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DETERMINATION OF METHOD AND TIMINGS OF RODENT CONTROL IN DIRECT SEEDED AND TRANSPLANTED BASMATI RICE CROPS

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ABSTRACT
Present study was carried out to determine critical timings and methods of rodent control in direct seeded (DSBR) and transplanted basmati rice (TBR) crops. Four blocks (each of 1.2 ha area) of each type of crop were selected in villages Kangraur and Kataria of district Hoshiarpur, Punjab, India. In block I, burrow baiting with 2% zinc phosphide bait was conducted at vegetative stage of the crop; in block II, crop baiting with 0.005% bromadiolone bait was conducted at reproductive stage of the crop and in block III, both burrow baiting with 2% zinc phosphide bait and crop baiting with 0.005% bromadiolone bait were practiced at vegetative and reproductive stages, respectively. Block IV was kept as untreated control. Rodent species found in selected fields were lesser bandicoot rat, *Bandicota bengalensis* followed by field mouse, *Mus booduga*. Rodent control success in treated blocks ranged from 44.47 to 65.64 % in DSBR and 49.76 to 61.68 % in TBR crops, being non-significantly high in fields of block III. Percent cut tillers and yield loss were found to be significantly ($P < 0.05$) low in treated blocks compared to untreated block in both DSBR and TBR crops. There was also significantly ($P < 0.05$) higher reduction in total live burrows in treated blocks compared to untreated blocks in which there was an increase in live burrows. Per cent cut tillers and yield loss were non-significanly low, whereas percent reduction in live burrows was non-significanly high in fields of block III. Present study thus suggests higher efficacy of two rodenticide treatments *i.e.* burrow baiting at vegetative stage and crop baiting at reproductive stage of the crop for effective control of rodent pests in both types of basmati crops.

INTRODUCTION

Rice (*Oryza sativa* L.) is the key crop responsible for national food security. It occupies 22 per cent of the cropped area and is the major source of livelihood for millions of Indians (Sarao and Makkar, 2016). In Punjab, both rice and basmati crops were sown over an area of 28.94 lakh hectares with total production of 166.61 lakh tonnes during *kharif* season 2014-15 (Annonymous, 2015). Pests and diseases have been associated with crops since times immemorial and are major constraints in rice production both at pre and post-harvest stages. Rodents have been identified as major destructive pests causing severe damage to food crops especially rice, in the field as well as in storage (Parshad, 1999; Rao and Kishore 2010). Out of eight species of rodent pests found in Punjab agriculture, the lesser bandicoot rat, *Bandicota bengalensis* Gray and Hardwicke and field mouse, *Mus booduga* Gray are major rodent pests under irrigated conditions in rice crop under Punjab conditions (Anonymous, 2015).

Annual damage to food grains caused by rodents is 5-10% during production, processing, storage and transport (Singleton and Petch, 1994; Singleton *et al*., 1999; Singleton, 2003; Singleton and Tuan, 2003; Hussain *et al*., 2006; Palis *et al*., 2007; Parshad *et al*., 2007; Meerburg and Kijlstra, 2008; Babbar *et al*., 2014). In India, at pre-harvest stage rodents cause severe losses of 6-8% in paddy, 10-12% in wheat and 20-25% in sugarcane (Chattopadhyay *et al*., 2010; Singla and Babbar, 2010 and 2012; Singla and Parshad, 2010; Babbar *et al*., 2014). Rodents also act as reservoir of human and animal diseases that are transmitted directly from bites of rats, rat fleas and lice or indirectly by eating or touching food or water contaminated with rodent urine and feaces (Pai *et al*., 2005; Singla *et al*., 2008 a and b, Meerburg *et al*., 2009; Singla *et al*., 2013). Among different rodent management methods in paddy crop, trapping and use of chemicals are best alternatives (Fitzwater and Prakash, 1989; Rao and Kishore, 2010 and 2014).

Rice is an important target for irrigation water use reductions, because of its relatively large water requirements as compared to other crops (Li, 2001; Wang *et al*., 2002; Tuong and Bouman, 2003). Increasing scarcity of water threatens the sustainability of food production from irrigated agriculture worldwide (Gleick, 1993; Postel, 1997). Direct seeding is a good alternative of transplanting and yield potential of direct seeded rice is equivalent to the transplanted rice under good water management and weed control conditions (Awan *et al*., 1989; Hussain *et al*., 2008; Farooq *et al*., 2011). Also it matures early and so provides a better option to be a best fit in different cropping systems (Gill and Dhingra, 2002; Yadav *et al*., 2007). Due to congenial environmental conditions in direct seeded sowing technique, there is more problem of rodents in direct seeded as compared to transplanted paddy crop. So, there is a need to provide some management strategy to control of rodents in paddy crop sown under direct seeded and transplanting methods.

