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The impact of rodent management on rice yields in four different lowland irrigated areas in Indonesia

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ABSTRACT

Rodent damage in rice crops is leading to reduced yields and poor food security for farmers throughout Indonesia. The goal of this study, conducted between 2015-2016, was to assess the impact of rodent management methods on rice yields in four different regions. The study sites, all in lowland irrigated areas, were in Aceh Province, Cirebon and Indramayu Regency in northern West java, and Purbalingga Regency in southwestern Central Java. Different data management methods ranging from full protection using plastic fences and bubu traps, fumigation, sanitation and synchronization of planting date were implemented depending on the severity of rat damage in the previous cropping season. In all region's farmers enclosed their crops using plastic fence equipped with bubu traps along the fence within a crop season. The number of rats captured during the crop cycle (planting to harvest) varied among locations: 1,331 rats from 44 traps for Aceh; 7,000 rats from 80 traps for Cirebon; 4,916 rats from 70 traps for Indramayu and 130 rats from 70 traps for Purbalingga. The rice yields before and after implementing the rodent management were different, with all regions showing increased yield: from 1.03 to 5.89 ton/ha in Aceh; 3.32 to 7.56 ton/ha in Cirebon; 4.76 to 8.93 ton/ha in Indramayu and 7.32 to 10.86 ton/ha in purbalingga. In summary, rat management particularly surrounding the crop with the plastic fence plus bubu traps increased yield by 1.5-5 times that of the previous season where these methods were not implemented. Farmers have indicated thay they will continue to use plastic fence and bubu traps.

Key words : *Rodent management, Rice yields, Lowland, West Java*

Introduction

Rodent is the major pest in agricultural sector leading to an enormous loss in Indonesia and Southeast Asian countries. Rat damage occurs from pre-planting (nurseries), planting and even post-harvest until storage periode. Rice field rat (*Rattus argentiventer,* Rob & Kloss) is the main pest causing damage in rice crop and have always been leading to big losses for farmers in Indonesia (Geddes, 1992; Murakami *et al.*, 1992; Singleton *et al.*, 1997; Sudarmaji and Rochman, 1997). The updated data from Mininstry of Agriculture (2016-2018) indicates that the average of annual damage area from rat attack is 91,881 ha (Anonymous, 2018a). The rice field rathas also been ranked as one of the main pests in three top group damaging rice crop. If the average of damaged area is correlated with the average of rice productivity 5.165 ton/ha and its price is Rp. 5,400/kg then the national yield loss equals to Rp. 2.5 billion anually (Anonymous, 2018b).

As a member of rodent group, the rice field rat performs a very fast breeding cycle (Goot, 1951; Murakami *et al.*, 1992; Rochman and Sudarmaji, 1997). This characteristic leads to an increase of their population rapidly if they have a good access to

abundant qualified food in adjacent area. This is a big problem for farmers to do their farming work especially in rice cultivation. Basically, a comprehensive work on controlling rats based on their bio-ecological aspects have been developed in developing countries (Singleton *et al.*, 1999a). This has been developed from the concept of integrated pest management but focused particularly to the rice field rats (Singleton, 1997). However, most farmers still rely on rodenticide use as their sole method to control this pest. They thought that this chemical is effective enough to control the rats as they can see the dead animal visually.

Baiting by using rodenticide is also the most favorite method implemented by farmer in several tropical countries (Buckle, 1999; Singleton *et al.*, 2003). Rodenticide application represents a non-environment friendly technique due to it has a potential risk to the non-target species and environment (Singleton *et al.*, 2003). The other weaknesses of this method is that we need a number of application triggering some residues in the field and water resources. Therefore, a knowledge on eco-biological rodent management is required to educate the farmers on controlling the rats in a good way and environmental safely.

This study is basically a dissemination of our eco-biological rodent management in several provinces around Indonesia. We hope that we can teach the farmers to protect their crop from rat attack. We show our technology to the farmers in the field and assess the impact of its implementation to the yield within a season. In this case we record the number of rat capture, list our activities to control this pest and also summarize the yield before and after the implementation of rat control management.

