Advances in IPM Rodent Control in Agriculture

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Abstract

Rodents exist closely with man, with rodent populations tending to increase as human populations increase. As man artificially creates concentrated sources of food, water and harbourage, for his own survival, he often inadvertently creates the ideal environment for rodents to thrive. Various control strategies are discussed in terms of integrated pest management (IPM) schemes. These include the use of preventative methods during storage and in-crop as well as the use of various poisons/rodenticides.

INTRODUCTION

Rodent pests significantly damage crops before and after harvest with an estimated 20% of the world's food supply consumed or contaminated each year. The most severe in-crop problems occur in tropical plantation crops such as sugar cane (Figure 1), oil palm, cocoa and coconut and also in rice, other cereals and other food crops. While the tropical climates allow many rodent species to flourish, virtually all climates are plagued by the ubiquitous commensal rodent species (Rattus norvegicus (Figure 2) and Mus musculus) which attack grain and other food and feed whilst in storage (Figures 3 & 4, Table 1).

Surveys of the degree of rodent crop damage have been conducted and indicate substantial levels in many regions. Examples for certain crops and regions and the primary species responsible are shown in Table 2.

IPM CONTROL STRATEGIES

The most effective, economical and environmentally sound control strategies involve the use of integrated pest management (IPM). To protect crops whilst in storage from rodent damage, a few preventative measures will go a long way towards controlling infestations and preventing them from becoming established in the first place. The principal measures include food source removal and harbourage reduction. If possible, crops should be stored in containment which has been rodent-proofed. Doors, windows and screens should be tight-fitting and any holes in the structure should be sealed (Figure 5). Rodents can easily enter any hole in a structure one metre below or above ground level. All potential entryways should be sealed up, as rodents can enter holes as small as 6mm. Holes should be sealed with hardware cloth, perforated metal, galvanised sheet metal or cement mortar. In indoor storage areas, particularly where the outer building has not been proofed, stored goods should be kept on pallets or in rodent-proof sealed containers. Any spillage around the outside of the store should be cleaned up regularly, as this will attract

Figure 1 (above)
Sugar cane damaged by rodents.
Photo courtesy of
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Figure 2 (below)
Rattus norvegicus with young.
Photo courtesy of
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Figure 3
Wheat store covered with rat tracks and tail drag marks.
Photo courtesy of Bell Laboratories, Inc

rodents. Outside debris and clutter which provide potential harbourage should be eliminated. Weeds and dense or high-standing vegetation should be eliminated for 3-10 m around the outside of stores, and any tree branches which overhang stores should be pruned back (Figure 6).

Standing water may also attract rodents and should be eliminated around stores if possible.

For controlling rodent pests in-crop, prevention is more difficult, as in most cases large areas are involved and exclusion is not practical (Figure 7). Several non-chemical deterrent measures are available, however, and may be used effectively in certain crops and regions. As much as is practical, measures may be taken to reduce harbourage areas in and around fields by eliminating unnecessary vegetation, garbage, piles of junk, etc. Other measures include burning fields after harvest to kill or displace rodent pests, a practice used particularly in sugarcane. Before planting, fields may be flooded to kill or displace rodent pests; after harvest, in some crops, deep ploughing is used to destroy nests and displace rodents. Removal of crop residues after harvest will cause rodents to look elsewhere for food and may be done in cereal crops by grazing livestock temporarily or by burning as noted in the case of sugarcane. Deep ploughing after harvest will also make crop residues less accessible to rodents.

