Bio-efficacy of Second Generation Anticoagulant Rodenticides in Pearl Millet - Moong - Moth Bean Cropping System in Indian Arid Region

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Abstract

Field efficacy of three second generation anticoagulant rodenticides was evaluated in pearl millet-moong-moth bean cropping system under arid ecosystem for the two crop seasons. The efficacy of all the three rodenticides was assessed by three methods viz., *live burrow count, census baiting and trapping methods simultaneously before and at 4 and 14 days after treatnment. Control success after two weeks of treatment with (0.0025%) difethialone, (0.005%) bromadiolone and (0.005% brodifacoum was 85.1, 85.1 and 82.1% at vegetative growth stage and it was 87.5, 89.0 and 88.8% at maturity stage, respectively. Second treatment of respective anticoagulant rodenticides yielded higher control success due to mortality of residual pest population. No significant difference was observed between treatments, methods and blocks and all treatments proved equally efficacious in containing field rodents.*

Keywords: Anticoagulant rodenticides, defethialone, bromadiolone, brodifacoum, millet-moong-mothbean cropping system, baiting

Introduction

Rodents inflict considerable damage to field crops, vegetables and fruit crops both during pre and post harvest stage. A complex of 2-5 species (*Meriones hurrianae, Tatera indica*, *Mus* spp. and *Gerbillus gleadowi*) are regarded as pests in arid agro-ecosystem. The region mainly being rainfed, pearl millet, moong and moth are major crops of the area. The crops suffer rodent damage to the tune of 5-10%. Zinc phosphide, an acute rodenticide is being used widely for rodent control in India. The pre-baiting requirements, development of bait shyness and poison aversion towards zinc phosphide limits its usefulness in effective management of rodent pests. Therefore search for improved alternative rodenticides vis-à-vis screening of their bio-efficacy is considered to be of paramount importance. The second generation anticoagulant rodenticides (bromadiolone, brodifacoum and difethialone) have shown excellent potency against rodent pests of Indian agriculture in laboratory (Jain *et al.*, 1992; Chaudhary *et al.*, 2002 and Chaudhary and Tripathi, 2003), but very little information is available pertaining to their efficacy in arid-ecosystem. The present study attempts to evaluate the field efficacy of three second generation anticoagulant rodenticides *viz.*,bromadiolone, brodifacoum and difethialone in pearl millet-moong-moth bean cropping system grown under rainfed condition.

Materials and methods

Study area

Field trials with bromadiilone (0.005%), brodifacoum (0.005%) and difethialone (0.0025%) were conducted at village Rampura and Anwana, district Jodhpur (in two crop seasons 2000 and 2001) in pearl millet-moong mothbean cropping system. Major portion of study field was sown with moong, moth bean and pearl millet as solo and in some stretches either of the pulses was intercropped with pearl millet.

An area of about 10 ha having fairly good infestation of rodent pests with no previous records of rodential treatments for at least one year was selected. The study sites were divided into four blocks by following randomized block design (RBD). Each block represented one replication and consisted of three plots of 0.5-0.55 ha (for treatment) with the distance of 25-30 meters between the plots as border area. In each block a plot of same size was left as reference plot well seperated from treatment plots where no rodenticidal treatment was given.

Rodenticidal baiting

Difethialone as loose bait was prepared 20 ml of 0.125% liquid concentrate into 1 kg of pearl millet to obtain desired concentration of 0.0025% bait. Bromadiolone and brodifacoum (0.005%) wheat based ready to use baits were

used. Burrow and station methods as suggested by Mathur and Prakash (1984c), was adopted for treating the study plots. Bait (10-15 g) was administered directly in active burrows and 50-100g rodenticidal bait was placed in each bait station inside the plots. The bait stations were placed randomly in the treatment plots @ 20-25 stations/plot. The treatments were given for one day only at two stages of crop growth *viz.*, one at vegetative growth stage i.e. 30 days after sowing (DAS) and another at fruiting/maturity i.e. 90 days after sowing (DAS).

Assessment of rodenticide efficacy

The efficacy of rodenticide was assessed by Live burrow count (LBC), Census baiting and Trapping methods simultaneously before and after treatment following Mathur and Prakash (1984 c). These methods provide information on rodent population inhabiting the study area. The data on per cent control success with each test rodenticide were worked out twice i.e, at 4 and 14 days after treatment (DAT) in both the crop seasons using the following formula.

Per cent control success = $100 [1-\{(T_2 x C_1)/(T_1 x C_2)\}]$

Where

T_1 = pre-treatment population of rodents in treatment plots.