Methodology

We disseminated our rat control technology based on eco-biological approach in four regions i.e. Aceh, Indramayu, Cirebon and Purbalingga. All regions represent low land irrigated rice crop in different provinces. The cropping season was started in Juneand terminated in September 2015 in Purbalingga. Moreover, farmers in Cirebon planted the rice crop in August then harvested in November 2015. The next year a similar study was performed in Aceh which was initiated in August 2016 and completed in November 2016. A parallel study was continued in Indramayu in December 2015 and finished in April 2016. There were several rice varieties planted in those four regions i.e. Inpago 8, Inpari 22, Inpari 30, Inpari 32, Inpari 33, Inpari 43 and HipaJatim 2.

We performed rat control activities in all regions differently, depended on the real situation including rat habitats, food source, cropping cycle, labor/ farmers availabilityand diversity of local crop. In Aceh we implemented full protection of rice crop by erecting plastic fence incorporated with 44 bubu traps; fumigation using Sulphur smoke and sanitation on the main habitats (Fig.1). The active burrows found during the land preparation and generative stage of rice crop were the main spots to become fumigation target spots. Since the matured females usually start to breed at this period. There were four main habitats, i.e. irrigation channel bank, village close to palm oil plantation, forest and oil palm plantation belonging to farmers.

Moreover, we conducted numerous actions which were more perfected in Indramayu such as full protection using 70 traps, fumigation, sanitation, mass hunting and synchronized planting, since we simply found collaborative farmers. We found rat habitats differently here, such as irrigation channel bank, rice field and mango garden. The similar rat control activities were implemented in Purbalingga as we have done in Indramayu. We also set the same number of bubu traps (70 units) as implemented in Indramayu. However, we found different habitats here, i.e. bamboo garden, irrigation channel bank, river and road bank. The sole action to control rat in Cirebon was implementing full protection. We arranged 80 traps along the plastic fence to protect the rice crop. The main habitats we concerned were idle land, teak forest and irrigation channel bank.

Fig. 1. Fumigation along irrigation channel bank, Indramayu 2016

Full protection was essentially a modification of TBS (Tap Barrier Sytem), a technology component established for years from Indonesian Center for Rice Research, Sukamandi (Singleton *et al.*, 1997; Leung and Sudarmaji, 1999; Sudarmaji and Herawati, 2009). This component consisted of plastic fence, bubu traps and bamboo sticks. Plastic fence was erected by bamboo sticks for every single 100 cm distance. We located bubu trap along the fence line in the bottom side by making a whole with the same square shape as indicated in bubu trap. The square whole was actually provided to address the rats get into the traps, as we located the bubu traps close tightly to the plastic fence. This component was implemented within a whole of cropping season. The technical setting of full protection can be seen in Fig. 2.

Fig. 2. Setting of full protection covering rice crop within a whole season, Indramayu 2016

Sanitation was mainly focused on cleaning of rat habitat from weeds and bushes. The goal of this action was principally to minimize their habitat to limit their breeding sites. These could be done manually by cutting the grass and the bushes growing along the irrigation channel bank or road bank. The other technique was implementation of particular herbicides. Mass hunting was conducted by flooding the burrows and close them with wet mud or dig them out. This actually is an effort to minimize the population size of the rats in the field (Fig. 3).

Synchronized planting was basically a coordination and cooperation among farmers in the study site to arrange the planting date quite similar. This means that the gap of planting dates among farmers in the same block was not more than 3 weeks. This was aimed to reduce the availability of generative rice crop as the source of qualified food to support their breeding. By reducing the gap of planting dates, then the cycle of generative rice crop was limited.

Fig. 3. Sanitation along the irrigation channel bank as the main habitat of *Rattus argentiventer*, Indramayu 2016

Results and Discussion

In general, we collected data for the number of rats captured and yield to assess the impact of the implementation of rat control technology on yield. Both yield data, before and after implementation, were recorded and compared. The data on the number of rats captured were varied among the region which depended on the presence of their habitat, food availability and cooperation among farmers. The presence of rat habitat and their food sources were important things which determine the population size within a whole season and the next cropping season. Moreover, the collaboration among farmers was also the essential factor which define the success of our control actions. Since the breeding cycle of rice field rat was very fast, therefore we need a collective and simultaneous work in large scale area in the same interval.

