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Modified trap barrier system for the management of rodents in maize fields in Jilin Province, China

Deng Wang [a, *], Quanxi Li [a], Ke Li [a], Yongwang Guo [b]

[a] College of Plant Protection, China Agricultural University, 2 Yuanmingyuan West Road, Haidian District, Beijing 100193, PR China
[b] National Agro-tech Extensions and Service Center, 20 Maizidian Avenue, Chaoyang District, Beijing 100026, PR China

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ABSTRACT

A trap barrier system (TBS) is widely used to manage rodents in farming areas of China. Traditional TBSs are constructed as a rectangle around crops on the principle that rodents are attracted to the enclosed trap-crop (TC) which maximizes the number of rodents captured. This study evaluated the efficiency of capturing rodents using rectangular TBS with and without a trap-crop (R-TBS + TC and R-TBS), and linear TBS (L-TBS) for rodent control in maize fields in Northeastern China. The overall number of rodents captured by R-TBS + TC and R-TBS were not significantly different, but the peak number of rodents trapped by R-TBS occurred later in time in comparison to that of R-TBS + TC. There was no difference in the community composition of the captured rodents by R-TBS and R-TBS + TC. The numbers, age structures and sex ratios of *Apodemus agrarius* Pallas, the rodent species most commonly trapped by R-TBS + TC and R-TBS were uniform. Thigmotactic movement of a rodent is a more likely explanation for rodent capture than the attraction of trap-crops in R-TBS. The efficacy of L-TBS in capturing rodents was not significantly different compared with R-TBS. The community composition of captured rodents and the characteristics of *A. agrarius* population (population size, age structures and sex ratios) trapped by R-TBS and L-TBS were similar. L-TBS could be more practical for farmers and appears to provide similar levels of rodent control compared to the traditional R-TBS in this farming system.

1. Introduction

Pest rodent populations are distributed worldwide and have significant adverse effects on agricultural production, natural environments and human health (Taylor, 1972; Battersby et al., 2008). Chemical management of pest rodents using rodenticides is common but can have unwanted side effects such as accidental poisoning of children and domestic animals, secondary poisoning of non-target wildlife and environmental pollution (Buckle, 1999). The development of effective and sustainable rodent management methods, with fewer adverse effects, is constantly sought.

The success of the trap-crop approach in managing pests including pathogens, plant nematodes (Leach, 1981) and insects (Martin and Woodcock, 1983) exhibits potential application in rodent management, where the attraction of a pest to a crop could be exploited by using mechanical traps to target incoming pests. A major advantage of this approach is a reduction in the use of pesticides. In adapting this approach to rodent management, Lam (1988) designed a trap barrier system (TBS) comprising a physical barrier to rodent movement combined with live-multiple-capture cages to control the rice field rat (*Rattus argentiventer* Robinson & Kloss) in rice (*Oryza sativa* Linnaeus) crops. Since then, TBS has been widely used as an ecologically based rodent management (EBRM) method (Singleton et al., 2007) in the rice crops of Vietnam (Palis et al., 2003; Brown et al., 2006), Malaysia (Singleton, 1997) and Indonesia (Singleton, 2003; Jacob et al., 2010).

In China, there is increasing attention to the problem of environmental pollution associated with the use of pesticides, including rodenticides. TBS has been used widely in crops of wheat (*Triticum aestivum* Linneaus) (Wang et al., 2009; Dai et al., 2011; Li et al., 2011; He and Mu, 2012; Liang et al., 2014), rice (Chen and Chen, 2009; Chen, 2010; Wang et al., 2011) and maize (*Zea mays* Linneaus) (Guo et al., 2011; Li et al., 2012), and in other crop types in Xinjiang, Sichuan, Jilin, Liaoning, Qinghai, Hunan, Anhui and Guizhou provinces of China. The results have generally shown TBS to provide effective rodent control, with higher crop yields in TBS-treated fields compared to non-treated ones; in these situations, farmers achieved economic benefits by using TBS and substantially

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* Corresponding author.
E-mail address: wangdeng@cau.edu.cn (D. Wang).

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reduced their use of rodenticides (Wang et al., 2009, 2011; Guo et al., 2011).

Applications of TBS in southeastern Asia and China incorporate the principles that rodents are captured because they are attracted to the trap-crop and will traverse the edge of a barrier that prevents them from accessing the crop (Singleton et al., 1998). The commonly used construction of TBS is a rectangular TBS (R-TBS). Previous trials have shown that R-TBS plus rice as a trap-crop (R-TBS + TC) is more effective for rodent management than R-TBS alone in rice fields (Singleton et al., 1999; Brown et al., 2003). Large-scale field maintenance of TBS in maize and wheat crops in China have followed this precedent by assessing the efficacy of R-TBS + TC since 2009 (Wang et al., 2009; Dai et al., 2011; Guo et al., 2011; Li et al., 2011, 2012; He and Mu, 2012; Liang et al., 2014). However, little is known about the efficacy of rodent pest management using R-TBS alone in comparison with R-TBS + TC. If the movement of rodents along an artificial barrier is a contributor to the efficacy of TBS in some agricultural environments such as a non-irrigated crop, then the enclosure of a trap-crop may not be essential to high captures of rodents.