In most cases where rodents represent a major threat to crops, poison baiting must be used in addition to the methods noted above to obtain adequate control. Before beginning a poison baiting programme, the available options and their respective benefits and limitations should be assessed. There are three main classes of rodenticide poisons in use today. The oldest are the acute poisons which include compounds such as arsenic, strychnine, zinc phosphide, sodium monofluoroacetate, and others. Of these, zinc phosphide is the safest and the only one still allowed for use in many developed countries. Traditionally, acute poisons have been available for purchase in technical active form either legally or otherwise by end-users to mix with various food materials and make up their own baits. Besides potentially inviting opportunity for accidental poisoning, these baits are often not particularly effective. Acute poisons share a common problem in that they act very quickly and rodents will become ill shortly after eating the bait. They then associate this illness with the bait and will not eat it again. This effect is known as bait shyness and occurs with all acute poisons. If the rodent did not eat enough to kill it in the first feeding, it will not eat the bait again and not die. Because of bait shyness, an acute bait should not be used at less than 60 day intervals and even in the best circumstances 100% control will not result in the field. Due to the bait-shyness effect and the often relatively poor quality of "home-made" formulations, control results are often quite poor with acute home-made baits. In the United States today, zinc phosphide is the only rodenticide allowed for in-crop baiting due to its lack of crop residue problems and lack of secondary hazard effects (predator animals eating dead rodents and also dying from the poison). A sophisticated, ready-to-use pelleted formulation of zinc phosphide has been developed in the US which is highly palatable (attractive) to rodents, relatively safe to use, and water-resistant for baiting in crops such as sugar cane. Such formulations are still quite economical to use and are aerially broadcast over large land areas. Due to the bait-shyness effect however, it is generally impossible to achieve 100% control with an acute bait.

The second and most widely used class of rodenticides are the anticoagulants which kill by causing internal bleeding. These are chronic, cumulative poisons which take several days to kill. Due to this delayed effect, the rodent never knows the poison is making it ill, hence the bait shyness effect does not occur. This delayed mode of action and the existence of an effective and readily available antidote (Vitamin K1) have made this group of compounds incredibly popular and successful since their introduction in the 1950s. There is however a down-side with anticoagulants as well. The early group of compounds developed which came to be known as the "first generation" anticoagulants including warfarin, coumatetralyl, diphacinone, chlorophacinone, coumachlor and others have been found to become ineffective after repeated use in some areas. This effect, in which the rodents eat what should be a lethal amount of the poison but do not die is due to a genetic

Figure 4
Rattus rattus.
Photo courtesy of Bell Laboratories, Inc

Table 1. The World's Major In-Crop Rodent Pest Species, by Region and by Crop

Rodent Pest	Region	Crops
Rattus spp. (argentiventer, tiomanicus, diardii)	Southeast Asia	oil palm, rice
Bandicota bengalensis	India, Southeast Asia	sugar cane, cereal, other food crops
Rattus spp. (rattus, exulans, norvegicus)	Oceana	coconut, other food crops
Meriones spp.	North Africa, Middle East	cereals
Arvicanthis nioticus, Praomys natalensis	Sub-saharan Africa	various food crops
Sigmodon hispidus	Latin America	rice, sugar cane, cotton
Microtus spp.	USA, Europe	top fruit, forestry
Rattus spp. (exulans, rattus, norvegicus) Sigmodon hispidus	Southern USA, Caribbean	sugar cane

(c.f. Report on the OECD/FAO/WHO expert consultation on rodent problems, control and research. Working Paper 3. Paris 2-5 May 1978.)

Figure 5
Holes in stores should be repaired to exclude rodents. Photo courtesy of Bell Laboratories, Inc

and inheritable resistance to the poison. Repeated use in the same area can select out the resistant rodents, leaving them to reproduce. Cross-resistance among first generation poisons occurs, so using two different first generation poisons will not solve a resistance problem.

