INTEGRATED RAT MANAGEMENT
Ecological Guide

IPM National Programme
Vietnam

Plant Protection Department
Food and Agriculture Organization

supported by the government of Australia
2010 (rev.)

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Contents

Introduction

Rats are one pest that causes much damage to agricultural production in Viet Nam and other countries. In agriculture, rats damage many different kinds of crops directly on the fields and the produce in store houses. Rats are also vectors of diseases dangerous to people and animals, particularly, bubonic disease which has killed millions of people all over the world. In addition, rats also destroy many other things due to their gnawing behavior, like precious cultural and art works and household items.

In recent years, agricultural development, like reclining waste lands, an increasing number of crops grown per year, and the building of irrigation systems, has provided favorable conditions, like food and environment, for rat development. This, as well as animal hunting that has reduced natural enemies of rats, are the reasons for the population explosion of rats in Vietnam.

Rats are not a new problem in agriculture. Farmers have traditionally developed methods to control rats in their villages. They are not so easy to control, and many people believe rats are very smart. Actually rats are not so smart, but they do have very good sense of touch, smell and taste. In fact, it is known that rats have a short memory. It is only possible to control these pest of rice by understanding their attributes and behavior.

There are many programmes which have been used to attempt to control rats: rat drives, rat trapping, rat tail campaigns, and burrow destruction. Most of these methods are better for boosting the political standing of local officials than for controlling rats. Long-term rat control requires sustained interests and an understanding of the way rats live. The focus of rat control must be on reducing yield losses. The number of rats killed during a rat drive does not indicate a reduction in yield losses because migration and many more births per rat after many rats are killed in an area (see biology below) cause the rat population to recover very quickly to high levels.

Rat control should be implemented continuously throughout the rice season. If there was high damage in the field during the previous season, then management measures must begin at transplanting time and continue until the latter stages of the rice crop. However, if damage in the previous season was light, rat damage monitoring is also is important. If rat damage begins to increase during the season, then they must be controlled. If rats are not controlled early in the season then there will be heavy damage because after booting rats will not usually accept baits.

Rat control is a social/community concern which must have the participation of everyone in the farmer group. Integrated rat control programmes include prevention methods (reducing habitat and cover), mechanical methods (direct killing in rat drives or traps), biological control (enhancing predators and/or using microorganisms like *biorat*) and chemical baiting methods. All these methods should be used together. When poisons should be used, they should be used with care, and the community should be aware of the effect of these poisons on animals and children. Care in handling the poisons is necessary to avoid self-poisoning. The important point is that community action is the key to rat control.

1. Species and rat distribution

In the rodent order (*Rodentia*), the rat family (*Muridae*) has the biggest number of species. In the world, there are about 6000 species in the rodent order, of which 150 are rat species. In Viet Nam, there are 56 rodent species. The rat family consists of about 43 species distributed throughout the whole country. Based on ecological distribution of rats, they can be divided into 3 major classes:

- Forest rats, consistsing of species living in the forest. They eat many kinds of pods, fruits and plants. Some species can go to fields that are near forests to cause damage, such as *Rattus koratensis*.
- Field rats, consisting of species living mostly in fields and waste lands. They can seriously damages fields. This class includes big field rats (*Rattus argentiventer*), and small field rats (*Rattus losea*), *Rattus molliculus*, *Rattus colori*, and *Bandicota indica*.
- House rats, consisting of species mostly living near people, in residential places, and places that are under construction. This includes *Rattus norvegicus*, *Rattus flavipectus*, and *Rattus exulans*.

Knowing about the classes that certain rat species belong to is important because of the different behaviors of rats in each class. And knowing about behaviors is important for implementing management methods. For example:

- *Chuot khuy* often live in forests but they can also go to fields at the forests' edge to damage rice fields. In the Mekong delta, *chuot khuy* is scattered in the fields in provinces such as Ben Tre.
- *Chuot dan* is a species that is very good at climbing, has a good ability to dig burrows, and can adjust to live in different places. It can live in residential places, places that are under construction, in the fields and in the forests.
- Big field rats (*Rattus argentiventer*), and small field rats (*Rattus losea*) mostly live in the fields or waste lands. This species has caused serious damage in the North and in the South.
- *Chuot dat* (*Bandicota spp.*) often lives on alluvial lands, in the garden, in secondary crop fields and pasture. They damage crops, such as peanuts, sweet potato, cassava, sugarcane as well as roots of industrial crops like coffee and jackfruit tree.
- *Chuot cong*, house rat, *chuot lat* are species living near people, but they can be found also in the fields near houses. They can cause damage in rice fields and stores.

