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EFFECTIVENESS OF VARIOUS RODENT CONTROL MEASURES IN CEREAL CROPS AND PLANTATIONS IN INDIA

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Abstract. In India, crops vulnerable to rodent attack include rice and wheat cereals and coconut, cacao and oil palm plantations. *Bandicota bengalensis, Rattus rattus, Tatera indica, Meriones hurrianae, Millardia meltada* and *Mus* sp. are the principal rodents associated with crop damage. In rice 0.005% bromadiolone in bait stations at 15 m interval provided 88.3% control success. Based on live burrow count and baits placed directly in the burrows, the percent control was estimated at 98.8%. Increased yield was recorded in fields treated with bromadiolone as against those of warfarin, zinc phosphide and no treatment. Optimum time of control is six weeks after transplantation. In wheat, which is followed by rice in many areas, bromadiolone bait reduced more than 98% of the rodent population. In coconut plantations, with an average damage of 45.3 nuts/palm/year, amongst a single method of trapping only, warfarin baiting, zinc phosphide baiting and bromadiolone cakes, the latter provided 100% success at the rate of 2 cakes or 33 g/palm in treated plots as indicated by fallen nuts. Single climbing to the crown in case of bromadiolone is an extra advantage in the form of saving in labour in comparison to warfarin and zinc phosphide, also providing 100% success. Cacao intercropped with coconut were treated with bromadiolone wax cakes tied at the fonds at a rate of 2 cakes per tree. After 15 days of treatment, damage was completely reduced. The working index of Economic Threshold Level (ETL), schedule of control operations, monitoring techniques and other integrated measures are discussed.

Key words: *Bandicota bengalensis*, bromadiolone, damage, live burrow count, plantations, *Rattus*.

INTRODUCTION

India exhibits highly diversified habitats with extreme variation in climate. Such diversity favours a number of crops to grow and also harbours a broad spectrum of rodent fauna. There are 8 genera and at least 15 species, responsible for economic damage or public health nuisance in India (BARNETT & PRAKASH, 1975; PRAKASH & MATHUR, 1987, 1988). Rice is major cereal crop vulnerable to rodent attack. The losses may be as high as 3 to 100% in endemic zones, average being 4.9-19% (RAO & SINGH, 1983; REDDY, 1989, 1993). Wheat is damaged to the tune of 4-21% in Northern and Central India (ADVANI *et al.*, 1982; PRAKASH & MATHUR, 1988). Among plantations, coconut, cacao and oil palms are severely attacked by *Rattus* sp. and *Funambulus* sp. both in monocrop and intercrop.

For rodent pest management in cereal and plantation crops, chemical control is still an important component of the Integrated Pest Management (IPM), since it is the quickest and most effective method to decrease rodent depredation. However, the suitable timing of the operation, minimum effective dosage and proper follow ups are essential for an effective IPM module in these crops. The present communication reports on the effectiveness of bromadiolone (Roban) against rodents in rice, wheat, coconut, cacao and oil palm crops and other chemical and non-chemical measures which are usually considered in a decision making process for rodent control in these crops.

MATERIAL AND METHODS

Bromadiolone was used in its two formulations (formulated by Pest Control (India) Limited): 1) bromadiolone 0.25% powder concentrate – it was mixed with cracked cereals (1:49) and 2% vegetable (arachid) oil as an adhesive to prepare 0.005% bromadiolone treated bait and 2) bromadiolone 0.005% ready-to-use wax cake – the 100 g slab contains six equal sized cakes of approximately 16.6 g each.

Rice and wheat

Six one ha plots were selected for burrow baiting and three one ha plots were taken for pulsed baiting treatment in rice, with one plot of equal size as control in each case. However, in wheat, an area of 100 acre (40 ha) was selected for the treatment as well as control. Cracked rice and cracked wheat were used as bait carriers for treatment in rice and wheat crops respectively. About 15 g freshly prepared bait was wrapped in a paper and placed directly inside the live burrows. During the pulsed baiting in rice, 50 g of 0.005% bait was placed on day 1, 7 and 14 in 20 bait stations/ha so that one bait station was available at every 15 m on the bunds and dykes.

