetpotato silage formulae

- **Formula 1 :**

  93.5 % pre-wilted SP vine + 0.5 % salt

  + 6 % cassava meal (or 6 % corn meal or 6 % rice bran)

- **Formula 2:**

  83.5 % pre-wilted SP vine + 0.5 % salt

  + 6 % cassava meal (or 6 % corn meal or 6 % rice bran)

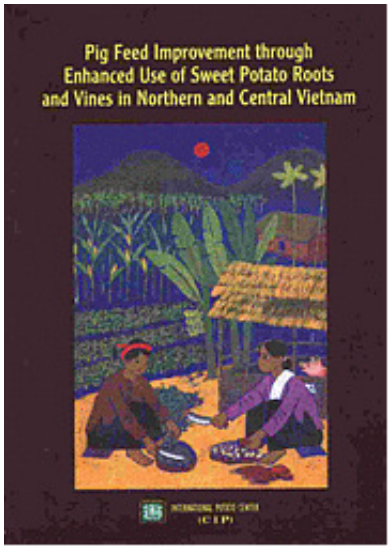
  + 10 % dried and ground chicken manure

- **Formula 3:**

  79.5 % SP root + 0.5 % salt + 20 % rice bran (or cassava leaf meal)

- **Formula 4:**

  79.5 % SP root + 0.5 % salt + 20 % dried, ground chicken manure.



Pig Feed Improvement through Enhanced Use of Sweet Potato Roots and Vines in Northern and Central Vietnam

Contents:

SOME PRINCIPLES OF PIG NUTRITION IN THE TROPICS

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Small-scale rural farmers cannot compete with the large-scale, peri-urban, and vertically integrated systems using the same type of feed resources (i.e. imported grain cereals and protein sources), animal genotypes and facilities. In order to succeed, these farmers need to develop alternative pig production systems, mainly based on the use of locally available feed resources, preferably produced in the same farm, and avoiding as much as possible any processing that will increase the costs of production. However, in order to make an efficient use of those resources, it is necessary to understand the principles that govern swine nutrition, as well as the impact of using feed resources with generally low dry matter content, and rich in sugars, lipids and/or fiber.

The Digestive Tract

The gastrointestinal tract of the pig is relatively simple. It has three compartments: the stomach, the small intestine and the large intestine (Figure 1). The stomach is a reservoir where ingested feed is mixed and subject to the action of pepsin to partially degrade the diet proteins. In the small intestine not only occurs the enzymatic digestion of sugars, starch, lipids and protein, but also the absorption of the products of digestion (glucose, fatty acids and amino acids). The large intestine is the fermentation compartment, where microorganisms (intestinal flora) attack the feed components that have not been digested in the previous compartments (including the fiber), intestinal

secretions and cell particles falling off from the mucosa that linens the small intestine. Absorption of part of the products of fermentation, water and minerals also occur in the large intestine.

While the fermentation ability of the pig in its large intestine is not comparable to that in the rumen-reticulum of ruminants (Figure 2), it is frequently underestimated. The volatile fatty acids produced during fermentation in the large intestine of the pig can supply up to 30% of the energy requirements of growing/finishing animals.

The digesta in all compartments is liquid, except in the last portion of the large intestine (the rectum) where massive absorption of water occurs, making the feces more solid. The length of time that the digesta is retained in the large intestine determines the entire transit time along the digestive tract. The inclusion of fibrous feeds in the ration (i.e., sweet potato vines) results in increased retention time in the large intestine, and consequently in the small intestine, giving better chance to the bile and enzymes secreted by the pancreas to digest the feed that reaches the small intestine. This also favors absorption.

The digestive capacity of the pig increases with age. Lactating pigs have a well developed stomach to cloth and digest milk, but during the first weeks of age the small intestine and the pancreas develop, favoring the use of solid starchy and protein feeds. The

maturation of the large intestine is slower, therefore it is better to delay the inclusion of fibrous feeds in rations, using these mostly for growing/ finishing and mature pigs.

