The relationship between a population index of the lesser Bandicoot rat (*Bandicota bengalensis*) and their damage to rice crops

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Abstract

On station experiment and farmers' field trial were conducted to evaluate the effect of Alternate Wetting and Drying water saving technology (AWD) on grain yield and water productivity of three irrigated lowland rice varieties in DaikU, Bago Region, Myanmar during the dry season 2015. In both experiments, grain yields were not significantly affected by water regime. However, grain yields were significantly affected by seedling age, and by variety in station. No significant interaction of water and seedling age was observed in Sinthukha variety at both experiments. Grain yields were the highest in 21-day old seedlings and the lowest in 14-day old seedling; highest in Yeanelo-1 and lowest in Hmawbi-2. Under AWD condition, Yeanelo-1 with 30-day old seedling gave the highest yield and water productivity, however, Hmawbi-2 with 14-day old seedling attained the lowest. Water productivity was significantly affected by water, seedling age and variety. The AWD treatment gave the highest water productivity and continuous flooding resulted the lowest. Among seedling ages, 21 and 30-day old seedlings gave the highest water productivity and 14-day old seedling obtained the lowest. The AWD had increased water productivity, although varieties showed variable responses and adaptation mechanism to varying seedling ages.

Key words: Rice, continuous flooding, AWD, Water productivity

Introduction

Over half of the world's population consumes rice as their staple food with more than 90% produced and consumed in Asian countries (FAO 2004). In Myanmar, rice is the main energy food source of a high proportion of the rural poor and half of the production area is used to grow rice for export (MOAI 2015). There are several constraints for rice production such as poor management systems on natural resources (water and soil), biotic (pests; insects, diseases, weeds, rodents, and birds), and abiotic factors (climate). Rodents are one of the top five pests for rice production in Asian countries (Singleton and Petch 1994; Brown et al. 2008). Singleton (2003) estimated that annual pre-harvest losses due to rodents in rice production range from 5-10% in Asia alone, and that amount of rice loss could be enough to feed 450 million people for 12 months. In Myanmar, 41% of farmers considered rodents to be their main pests in rice fields and the yield loss was 13% in lowland rainfed agricultural system (Brown et al. 2008). Htwe (2006) observed that 6% of the rice yield was reduced by rodent damage in fields in Bago and Ayeyarwady Regions.

There are more than 2700 species of rodents over the world. Forty two percent of all the mammal species on earth are rodents. Most of major rodent pest species found in South and Southeast Asia belong to the family Muridae (Aplin et al. 2003). Among the field rats, mole rat and bandicoot are most notorious for their burrowing behaviour (Hussain 2005). The lesser bandicoot rat (*Bandicota bengalensis*) is a solitary rat and one burrow system was occupied by one adult, sometimes with their youngs (Greaves et al. 1975). The burrow systems are complex and usually occur on the bunds. Burrows of *B. bengalensis* are elaborated interconnected tunnels having multiple openings, with a nest chamber and more than one food-storage chambers

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(Malhi and Sheikher 1986). Only females seem to hoard the significant amount of food in their burrows (Aplin et al. 2003). They live in rice fields throughout the year and their highest population is at the tillering and harvesting stages (Htwe 2006; Thwe 2007). Their abundance may vary according to the availability of food and shelter in agricultural fields.

The control measures adopted to manage the lesser bandicoot rat include traditional catching by digging the burrows. In Myanmar, farmers mainly rely on rodenticides and rat hunter to overcome the losses due to rodents in their rice fields. Rat hunters, however, catch rodents when they see a high population in field and heavy use of chemicals can cause risks to non-target species and to the environment, and generally provide poor return on investment (Singleton 2003).To achieve satisfactory control of *B. bengalensis*, recommendations are based on the breeding potential and population level. Pests should be controlled before build-up of populations in the field. Effective pest control requires a thorough understanding of the biology and population dynamics of the pest species (Conover 2002). In Myanmar, little is known about the population ecology of *B. bengalensis* and this hinders the development of sustainable management.