This said, however, first generation anticoagulants are still quite effective in the majority of land area in the world, particularly in developing countries. In the mid to late 1970s, a group of compounds known as the "second generation" anticoagulants were developed. These compounds

Table 2.
Rodent Crop Damage Examples

Rodent Pest	Region	Crop	Damage Level
Bandicota	Pakistan	cereals	20-40%
Bandicota	Bangladesh	wheat	0-30%
Bandicota	India	rice	5-22%
Rattus argentiventer	Southeast Asia	rice	2-47%
Rattus tiomanicus	Malaysia	oil palm	5%
Microtus	USA	apples	6%
Microtus	France	lucerne	1-22%
Microtus	Finland	forestry	0.2-40%
Apodemus	Northwest Europe	sugar beet	10-20%
Rattus rattus	Cyprus	carob	up to 20%
Hylomyscus, Praomys	West Africa	cocoa	7-15%
Xerus	Kenya	maize	10%
Praomys	Tanzania	food crops	up to 50%
Rattus spp.	Caribbean and South Pacific	coconut	5-77%
Rattus spp.	Hawaii	sugar cane	40%
Sigmodon	South America	rice	10%
Holochilus	South America	sugar cane	15%

(from BJ Wood, Rodents in agriculture and forestry, in Rodent pests and their control, eds. AP Buckle and RH Smith, CAB International, Wallingford, Oxon, UK (1994).)

Figure 6
Rattus rattus will nest in palm trees and other vegetation. Photo courtesy of Bell Laboratories, Inc

include bromadiolone, difenacoum, brodifacoum, flocoumafen and difethialone, and are considerably more toxic, killing rodents that are resistant to the first generation anticoagulants. With these compounds rodents may eat enough to kill them in a single day or in some cases in a single feeding, but they still will take several days to die. While very successful and widely used, these compounds and particularly the latter three have quite a high toxicity to non-target animals and pose a significant secondary hazard threat. In a sense, they lack some of the advantages of the first-generation anticoagulants. Some resistance has also been documented to second-generation anticoagulants in a few areas.

The third and final class of rodenticides, which are not as widely used at this time, are the sub-chronic poisons which include the calciferols (Vitamin D) and bromethalin. While faster acting than the anticoagulants, these poisons are not strictly acute and typically take about 1-3 days to kill. The advantages of these compounds are that they will kill anticoagulant resistant rodents, but since they are not strictly acute, they don't have the problem of bait shyness. They also have a very low potential for secondary hazards and exhibit a "stop-feed" action in that rodents will seldom eat much more than a lethal dose. The disadvantages include the lack of an antidote to treat accidental poisoning, and the cost, primarily. Baits made from these poisons in a broad sense have traditionally been found to be less palatable to rodents than anticoagulant baits, though much depends on the specific formulation.

Beyond the type of poison incorporated, other features are extremely important in determining the effectiveness of a bait. Palatability is the most important. Rodents must eat bait in order for it to kill them and they must eat it in preference to an existing source of food which may be ample, for example in a grain store or in a ripened field crop. Baits must also be weatherable as they are often used in damp environments where they must maintain their palatability in order to be effective. Lastly, a ready-formulated bait must have a suitable shelf-life wherein palatability and potency are maintained for a period of at least one to two years. Baits made with advanced formulations in the form of pellets or extruded all-weather blocks (Figure 8) typically provide the best option in terms of palatability, weatherability, and shelf-life.

A viable control strategy for rodents around stores would involve the preventative measures discussed earlier as well as a baiting programme. When treating an active infestation, it is very important to put the bait where the rodents are: do not expect rodents to come and find the bait. For Rattus norvegicus, baiting directly in the burrows is very effective. For Rattus rattus or mice, bait should be placed in nests if they can be located and extruded blocks may be wired or nailed up along beams and other runways where the rodents are travelling. If bait must be placed in an area accessible to livestock or children, tamper-resistant bait stations should be used and secured down. Once the infestation is under control, a permanent perimeter baiting programme should be set up placing tamper-resistant bait stations every 10-15 m around the outside of stores which should be maintained with an all-weather anticoagulant block bait (Figure 9). In most cases, baits based upon bromadiolone typically represent the best choice in terms of palatability, effectiveness and safety, though others may be effective as well. In the long term, a permanent preventative baiting programme is much more economical than allowing infestations to become established and breed, consume and contaminate the stored crop and cause other damage.

