Food Resilience Through Root and Tuber Crops in Upland and Coastal Communities of the Asia-Pacific (FoodSTART+)

Training on Ensiling Sweetpotato, Cassava and other Locally Available Material for Feeding Pigs and Cattle

Training Guide and Summary of Content

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With funding by

TRAINING ON ENSILING SWEETPOTATO, CASSAVA AND OTHER LOCALLY AVAILABLE MATERIAL FOR FEEDING PIGS AND CATTLE

TRAINING GUIDE AND SUMMARY OF CONTENT

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1. ABOUT THE TRAINING

This training is one of the several activities conducted in the framework of the collaboration between the Food Resilience Through Root and Tuber Crops in Upland and Coastal Communities of the Asia-Pacific (FoodSTART+) project and the Meghalaya Livelihood and Access to Market (LAMP) project. FoodSTART+ is led by the International Potato Center (CIP) with financial support by the International Fund for Agricultural Development (IFAD) and the European Union. LAMP is implemented by the Meghalaya Basin Development Authority (MBDA) with financial support by IFAD.

Objectives of the training

By learning theories, doing, observing and analyzing practices, at the end of the session participants will learn:

- Theories, practices and benefits of processing crop residues and other available local resources into feed;
- Methods for conserving sweetpotato (SP) vines and roots as well as other feed resources (e.g. cassava leaf and root, groundnut, fish, and soybean);
- Proper use of the stored feeds to formulate balanced ration for enhanced efficiency of fattening.

Participants

Training sessions are conducted in West Garo Hills and East Khasi Hills districts in Meghalaya. Each training is conducted by 2-3 facilitators with about 30-35 participants.

Participants include:

- LAMP staff
- Farmer Business School (FBS) facilitators and FBS participants (farmers)
- Progressive farmers (rearing livestock)
- Officials from Directorate of Horticulture/Agriculture/Animal Husbandry and Veterinary, Department, Meghalaya
- Participants from IFAD-supported FOCUS project in Mizoram and Nagaland.

Criteria for selecting farmer participants include: a) directly engaged in and/or supporting sweetpotato and/or cassava production and pig and/or cattle raising, b) express interest to participate in learning and experimentation on feed innovations over a sustained period of at least six months, c) commit to help other farmers and relevant stakeholders by sharing and disseminating innovations learned from the training.

Venue of the training

A commune is selected through preliminary field visits and consultations with LAMP staff and local leaders. It is ideally a community where production of sweetpotato, cassava and livestock, in particular pigs, are important contributors to rural livelihoods. A good venue for the training is a meeting hall in the commune, cultural house of a village or a house of one of the local farmers. It would be advantageous if the training venue is close to a pig production farm, so that short field visits and exercises can be organized during the training.

Materials for practical sessions of the training

For each training session the following material is needed:

* Notebooks and pens: about 30 of each
* Permanent markers: 3 (black or dark blue colour)
* Scales: 3
* Chopping or slicing machine: 1 or more, or knives for chopping by hands if no chopping machine is available
* Blades, hoes or rakes
* Silage containers: plastic bags, synthetic sacks, plastic drums: as big and as many as possible
* SP vines, SP roots, cassava roots, cassava leaves, residues of cassava starch processing (pulp, peel), grass (elephant, ruzi): as many and as much as possible depending on availability
* Maize meal (maize powder), cassava meal (dried cassava root powder) or rice bran as additive: depending on amount of silage (3% of silage)
* Salt: depending on amount of silage (0.5% of silage)

2. INTRODUCTION TO SOME FEED MATERIALS

Vines and roots of sweetpotato (SP), cassava roots and leaves, residues of cassava and canna starch production can be used for animal feeding. In addition, some forages (elephant grass, ghine grass and stylo), forage maize and other crop by-products (groundnut vine, maize stover) can also be used to feed livestock.

˜ Sweetpotato

Sweetpotato can be produced by two systems as below:

- Dual purpose SP production: SP is produced for both vines and roots. In this system vines can be harvested once (at time of root harvest) or twice (first time at day 70-75 after planting and second time together with root harvest). In the latter, fresh vine yield can reach 39.1-52.4 t/ha.