In this ecological field guide, we shall focus on big field rats (*Rattus argentiventer*) because this species is the most common in Vietnam and is the one causing most damage.

Recognizing rat species

Characteristics	*Rattus argentiventer* *(chuot dong lon)*	*Rattus losea* *(chuot dong nho)*		*Rattus mollicubus* *(chuot dan)*	*Rattus koratensis* *(chuot khuy)*		*Rattus colori* *(chuot nhat dong)*		*Baudicota indica* *(chuot dat lon)*	
		North	South		North	South	North	South	North	South
Body length (mm)	145 - 224	145 - 170	137 - 176	140 - 155	163 - 169	145 - 170	62 - 93	51 - 87	180 - 345	231 - 350
Tail length (mm)	120 - 220	121 - 172	129 - 183	145 - 170	169 - 174	150 - 179	70 - 90	57 - 85	167 - 340	179 - 233
Hind feet length (mm)	32 - 44	28 - 32	27 - 32	28 - 33	33 - 35	33 - 36	13 - 19	13 - 16	37 - 70	39 - 72
Ear length (mm)	16 - 20	17 - 21	16 - 20	17 - 21		18 - 21	11 - 15	11 - 14		
Weight (gm)	120 - 200		100 - 169			126 - 165	12 - 19	18 - 32		117 - 150
Back hair	dark brown	yellow	yellow	brown	pale reddish	pale reddish	pale reddish	pale reddish	light black or brown black	light black or brown black
Belly hair	opalescent	light white	light white	opalescent	milky white	milky white	yellowish white	yellowish white	light brown or yellowish	light brown or yellowish
Breasts (prs)	6	6	6	4	6	6	5	5	6	6
In step	dark	light	light				white	white	dark	dark

2. Biology of field rats

2.1. Distinguishing between male and female:

Knowing about the difference in male and female rats is important to understand about population dynamics of rats. Also, males and females have different behaviour. For example, when a female is pregnant and after delivery of your rats, it stays in burrows. The females don't move into the field. Only males do. If we find many rats in the field that are males, and we decide to control rats in the field, we will not affect the females and the very young ones in the burrows. Even if we catch many male rats, the population can increase very rapidly because females and the youngs are not caught.

It is very difficult to distinguish between male and female rats when they are young, even by dissecting them. It is easier when rats are already adults. In order to distinguish between male and female in different stages, the following indicators may be used:

2.1.1. *Male rats*

- Young: testis is lying in the belly, not yet descended to the scrotum
- Reproductive: testis descended to scrotum and turgid
- Old: testis still in scrotum but shriveled

2.1. 2. *Female*: based on the development of breast and reproduction hole

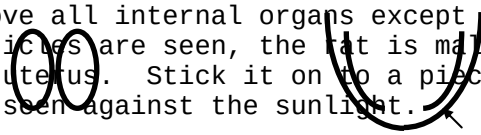
- Young: teats are small, not distinct because many hairs cover them, no milk when squeezed, reproduction hole has wax. (???)
- Reproductive: teats are distinct, milk gland is turgid, hairs surround the teats, no milk when squeezed, reproduction hole is dilated.
- Nursing: teats are big, no hairs surrounding teats, have milk, reproduction hole dilated largely.
- Old: teats are big with hair surrounding, no milk when milk glands are squeezed.

Procedure for dissecting rats

Materials: Tray, scissors, knife, alcohol, cotton, blade, forceps, piece of glass

Procedure:

1. Make sure that the rat you are going to dissect is dead.
2. Put the rat on its back with its head towards the person who is dissecting.
3. Hold the forceps with the left hand, the knife or scissors with the right hand. If using scissors, cut from inside; if using a knife, cut from outside. Use forceps to turn the rat over while cutting. Cut from the head to the anus.
4. Remove all internal organs except the reproductive organs. If two testicles are seen, the rat is male. If it is not a male rat, cut out the uterus. Stick it on to a piece of glass which can then be raised and seen against the sunlight.