T_2 = Post-treatment population of rodents in treatment plots.

C_1 = Pre-treatment population of rodents in reference plots.

C_2 = Post-treatment population of rodents in reference plots.

Results and discussion

Rodent species composition

The predominant rodent pest species at Rampura were *M. hurrianae* followed by *T. indica* in the sandy plains and *G. gleadowi* was encountered on the sandy hummocks along with *M. hurrianae*, whereas, at Anwana *M. hurrianae* and *T. indica* were the predominant species with a minor presence of *Millardia meltada.*

Efficacy of rodenticides

Live burrow count method. Control success after first treatment (at vegetative growth stage) for both the years at 4 and 14 days after treatment was recorded as 30.8 and 80.6% with difethialone (0.0025%), 31.2 and 80.8% with bromadiolone (0.005%) and 29.7 and 80.5% with brodifacoum (0.005%), respectively (Table 1).

Control success on 4th day of treatment with all test rodenticides was significantly lower than that on 14th day after treatment. It was mainly because, the anticoagulants are chronic in action and the mortality of rodents is mainly initiated on 3rd day with a maximum between 7-10 days. Thus significantly higher success was obtained on 14th DAT. However, after second treatment at maturity stage the control success was slightly improved to 87.5, 84.9 and 84.8% with defethialone (0.0025%), bromadiolone (0.005%), respectively after two weeks of second baiting (Table 1).

Census baiting method. This method revealed similar trends in control success. The second treatment at crop maturity stage yielded higher control success than at vegetative growth stage. At vegetative growth stage the success on 4th day after treatment was less than 30% (28.4-29.9%) which reached to above 80% with in two weeks of baiting with respective rodenticides. Poison baiting at maturity resulted in 33.6 and 85.2, 33.0 and 85.3 and 33.2 and 83.8% control success with difethialone (0.0025%), bromadiolone (0.005%) and brodifacoum (0.005%), respectively at 4 and 14 days after treatment (Table 2).

Trapping method. This method indicated control success of 20.4, 18.5, 23.9% at 4 DAT and 94.4, 94.9 and 84.9% at 14 DAT with difethialone (0.0025%),

Table 1. Bioefiicacy of anticoagulant rodenticides (live burrow count method) in pearl millet-moong-moth bean cropping system during *Kharif* 2000 and 2001

	Per cent control success											
	Vegetative growth stage						Maturity stage					
	4DAT		14DAT		Mean		4DAT		14DAT		Mean	
Treatment	2000	2001	2000	2001	4DAT	14DAT	2000	2001	2000	2001	4DAT	14DAT
Difethialone (0.0025%)	31.0 (33.8)	30.6 (33.6)	80.6 (63.9)	80.6 (63.8)	30.8 (33.7)	80.6 (63.9)	33.0 (35.1)	34.1 (35.7)	85.9 (67.9)	85.1 (67.3)	33.6 (35.4)	87.5 (67.6)
Bromadiolone (0.005%)	30.9 (33.8)	31.5 (34.2)	80.1 (63.5)	80.5 (63.8)	31.2 (34.0)	80.8 (63.7)	33.3 (35.3)	33.9 (35.6)	85.7 (67.7)	84.1 (66.5)	33.6 (35.4)	84.9 (67.1)
Brodifacoum (0.005%)	30.2 (33.3)	29.7 (33.0)	80.4 (63.8)	80.7 (63.8)	29.7 (33.2)	80.6 (63.6)	32.6 (34.5)	33.0 (35.6)	85.0 (67.2)	84.6 (66.9)	32.8 (35.0)	84.8 (67.0)

Figures in parentheses are the arc sign transformed values of per cent success

Table 2. Bioefiicacy of anticoagulant rodenticides (census-baiting method) in pearl millet-moong-moth bean cropping system during *Kharif* 2000 and 2001