- Single purpose SP production: SP is produced only for vine (forage SP). The most suitable season for this is spring. There are at least 3 vine cuttings during the whole cropping time. Total fresh vine yield can be 61.2 t/ha with dry matter (DM) content of 11.6% and crude protein (CP) content of 15.1% in DM.

SP root has high water content (76.1-84.5%), it can easily rot and it is often attacked by weevils. It has high energy due to high starch and sugar content but starch of SP root is less digestible because of larger starch molecules. CP content in SP root is higher than in cassava root but still low (2.7-6.5% in DM). SP root needs to be processed for better digestion, properly storage and use.

SP vine has high CP (11.8-21.5%) and carotene content but it is perishable due to very high water content (86.3-92.0%). It should be processed for longer storage and use.

˜ Cassava root

Cassava root is an energy rich feed material because of high starch and sugar content (3,530 kcal of metabolizable energy-ME/kg of DM). However, fresh cassava root has high water content (57-69.3%, low CP (2-3% in DM) and Ca, and P content, and high content of toxic of cyanide (HCN) (313 mg HCN/kg of DM). It is highly perishable and, therefore, methods for processing and conserving fresh cassava roots over a long period of time are needed.

˜ Cassava leaf

Cassava leaf is often a by-product of cassava production. It has high CP (19.6-26.5% in DM) and carotene content. If leaves are progressively harvested 5 times until root harvesting, yield of fresh leaf of 4.2 t/ha can be obtained while that can be only 0.3 t/ha from a single harvest at root harvest. Similarly to cassava root, cassava leaf has very high HCN content (1,380 mg/kg in DM) that can harm animal health. Hence, processing methods are needed to reduce the toxic content and to use this protein rich by-product for animal feed.

˜ Cassava and canna starch residue

Cassava and canna starch residue (waste) are by-products of processing cassava and canna into starch. Cassava starch residue is about 30-50% of fresh cassava root while canna starch residue is about 22% of fresh canna root depending on water content of the residues from different starch processing technologies. These huge amounts of the residues cause water and air pollution and may cause some diseases like cancer and respiration diseases. These residues still have high starch content (60-68% and 72% in DM in cassava and canna starch residues, respectively) that can be used for animal feed. Nevertheless, they have very high water content (water content of cassava residue is 82-89%; that of canna residue is 88%), low CP content (2-3% in DM) and high crude fiber (CF) content (13.6 % in cassava waste DM and 16.6% in canna residue DM). Hence, they need to be processed, stored and properly used for better quality feeds and reducing environmental pollution.

˜ Forages

Elephant grass

Elephant grass is easily planted, has high yield because it can be harvested 5-6 times in a year, after every 20-40 days for each cutting. Its total fresh biomass yield can reach 100-500 t/ha/year. Especially, VA06 variety is high cold and dry tolerant and helps protecting soil against erosion. Elephant grass has water content of 79.2-85.4%; CP content is 6.8-14.4% in DM, depending of conditions, seasons and time of cuttings.

Ghine grass

Ghine grass can be produced on dry land, hot and shady under big trees. This grass also has high yield (150-300 t/ha): 5-7 cuttings/year (after every 25-30 or 40-50 days/cutting), for 4-6 years. It has water content of 70.3-86.8%; CP content is 7.0-15.3% in DM.

Stylo CIAT184 (*Stylosanthes Guianensis*)

This legume can be planted on highland or hilly lands. It is drought but not cold tolerant. It is produced for improving soil and covering it against erosion. Stylo CIAT184 has high total fresh yield of 40-72.5 t/ha with 5-6 cuttings/year and can be produced for 4-5 years. Moreover, it is a good quality legume. Its water content is 85.8-89.6% and CP content is 18.9-20% in DM.

- Maize

There are two types of maize plants that can be used for animal feed: Maize stover after harvesting mature grains and forage maize (more densely planted and harvested at young, milky stage). A special source of the first type is sticky maize when this is intercropped with sweetpotato. After harvesting the cobs, the maize plants are still quite green. It can be harvested with SP vine of the first cutting at 75-80 days after planting. Fresh yield of sticky maize is 2.2-11.1 t/ha, with water content

of 75-80.8%, CP content of 5.6-8.6% in DM. Silage of cassava starch residue ensiled with sticky maize plants and SP vine is a good feed for ruminants.