One disadvantage of R-TBS is its cost of implementation within the constraints of agricultural mechanization (Li et al., 2011, 2012), which is increasing in China. The establishment and maintenance of R-TBS that enclose a trap-crop pose operational problems for farmers using tractors and other machinery. Currently this limits the extended application of R-TBS in Chinese farmlands. If R-TBS alone has similar effects on rodent management as R-TBS + TC, simple linear TBS (L-TBS) designs could be as effective as R-TBS in some situations, which can be more readily implemented as it interferes less with mechanized farming practices.

In this study, we compared the composition of the rodent community and the characteristics of an *Apodemus agrarius* Pallas population, which is the most commonly captured species, by R-TBS and R-TBS + TC, and evaluated the efficacy of L-TBS in comparison to R-TBS, in maize fields in Gongzhuling, Jilin Province, China.

2. Materials and methods

2.1. Study sites

The study was conducted in Gongzhuling county, Jilin Province, China (E:124°54′, N:43°46′). We selected six and eight blocks (>50 ha) of maize fields as sample sites in 2014 and 2015, respectively. Block A was centered among a village on the east boundary, a national reserves granary on the west boundary, a tree belt on the north boundary, and adjoined maize fields in other directions. Block B was north of A, and there was a road and a tree belt between them. Block C adjoined a village on its northwest boundary and had maize fields in other directions. Block D neighbored C across a road on its north boundary. Blocks E and F were located in the center of a tract of contiguous maize fields. In 2015, we added blocks G and H, which were greater than 1 km away from the other sites, and they were located in the center of a large area of maize fields. We built R-TBS + TCs and R-TBSs with three replicates in blocks A, C and E and blocks B, D and F in 2014, respectively. In 2015, R-TBSs and L-TBSs were set with four replicates in blocks A, C, E and G and their neighbored blocks B, D, F and H, respectively. All TBSs were more than 1000 m away from the closest village or building (Fig. 1).

Gongzhuling County is in a transition zone from northern mountains to southern plain and has four distinct seasons. The dominant crop is maize, which is planted annually. Maize is usually sowed in late April or early May and harvested in late September or early October. Considering that rodent population dynamics are potentially mediated by both limiting resources and biotic interactions (Morgan Ernest et al., 2000), we divided the whole growth cycle of maize into five stages for analyzing rodent communities and population characteristics. The stages were as follows: sowing-seedling (days 1–13), seedling-jointing (days 14–42), jointing-tasseling (days 43–74), tasseling-milk (days 75–103) and milk-harvesting (days 104–138). TBS treatments were constructed at the beginning of sowing and remained in place during the whole maize growth cycle. The main target rodent pests are surface-active in the region (Wang et al., 2015). There had been no other rodent control operations carried out in the treatment locations in recent years.

2.2. TBS design

All R-TBSs and L-TBSs were constructed using 20 × 10 m and 60 m metal fences with traps, respectively. The fences were made of 60 cm high metal mesh (diameter≦1 cm) that was buried approximately 20 cm underground and fixed upright to the ground with 50 cm bamboo sticks. A total of 12 semicircular barrel traps were spaced at 5 m intervals along the mesh fence in each R-TBS, with a 5 × 5 cm hole made in the mesh over each trap to allow rodents to be captured. The traps themselves were 45 cm deep and were tapered with 25 cm and 32 cm top and bottom diameters, respectively. The barrel traps had three 1 cm-diameter holes at the bottom for drainage and were buried so that the top of the barrel was at ground level. In addition, the traps opened in only one direction. A trap-crop of maize was planted in the enclosed area of each R-TBS + TC site 3 weeks before the establishment of the R-TBS in 2014.

Using the same specifications as the R-TBS, 60 m long L-TBS including 12 barrel traps were built. Cropping patterns and the cultivation of maize in all sites were consistent with common field cultivation throughout the trial year.

2.3. Data collection

Barrel traps of TBS were checked, and captured rodents were collected every morning during the whole growth period of maize. For all captured animals, the species, sex and body weight were recorded. All rodents were killed by cervical dislocation and stored at −20 °C. We treated Laxmann's shrews (*Sorex caecutiens* Laxmann) as a pest in our analyses, although it does not belong to a rodent family. The individuals of *A. agrarius*, the most common rodent species caught by TBS, were divided into juvenile, sub-adult, adult I, adult II and old age groups according to Yang et al. (2002).

2.4. Statistical analysis

Number of rodents and the number of *A. agrarius* were analyzed with a two-way repeated measures ANOVA with TBS type (R-TBS + TC and R-TBS-TC in 2014; R-TBS and L-TBS in 2015) and maize growth stage as fixed effects. A Greenhouse-Geisser correction for sphericity was used when necessary. Significant main or interaction effects were followed by a one-way ANOVA with TBS type as the fixed effect at every stage of maize growth. A one-way MANOVA was used to test the effect of TBS type on the percentage of the seven rodent species. The same analysis was also run to determine the effect of TBS type on the proportion of different age classes in the *A. agrarius* population. A one-way ANOVA was conducted to determine the variation among the percentage of rodent species and different age classes in *A. agrarius* population caught by TBS in the same year. In all above analyses, data were square root-transformed before analysis to improve normality. We used a one-way ANOVA to compare the Shannon-Weiner index of the