Figure 7
Large areas make rodent exclusion difficult in-crop.
Photo courtesy of
Bell Laboratories, Inc

For field crops, an ongoing baiting strategy to keep infestations at an absolute minimum is the most economical option to minimize crop loss. From the point of view of both economics and resistance management, an integrated approach could include a bait rotation programme. An initial treatment with a water-resistant zinc phosphide pellet is quite economical as a knock-down measure, followed by treatment with an all-weather extruded block bait containing a second-generation anticoagulant. The zinc phosphide treatment should be repeated at six-month intervals due to economics and to help prevent anticoagulant resistance build-up. For field crop baiting, frequent, small placements are the most effective, placed by hand or broadcast. Zinc phosphide should be used at about 1-2 g per placement, with single water-resistant pellets being the best option, and second-generation anticoagulant bait should be used at 4-5 g per placement, with single small extruded blocks being the best option. Again, weatherability is of paramount importance, particularly in tropical climates. Weatherable baits are much more economical to use as less is needed due to its remaining effective in the field for longer times.

Where an ongoing in-crop rodent management effort is maintained consistently, results are quite good. In Florida, USA, sugar cane, water-resistant zinc

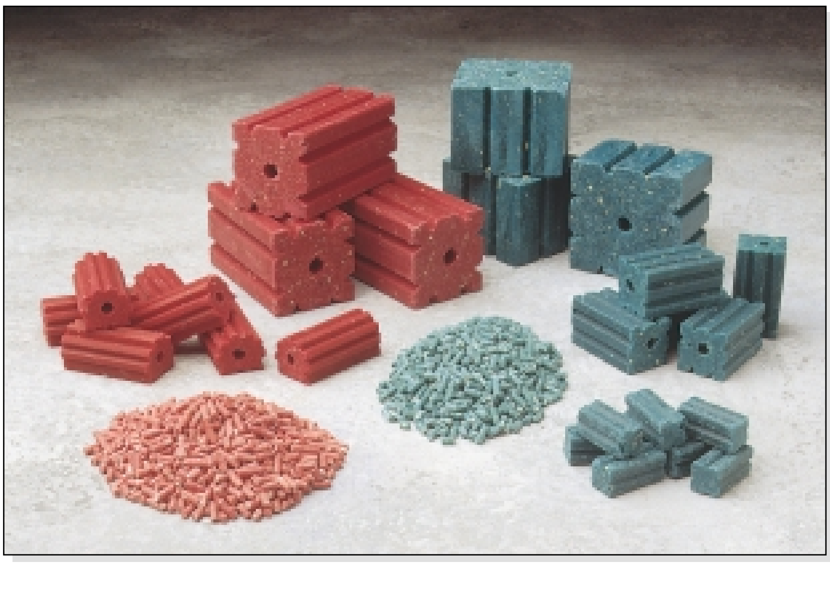

Figure 8
Pellets and extruded blocks are attractive to rodents and weather-resistant.
Photo courtesy of
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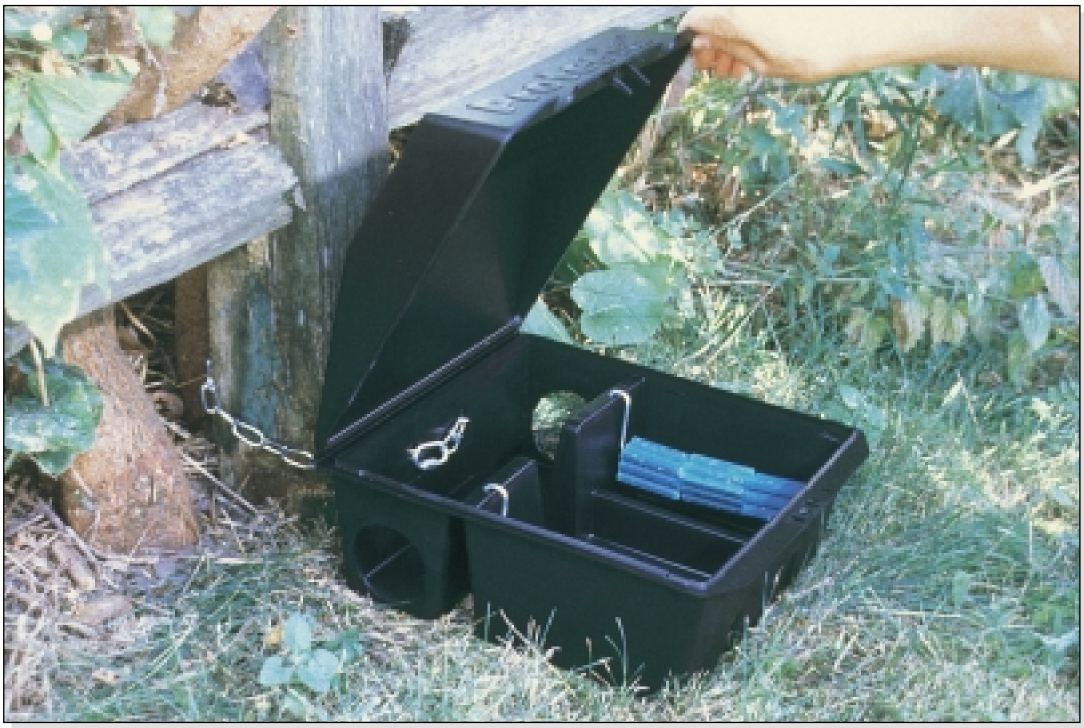

Figure 9
Permanent tamper-resistant bait stations should be installed around stores and maintained with anticoagulant extruded block baits to prevent rodent infestations.
Photo courtesy of Bell Laboratories, Inc

phosphide pellets have been used exclusively for more than 10 years with excellent results. The bait is applied by aerial broadcast at a rate of 5 kg/ha, up to four times per crop (sugar cane is a one year crop in Florida), with the last application being at least 30 days before harvest. Even with the bait shyness effect of the acute poison, adequate control is still maintained using a specially developed, economical formulation. The other excellent