o o

testicles o

o uterus

o o

scar

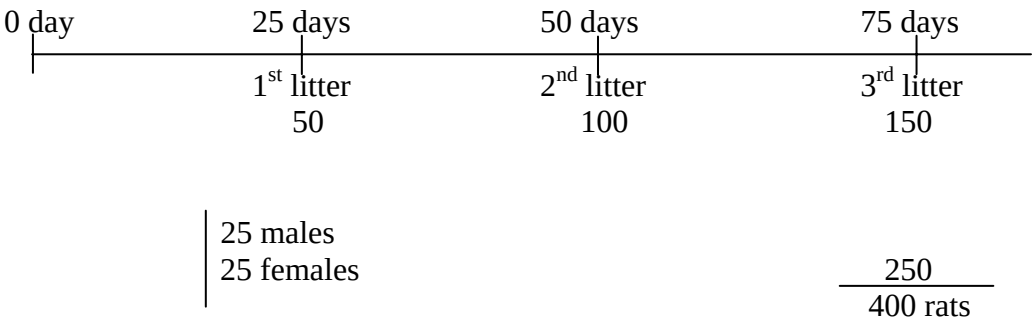
6. The number of offsprings in one litter is equal to the number of scars that can be seen on the inner edges of the uterus. The scars can

2.2. Reproduction of big field rats:

The average life cycle of a rat is about one year. Females can live about 422 days and males 372 days. They become sexually mature when about two months old. The gestation period (pregnancy time) is 21 days. The average number of offspring in each litter is 10. The weaning time for offspring is 30 days. The intervals between two litters is about 40-60 days. In the fields, sometimes two generations can be seen in the same burrows. This means that several days after delivery a female rat can be pregnant again. Each female in its whole life can have 3-5 litters.

Rats reproduce very fast. If 90% of rats are killed in one campaign, 50 days later the rat population will already be half of the original number. After 75 days the rat population will already be 4 times the original number. (This is why rat drives are usually not very successful for reducing yield losses, unless the drives are followed by continuous control programmes.)

Rat population before campaign	Rat population after campaign
100 rats	10 rats (5 male; 5 female)



Fortunately not all these rats will live to damage the rice crop. When rats first invade an area where there are not many other rats (beginning of season or after a big rat drive), rats will produce more offspring than when there are many other rats already in the area. This is because there is less competition for food. Rats can also migrate into new areas from far distances and will move into areas where there is no competition from other rats. The large number of rats being born and the large number of migrating rats into areas with few rats is the reason that rats increase in number very quickly after a big rat drive in which many rats are killed at one time and there is no sustained activities. This is why rat drives are usually not very successful for reducing yield losses, unless the drives are followed by continuous control programmes. The number of rats killed during a rat drive does not matter: what matters is the number of rats remaining in the field!

2.3. Ecology of field rat

Almost everyone knows what a rat looks like, but it is the behavior of the rat which is important to know. Rats are active mostly at night. The vision of a rat is not very good, and rats may not even be able to distinguish colors. But the senses of hearing, touch, smell and taste are very good. Rats need food and shelter to survive and reproduce. Understanding how they behave to find food and shelter helps in controlling rats.

2.3.1. *Food:* Food is one factor which determines rat reproduction. Field rats can reproduce when they have enough food from the different food groups: proteins, carbohydrates, minerals and vitamins. Reproduction is reduced substantially if there is a lack of one of these food groups in the diet of the rats.

Normally you can only find pregnant rats in the rice field at booting stage. Observations in a rice field with IR 64 variety (Luk Lung, 1998) showed that at 50-60 DAS, there were no pregnant rats. Copulation occurs at the end of tillering stage and rats deliver at the end of booting stage. In other places such as wastelands, forests and edge of dikes, most of the time there are no pregnant rats.

Because rats are eating food throughout the rice season, the longer the rice season, the more rat litters are produced.

2.3.2. *Habitat*: Rats usually live in burrows in the ground, especially in the rice bunds. But as the rice matures most rats live and move mostly in the open rice fields, often making nest right in the rice plants. You can find nests of field rats in the following places:

- Straw piles, weedy bunds or the center of the fields (if fields are dry)
- Burrows: Most female rats dig burrows to live when they are pregnant. Male rats rarely live in burrows. During floods some families of rats might move into the same burrow, because some burrows become unsuitable.

Burrow structures are varied. Some burrows are very simple like underground trenches with one entrance. Some burrows are relatively complicated with many entrances and exits. Exits are covered with a thin soil layer. Rats use them to escape when there is danger. Burrows with pregnant rats are often located in big bunds. In the dry season the burrow is often deep and has many branches. Each burrow has 1 - 7 entrances (about 40-450 cm long and 15-150 cm deep). The exits are often located in a bushy area. From the entrance to the “maternity room” the way is blocked with soil at 2 or 3 sections.

