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Research article

EVALUATION OF VARIOUS INTEGRATED RODENT MANAGEMENT MODULES IN IRRIGATED RICE ECOSYSTEM

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ABSTRACT: Rodents are one of the major biological production constraints of paddy. Field experiments were carried out to evaluate the efficacy of seven different integrated rodent management modules against rodent pests in irrigated rice ecosystem during *kharif* and *rabi* seasons of 2011-12. The modules efficacy was assessed by live burrow count and diagonal methods simultaneously before and after imposition of treatments at tillering, panicle initiation and harvesting stages of the rice crop. All the modules were significantly superior over control in reducing the rodent population and their damage. However, the module M3 consisting of cultural practices, burrow fumigation and poison baiting with the rodenticide bromodiolone was the most effective integrated rodent management module in all the stages of the crop growth resulting in 86.5 & 80.3 % control of rodent population and 83.4 & 80.9% control in reducing their damage with a higher benefit cost ratio of 26:1 & 30:1 in *kharif* and *rabi* seasons respectively. The non chemical and eco friendly module M5 (cultural practices + trapping + Ecodon + burrow fumigation) was also proven to be superior next to M3 in order of efficacy against rodent pests.
Keywords: Rodents, Integrated Management modules, Rice

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal crop in India grown in 45.5 million hectares with an annual productivity of 99.18 million tons (www.indiaagristat.com). In paddy cultivation besides pests and diseases attack the rodents also cause significant yield losses [28]. The rodents attack rice plants throughout their growth periods *i.e*., from seedling to harvestinging. However, the attack intensifies during maximum tillering, when the rice canopy becomes dense [4]. In India, rodents have been estimated to cause 0.44 to 60 percent tiller damage which accounts for 5-10 % of the total grain yield losses in pre harvested rice [25]. The irregular rodent outbreaks are sometimes responsible for extreme crop losses of 30-100%, occasionally leading to localized or widespread famine [9]. Methods for controlling rodent damage in rice ecosystem includes cultural practices such as field sanitation, trimming of field bunds and synchronized planting [18], trapping rodents in fields and premises [13], fumigating the live burrows with natural smoke, hunting, physical barriers such as trap barrier system [23, 27], fumigating the rodent burrows with aluminium phosphide [3] and poison baiting with rodenticides [5, 26]. Among all the available rodent control practices, use of rodenticides is the most common and expedient method (Makundi 2005). But repeated and inappropriate use of rodenticides results in genetic resistance, bait shyness, behavioural avoidance, non target poisoning and environmental risks [8, 10, 11, 16]. The rodent menace to rice crop can be managed by adopting all the available management practices in integrated manner rather than relying on rodenticides [26]. Hence, the present study was undertaken to evaluate the field efficacy of various integrated rodent management modules against rodent pests in irrigated rice production which are cost effective and also eco friendly.

MATERIALS AND METHODS

Study area

The present study was carried out to evaluate the field efficacies of seven different integrated rodent management modules (M1-M7) including control against rodent pests in irrigated rice(Table 1) .Field trials were conducted at Lankalakoderu village of Palakol Mandal, West Godavari district in rice-rice-fallow/pulses cropping system for *kharif* and *rabi* seasons of 2011-12. An area of about 30 ha having fairly good infestation of rodent pests with no previous record of rodenticides treatment for at least one season was selected. The study sites (30 ha) were divided into three blocks following randomized block design (RBD). Each block (10 ha) represents one replication and consisted of seven plots of 1 ha area for each treatment. These plots were separated by a distance of 0.40-0.45 ha between the plots as boarder area.

Treatments (modules) imposed

The field experiments were laid out in the paddy fields with seven treatments (Modules) that were replicated thrice. For each module various integrated rodent management operations were made in three different stages of crop growth *i.e*., tillering, panicle initiation and harvestinging stages to assess the percent rodent control success of the various modules in reduction of rodent population and their damage at all the stages of the crop growth (Table 2).