In rice, two census methods were employed viz. live burrow count (burrow baiting) and census baiting (pulsed baiting) where as the former was used in wheat treatment.

Live burrow count

All the burrow openings, occupied as well as abandoned, were plugged with mud in the experimental area. The reopened burrows were counted and baited the next morning. After completing the treatment and lag period (15 + 4 days), the burrows were again plugged late in the evening and counted the next morning (MATHUR & PRAKASH, 1984). The difference in the per centage of pre and post treatment was considered as reduction in rodent population.

Census baiting

Empty bait stations were placed in three plots, four days before the pre treatment census started for familiarization purposes. Ordinary bait was placed in the bait stations for three days before and after treatment and lag period. The amount of bait consumed was measured to the nearest 0.1 g. Position of bait stations with rodenticide bait were altered slightly to remove the bias of pre-baiting (MATHUR & PRAKASH, 1984). The bait stations with complete takes of the bait material were replenished with double the quantity.

Coconut

Following treatments were carried out in coconut palms, with a control plot for each treatment about 250 metres away from treatment plots.

Two types of traps, snap traps and live traps, were used. A total of 100 palms were selected for evaluation. Fifty of the trees were selected for trapping at ground level and 50 for crown trapping. Further only 30% of the trees were trapped. The traps were prebaited for three days with vada, a fried gram (pulse) preparation; this was followed by trap setting on the fourth and fifth day.

Bromadiolone was evaluated in an area of 90 palms of which only 50% were baited with bromadiolone wax cakes at the rate of two to three cakes, placed at the base of the panicle, on either side of the crown. Warfarin was also placed as cake with 0.025% active ingredient. Out of the 100 trees selected, 47 were baited on day 1 and 5. Two to three 30 g cakes were placed at the base of the panicle. Zinc phosphide was tested in an area containing 107 palms, 50 of which were baited. After prebaiting for two days 2.5% poison baiting was carried out on the third day. The bait used was rice flour with 10% groundnut oil wt/wt. Bait (20 g) was packed into 10 cm x 5 cm polythene bags and placed on the crown.

Treatments were assessed by reduction in number of damaged and fallen nuts. The damaged nuts were counted for three days prior to each treatment and for two days post treatment and a lag period of 4 days. The reduction in mean nut fall before and after treatment were compared. The count on the first day of operation was discarded.

The cost:benefit ratios were calculated on the basis of cost of candidate treatment plus labour against cost in saving through reduction in damage.

Cacao

In a plot of 3 ha. with 295 trees and 155 coconut palms, one to two bromadiolone cakes were placed on 260 pod bearing cacao trees and two cakes on the crown of each coconut palm. Efficacy of treatment was determined by pre- and post-tratment counts of fallen/damaged pods.

RESULTS AND DISCUSSION

In rice fields, only *Bandicota bengalensis* (Gray, 1835) burrows were observed. After 10 days, the percent reduction as measured by decrease in number of live burrows was about 92% whereas activity reduction increased to 98.8% after 15 days (Table 1).

TABLE 1

Efficacy of 0.005% bromadiolone against Bandicota bengalensis *in rice. Census by live burrow count*

Plot	*No. of burrows treated*	*No. of reopened burrows after days*		*Per cent Control after days*		*Mean % Control*
		10	15	10	15	
1	45	02	00	95.6	100	
2	48	06	00	87.5	100	
3	54	03	02	94.5	96.3	98.8
4	60	06	01	90.0	98.4	
5	58	05	00	91.4	100	
6	57	03	01	94.8	98.2	
Control	50	48	49	04.0	02.0	

During pulsed baiting (Table 2), 0.68 to 0.78 kg bromadiolone bait was consumed per ha in the 3 pulses. In majority of the trials with bromadiolone in rice where *Bandicota bengalensis*, *Mus booduga* (Gray, 1837) *Millardia meltada* (Gray, 1837) are prevalent, the reduction in rodent population has been reported to be 80-100% (CHOPRA, 1988; REDDY, 1989; SIVAPRAKASAM & DURAIRAJ, 1992; MATHUR *et al.*, 1992; BASKARAN *et al.*, 1995). Lower percent control as computed by census baiting in comparison to live burrow count can be attributed to consumption of plain bait by non target animals like ants and birds etc. (MATHUR & PRAKASH, 1984). However, it can be inferred that burrow counting is more accurate and can be fairly applicable as a monitoring technique since bandicoots and other field rodents in India live a solitary life in their burrows (BARNETT & PRAKASH, 1975), except that females live with young ones till they are weaned.