Young rats that have been weaned, but that are not yet sexually mature often live in cracks and bushes during the daytime and go out to find food at night.

Rats often make nests in high and big weedy bunds especially in bunds that are higher than the water level in the field. If the bunds are narrow and if there is a lot of water in the field, we can rarely find rat nests. Rats often travel 200-800 m to find food. If the environmental conditions are favorable, the distance they travel is shorter. If the environmental conditions are more difficult, they travel a longer distance. For hiding, rats can dive and swim among the rice plants and aquatic weeds. This is why most damage to rice occurs in the center of the field and not adjacent to the bund.

2.3.3. *Water and rat development*: Water is limiting factor for rat development in many production regions in Viet Nam, especially in the Mekong delta. In Southern provinces, the rat reproduction stage is during the dry season or at the beginning of the rainy season. Rats reproduce much more in dry fields than in fields with water. They do not reproduce when fields are flooded.

During drought, there is a higher probability of rat outbreaks than in years when there is much rain. However, when there is lack of water, rats can eat roots of perennial plants to obtain their water requirements.

2.3.4. *Rat movements*:

Rats will often travel the same route to the same feeding place each night. In some areas it is possible to distinguish rat trails where the rats pass very often.Rats are animals that move lot in their whole life. Their movements can be divided into 3 kinds:

- Movement due to requirements based on development stage of rats. If food and habitat is favorable, rats travel the distance of about 100 - 200 m only. However, when they need more nutritious food for reproduction, they normally move further to make burrows/nests in fields where food is available and suitable for them, e.g., rice fields at booting and ripening stages. This is to maintain population and provide better conditions for and to ensure development of the next generation.
- Movement to adjust population. If a rat population is too high and competition for food occurs, rats will migrate into new surrounding areas where there is less competition from other rats. Rats might move to areas where rat campaigns have reduced rat populations.
- Movement because of unfavorable conditions such as flooding or lack of food in rice fields after harvest.

It is necessary to study rat movements for decision making on suitable rat management methods. For example, in some areas with high rat populations farmers have experienced that rats are not attracted by the trap crop, i.e., that the number of rats trapped is low. In this case, it would be helpful for farmers to know that rats may travel to other places where there is more suitable food for their stage of development.

2.3.5. *Natural enemies of rats*: There are many animals that are natural enemies of rats. They should be preserved in order to have a balanced ecology. Public awareness and education, advocacy and use of administrative methods to prevent killing and selling animals that are natural enemies of rats is important. These animals include many kinds of snakes like pythons, owls, cats, etc. They are not harmful to people and they help to lower rat populations. It is important to limit pesticide use which harms these natural enemies. For example, the use of rodenticides which rats may eat can consequently kill cats that eat poisoned rats.

The public may be encouraged to rear dogs, cats, and pythons to restore natural enemies. To some extent, human beings are also considered a natural enemy of rats. In some areas in Vietnam, rat meat is used for human consumption. This also helps to reduce rat populations.

2.3.6. *Rat population dynamics*: Rat development and damage depends on many factors like food, habitat, water, and natural enemies. Among these factors, food is most important in determining rat population dynamics. The peak (highest population) of rat population is determined by the number of cropping seasons/year.

- One rice season/year = one peak
- Two rice seasons/year = 2 peaks
- Three rice seasons/year = 3 peaks

The peak often occurs at the end of tillering stage and at booting stage. Later in the season the rat population is lower, because female rats stay in burrows to reproduce. Early or late peak occurance depends on the length of the season. The longer the crops stay in the field before harvest, the more damage rats cause. With favorable conditions, e.g., little rain, warm weather, etc. rats reproduce well and rat populations will be very high and vice versa.