The cultural practices included field sanitation, synchronized planting, trimming of field bunds, reduction in size and number of field bunds to the maximum extent possible. Through burrow fumigation natural smoke was fumigated in to live rodent burrows. Trapping included erection of local basket traps (butta) @ 50-60/ha for 2 alternate days at one month after transplanting and one month before harvesting. Aluminium phosphide tablets two @ 0.6g pellets were placed in each live rodent burrows with help of an applicator (through which phosphine, a toxic gas will release in presence of atmospheric moisture or the moisture present inside the burrows). Ecodon, an castor based repellent (commercial product) @ 5ml per 1 liter of water were sprayed along each and every field bund for one day at two stages of the crop growth *viz*, tillering and panicle initiation stages. The Poison bait prepared is same for zinc phosphide (2%) and bromodiolone (0.005%) rodenticides *i.e*., 96% locally grown food grains (broken rice), 2% vegetable oil and 2% poison (*i.e.*, for 1kg poison bait preparation, 960g of broken rice are mixed with 20 g of vegetable oil and later with 20 g of the poison). No pre baiting is done for bromodiolone poison bait. But pre baiting for 2-3 days without poison (98% broken rice and 2% vegetable oil) is done for zinc phosphide baiting and is used only once in the season during panicle initiation stage as it registers bait shyness among rodents for 3-4 weeks. The prepared poison bait is pocketed and used to avoid wastage and make less toxic to non target organisms.

Assessment of modules efficacy

The efficacy of modules was assessed in terms of per cent reduction in the rodent population and their damage incidence over control at tillering, panicle initiation and harvestinging stages of the crop.

The rodent population was assessed by live burrow count method, for which all the burrows in the study area are plugged a day before and freshly opened burrows in the next morning were counted. These active burrows were considered as index for rodent population.

The rodent damage incidence in terms of per cent tiller damage was assessed by diagonal method in which 75 hill samples/ha are diagonally selected and counted the number of damaged (cut) and undamaged (uncut) tillers and per cent rodent damage incidence (P.D.I.) was calculated as proposed by Mathur and Prakash, [22].

$$P.D.I. = A/ (A+B) \times 100$$

Where,

A=Total number of damaged tillers in 75 hill sample

B= Total number of undamaged tillers in 75 hill sample

Through these methods rodent population and their damage incidence in the study area before and after imposition of treatments were recorded for each module. The data on percent rodent control success for each module at tillering, panicle initiation and harvesting stages of the crop were worked out [22].

$$\text{Percent control success} = 100 (1- ((T2 \times C1)/ (T1 \times C2))$$

Where,

T1- pre treatment population of rodents/rodent infestation in treatment plots.

T2- post treatment population of rodents/rodent infestation in treatment plots.

C1- pre treatment population of rodents/rodent infestation in control plots (M7).

C2 - post treatment population of rodents/rodent infestation in control plots (M7).

RESULTS AND DISCUSSION

Rodent species composition

The predominant rodent species at Lankalaokoderu village were the lesser bandicoot, *Bandicota benaglensis* (87.6 %) followed by the field mouse, *Mus booduga* (12.4%). The population growth estimates indicated that *Bandicota benaglensis* and *Mus booduga* reproduced with a seasonal productivity of 36.4 and 8.11% in *kharif* and 31.15 and 5.97 % during *rabi* seasons of 2011-12 respectively (Table 3).

Efficacy of modules

Live burrow count method

All the modules were significantly superior over control in reducing the rodent population at tillering, panicle initiation and harvesting stages (Table 4). Among all, the module M3 (cultural practices + bromodiolone poison baiting + burrow fumigation) has significantly reduced the rodent population with 79.6, 90.2 and 83.3% during *kharif* and 78.7, 88.3 and 86.7% control success during *rabi* at tillering, panicle initiation and harvesting stages respectively.

Table 1. Modules evaluated for efficacy against rodents in irrigated rice

Modules	Rodent control practices
M1	Cultural practices + zinc phosphide poison baiting + bromodiolone poison baiting
M2	Cultural practices + bromodiolone poison baiting
M3	Cultural practices + bromodiolone poison baiting + burrow fumigation
M4	Cultural practices + bromodiolone poison baiting + aluminium phosphide tablets usage
M5	Cultural practices + trapping + ecodon+ burrow fumigation
M6	Farmers practices
M7	Control