example of good results from a consistently applied programme is in Malaysian oil palm. Individual wax block baits containing a second generation anticoagulant are applied at the base of each oil palm tree on a 6 monthly cycle. In both Florida sugar cane and Malaysian oil palm, the key to good results is in a consistently applied programme, wherein applications are made regularly on schedule and large areas are treated at one time. Indeed, the greatest challenge in rodent control is not finding effective treatments, but in organizing their execution at the community level. This problem is particularly acute in areas dominated by small holdings where efforts are inconsistent. Often in such cases, no real control programme is implemented until the problem reaches crisis level, wherein government bodies will step in with large treatment campaigns. While they are effective short-term, they are often not maintained and the cycle simply repeats itself. This type of crisis control programme is far more expensive in terms of amounts of poison needed and in crop losses sustained than a consistently applied ongoing programme which prevents rodent populations from ever reaching crisis levels.

In any rodent control programme, it is important to control as close to 100% of the population as possible. Due to the rapid reproduction rates of rodents, even controlling 90% will only have a very short term effect on minimizing damage, if the other 10% are left to rapidly reproduce. The most effective control programmes involve an integrated approach consistently applied, which includes prevention, exclusion and the strategic choice of a range of poisons for the best and most economical results.

ABOUT THE AUTHOR

Dr. Spragins received her masters and doctoral degrees in chemistry and physics from the University of Wisconsin-Madison USA. She was then employed by a leading rodent control products manufacturer for 9 1/2 years in the successive capacities of laboratory researcher, technical director, and international business manager. In 1998, she founded Rockwell Laboratories, Ltd., a specialist manufacturer of professional pest control products. She has lectured and advised extensively on rodent control on a worldwide basis.

IF YOU HAVE ANY ENQUIRIES REGARDING THE CONTENT OF THIS ARTICLE, PLEASE CONTACT:

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