In an earlier study (anonymous pers. comm.), observations on mean tiller damage and grain yield in the treatments revealed that when bromadiolone bait was applied on bunds and fields, grain yield was highest and tiller damage was lowest in comparison to treatments with zinc phosphide and warfarin.

It has been reported (CHOPRA, 1988; SIVAPRAKASAM & DURAIRAJ, 1992; REDDY, 1993) that rodent control in rice should be undertaken 30-40 days after transplantation beyond which the efficacy of chemical control decreases considerably because rodents shift their preference to rice panicles.

In the 100 acre area of wheat, 1128 burrows were located and treated at the rate of 15 g bromadiolone bait in a paper packet per burrow. On the 10th day, 65 live burrows were observed, showing a 94.3% population reduction. After 15 days, when bromadiolone produced its maximum effect, the number of live burrows was only 21 *i.e.* a reduction of 98.1% of the prevailing rodent population comprising of *B.bengalensis* (65%), *M.meltada* (24%) and *M.booduga* (11%). In the control plot 500 metres away in similar habitat pre-treatment live burrow count was 976 which after 15 days during post treatment census in treatment plot, marginally increased to 992. The percent rodent control in wheat with bromadiolone in different agro-climatic zones in India including the present study (MATHUR *et al.*, 1992) indicate that bromadiolone provides a very high level of control in wheat crop. ADVANI *et al.* (1982) reported that with 85% control success, the increase in yield of wheat can be 249-368 kg/ha. In wheat, the damage is visible from very initial stages when seeds are sown. One control operation at this stage (November-December) and other one near maturity (February-March) can reduce the damage to a large extent (MALHI *et al.*, 1986).

TABLE 2

Efficacy of 0.005% bromadiolone pulsed baiting in rice as measured by census baiting

Plot	*Pre-treat/Post treat plain bait consumption (g) for 3 days*	*Bromadiolone bait consumed/ha (g)*	*% Success*	*Mean*
1	883/92	780	89.5	
2	785/95	720	87.9	88.3
3	668/83	685	87.5	
Control	725/738	-	-	

Rattus rattus (L.) and *R.r.wroughtoni* Hinton, 1919 are the most predominant species in coconut (SHAMSUDDIN & KOYA, 1985; ADVANI, 1986; BHAT & SUJATHA, 1991; present study). In the coconut nurseries, *B. bengalensis, Tatera indica* (Hardwicke, 1807), *M.booduga* and *M.meltada* were trapped. In the present study, rodent damage to nuts by *R.rattus* were observed to the tune of 45.3 nuts/palm/year or 51.1% at a density of 150 palms/ha. The damage caused is 3.72 nuts/palm/month amounting to Rs.16,995/year/ha (US $ 472).

In the 130 snap traps laid, only one *M. booduga* was trapped whereas nothing was trapped in wooden live traps placed both at ground and crown level. The decrease in damage to the nuts was insignificant where trapping treatment was given (Table 3). Bromadiolone, warfarin as well as zinc phosphide baiting at crown level resulted in 100% reduction of damaged, fallen nuts. RAO *et al.* (1984) found 100% and 84% reduction in rodent population consequent to bromadiolone and warfarin baiting respectively. SHAMSUDDIN & KOYA (1985) and BHAT & SUJATHA (1991) also obtained 100% control of *R.rattus* on coconut palms using bromadiolone. The cost of operation for bromadiolone, warfarin and zinc phosphide works out to Rs. 87.50, 90.50 and 112.95 respectively for almost equal number of palms. The higher cost of zinc phosphide baiting was due to labour charges since the palms had to be climbed for two days prebaiting and one day baiting.