3. Rat damage and rat population

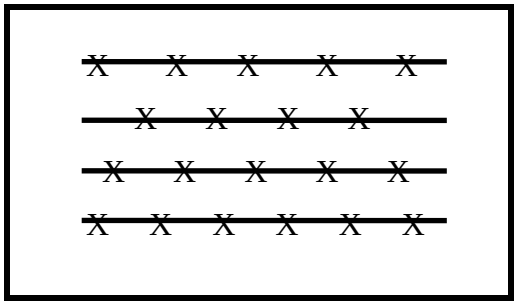
Farmers can observe damage in the field that is caused by rats. Farmers can also make obervations on the rat populations, though this is not always very easy. Damage in the field caused by rats is the biggest problem for farmers. It is important to observe fields very regularly for rat damage, and use the observations in decision making on what to do about rats. Rat populations can increase very rapidly. Besides the damage in the field, regular observations can be done by farmer groups on the development of rat populations. When observations are done on a regular base, they give farmer groups information on the changes in the rat populations, even if damage in the field is low. This can allow for timely action against rats, before populations get so high that damage in the field is occurring.

3.1. Rat damage assessment

Rats reduce yields of plants by direct feeding on the tillers and on the young rice grains. In newly planted fields rats can remove new transplants resulting in missing hills. In older fields, the rats cut or bend the tillers to feed on the top foliate or panicle. During the booting stage, rats will feed through the sheath on the young panicle. Near maturity, the rats cut and bend tillers to feed on the grains. A cut tiller is usually cut at a 45^{o} angle with a small part of tiller stills ticking up from the cut tiller. From the edge of the field, the damage may not b readily seen until a large number of tillers are already cut. Newly cut and dying tillers may even look like a deadhart or diseased tiller from the bund. It is very important for monitoring to enter the field and examine the field looking for cut tillers.

Monitoring for rat control should be done at the end of one season in preparation for the next season. To monitor, visit the field two weeks before harvest. Rat damage in the rice fields is not uniform. Rat damage is often more serious in fields that are near the village edge, hills, or on edges of big canals.

Evaluate rat damage in the rice fields using the method developed by IRRI. Select a typical site representative of the area damaged by rat. Observe 10 rows distributed throughout the field. For each row, observe 10 hills at random.



On each hill count the total number of uncut tillers and the number of tillers which have been cut. A cut tiller is usually with a tuft of plant material. To determine the percent cut tillers use the following formula:

Total number of tiller = total uncut tillers + total cut tillers

%cut tillers = total number of cut tillers/total number of tillers X 100

If the percent cut tillers is greater than 5%, then a control programme for the next season should be considered.

If a new season is just beginning and the level of potential rat damage cannot be estimated, then weekly monitoring of the field will be necessary. For each 1000m2 of field 30 plants should be observed for rat damage using the formula described above for computing percent cut tillers. To determine rat damage use the following scale.

Development stage	Rat damage (%)		
	Slight	Moderate	Serious
Tillering stage	5 - 10%	> 10 - 20%	> 20%
Booting stage	2 - 5%	> 5 - 10%	> 10%

At tillering stage, the rice plant can compensate for damage. The above rat damage scale is only used for reference. When moderate to serious damage levels are reached early in the season, a chronic bait programme should be implemented immediately. If the damage is already in the booting stage, a baiting programme might not be effective because the plants are already more desirable food than bait. As noted above, if damage takes place without being noticed early, it will be very difficult to control the problem.

At the end of season, summarize data from previous observations and take crop cuts to determine yield losses caused by rat damage.

3.2. Observation methods for rat population dynamics

Rat migrate to find food, habitat and to hide from their enemies. Therefore it is very difficult to observe rat populations. In addition to the rice grown in the main seasons, there are also other crops in the winter season. Likewise, there are industrial crops, maize, soybean, vegetable, potato, rice in the summer-autumn season. This makes the rat population situation very varied and complicated. That is why we should observe rat populations in rice fields and based on that apply observation methods for other crops. Following are descriptions of some methods for observing rat population dynamics.

3.2.1. *Tracking tiles*:

- *Materials*: Steel pieces (wood and carton can also be used) 20 X 20 cm; apply a thin layer of cow fat on its surface to keep rats' footprints.
- *Procedure*: Set up 30 - 100 pieces for 3 nights in succession in surrounding rice bunds or other places that need to be observed. Keep a distance of 10 meters between each tracking tile. In the mornings, count the number of footprints and calculate activity index as follows:

$$\text{Rat activity index (\% tiles with footprints)} = \frac{\text{\# of tiles with footprints}}{\text{Total \# of tiles}} \times 100$$

- < 20% = rat activity is low
- 20 - 40% = rat activity is moderate
- > 40% = rat activity is high

Note: Applying mud on bunds can also be done using the same dimension of 20 X 20 cm. Cover the areas on the bund with mud to observe but avoid rain and apply fresh mud often to prevent from drying.