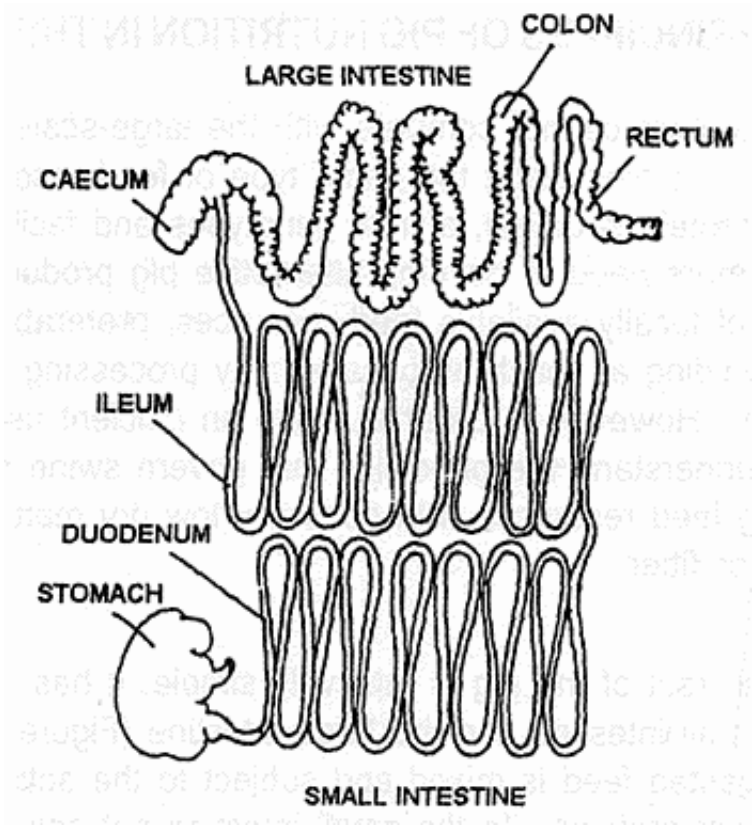

Figure 1. Gastro intestinal tract of a pig.

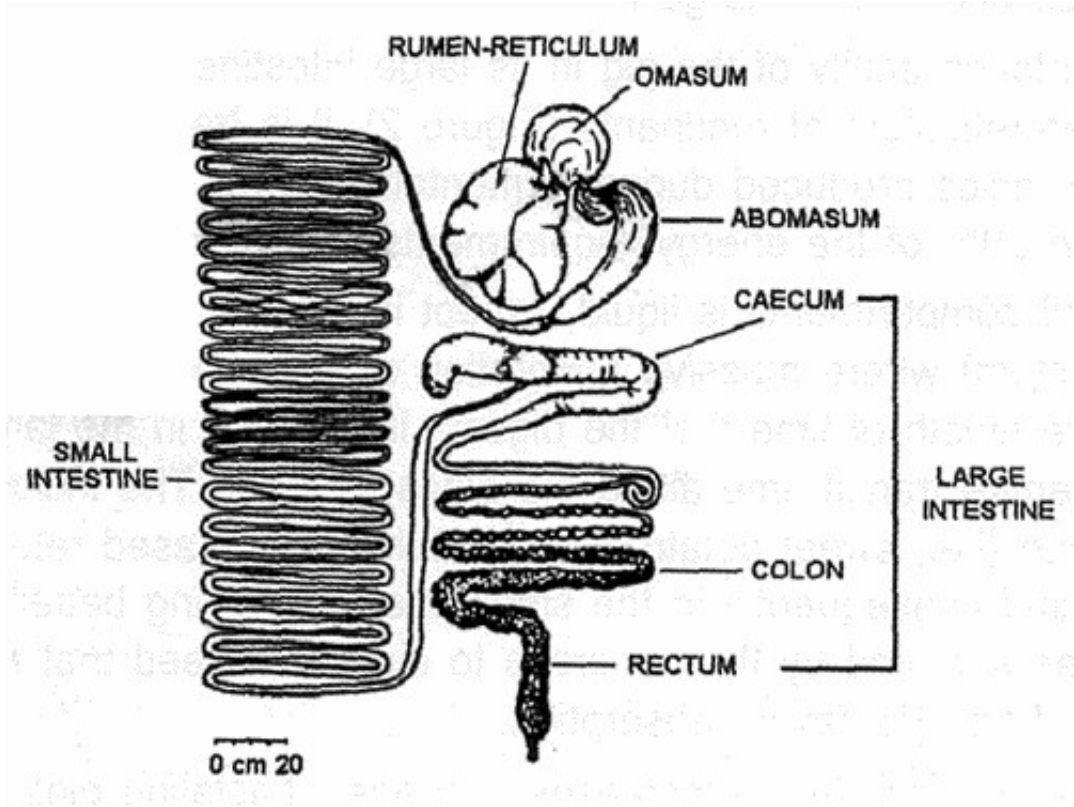

Figure 2. Gastro intestinal tract of a sheep

Energy and Protein Requirements

While industrial systems aim to obtain the maximum biological performance of animals, this should not be the goal for small-scale pig production systems in the tropics. The law of diminishing returns applies to animal feeding, as it does in other biological processes. Therefore, the increments in response require each time higher levels of inputs, and it is more critical