- Groundnut vine

Groundnut vine is a by-product of groundnut production. Its fresh yield is about 8-10 t/ha. Fresh groundnut vine after harvesting pods contains water content of 79% and CP content of 17% in DM, similar to that of SP vine and stylo.

3. METHODS FOR ENSILING FEED MATERIALS

3.1. Purpose of ensiling - Why ensiling and storing feed materials are needed?

The above mentioned feed materials have similar characteristics and constraints. Most of the ensiling materials have high water content. This makes them highly perishable, potentially causing waste and environmental pollution. In addition, these materials have either low protein or low energy content or high fiber content. Cassava root and cassava leaf have high HCN content. These characteristics and constraints are indicated in table 1 and 2.

Table 1: Characteristics and constraints of some feed materials

Material	Used for	Characteristics	Constraints
Cassava root	Pigs, cattles, buffaloes	High water, low CP, high ME, high HCN content	Easily rot, easily poisoning
SP root	Pigs, cattles, buffaloes	High water, low CP, high ME content	Easily rot, attacked by weevils
Cassava residue	Pigs, cattles, buffaloes	High water, low CP, rather high crude fiber content	Easily rot, causing environment pollution
Canna residue	Cattles, buffaloes	High water, low CP, high crude fiber content	Easily rot, causing environment pollution
SP vine	Pigs, cattles, buffaloes	High water, rather high CP, rather high crude fiber content	Easily perishable
Cassava leaf	Pigs, cattles, buffaloes	High protein, rather high CF, high HCN content	Easily perishable, easily poisoned
Elephant grass, Ghine grass	Cattles, buffaloes	Rather low CP, high CF content	Fast matured, perishable
Stylo	Pigs, cattles, buffaloes	Rather high CP and carotene, high CF content	Perishable
Maize stover	Cattles, buffaloes	Rather low CP, high CF content	Perishable
Groundnut vine	Cattles, buffaloes	Rather high CP, high CF content	Perishable

Table 2: Chemical composition of feed materials

Material	Water content (%)	CP content (% in DM)	CF content (% in DM)	ME (kcal/kg DM)	HCN content (mg/kg DM)
Fresh cassava root	56.7-69.3	2.0-3.0	2.8-4.2	3,530	313
Fresh cassava leaf	65.7-75.7	19.6-26.5	13-14.8	2,821	1,380
Cassava residue	81.8-89.0	2.0-3.0	12.9-14.4	2,300	
SP root	76.1-84.5	2.7-6.5	4.0-4.8	3,686	
SP vine	86.3-92.0	11.8-21.5	19.0	2,266	
Canna residue	88.2-90.7	2.6	16.6-17.1	2,268	
Elephant grass	79.2-85.4	6.8-14.4	27.1-37.8	1,966-2,269	
Ghine grass	70.3-86.8	7-15.3	30.3-37.9	2,018-2,310	
Stylo	89.6-85.8	18.9-20	28.1	2,308	
Sticky maize plant	75.0-80.8	5.6-8.6	28.1	1,961	
Groundnut vine	79.2	17.0	21.1	1,921	

Therefore, it is necessary to have methods for processing, storing, properly using and mixing the materials to overcome the constraints and provide abundant quality feed sources for animal production and reduce environmental impact.

3.2. Advantages of ensiling

- Proper processing and storing of feed materials prevent losses due to rot and weevils, reduces HCN toxicity and prolongs availability of feeds.
- Utilizing by-products (cassava leaf, cassava starch residue, canna starch residue, small SP roots, maize stover, groundnut vine) to obtain valuable feed sources, to solve problem of feed scarcity, especially in winter season and to contribute in reducing environmental pollution.
- Increasing the nutritive value of feed via ensiling (volatile fatty acids such as lactic acid, propionic acid and acetic acid, microorganisms).
- Allowing harvesting and processing more volume of products/by-products from larger areas at the same time.
- Reducing investment for farmers to purchase commercial feeds for animal production.
- Raw feeding is easier and more convenient, reducing labor requirement as well as cost of firewood for feed preparation. In addition, proper use of feed materials and balanced ration increases number of animals raised at the same time hence, enhances efficiency of pig fattening.