Number of rats captured

Regarding the number of rats captured, we found that there was a declining trend within a whole season in Cirebon. As we can see in Fig. 4, at the first two weeks after planting, the number of rats captured was relatively the same with the average 67 individuals daily. From this point, then it declined for the next week gradually. However, at the late of vegetative stage of rice crop, the number of rats captured was back to increase very sharply. This phe-

nomenon occurred in two weeks interval with the peak number of rats captured was 189 animals. The next week after the number of rats captured was fluctuated even though still in relatively high number which was more than a hundred. Again, rat captured decreased abruptly, and remained steady with the similar numbers. For the rest of the copping season, rat captured was back to increase suddenly and then declined extremely until reach the lowest number of rats caught.

The implementation of rat control technology in Cirebon effectively catch the rice field rats in a huge number. The total number of rats captured was 7,507 individuals within two months of implementation (Fig. 4). It was predicted that since there were two blocks of idle land as the main habitat for the rice field rat. These two blocks were located at northern and eastern side of our demonstration plot. Moreover, the site was also close to the irrigation channel bank which represented one of the most preferable habitats for this species (Sudarmaji and Herawati, 2009). The irrigation channel bank was also a good environment to provide the rice field rat with enough water.

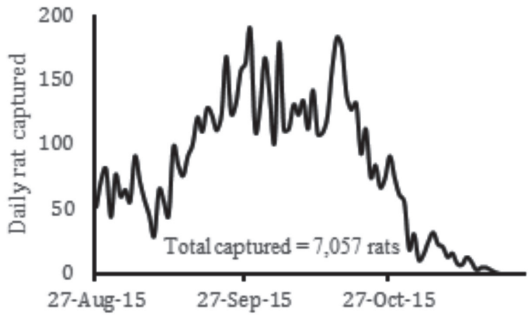

Fig. 4. Total rat captured from traps in Cirebon, August-October 2015

Based on the number of rat captured within the cropping season, there were two peaks of rat population which are recorded on 28th September 2015 and 17th October 2015. These two peaks might be an accumulation of different generations born during the previous generative stage of rice crop and harvesting time. This generative rice crop was predicted as the main food supporting the females breeding. As previous studies revealed that there was a link between rice crop stage (generative) and rat breeding. The presence of rice crop at the maximum tillering stage (early generative stage) was a trigger for the males to become matured sexually (Tristiani and Murakami, 1998; Tristiani and Murakami, 2003). Therefore, their breeding was started at the maximum tillering of rice crop, followed by delivering babies at the generative stage and continued until early fallow (Murakami *et al.*, 1992; Sudarmaji, 2004). Other study also indicated that the booting stage of rice crop was the most preferable food for the rice field rats which triggered their breeding (Sudarmaji, 2004; Brown *et al*., 2001; Brown *et al*., 2003). Therefore, synchronized planting was strongly recommended to anticipate the mature rats to keep breeding along the cropping season. This means that if the rice crop was planted unsynchronized, there will be generative rice crop available in the field continually.

The trend for the number of rats captured in Aceh region was different from the one occurred in Cirebon. The number increased at the first three week after planting with the peak reached at 43 animals. However, the number of the peak was lower compared to the peak from Cirebon. The total number of animals was also lower (1,331 rats) than we have obtained (7,057 rats) from Cirebon (Fig. 5). This value equals almost 19% from the value have been obtained from Cirebon. The number of rats captured tended to decrease and remain stagnant after a month of planting with the average was between 7-25 rats. In Aceh study site, there were four habitats, i.e. irrigation channel bank, oil palm plantation, village and forest. These habitats represented their main habitat providing them as the breeding site. This led to the rice field rats keep reproducing and multiplying their generation continually (Sudarmaji and Herawati, 2009). This led to a bigger size of rat population in the fields.

Regarding the number of rats captured, Aceh showed lower number compared to Cirebon. This because of the local farmers conducted fumigation

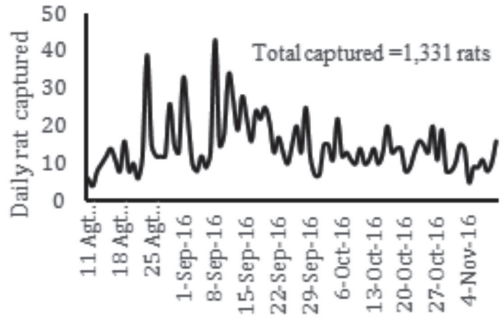

Fig. 5. Total rat captured from traps in Aceh, August-November 2016

and sanitation at the beginning of rice crop. By implemented those two actions implies that the real population was minimized earlier before they start to breed which coincide with generative stage of rice crop (Tristiani and Murakami, 1998; Tristiani and Murakami; 2003; Sudarmaji, 2004; Brown *et al*., 2001; Brown *et al*., 2003). Therefore, there were few survived rats left in the field when they get into their breeding period. These actions were also caused destruction of rat habitat, since the farmers dig out the burrows and cleaned the environment from bushes and weeds. As we noted that they prefer to stay at the spot with dense canopy covering them from the predators.