There are different ways to study population dynamics for different species by calculating trap success, using tracking tiles and census cards, and counting burrows. *B. bengalensis* are aggressive and trap-shy animals and the burrow count method is useful for estimating their abundance in rice and wheat fields in India and Bangladesh (Aplin et al. 2003).

The relationship between abundance of rodent pest species and their damage to crop is generally not linear (Brown and Singleton 2002). It is important to understand this relationship if simple thresholds for management action are to be identified. However, in Myanmar, evidence is lacking on the relationship between damage to rice crops and rodent population abundance.

Positive correlation between rodent damage and rodent population abundance in rice fields was hypothesized in this study. The study was designed also to examine whether recommendations could be made when rodent management strategies should be started before high damage occurred.

Materials and Methods

Study area

Experiments were carried out in irrigated rice field of Yezin Agricultural University Campus, which is located at 19.8332° N, 96.2751° E. Five plots (0.5 acre (0.20 ha) in each plot) were studied one week before harvesting of monsoon rice in November 2015.

Rodent species composition and breeding study

Ten plastic snap traps baited with aromatic rice variety (Paw San Hmwe) were set in each plot near the entrance of rat burrows and along their runways. Trapping was carried out in the evening and the killed traps were checked in the next morning. Trapping was carried out for two consecutive days. The rodents caught in the traps were identified to species. Breeding performance of females was studied to estimate their conception time.

Estimating population index by burrow count

To count the number of active burrows and inactive burrows to estimate the population index, all potential burrow openings along the rice bunds of the study plots were closed with mud in the evening. Burrows were checked in following morning. Opened burrows were marked as active burrows and closed ones as inactive burrows.

Damage assessment

Damage assessment was carried out at two weeks before harvest. A stratified random sampling method was used. All studied field plots were rectangular in shape. For example, if the field size is ($75\times25\text{m}^2$), three transect lines were set at 25m (breadth of rectangular). The first transect was started at 4m from the edge of field. The second and third lines were at 8m and 12m. The sampling area covered half of the plot size. Damage to plants was assessed at 4 distances into the crop along each transect line. Four strata were set along each transect line. Ten sampling points were assessed in each stratum and total samplings were 40 at each transect line. The number of damaged tillers, undamaged tillers and regenerated tillers were recorded.

Relationship between population index and damage

The relationship between population index and damage was calculated by comparing the number of rodent active burrows and their cut tillers in each plot.

Statistical analysis

The number of active burrows in each plot and the associated rodent damage were analyzed by using a general linear model. The relationship between population index and damage was calculated by using a regression analysis.

Result and discussion

Species composition and breeding study

Two main rodent species *Bandicota bengalensis* and *Rattus rattus*were recorded. *B. bengalensis* was the most abundant species (Fig. 1). *B. bengalensis* is recorded as a major agricultural and urban pest in most of South Asia lowland rice ecosystem (Aplin et al. 2003, Htwe et al. 2013). Similarly, in the lower delta in Myanmar, it is also a common species in rice agroecosystems and causes highest damage at the ripening stage (Htwe et al. 2013). Htwe (2006) found that *R. rattus* was the common species in rice field in Pyinmana area in both wet and dry seasons, which contrasts with the findings of this study. Further study is needed on what factors influence the shift in dominant pest species from 2004 to 2015. Like *B. bengalensis* and *R. rattus*, voles also have digging burrows behavior. Among three rodent species of long-tailed vole, southern red-backed vole, and American shrew-mole, removal of "resident" species resulted in rapid colonization by the less common species. Both the long-tailed vole and shrew-mole readily occur in early-successional coastal forests after clear cut harvesting or wildfire, as well as in riparian habitats (Carraway and Verts 1991). A dramatic increase in numbers of shrew-moles after removal of all other small mammals also was reported (Dalquest and Orcutt, 1942). The factors influencing the dominant behavior of *B. bengalensis* still needs to be studied.