3.2.2. *Paddy mounds:*

- *Material*: paddy rice (about 10 gms per mound)
- *Procedure*: Set up 30 - 100 paddy mounds on surrounding bunds or other places that need to be observed for three nights in succession. Keep a distance of 10 meters between each paddy mound. In the mornings, count the number of mounds which have been eaten from and calculate activity index as follows:

$$\text{Rat activity index (\% of eaten mounds)} = \frac{\text{\# mounds eaten from}}{\text{Total mounds}} \times 100$$

- < 20% = rat activity is low
- 20 - 40 % = rat activity is moderate
- > 40% = rat activity is high

3.2.3. *Live traps and snap traps:*

- *Material*: Any kind of trap which can catch live rats (live traps); any kind of snap trap (traps which kill rats immediately); baits like sweet potato, broiled crab, dried fish, etc.
- *Procedure*: Set up live traps in different places in the fields (early or late transplanted rice fields, fields with secondary crops, big canal bunds, tree clumps/bushes or hillocks) to determine abundance index of rats and to observe rat population dynamics and rat migration. (Keep the live rats for exercises on identification and reproduction observation.)
- Keep a distance of 10 meters between each trap. Between the traps, set up tracking tiles to evaluate rat activity index at different times of observation. Observe for 3 nights in succession, twice a month. Evaluate effectivity of live traps (live traps with rats inside and without rats but that have traces of blood or some hairs on it are considered traps with rats). Calculate abundance index of rats as follows:

$$\text{Abundance index of rats} = \frac{\text{\# of traps with rats}}{\text{Total of traps}} \times 100$$

Using Dr. Dao Van Tien's classification, classify rats in the fields and calculate abundance index of each rat species as follows:

$$\text{Abundance index of rat species} = \frac{\text{\# of traps with rats of that species}}{\text{Total of traps}} \times 100$$

The rat population dynamics in general and for each species can be inferred from the abundance index. A high abundance index means a high rat population and vice versa.

- < 3% = rat population is low
- 3 - 5% = rat population is moderate
- > 5% = rat population is high

Note: For snap traps, use the same procedure. Compute for abundance index of rats and abundance index per specie using the same formula. Also use the above interpretation for rat population dynamics.

3.2.4. *Counting rat burrows*

- *Procedure*: While visit fields or taking care of rice fields everyday keep a look out for, count and check rat burrows/nest to estimate relative rat populations.

How to recognise burrows with rats: Newly dug burrows have new soil. There are rat footprints at the entrance, there is mud and rat droppings. You can use straw to block the entrance at late afternoon. Next morning, if the straw has been pulled out (not in the same place) this indicates that the burrow has rats.

To calculate the burrow index, divide the number of rat burrows counted by the total number of meters observed of field bunds or canal edges. If the burrow index/meter is high, rat population is high and vice versa.

In summary,

- % traps with rat footprints
- % eaten paddy mounds
- abundance index of rats
- number of rat burrows/meter

help us to determine rat population dynamics in the fields at different times and different places. Information about this can be used to make decisions on suitable management methods.

4. Rat management methods

Prevention

The best control of rat damage and protection of the crop is through early season control of rats. The decision to control rats can be made at the end of the previous season in preparation for control programs in the current season if rat damage was heavy (see above, monitoring). In this case, rat control must begin at the beginning of the season and continue until crop maturity. If the previous season's damage was not high, then field monitoring should begin early in the season. However, significant yield loss will already take place if control measures are delayed until the rat damage is easily seen from the edge of the field. Individual protection of fields is possible even if not everyone in the area is willing to control rats by using a combination of plastic fences, habitat management and baiting.
Before transplanting: Cut weeds along bunds and irrigation canals, looking for rat burrows which should be destroyed. Fumigation guns which use burning straw and sulphur area available in some areas for killing rats in their holes. If rat damage was very severe in the previous season, using an acute poison under the advice of a technician in the field and village areas or rat drives to kill rats directly during the seedbed period will reduce populations significantly. However, initial investments must be followed by a sustained programme.
After transplanting: A sustained baiting programme is the best way for farmer groups to control rats. For sustained baiting, poisons which kill after several feedings are used. The rats must eat the poisoned bait for rats to die. These poisons make the rats bleed to death. Unlike other methods, many dead rats will not be accumulated in a short time because many rats will die inside the burrows. This may be a problem for some farmers who usually like to see the results of the baiting quickly. It is possible to