The trend for the number of rats captured in Purbalingga fluctuated along the cropping season (Fig. 6). However, it tended to decrease gradually until the end of the season. Compared to other regions, Purbalingga had the lowest number of rats captured. This is due to that the local farmers maximized the rice bund and road bank for their secondary crop farming. They planted several crops such as snake bean, cassava, sweet potatoes and eggplant. Therefore, there was no chance for the rice field rats to stay and keep breeding in these habitats. By planting this bank and rice bund also minimized the weeds and bushes to grow which could be a good cover for these animals to hide from their predator. Moreover, we also obtained cobra snake frequently which get into the bubu trap. This means that the rats might move to other side having a good place to stay without any disturbance from their predator and also farmers farming activities.

The other reason for the smaller number of rats captured in Purbalingga was that the local farmers are keen to do fumigation frequently at the beginning of planting season. This action led to decreasing of founding population which in turn can reproduce to become more number during the generative stage of rice crop. This finding was consistent with previous study which mentioned that fumigation was one action of community rat management and can remove high numbers of rodents from agricultural land within short periods of time (Jacob *et al*., 2002). This is a key point to be aware that such action can suppress the next population growth (Sudarmaji and Anggara, 2006). By killing one rat at the beginning of rice planting equals to kill 80 rats at the harvesting time (Sudarmaji, 2004). Those factors could be the reasons defined the lowest number of rats captured among other regions.

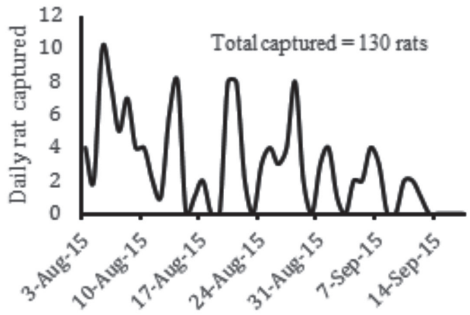

Fig. 6. Total rat captured from traps in Purbalingga, August-September 2015

For Indramayu study site, we recorded the number of rats captured both from full protection and mass hunting. The total number from those two actions was 4,916 rats as shown in Fig. 7 and Fig. 8. This region had very keen and cooperative farmers to get involved in this dissemination program on controlling the rice field rats. As we know that this animal was the most destructive pest in farmers' field for years. Therefore, they get motivated to protect their crop from rat damage by involving several actions during the cropping season. They work in a team for several times especially at the beginning of the cropping season to control the rice field rats from being breed. This is important to minimize the population size on the next rice stage if we do not control them as early as possible.

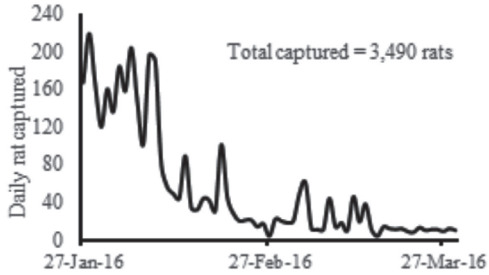

Fig. 7. Total rat captured from traps in Indramayu, January-March 2016

Based on the number of rats captured from those two actions, it seemed that their population was very high. As we can observe that the fumigation and full protection record was conducted almost at the same time. As their population was very high then they were distributed broadly in several habitats. We obtained high numbers (1,426 individuals) of rat from mass hunting which was performed

along the irrigation channel bank and mango garden. The higher number was added from full protection (3,490 rats) which have been set in the rice field. Even these two actions were also incorporated with other control action at the beginning such as sanitation to minimize rat habitat. However, we can still obtain a huge number of rats captured from full protection and fumigation after the sanitation have been done.