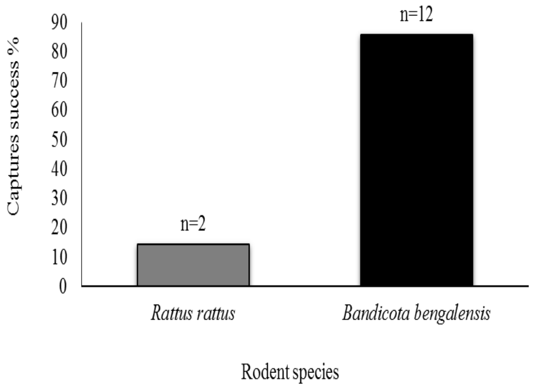

Figure 1. Species composition by trapping in rice fields of YAU campus (one week before

In Myanmar, farmers usually control *B. bengalensis* at the booting stage and two weeks after harvest. In this study, the breeding data indicated that 25% of female *B. bengalensis* were pregnant or lactating and more breeding females occurred at the time of harvest (Table 1). Htwe et al. (2016) found most of adult females were either pregnant or lactating 2 weeks after harvest. Rodent must be controlled before the main breeding season. It can be recommended that rodent management should be started before the maximum tillering stage of the rice crop.

Estimating population index by burrow count

The average total (both active and inactive) of rodent burrows was 40.2± 8.52 for each plot (0.5ac). The average number of old burrows (inactive) was 28.2± 4.75 and active burrow was 12.2± 5.22 (Fig. 2). The number of active burrows per site ranged from 1 to 30. In previous studies, *B.bengalensis* invaded fields of rice one or two weeks before harvest (after draining out last irrigation water) and quickly establish burrows systems, while in wheat crops, after 3-4 weeks of sowing the rats moved to the interior of fields from the dikes (Malhi and Sheikher 1986). There is no comparison among the number of active burrows at different crop stages in this study and this kind of study needs to be conducted to understand more about the behavioral ecology of *B.bengalensis.* In another study in the lowland ecosystem in Myanmar, more *B. bengalensis* burrows were observed in the rice field when the field got dry (Htwe et al. 2016). Htwe (2006) also found that rodent damage at the ripening stage was highest in the field where

Table 1. Breeding performance of *Bandicota bengalensis* in the field one week before harvest

Species	Total	Adult female	Breed-ing female	Breeding female %	Litter size	Conception time
Bandicota bengalensis	12	8	2	25	8.6	Heading

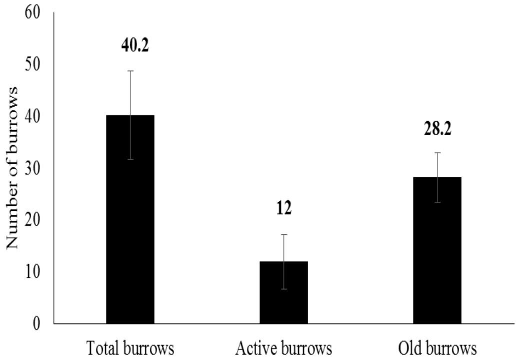

Figure 2. Average number of rodent active burrows and inactive burrows (old burrows) in monsoon rice fields, YAU

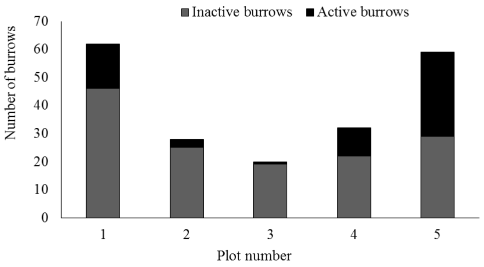

Figure 3. Percentage of rodent active burrows in each plots, one week before harvest, 2015

B.bengalensis was the most common species.