Table 2. Rodent management operations of various modules in rice crop

Module	Rodent management operations		
	Tillering stage	**Panicle Initiation stage**	**Harvest stage**
M1	Bromodiolone poison baiting	Zinc phosphide poison baiting	Bromodiolone poison baiting
M2	Bromodiolone poison baiting	Bromodiolone poison baiting	Bromodiolone poison baiting
M3	Burrow fumigation (once in a week)	Bromodiolone poison baiting Burrow fumigation (once in a week)	Burrow fumigation (once in a week)
M4	Aluminium phosphide tablets application	Bromodiolone poison baiting	Aluminium phosphide tablets application
M5	Trapping (1 month after transplanting for 2alternate days) Ecodon spraying (once)	Burrow fumigation Ecodon spraying (once)	Trapping (1 month after transplanting for 2 alternate days)
M6	Application of phorate granules	Bromodiolone baiting, trapping	Fumigation with natural smoke
M7	-	-	-

Table 3. Population growth estimates of rodent species at Lankalakoderu village

S. No	Population growth parameter	Values			
		Kharif 2011		***Rabi 2011-12***	
		B.b	***M.b***	***B. b***	***M.b***
1	Reproductive rate F*	2.89	1.93	2.75	1.67
2	Average litter / female	12.6	4.20	11.33	3.58
3	Productivity per season (F x Avg. litter/ female)	36.4	8.11	31.15	5.97

B.b-Bandicoota bengalensis; M.b Mus booduga

*F= P (t/v), where P- Prevalence of pregnancy (Avg. % Pregnant / season), t- Time period of samples in days, V- time of gestation.

The next superior module was M5 (cultural practices + trapping + Ecodon+ burrow fumigation) which recorded 70.2, 76.3 and 73.3% control success during *kharif* and 68.2, 76.4 and 73.2 % control success in *rabi* at tillering, panicle initiation and harvesting stages respectively. On the basis of analysis of pooled data on per cent control success of all the seven modules in minimizing the rodent population, the module M3 was proven to be significantly superior to remaining treatments with 86.5 and 80.3% control success followed by M5 with 73.2 and 71.4% control success in *kharif* and *rabi* seasons respectively. The next better modules in order of efficacy were M4, M1 and M2 (Table 5).

Table-4. Efficacy of rodent management modules in irrigated rice in reduction of rodent population (Live burrow count method)

Modules	Mean per cent control success					
	Kharif-2011			Rabi 2011-12		
	Tillering stage	Panicle initiation stage	Harvest stage	Tillering stage	Panicle initiation stage	Harvest stage
M1	52.4(46.38)	58.2(49.72)	56.9(48.97)	51.3(45.74)	57.8(49.49)	53.2(46.83)
M2	39.6(39.00)	44.4(41.78)	42.7(40.80)	32.6[a](34.82)	37.2(37.58)	35.1(36.33)
M3	**79.6(63.15)**	**90.2(71.76)**	**83.3(65.88)**	**78.7(62.51)**	**88.3(70.00)**	**86.7(68.61)**
M4	64.1(53.19)	70.3(56.98)	66.1(54.39)	60.4(51.00)	62.1(52.00)	60.9(51.30)
M5	70.2(56.91)	76.3(60.87)	73.3(58.89)	68.2(55.67)	76.4(60.94)	73.2(58.82)
M6	(20.6)(26.99)	17.3(24.58)	18.6(25.55)	29.1[a](32.65)	20.3(26.78)	24.7(29.80)
M7(control)	-	-	-	-	-	-
F test	*Sig*	*Sig*	*Sig*	*Sig*	*Sig*	*Sig*
CV	4.70	2.60	3.81	5.16	4.08	4.43
Sem	1.27	0.70	1.07	1.36	1.15	1.22
CD(P=0.05)	3.90	2.36	3.30	4.20	3.54	3.76

Figures in Parenthesis are the arc sine transformed values.
Means followed by same letters are not significantly differ at 5% level.