when approaching the maximum. Swine production based on non-traditional feed resources that are mostly energy-rich creates a greater dependence on high quality protein sources, which are expensive and difficult to be produced at the farm level.

Although energy and protein requirements for pigs have been already developed in temperate areas, these need to be revised under tropical conditions, not only considering the type of feed resources available, but also the impact that temperature and relative humidity have on feed intake and heat load dissipation. Higher ambient temperature results in lower feed intake, therefore diet composition needs to be adjusted to provide the nutrients required, trying to maintain an adequate protein-energy ratio as well.

Frequently, energy and protein requirements for pigs are considered separately, but the balance between these is critical on the efficiency of feed conversion. Although in practical terms we refer to protein requirements for pigs, there are specific needs for essential amino acids, with lysine, methionine and tryptophan being the most limiting under ordinary farm conditions.

Most tubers, roots, fruits and other non-traditional feed resources used for pig feeding in small scale systems in the tropics, including sweet potato tubers, are rich in energy but

have much lower crude protein content than grains (1.5-5% vs. 8-10%, respectively). Although some may consider this a disadvantage, in fact this could be the contrary, as it is easier to find a protein supplement already balanced for essential amino acids, rather than try to compensate for the imbalanced amino acids in the basal diet, as in the case of grain-based rations.

In general it has been suggested that a growing/finishing pig, weighing from 25 to 90 kg, and fed tropical roots, tubers or sugar cane, requires 2.5 to 2.8 kg of dry matter (DM) per day. These rations generally consist of 2.0 to 2.3 kg of DM of the energy source and 500g of a protein supplement. Since the supplement is about one-fifth of the total intake, then vitamins and minerals should be included at five times the concentration recommended for grain-based concentrates.

Supplementation of Sweet Potato-based Diets

Sweet-potato tubers are rich sources of starch, vitamin A, vitamin C and several vitamins of the B complex (niacin, thiamine and riboflavin), but poor in protein and fat, and low in fiber. As indicated before, to obtain adequate live weight gain responses, it is necessary to have a balance between amino acid and energy contents in the diet; therefore, diets based on the use of sweet potato tubers need to be accordingly supplemented with protein sources.

Another aspect to be considered when sweet potatoes are fed to pigs is that raw tubers have trypsin inhibitors that interfere with protein digestibility, resulting in poorer live weight gains of growing/finishing pigs. Cooking not only reduces those compounds, but also increases starch digestibility. Ensiling can lower the anti-trypsin factors, but do not eliminate them, therefore protein digestibility in ensiled sweet potato is intermediate between fresh and cooked. Sun drying of sweet potato chips also reduces the presence of trypsin inhibitors to levels equivalent to the ones obtained by cooking. Also, peeling sweet potatoes significantly increases their protein digestibility. However, it does not have an effect on the digestible or metabolizable energy values of sweet potato tubers.

Sweet potato vines are rich in protein, sugars, vitamins, but are relatively high in fiber and have a very low dry matter content. The last two factors may explain why the introduction of sweet potato vines in the diet usually results in reduced dry mater intake. Sweet potato vines can be used to partially replace other protein sources (e.g., soybean meal), but it should not exceed 13% of the total ration in growing/finishing pig diets. The use of sweet potato vines could be higher in diets for mature females and males (reproductive animals), as in those cases the interest is on maintaining rather than gaining weight, besides the fact that in those animals the large intestine has reached maximum development.

Sources of Figures:

Figure 1

Perez, R. 1997. Feeding Pigs in the Tropics. FAO Animal Production and Health Paper No. 132. FAO, Rome, Italy. 185 p.

Figure 2

Van Soest, PJ. 1982. Nutritional Ecology of the Ruminant. 0 & B Books, Corvallis, Oregon. 374 p.