The number of active burrows in the field plot where the crops were grown lately was higher than those of other plots where the crops were grown synchronously (Fig. 3). An extension of their food availability in fields due to asynchrony of cropping could extend the breeding season of rodent pest species and lead to higher populations in the next season crops (Singleton et al. 2010; Htwe 2013).

Individual burrow systems of *B. bengalensis* are often very complex with multiple chambers and entrances (as many as 12-16 per burrow) (Aplin et al. 2003). Similar complex burrow system was observed in this study (Fig. 4).

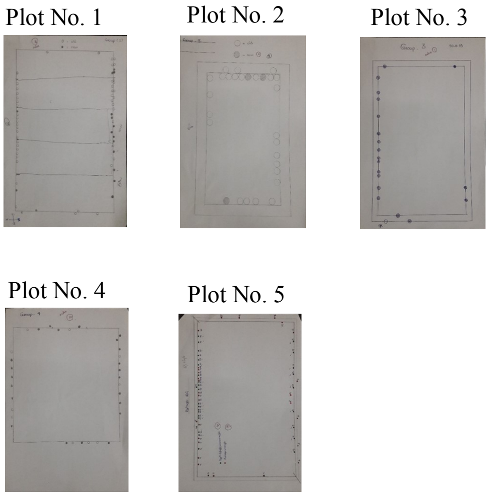

Figure4. Distribution of rodent burrows in field (the patterns of burrow distribution on paper) -active burrow, - non active bur-

One individual system is usually four-meter long (Magpool et al. 2011). Burrows are usually occupied by one adult male or female, or by a female with her youngs (Aplin et al. 2003). The number of *B. bengalensis* in each sampling plot was estimated by assuming one individual burrow system is one meter long and it was occupied by one adult male and female. Since it is difficult to measure the burrow length and further study and methodologies need to be developed to estimate the number of rats based on the numbers of active burrows.

Damage assessment

Damage was estimated at ripening stage of crop and the average rodent damage was 6.18 %.

Table.2 Rodent damage percent and estimated yield loss (t/ha) (Ref: MyPhyung et al. 2010)

Plot	1	2	3	4	5
Damage	4.9	1.79	1.32	3.55	19.48
Estimated yield loss	0.52	0.19	0.13	0.38	2.06

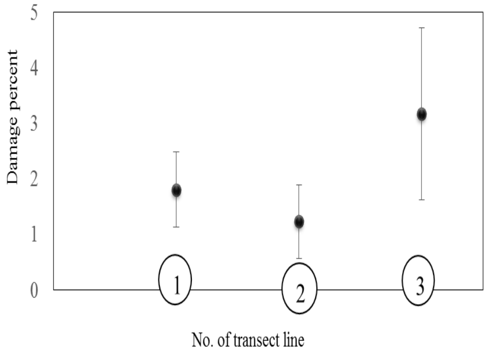

Figure 5. Average damage percent at three transect lines in rice fields of YAU campus

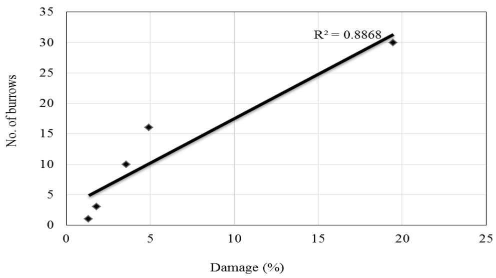

Figure 6. Relationship between rodent abundance and damage percent in monsoon rice fields, YAU campus, one week before

Highest damage percent was 19.48% and the lowest was 1.32% (Table. 2). The highest rodent damage was observed in the field plot which was harvested later than the surrounding plots. In the Ayeyarwady region, cyclone Nargis led to significant delays in planting of the monsoon rice crop for many farmers which in turn lead to asynchronous cropping. In 2008, asynchronous cropping after the cyclone led to an increase in rodent damage (33%), with losses considerably higher than 2007(1.0%) in monsoon rice (Htwe et al. 2013).