Table 5. Efficacy of rodent management modules in reduction of live rodent burrows in irrigated rice (pooled mean)

Modules	Mean no. of live burrows / ha					
	Kharif 2011			Rabi 2011-12		
	Pre treatment	Post treatment	Per cent control success	Pre treatment	Post treatment	Per cent control success
M1	33.2 35.18)	12.2(20.44)	53.7(47.12)	29.6(32.96)	10.3b(18.72)	55.9(48.39)
M2	41.2(39.93)	19.3(26.06)	41.0(39.82)	34.5(35.97)	17.8(24.95)	34.7(36.09)
M3	**39.3(38.82)**	**4.2(11.83)**	**86.5(68.44)**	**32.7(34.88)**	**5.1** b**(13.05)**	**80.3(63.65)**
M4	37.3(37.64)	9.4(17.85)	68.3(55.73)	28.3(32.14)	8.6a(17.05)	61.6(51.71)
M5	30.1(33.27)	6.4(14.65)	73.2(58.82)	31.8(34.33)	7.2ab(15.56)	71.4(57.67)
M6	41.2(39.93)	26.4[a](30.92)	19.3(26.06)	35.8(36.75)	21.3(27.49)	24.7(29.80)
M7	34.5(35.97)	27.4[a](31.56)	-	37.5(37.76)	29.6(32.96)	-
F test	NS	Sig	Sig	NS	Sig	Sig
CV		6.68	3.76		8.77	3.21
Sem		0.59	1.06		0.70	0.87
CD(P=0.05)		1.80	3.27		2.17	2.68

Figures in Parenthesis are the arc sine transformed values.
Means followed by same letters are not significantly differ at 5% level.

Table 6. Efficacy of rodent management modules in irrigated rice in reduction of per cent tiller damage by rodent (diagonal method)

Modules	Mean per cent control success					
	Kharif-2011			Rabi 2011-12		
	Tillering stage	Panicle initiation stage	Harvest stage	Tillering stage	Panicle initiation stage	Harvest stage
M1	49.1ab (44.48)	51.3a (45.74)	49.7a(44.83)	44.8ab (42.02)	49.4 (44.66)	50.0a(45.0)
M2	46.3ab(42.88)	48.2a(43.97)	48.8a(44.31)	37.6a(37.82)	40.1(39.29)	39.5(38.94)
M3	**76.3(60.87)**	**91.3(72.84)**	**84.2(66.58)**	**79.3(62.94)**	**87.6(69.38)**	**86.0(68.03)**
M4	53.6a(47.06)	60.1(50.83)	58.5(49.89)	50.5b(45.29)	58.1(49.66)	55.1a(47.93)
M5	64.2(53.25)	76.2(60.80)	71.1(57.48)	62.6(52.30)	71.8(57.92)	71.0(57.42)
M6	24.4(29.60)	19.6(26.28)	20.4(26.85)	18.4(25.40)	13.2(21.30)	14.7(22.54)
M7(control)	-	-	-	-	-	-
F test	*Sig*	*Sig*	*Sig*	*Sig*	*Sig*	*Sig*
CV	11.23	7.61	5.69	11.98	10.02	10.10
Sem	2.91	2.18	1.56	2.90	8.04	2.63
CD(P=0.05)	8.96	6.71	4.81	8.93	2.61	8.12

Figures in Parenthesis are the arc sine transformed values.
Means followed by same letters are not significantly differ at 5% level.

Diagonal method

Observations on efficacy of modules in reducing the damage incidence (per cent tiller damage) of rodents indicated that all the modules were significantly superior to control (Table 6). In tillering, panicle initiation and harvesting stages the per cent control success was higher in the module M3 which recorded 76.3, 91.3 & 84.2% control success in *kharif* and 79.3, 87.6 & 86.0% control success in *rabi* respectively. In M5 also there was substantial reduction in damage incidence with 64.2, 76.2 & 71.1% control success in *kharif* and 62.6, 71.8 &71.0% control success in *rabi* seasons at tillering, panicle initiation and harvesting stages respectively and is proven to be the next superior module.

The pooled data pertaining to per cent rodent control success against rodent damage incidence in various integrated modules revealed that all the modules showed significant difference among themselves. However, significantly higher reduction with respect to per cent tiller damage was observed in module M3 with 83.4 and 80.9% control success followed by M5 with 69.3 and 63.4% control success in *kharif* and *rabi* seasons respectively. Based on damage incidence index, the order of modules efficacy were M3>M5>M4>M1>M2>M6 (Table 7).