demonstrate the effects of these poisons on captured rats and this may be necessary to convince farmers that these poisons are useful. Remember that the goal of rat control is to keep populations low, and to reduce damage to the crop--not just to kill large numbers of rates. We have to be smarter than rats. (See baiting programme below.)
Community action: Group activities which emphasize participation and co-operation can be used to begin a programme of working together to control rats. Individuals cannot control rats alone on areas smaller than several hectares. Poster making by members of farmer groups are good activities to alert other farmers to proper sustained baiting programmes and other methods to prevent the build-up of rat populations.
It is always better for groups to participate in rat control programmes.
In some areas, planting at the same time may be possible. Areas which are planted and harvested together seem to have less rat damage than areas where rice is always available. This is because rats can migrate from field to field in areas with continuous planting and always find a good meal. In areas with simultaneous planting, the best meals are available a short period during the year. In population growth terms, more food - more rats, more continuous food - more continuous rats.

There are many rat management methods in Vietnam and all over the world. Following are some major methods.

4.1. Cultivation methods:

4.1.1. *Cropping pattern :* Use of cropping pattern which limits food supply and habitat for rats. For example, do not grow dry crops continuously. Do rotation cropping with rice.

4.1.2. *Timing of the season*: Synchronize planting. Seeds should be sown at the same time and harvested at approximately the same time to limit continuous food supply and habitat of rats.

4.1.3. *Field sanitation*: Cut weeds on bunds regularly, clean out bushes, level off hillocks and remove crop residues before the season and after harvest, to limit rat habitat.

4.1.4. *Cultivation technique*: Limit high and large bunds. Irrigating fields limits and narrows down rat habitat which facilitates rat management.

4.2. Mechanical methods

4.2.1. *Traps:* Make use of all kinds of existing traps, simple to complicated ones, cheap, easy to find, effective in catching rats (live traps, snap traps, etc.). Experience sharing and training should be conducted on how to make traps, set up traps, prepare baits to increase effectivity of traps as a management method.

4.2.2. *Rat drives*: Use dogs to hunt rats. Combine with burrow digging, fogging and driving to catch rats. In the South, farmers also make plastic fences, put the traps at the end, and make noise so the frightened rats run into the traps.

4.2.3. *Burrow digging, fogging and flooding*: Mobilize many people as in a campaign. Conduct burrow digging, fogging and flooding regularly combined with other methods to achieve more effect. It is necessary to train and guide people in using these methods to protect the irrigation system.

4.2.4. *Plastic fences*: Put plastic fences around the field bunds (about 50 - 100 cm high) to prevent rat damage. It is very easy to do but it requires much investment for materials.

4.2.5. *Plastic fences combined with traps*: Put plastic fences around the field or on borders between fallow lands and fields with crop. Also set up one trap between distances of 15 meters each to catch rats.

4.2.6. *Trap crop*: Combine plastic fences and traps with early crop to catch rats. This method is effective but costly and should have the participation of the community.

4.2.7. *Torches and scoop nets*: In general, rats have poor eyesight. At night, blinded by light from the torch, they move badly. You can hit them to kill or use scoop nets to catch. This method is not popular and can only be used by people with the necessary equipment and experience.

4.2.8. *Sticky glue*: Put the sticky glue along routes where rats often cross/pass. In the middle of the trap put baits to attract rats. This method is effective when used in houses or in store houses.

4.3. Chemical method

Rats can even taste food without putting the food in their mouth because their teeth stick out so far. Rats are very suspicious of new places and foods. When using poisons which kill after one feeding (acute), it is important to remember that rats will taste the food before regularly feeding. This is why acute poisoning methods recommend putting out unpoisoned bait for 5 days before putting out poisoned baits. The rats 'learn' that good food is readily available at a particular place, and will visit for several days eating the bait. By the time poisoned bait is placed, the rats already are happy to eat a lot. If poisoned bait is placed directly in the bait holder, the rats will try a little bit of the food, get a sick stomach, recover, and never go back to the bait again. This is sometimes called bait shyness. It is the same thing as trying out a new restaurant. If the food is good we visit again. If we get sick from the food, we never go back. Rats are not stupid. Try to think like a rat.

4.3.1. *Acute poisons*: We often use Zinc Phosphide (20%) to kill rats. This method can kill rats fast and is highly effective at first use. But it is very poisonous for people and warm-blooded animals. Baits mixed with poisons should be changed regularly to increase effectivity.