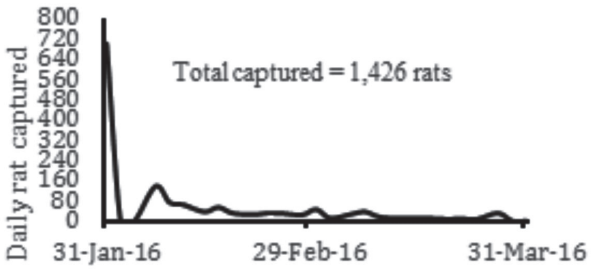

Fig. 8. Total rat captured from mass hunting in Indramayu, January-March 2016

The main reason for achieving the high number of rats captured from Indramayu was due to the reason that there were lots of mango gardens scattered among the rice field. It has been known that Indramayu is one of the mango producers in West Java. Therefore, the rice field rats were really supported for obtaining a refugee habitat and alternative food when the rice crop was harvested. They moved from the rice field to the mango gardens to stay for a temporary period as long as the farmers doing harvest. During this time, they consumed alternative food i.e. golden snail, grass root, small insect and other grain for survival effort. This was revealed by visual observation that we found golden snail shells and grass root left close to their active burrow entrance. Then they shifted their stay directly back to the rice field after the harvesting time terminated. This fact consistent with previous study that mango garden was the main site having the highest number of rats captured when we fumigated in similar agro-ecosystem in Karawang (Sudarmaji *et al*., 2010). However, there was a similar trend that the number of rat captured decreased sharply either from fumigation or full protection until the harvesting time. These two actions decreased the rat population effectively at the same time. The decreasing of rat number provides an advantageto the local farmers as their crop grew nicely until the harvesting time.

Rice Yield

The yield from each study site was presented in Table 1. The rice yields before and after implementing the rodent management were different significantly ($P < 0.05$), with all regions performing increased yield: from 1.03 to 5.89 ton/ha in Aceh; 3.32 to 7.56 ton/ha in Cirebon; 4.76 to 8.93 ton/ha in Indramayu and 7.32 to 10.86 ton/ha in Purbalingga. In summary, rat management particularly surrounding the crop with the plastic fence plus bubu traps increased yield by 1.5-5 times that of the previous season where these methods were not implemented.

Generally, the data in Table 1 represented the impact of rat controls on farmers' yield. The highest yield was obtained in Purbalingga, followed by Indramayu, Cirebon and Aceh, respectively. It seemed that the frequency of farmers doing rat control at the commencement of the planting season defined the final impact on rice yield. As revealed from previous study that killing one rat at the beginning of planting season equals to 80 kill 80 rats at the end of the planting season (Sudarmaji, 2004). This means that we require less effort if we do rat control at the beginning instead of do the same thing when they have already reached their breeding season which coincide with generative stage of rice crop.

The data were consistent with similar study which indicated an increase on yield after implementing rat control action. The yield was 18% higher when the farmers set the TBS to control rats and protect their crop (Singleton *et al*., 2002). These yields were sustained up to 200 m from the crop. These results confirm the 200m "halo of protection "reported by Singleton *et al*., (1998). The same finding was also reported by Singleton *et al*. (1999b) which mentioned that similar rat management conducted in West Java and coordinated at the community level, provided a huge benefit for farmers with small holdings, reduced reliance on rodenticides.

Table 1. Rice yield (ton/ha) before and after implementing rat control activities from all regions

Region	Yield (Ton/Ha)	
	Before	After
Aceh	1.03	5.89
Indramayu	4.76	8.93
Purbalingga	7.32	10.86
Cirebon	3.32	7.56

Sudarmaji *et al*. (2003) also reported that regarding this issue, farmers in West Java also agreed that by controlling rats they could increase rice yields, and believed that rats could be controlled successfully.

Farmers in all regions have indicated that they will continue to use plastic fence and bubu traps. However, cooperation between farmers was identified as important factor for successful rat control, although some farmers sometimes still prefer to do rat control by themselves. The cost of these management actions will have to be compensated with potential benefits. Therefore, the involvement of local extensions and local government was essential for continuing this program. In summary by implementing rat management continually, this will lead an increase on farmer benefit. As stated previously that the farmer crop will be protected from rat attacks. Moreover, they also can minimize the cost for rodenticide application. However, it is a hard work for the local extensions and local government to convince the farmers about the effectiveness of these rat management.

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