Table 7. Efficacy of rodent management modules in reduction of percent tiller damage in irrigated rice (Pooled mean)

Modules	percent tiller damage/ha					
	Kharif 2011			Rabi 2011-12		
	Pre treatment	Post treatment	Per cent control success	Pre treatment	Post treatment	Per cent control success
M1	12.4(20.62)	6.3(14.54)	50.66ab(45.38)	10.2(18.63)	5.4(13.44)	44.2 a(41.67)
M2	13.6(21.64)	7.6(16.00)	45.73a(42.55)	13.4(21.47)	6.8(15.12)	38.2 a(38.17)
M3	12.9(21.05)	2.2(8.53)	83.4(65.96)	11.6(19.91)	2.1(8.33)	80.9(64.08)
M4	10.6(19.00)	4.9(12.79)	55.1b(47.93)	9.3(17.76)	4.1(11.68)	53.5(47.01)
M5	9.8(18.24)	3.1(10.14)	69.3(56.35)	12.4(20.62)	4.3(11.97)	63.4(52.77)
M6	11.3(19.64)	8.9(17.36)	23.5(29.00)	10.9(19.28)	8.8(17.26)	14.9(22.71)
M7	13.4(21.47)	13.8(21.81)	-	11.7(20.00)	11.1(19.46)	-
F test	NS	Sig	Sig	NS	Sig	Sig
CV		5.48	7.04		4.12	10.18
Sem		0.22	1.90		0.16	2.48
CD(P=0.05)		0.66	5.86		0.48	7.64

Figures in Parenthesis are the arc sine transformed values.
Means followed by same letters are not significantly differ at 5% level.

Yield and benefit cost ratio

All the modules recorded significantly higher yields over control. Paddy yield benefit per hectare over control was higher in module M3 with 245 & 285 kg followed by M5 with 205 & 250 kg yield benefit during *kharif* and *rabi* seasons of 2011-12 respectively. The results on economics revealed that M3 recorded higher benefit cost ratio of 26:1 & 30:1 followed by M5 with 14:1 &17:1 in *kharif and rabi* respectively with efficacy in reduction of rodent population and their damage.

Table 8. Efficacy of rodent management modules over crop save in irrigated rice

Modules	Approximate cost incurred for treatments/ha (Rs.)	Estimated crop save					
		Kharif 2011			Rabi 2011-12		
		Yield benefit/ha over control(Kg)	Monitory benefit /ha @ Rs.10/Kg	Benefit cost ratio	Yield benefit/ha over control	Monitory benefit /ha @ Rs.10/Kg.	Benefit cost ratio
M1	140	160	1600	11:1	200	2000	14:1
M2	115	130	1300	10:1	175	1750	14:1
M3	95	245	2450	26:1	285	2850	30:1
M4	130	185	1850	14:1	225	2250	17:1
M5	160	205	2050	13:1	250	2500	16:1
M6	250	50	500	2:1	80	800	3:1
M7	-	-	-	-	-	-	-

In the present study, the module M3 with cultural practices, burrow fumigation and bromodiolone poison baiting was the most promising module showing higher efficacy in reduction of rodent population and their damage and also recording higher benefit cost ratio in irrigated rice ecosystem during both *kharif* and *rabi* seasons. The results are in close agreement with the findings of Singleton [26], who reported that integrated rodent management increased rice yield over conventional management based on synthetic rodenticides. Burrow fumigation operation in all the stages of the crop has offered better results in suppression of rodent damage. Earlier, Fiedler, [12] and Singleton [27] also reported the same. The usage of second generation anticoagulant bromodiolone (0.005%) as poison bait during panicle initiation could have effectively controlled the rodent infestation [2, 5, 7, 19]. The M5 module comprising of the non chemical rodent control practices (cultural practices + trapping + ecodon+ burrow fumigation) also showed its superiority over all other modules except M3. These findings are in close accordance with statement of Leung, [18] that ecologically based rodent management was equally effective as typical practices for rodent management. Similar inferences were also drawn by Brown [6] and Jacob [17] relating to ecologically based rodent management. Ecodon also offered good repellency against rodent pests [21, 24]. Trapping could have effectively managed the migratory rodents [14, 29, 1, 15]. Therefore, it is concluded that all the integrated rodent management modules tested in the field trial were effective for management of rodents in irrigated rice ecosystem and of all the seven modules tested the M3 and M5 modules were proven to be superior with highest per cent control success.

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