3.3. Principles of ensiling

˜ Anaerobic fermentation

Ensiling is a microbial fermentation taking place in an anaerobic environment. The microbes are available in the feed material, with no addition of yeast. The prerequisite condition for this process is to reduce air at minimum from the ensiling material. This can be obtained by keeping the materials in plastic bag, strongly pressed to release the air from the bag and tightly close it to avoid the air from entering into the bag. This practice should be maintained during the entire period of storing and feeding. The bag must be closed tightly after taking out a certain amount of the silage.

˜ Using additives

The use of additives (rice bran, corn meal, cassava meal) for ensiling the energy-poor materials is required to provide precursors/substrates for the microorganisms, enabling them to develop and start the fermentation process. These additives also reduces pH and control the respiration process. On the other hand, rice bran, corn meal and cassava meal act as absorbents in increasing dry matter content of the silages.

3.4. Procedure of ensiling

Table 3. Procedure of ensiling SP root and vine

Ensiling vine, leaf	***Ensiling fresh root***	***Ensiling starch residue, pulp***
Chopping	Chopping, grating, slicing	-
Weighing chopped vine, leaf	Weighing chopped root	Weighing residue, pulp
Weighing cereal additives	-	-
Weighing salt (additive)	Weighing salt (additive)	Weighing salt (additive)
Mixing cereal and salt additives together	-	-
Mixing additive mixture with chopped vine, leaf	Mixing salt with chopped root	Mixing salt with residue, pulp
Putting into bag, pressing, tightly closing, dating	Putting into bag, pressing, tightly closing, dating	Putting into bag, pressing, tightly closing, dating
Packing, storing bags	Packing, storing bags	Packing, storing bags

- Chopping of raw materials (SP root, vine, cassava root, leaf, grasses, maize stover, groundnut vine)
- Weighing of the chopped materials or residues
- Calculating amount of cereal additive (rice bran or corn meal or cassava root meal) and salt needed according to the amount of the ensiling material(s) according to the formula
- Weighing the amount of cereal additive (rice bran or corn meal or cassava root meal) if needed
- Weighing required amount of salt
- Mixing salt with cereal additive (rice bran or corn meal or cassava root meal)
- Mixing the salty additive mixture or only salt with the ensiling material(s)
- Putting the amount of the mixed material into the bag(s), tightly compress and close it. Noting down the date of preparation on the bag
- Storing the bags of silage in a cool and dry place.

Chopping materials

Chopping is done for SP vine and roots, cassava root and leaf, grasses, maize stover or groundnut vine. There is no need to wash the roots before chopping if they had been harvested from dry soil on dry days. During chopping, remove the rotted or weevil-attacked parts of roots or discard the whole root if it is severely damaged. Ensiling should be done as soon as chopping is completed to keep quality of silage. Roots can be chopped, grated or sliced. Roots must be roughly chopped manually into optimum size before placing it in the chopping machine. The particles should be small, similar to the size of a whole rice or broken rice or corn seed.

Note: All materials are ensiled directly in fresh form. Preliminary cooking, pre-wilting or addition of yeast to the materials is not required. Therefore, labor and capital can be saved and it does not depend on the weather conditions. For pig feed, SP vine, cassava leaf or groundnut vine is chopped for about 0.5-1 cm length while for cattle or buffaloes, grasses, maize stover or groundnut vine is chopped at a size of 1-3 cm. For pig feed, leaf of cassava tops is gradually chopped from the bottom tip until the last leaf. The wooden stem with high fiber content cannot be used for feeding pigs.

Weighing materials

- First, weigh the material and place them separately

- Calculate the amount of rice bran or corn meal or cassava root meal (if needed) according to the amount of the ensiling material(s) according to the formula
- Weighing and separately adding rice bran/corn meal/cassava root meal if needed
- Weighing salt.

Mixing

In the case of using rice bran or corn meal or cassava root meal as additive, first, mix one of these additives with salt. Otherwise, if these additives are not needed, mix the salt with a small amount of cereal powder. This is for the salt to be evenly mixed and distributed in the silage providing a good and uniform salty condition for microorganisms to grow faster and evenly. This makes fermentation faster and contributes to better silage quality. The weighed ensiling material is then mixed with the salty mixture. Mixing can be done by hands or hoes. During mixing the chopped root or residue, use hoes or rakes to break the lumps so that salt and other additive particles can evenly adhere to the root particles or residue to ensure better fermentation.