4.3.2. *Chronic poison (slow action)*: This poison often uses anti-coagulants such as Klerat. Rats die slowly and they are less fed up with baits. It is less poisonous for people and warm-blooded animals compared to acute poisons.

4.3.3. *Chemicals for fogging rat burrows/nests*: Use sulfur (SO2) and calcium carbide to fog the rat burrows/nests. Put sulfur or a piece of calcium carbide about 100 - 200 grams. Pour water and close the burrow by soil or clay. Calcium carbide or sulfur gas will kill rats. This method can be applied only to loamy soil with few cracks or in sandy soil. In the dry season it is less effective.

In summary, chemical methods are often used especially in rat campaigns or when rat population is high because at that time we should reduce rat populations in a short time. However, we should limit using chemicals, especially acute poisons, because they are harmful to people and animals. Care should be taken when using chemicals.

4.4. Biological and botanical methods

4.4.1. *Natural enemies of rats:*

- Encourage and help farmers raise cats. Limit use of rodenticides which causes death of natural enemies like cats when they eat poisoned rats.
- Disseminate information on problems brought about by hunting, killing and eating natural enemies of rats such as cats, snakes like pythons, owls.
- Advocate for laws and decrees which favor the restoration and protection of natural enemies of rats. For example against their selling and exportation.
- Advocate for laws and decrees which support the implementation of management methods for rats.

4.4.2. *Microorganisms:* Using microorganisms to cause infectious diseases to kill rats

- *Advantages:*
  - ⇒ Kills rats on a large scale at the same time.
  - ⇒ Safe for humans, other animals and the environment.
  - ⇒ Considerably reduces rat populations and its damage over long periods of time
- *Disadvantages:*
  - ⇒ Costly
  - ⇒ Short shelf life/storage period (the time it keeps its potency)
  - ⇒ Does not cause immediate death (rats die from 4 - 14 days after eating) so farmers do not like to use
  - ⇒ Use in the field is very much affected by weather conditions

Use of preparations with microorganisms will be more successful if the following are considered:

- Avoid using in weather conditions such as scorching sun or heavy rains
- Use at the same time on a large area
- Use recommended dosage of 3 - 5 kg/ha or higher, depending on rat density. Concentrate on edges of large fields, hillocks/earth mounds, bushes, cemeteries, ect., where rats usually dig burrows. If an under dose is used, the effectivity cannot be guaranteed.
- Should not be used more than twice a year in one place
- Apply when food is not available in the field. Rats will eat more baits (about 80 - 95 %). At booting, rats will rarely eat baits so the effectivity of the baits will be low.

Areas of possible cooperation between the Vietnam Institute of Agriculture Science and Technology as well as the National Institute of Plant Protection, farmers and communities to produce biological substances for rat management (*biorat*):

- To bring the price down by 30-50 %, farmers groups and communities can produce *biorat* themselves. This is done by boiling paddy rice, drying it, then mixing the microorganism fluid provided by VIAST an NIPP. (This approach was used in the rat campaigns in the provinces of Hai Duong, Nam Dinh, Ha Tay, Phu Tho, Quang Ninh, Vinh Phuc, etc.)

- Technical back stopping by the VIAST and NIPP to ensure that requirements for production of *biorat* are met which will guarantee its effectivity. For example, farmers will benefit from assistance from technicians on the duration of paddy rice treatment and provision of fluid. (Boiled paddy rice/unhusked rice require an appropriate angle of 'openness' and dryness; it should be evenly mixed with bio-fluid; and the mixture must be used during the day.)

4.4.3. *Botanicals:* Following traditional experience, use seeds of *pachyrrhizus*, *nux vomica* for poisons. Care must be taken when these are used because they are very poisonous for humans and animals.

Strengthening the implementation of integrated rat management:

1. Integrated rat management is important for each community. Different suitable methods should be used. However, the use of cultivation practices, mechanical and biological methods must take preference. Limit/restrict use of chemicals.
2. Farmer groups and communities should demand support for rat management activities from the government. This can come in various forms such as concrete policies for researches to produce bio-rat and to subsidy for the users, among others.
3. It is necessary to apply suitable methods that everybody can use. It is important to manage rats in fields with different crops but also to pay attention to controlling rat in villages, subvillages, roads, storage areas, ports, and livestock cages. Rat control is also necessary in offices, schools and hospitals. Rat management requires close and thorough assistance from the government at various levels and needs action at the community level.