Rodent damage was patchily distributed in the rice fields and the uneven and patchy distribution made spatial comparisons challenging. In several parts of Southeast Asia, the highest rodent damage was often found in the middle of rice fields rather than around the edges, producing the so-called ‘stadium effect’ (Aplin et al. 2003). Similar finding was also observed in this study that the numbers of damaged tillers in the center of field was higher than in the margins of field, but these were not statistically different (Fig. 5). The patchy distribution of damage is assumed to be predator crops in the Mekong delta, Vietnam, yield loss was related to the damage and growth stage of the rice crop and was strongly associated with damage intensity at the ripening stage. There were no significant relationship between yield loss and damage at the tillering stage (MyPhung et al. 2010).

The damage was measured only at ripening stage in this study. Rice tillers can regrow after rodents cut them near their base. It was multiplied the fresh damage by 6.5 to obtain an estimate of cumulative damage (Singleton et al. 2005). They also reported that yield loss, based on damage at the ripening stage, could be obtained by multiplying by 4.2. If the multiplied factor suggested in their paper is used to estimate the cumulative damage that will become more than 100% in the plot 5 (19.48 ×6.5=126.62%). MyPhyung et al. did not estimate the cumulative damage and there is still no figure to compare with Singleton et al. for cumulative damage.The common rodent species in both studies was *R.argentiventer,* whereas the main pest in this study was *B. bengalensis*. A longitudinal study of damage to rice by *B. bengalensis* needs to be done to get the multiplying factor for in Myanmar to calculate the cumulative damage from damage scores at the ripening stage. Because of their hoarding behavior, the amount of stored food loss inside their burrows may result in more losses in the field. The quantity of grain stored by the lesser bandicoot rat has been well documented in Bangladesh, India and Pakistan because of its pest status and economic impact on rice and wheat productivity (Poche et al. 1982). In Myanmar, the grain lost to rodents via their hoarding behavior per family (mean farm size 6 ha) was 268.8 kg in 2013 and 133.2 kg in 2014 (Htwe et al. 2016).

Relationship between the population index and rodent damage

The number of active burrows was positively correlated with the damaged tiller percentage (r^2= 0.8868) (Fig 6). Highest rodent damage occurred in the field where the population index was the highest and the lowest damage was observed in the field where the population index was lowest. However, the relationship was largely driven by one point because damage was much higher in one of the plots (Fig. 6). We can also predict that increases in active burrow numbers may lead to increases in yield loss because of the hoarding behavior of *B. bengalensis.*

This finding provided evidence that supported the hypothesis of this study. Farmers usually manage rodent populations once they see high rodent damage in the field. The finding in this study supports the assumption that rodents should be managed before high damage was occurred in the field. Rodents should be managed before the build-up of high population in fields. In the YAU campus, rodent management should be started at the planting time and maximum tillering stage. Community rodent management must be done to avoid the intrusion of rodents from fields with high population abundance to low populations.

Conclusion

In this study, the dominant rodent species was *B.bengalensis* which have burrowing and hoarding characteristics. They can construct complex burrow system and store food in their burrows. They can establish in fields after planting of the crop and their breeding season began after the maximum tillering of the rice crop. The occurrence of active burrows is the indicator of their invasion into the field. The level of damage was directly related with the number of active burrows. Based on research findings, it can be recommended that farmers must control rodents before high populations build up in fields (at planting time and maximum tillering stage) with strong understanding of ecology of common rodent species. In addition, given the average farm size in Myanmar is about 5 acres then rodent management must be done as community campaign activities. If not, rodent would soon reinvade into fields from neighboring fields where farmers do not control rodents. Their population was higher in late sown field plots than other plots, it indicated asynchronous planting and harvesting should be avoided to prevent extending food availability which is an important platform for high rodent populations. Rodent damage was found as stadium effect and predator avoidance behavior of rodent needs to be studied (see Jones et al. 2017).

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