	Per cent control success											
	Vegetative growth stage						Maturity stage					
	4DAT		14DAT		Mean		4DAT		14DAT		Mean	
Treatment	2000	2001	2000	2001	4DAT	14DAT	2000	2001	2000	2001	4DAT	14DAT
Difethialone	28.7	31.4	79.1	81.7	29.9	80.4	34.1	33.1	85.5	84.8	33.6	85.2
(0.0025%)	(32.5)	(33.9)	(62.8)	(64.6)	(33.2)	(63.7)	(35.8)	(35.1)	(67.6)	(67.1)	(35.5)	(67.4)
Bromadiolone	26.9	29.8	79.7	79.8	28.4	79.7	33.5	32.4	86.2	86.2	33.0	85.3
(0.005%)	(31.2)	(33.1)	(63.2)	(63.3)	(32.2)	(63.2)	(35.4)	(34.7)	(68.2)	(66.8)	(35.0)	(67.5)
Brodifacoum	27.5	30.5	80.1	80.6	29.0	80.9	33.2	33.2	84.0	84.0	33.2	83.8
(0.005%)	(31.7)	(33.5)	(63.5)	(63.9)	(32.6)	(63.7)	(35.2)	(35.2)	(66.4)	(66.1)	(35.2)	(66.3)

Figures in parentheses are the arc sign transformed values of per cent success

bromadiolone (0.005%0 and brodifacoum (0.005%), respectively at vegetative growth stage (or 30 DAS), and 22.6, 25.5 and 34.0% at 4 DAT and 89.8, 96.8 and 95.9% at 14 DAT with difethialone (0.0025%), bromadiolone (0.005%) and brodifacoum (0.005%), respectively at maturity stage (Table 3). Control success with different test rodenticides assessed by this method was at lower side (18-25%) as compared to other two methods, which recorded more than 30% success on 4th day at both the respective crop growth stage. This trend was however reversed with the control success data of 14th DAT, where success rate with trapping method was higher, such a variation in trend might be due to indifferent behaviour of *M. hurrianae*, the major rodent pest of the region towards traps.

Interaction between methods and rodenticidal treatments

Interaction between evaluation methods and treatments showed non significant variation indicating that using any of the method, the trend in efficacy of the rodenticides remained the same. Non-significant variation with in the treatments also indicated that all the three anticoagulant rodenticides are equally potent in tackling the rodent problem in the fields. However, significant difference was indeed found between the methods, because results obtained with trapping method differed significantly with that of live burrow count and census baiting methods which were however at par with each other (Tables 4 &5). Mathur and Prakash (1984c) evaluated all the three methods in arid grassland ecosystem predominantly inhabited by *M. hurrianae* and reported that live burrow count method is more realistic in indicating per cent control success, because census baits are likely to be consumed by non-target birds, ants etc. whereas, trapping mainly depends on behaviour of native rodents towards traps. Moreover, live burrow counting method is relatively easy and requires no extra inputs like bait stations, baits, traps etc. Trapping is however useful in understanding the pest species composition of the area.

Mortality pattern. During regular monitoring of treated fields, first dead rodent (*M. hurrianae*) was found

Table 3. Bioefiicacy of anticoagulant rodenticides following trapping method in pearl millet-moong-moth cropping system during *Kharif* 2000 and 2001

	Per cent control success											
	Vegetative growth stage						Maturity stage					
	4DAT		14DAT		Mean		4DAT		14DAT		Mean	
Treatment	2000	2001	2000	2001	4DAT	14DAT	2000	2001	2000	2001	4DAT	14DAT
Difethialone	24.2	16.6	94.4	94.3	20.4	94.4	19.8	25.4	90.5	89.1	22.6	89.8
(0.0025%)	(29.5)	(24.0)	(76.3)	(76.2)	(26.8)	(76.3)	(26.4)	(30.2)	(72.0)	(70.6)	(28.3)	(71.3)
Bromadiolone	30.3	6.7	89.8	100	18.5	94.9	32.9	18.1	100	93.6	25.5	96.8
(0.005%)	(33.3)	(15.0)	(71.3)	(90.0)	(24.2)	(80.7)	(35.0)	(25.2)	(90.0)	(75.4)	(30.1)	(82.7)
Brodifacoum	22.0	25.8	85.9	83.2	23.9	84.9	33.8	34.3	100	91.8	34.0	95.9
(0.005%)	(28.0)	(30.4)	(67.9)	(66.3)	(29.3)	(67.1)	(35.6)	(35.9)	(90.0)	(73.8)	(35.7)	(81.7)

Figures in parentheses are the arc sign transformed values of percent success

on the 3rd day of poison baiting. Retrieval of carcasses continued upto 14 days. Maximum mortality was noticed between 6-8 days. This clearly indicated that mortality pattern by different test rodenticides in fields was almost similar to that observed in laboratory. Most of the rodents died inside the burrows, which were evident from the foul smell emanating from the burrows after a week of poison baiting.