Putting material into bag(s) and pressing

The mixture is put into a two layer bag, lined with a plastic bag from inside and a sack on the outside (if roots or residue are ensiled, use 2 plastic bags inside to avoid leakage of water). As mentioned above, the plastic bag does not allow air to enter into the bag so the anaerobic condition is maintained and the silage will not rot or mould. The sack protects the bag from tearing off and facilitates pressing of the materials.

There are two types of sacks that can be used for containing silage:

- *Small bags:* small bags can have a size of 0.5x0.8 m or 0.8x1.2 m. The used bags of commercial feed can be re-used. One bag can contain about 20-40 kg or 100 kg depending on the size and type of silage. From the experience of some farmers, these small bags are recommended for use on smallholder scale because this amount can be fed to pigs for some days. Disadvantages of these small bags is it contain less silage, hence they are used only for feeding pigs. Farmers would need more bags for storing large amount of silage and a large area for parking the bags.

- *Large bags:* These bags have a size of 1.8x2.2 m. This type of bags can contain up to 600-800 kg of silage after putting them in a container and pressing the silage tightly by stepping on it. These bags are good to make silage for cattle and buffaloes. The container consists of a metal frame, made from two 200 liter oil barrels, as two separate parts that can be dismounted and assembled easily with screws. Inside the metal frame two layers of plastic bags and one sack are used to maintain the anaerobic condition of the silage and to protect it from insects and rodents. Using these big container makes it easier and more comfortable for pressing. About, 2 or 3 people can step on it and press it resulting in a more anaerobic condition of the silage.

The mixture of ensiling materials is put into the plastic bag by hands or hoes, evenly distributed, and then strongly pressed by either hands or feet to release the air from the ensiling materials. This is done for every layer of 15-20 cm until it reaches the top of the bag, leaving enough space for tying. Avoid damaging the plastic bag. Tie the plastic bag(s) first with a good string, then tie the sack. Use a permanent marker to write date and content of the silage on the sack. There are some alternatives to sacks such as a metal or crockery containers or building containers. However, it is necessary to have plastic bags inside these containers to keep the anaerobic condition. If the bag or any container is not full yet, it can be filled next time. Remember to open the bag to fill it just after mixing has been done. Continue filling and pressing as per abovementioned procedure.

Parking and storing the bags of silage

The bags containing the silage should be kept in a dry, cool place to maintain its quality. Avoid holes or scratches made by mice and insects, since these can cause rotting or development of white mould.

Note: Check the bags during the first 3-4 days after ensiling. If the bag is ballooned with too much

air, open it and press the silage inside firmly to release the air from the bag then close it tightly again. This air is CO_2 resulting from the respiration of the ensiled material.

Respiration or transpiration

This is an unavoidable phenomenon or process during the first 3-4 days of fermentation. Fermentation starts when the fermenting micro-organisms starts to develop. Fermentation continues until the pH has reached the normal value for silage. Respiration is the opposite of photosynthesis. Due to oxygen in the air and high temperature, carbohydrates (sugars, starches, $C_6H_{12}O_6$) in roots or vines degrade and get converted into carbon dioxide (CO_2) and water (H_2O).

Carbohydrates (sugars, starches, $C_6H_{12}O_6$)

↓ O_2 and heat

Carbodioxide (CO_2) and water (H_2O)

Respiration of root is higher than that of vine due to higher carbohydrate content. Therefore, it is necessary to check the bags several times in a day.

3.5. Formulas for ensiling

For ensiling one type of material:

- 96.5% chopped SP vine (or cassava leaf or grasses/maize plant or groundnut vine) + 3% corn meal + 0.5% salt
- 99.5% SP root (or chopped cassava root or cassava residue) + 0.5% salt
- 96.5% canna residue + 3% corn meal + 0.5% salt

For ensiling mixture of two or more materials: roots (SP or cassava root) or residues (cassava or canna residue) can be ensiled with vine (SP or groundnut vine), grasses, stylo or maize plant. These materials can be ensiled together in any proportion depending on availability of the materials.

For example:

- SP root + SP vine or stylo or groundnut vine
- Cassava root or cassava residue + SP vine or cassava leaf or stylo or maize plant or grasses or groundnut vine

In this case the following formula can be applied:

- 99.5% mixture of materials + 0.5% salt.

4. USING SILAGES FOR ANIMAL FEEDING

- When can the ensiled feeds be fed to animals?