In cacao and coconut intercrop, a single treatment resulted in 100% reduction in damage after 15 days of treatment. *Rattus r.wroughtoni* and *Funambulus tristriatus* (Waterhouse, 1837) were principal species in cacao. BHAT & SUJATHA (1991) obtained 100% kill of *R.r.wroughtoni* with bromadiolone yet for squirrels, the maximum kill achieved was only 50%. The higher level of control in the present study is attributed to baiting on both cacao and coconut trees so that squirrels had access to the bait even at nesting sites. Trapping with wooden or wire mesh live traps is recommended for 100% protection to cacao pods from squirrels (BHAT & MATHEW, 1983). Increase in harvest from 12 to 21 times in a year has been found to reduce squirrel damage from 52% to 25% (ABRAHAM *et al.*, 1979). In the present study, the cost of rodenticide for treating 415 palms was Rs.1155/- (US $ 32/-) for 10.5 kg bromadiolone cakes. In other words, cost of treatment per palm is Rs.2.78 i.e approximately 12 palms can be treated for a US dollar which is within affordable limits, looking into the magnitude of damage. Oil palm is another upcoming crop in India and 400,000 ha are being added to boost oil palm production. Considerable damage is caused to this crop by rodents, but studies indicated that bromadiolone provides good protection to oil palm at all stages (SUBIAH & MATHUR, 1992).

TABLE 3

Comparison of four methods of rodent management in coconut plantations

Treatment	*No. of palms*	*No. of fallen nuts/day*		*% damage prevented*	*Cost Benefit Ratio*
		Prior to treatment	*After treatment*		
I BROMADIOLONE					
1 Control plot	90	11.0	13	-	-
2 Treated plot	87	15.0	-	100	1:67
II WARFARIN					
1 Control plot	80	8	6	25.0	-
2 Treated plot	100	17	-	100	1:54
III ZINC PHOSPHIDE					
1 Control plot	90	6.33	4.9	22.6	-
2 Treated plot	107	14.33	-	100	1:50
IV TRAPPING					
1 Control plot	75	15.66	13.66	-	-
2 Snap traps	211	19.33	12	-	-
3 Live traps	435	51.66	40	-	-

With high densities and severe losses and low budgets dedicated by the cereal growing farmers to rodent control, long-term continuation of management strategy is not usually followed. It is therefore, necessary to evaluate the efficacy of each method and the optimum timing to get the maximum out of it. The threshold level of 15 burrows/ha is worked out on the basis of number of burrows usually observed at the time of the crop stage when the damage is picking up, hence, it becomes the optimum time to take up a chemical control measure, which can bring the damage curve down. Since most of the field rodents in cereal fields are burrow dwellers, live burrow count is an effective monitoring technique (MATHUR & PRAKASH, 1984). It is interesting but frustrating that rodents do not accept rodenticidal baits adequately after panicle initiation stage. Hence, it is more useful from that stage onwards to go for trapping, using local traps or fumigation by employing smoke generators or aluminium phosphide tablets. The agronomic practices coupled with cultural control methods (bund trimming and weed control) also play crucial roles. In high return plantation crops, the options are few and second generation anticoagulant baiting has proven effective even as a single treatment (one exposure of rodenticide) in most of the situations. It can, however be integrated by keeping the crowns, ground and palm circles clean to reduce rodent harbourages. Live trapping and baiting on trees which are nesting sites for squirrels enhance the success of the operation. Rodenticides and trapping are still important components of IPM for rodents, however, the use of ecological parameters like density in relation to crop stage, damage appraisal, reinfestation pattern and proper timing of suitable control measures, strengthen the decision making process. The present study indicates that bromadiolone provides excellent rodent control success in cereals as well as in plantations by integrating proper formulations, placement and timing of control operation. Warfarin and zinc phosphide also provided 100% kill in coconut plantations but the lengthy baiting process with the former and necessity of prebaiting and a follow up programme with the latter weigh the balance in favour of second generation anticoagulants.

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