Analysis of data assessed by all the three census methods for both the years revealed that all the three anticoagulant rodenticides were quite efficacious in managing the field rodents in arid ecosystem. Second treatment of respective anticoagulant at maturity stage enhanced the control success further. Control success with difethialone (0.0025%), bromadiolone (0.005%) and brodifacoum (0.005%) at vegetative growth stage was 85.1, 85.1 and 82.1% and at maturity stage was 87.5, 89.0 and 88.2% respectively after 14 days of treatment (Tables 4&5).

Laboratory and field efficacy of the three second generation anticoagulant rodenticides has been reported earlier. Saxena *et al.*, (1992), Mathur *et al.*,(1995) and Sridhara *et al.*, (2000) with difethislone (0.0025%); Christopher *et al.*, (1984) and Bhaskaran *et al.*, (1995) with bromadiolone (0.005%) and Mathur and Prakash (1984a&b), Soni *et al.*, (1985) and Jain and Tripathi (1986) with brodifacoum (0.005%). Present findings in pearl millet-moong-moth bean cropping system are in good agreement with other field trials reported by these authors.

Although all the three anticoagulant rodenticides were equally efficacious in checking the rodent menace in field conditions, difethialone (0.0025%) proved superior because this rodenticide yielded similar control success at half the dose (0.0025%) as compared to the other two anticoagulants.

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Table 4. Interaction effects between blocks, treatments and methods on rodent control success (%) in pearl millet-moong-moth cropping system during *Kharif* 2000-01 at vegetative growth stage

	Trapping		Census baiting		Burrow counting		Mean	
Treatment	4DAT	14 DAT	4DAT	14 DAT	4DAT	14 DAT	4DAT	14 DAT
Difethialone (0.0025%)	20.4 (26.8)	94.4 (76.3)	29.9 (33.2)	80.4 (63.7)	30.8 (33.7)	80.6 (63.9)	27.0 (31.2)	85.1 (67.9)
Bromadiolone (0.005%)	18.5 (24.2)	94.9 (80.7)	28.4 (32.2)	79.7 (63.2)	31.2 (34.0)	80.8 (63.7)	26.0 (30.1)	85.1 (69.2)
Brodifacoum (0.005%)	23.9 (29.3)	84.6 (67.1)	29.0 (32.6)	80.9 (63.7)	29.7 (33.2)	80.6 (63.6)	27.6 (31.7)	82.1 (64.9)

Analysis of Variance

Source	SS	df	MS	F	P-vlue	F crit
4 Days after treatment						
Treatments	3.9129	2	1.956	0.795	0.5118	6.944
Methods	83.354	2	41.677	16.94	0.0111	6.944
Error (T x M)	9.8391	4	2.4597			
Total	97.106	8				
14 Days after treatment						
Treatments	29.317	2	14.658	0.883	0.4812	6.944
Methods	242.45	2	121.22	7.303	0.0462	6.944
Error (T x M)	66.397	4	16.599			
Total	338.17	8				

Values in parentheses are the transformed values

Table 5. Interaction effects between blocks, treatments and methods on rodent control success (%) in pearl millet-moong-moth bean cropping system during *Kharif* 2000-01 at maturity stage

	Trapping		Census baiting		Burrow counting		Mean	
Treatment	4DAT	14 DAT	4DAT	14 DAT	4DAT	14 DAT	4DAT	14 DAT
Difethialone (0.0025%)	22.6 (28.3)	89.8 (71.3)	33.6 (35.5)	85.2 (67.4)	33.6 (35.4)	87.5 (67.6)	29.9 (33.1)	87.5 (68.8)
Bromadiolone (0.005%)	25.5 (30.1)	96.8 (82.7)	33.0 (35.0)	85.3 (67.5)	33.6 (35.4)	84.9 (67.1)	30.7 (33.5)	89.0 (72.4)
Brodifacoum (0.005%)	34.0 (35.7)	95.9 (81.7)	33.2 (35.2)	83.8 (66.3)	32.8 (35.0)	84.8 (67.0)	33.3 (35.3)	88.2 (71.7)

Analysis of Variance

Source	SS	df	MS	F	P-vlue	F crit
4 Days after treatment						
Treatments	10.413	2	5.2066	1.0340	0.434	6.944
Methods	27.706	2	13.853	2.7512	0.177	6.944
Error (T x M)	20.141	4	5.0353			
Total	97.106	8				
14 Days after treatment						
Treatments	22.353	2	11.1768	0.769	0.5214	6.944
Methods	261.21	2	130.605	8.994	0.0330	6.944
Error (T x M)	58.083	4	14.520			
Total	341.64	8				

Values in parentheses are the transformed values

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