The ensiled feeds can be fed to pigs 14 days after ensiling. This period is needed for the pH to become stable. However, it is better to use the silages after one month of ensiling.

- How long can the ensiled feed be stored?

It depends on the anaerobic conditions of the silage bags. If it is mostly anaerobic (well pressed, airtight, no hole or no scratches), it can be stored for a long time, at least nine months with no significant reduction in nutritive value.

Note: The bag(s) must be tightly closed after each feeding to maintain the anaerobic condition within the bag during the period of use.

- At what stage or age can animals be fed with the ensiled feeds?

Fattening pigs can be fed with silage from the age at live weight (LW) of 18-20 kg or from the age of 2.5 months but it is recommended from the age at 25 kg LW or 3 months to ensure better efficiency of fattening. By this time the physiology and functions of the digestive tract are fully developed, therefore there would be no problem of eating the ensiled feeds. In addition, sows, including nursing sows, can be fed with the silages but not the young piglets under the age of 2-2.5 months. Cattles and buffaloes can be fed to the silages after the age of one year.

- Method of feeding with ensiled feeds

For pigs

The silage(s) can represent up to 75% of the feeding ration, the remaining portion consisting of compound feed. Nevertheless, it is recommended to use 50% of compound feed and 50% of silage(s). The silage is mixed with the compound feed and some water, and then fed to pigs without cooking. In winter the water should be heated. The daily feed amount should be divided into three meals: in the morning, at noon and in the evening. Amount of feed must be *ad libitum* (the animals should be fed with as much feed as they can consume) so that they can have enough nutrients requirement for high weight gain. Feeding this way is simple, convenient and economical because no fuel, time and labor is needed to cook the feed. When the silage is offered the first time to pigs, they must need some time to be adapted to this new diet.

For cattle or buffaloes

Mix the silage(s) with compound feed (mixture of corn meal, cassava root meal, rice bran and mineral mix or lime powder) then feed it to the animals in raw and dry form. Amount of the compound feed is about 1/10 of the silage(s).

- Ration formulation with balancing nutrients when using silage

- Silages are only processed and stored roughages
- Silage of roots and residues (cassava root, sweetpotato root, cassava residue and canna residue) has low protein content
- Silage of grasses, SP vine, cassava leaf, maize plant, groundnut vine have low energy content.

Therefore, farmers should use compound feeds that have high protein or energy to supplement and balance ration, and provide enough quality and quantity rations to meet the requirements of the animals. Hence, they can reduce the feeding cost, shorten the fattening time, and increase the number of rotations of animal pens/houses for increase profitability. As mentioned before the ideal ration for fattening pigs should consist of 50% silage and 50% compound feed. Compound feed mixture is a feed with balanced nutrients that may complement other feed sources including the ensiled feed. It is a concentrated feed mixture made from various feed ingredients including energy source (corn meal, cassava root meal), protein and fat source (rice bran, cassava leaf meal, soybean, fish meal, shrimps' head and shell, commercial concentrate) and mineral source (mineral premix, dicalcium phosphate) to supply the basic requirements of the diet for animals.

- Using silages for cattle and buffaloes

Ways of using silages (silage of sweetpotato root, cassava root, cassava residue and canna residue) for cattles and buffaloes are the followings:

- Completely tethered: Feed them with the silage(s) supplemented with compound feed (mixture of corn meal, cassava root meal, rice bran and minerals or lime powder) and fresh grass during the day, then rice straw at night.
- Combination of tethering and grazing: Grazing during the day, tethering and supplementing with silage(s) and compound feed at night.

Feed animals with amount of silage(s) according to the availability of the silage(s) at household level. Way of supplementing compound feed: the amount of compound feed is about 10-15% of the amount of the silage(s). Mix the compound feed with silage(s) then feed the animal(s) three times per day. In this way the silages can properly contribute to protect the animals against malnutrition and cold during winter in highlands.

- ***Composition of compound feed for cattles and buffaloes:***

75% of corn meal + 20% rice bran + 5% minerals or lime powder

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- Project PRDU: "Participatory Research for Development in Highlands" - CIAT;
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- Master student project from Gines-Mera funds: "Improving Feeding Systems by Producing and Using Cassava with Stylo and Other Feed Materials for Smallholder Pig Production in Vietnam" - CIAT;
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