Not much work on rodent damage and its control in direct seeded and transplanted basmati rice crops has been done, so far. Present study was hence conducted to determine rodent damage and infestation along with critical timings and methods

of rodent control in basmati rice crop.

MATERIALS AND METHODS

The study was carried out during 2014 in villages Kangraur and Kataria of District Hoshiarpur, Punjab, India. In this area, many farmers practice direct seeded technique for rice production. There were selected four blocks, I, II, III and IV of both direct seeded and transplanted basmati crops, with each block further consisting of three replicated fields of 0.4 ha area. In all the selected blocks, the farmers grew varieties Basmati 1509 and Basmati 1121, and had adopted agronomic practices (irrigation, fertigation, weed and insect control *etc.*) as per the recommendations in Packages of Practices for *Kharif* crops of Punjab (Anonymous, 2015). Rodent species found in selected areas were determined based on their characteristic burrow entrances (Singla and Parshad, 2010).

Rodenticide treatment

In block I, burrow baiting with zinc phosphide (2%), in block II paper baiting with bromadiolone (0.005%), whereas in block III, both burrow and paper baitings were practiced. Block IV was kept as untreated control where no rodenticide baiting was practiced. Burrow baiting was done during vegetative stage of basmati crop and paper baiting was done during reproductive stage of the crop. The baits of zinc phosphide and bromadiolone were prepared as per the recommendations in Packages of Practices for *Kharif* crops of Punjab (Anonymous 2015). For burrow baiting, all the burrows were closed with soil a day before treatment in the evening and all the re-opened burrows next day (called live burrows) were treated with rodenticide bait. About 10g of rodenticide bait was taken in a loose paper boat and placed about 6 inches deep inside each live burrow with the help of a stick and again covered with soil. Similarly, for paper baiting, 10g of bromadiolone bait (400g per 0.4 ha) was placed on a piece of paper at 40 bait points in a 10×10m grid in fields and near bunds as described in Babbar *et al.*(2014).

Rodent control success and damage caused

To determine per cent rodent control success, pre-treatment bait census was taken in all the fields by placing 10g of plain bait (cracked wheat, powdered sugar and groundnut oil in 96: 2: 2) on a piece of paper at 40 bait points per 0.4 ha in a 10×10m grid (400g per 0.4 ha). Remaining bait was collected after two days to record the consumption (g/400g bait). After 15 days of treatment, again plain bait was placed for two days as per the method described above and post census bait consumption was recorded. Live burrow count was also recorded before and after treatment. Per cent rodent control success was calculated as per the formula described in Singla and Babbar (2010) which is given below:

$$\text{Per cent control success} = 1-(t_2 \times r_1 / t_1 \times r_2) \times 100$$

Where, t_1 and t_2 are the plain bait consumptions in treated field during pre-census and post-census, respectively and r_1 and r_2 are the similar bait consumptions in untreated control fields.

Rodent damage (per cent cut tillers) in basmati rice crop was assessed at pre-harvest stage by taking five samples of $1m^2$ per field of 0.4 ha in two diagonal lines to cover center as well as all the four geographical sides of a field. In each sample, the number of healthy tillers and tillers cut by rodents were counted (Young, 1974; Singh and Rao, 1982). Yield loss (kg/0.4ha) was calculated as per the methods described by Singla and Babbar (2010).

Statistical analysis

The data was represented as mean ± SE and analyzed using one way analysis of variance. Mean values were considered significant at 5% level of significance.

RESULTS AND DISCUSSION

In treated fields of DSBR crop, per cent rodent control success (on plain bait consumption basis) was found to be 57.30±3.17, 44.47±2.37 and 65.64±4.72 in blocks I, II and III, respectively. Similarly, in treated block of TBR, the per cent control success was found to be 58.44±2.52, 49.76±5.87 and 61.68±6.51, respectively (Table 1). Results thus indicate comparatively higher percent control success in block III where burrow baiting during vegetative stage along with paper baiting during reproductive stage of crop growth

Table1: Census bait consumption and per cent rodent control success in direct seeded and transplanted basmati rice crops

Block	Plain bait consumption in DSBR (g/400g bait)		Plain bait consumption in TBR (g/400g bait)		Control success (%)	
	Before treatment	After treatment	Before treatment	After treatment	DSBR	TBR
I	392.66±5.99	167.82±11.26	355.33±3.10	147.67±8.02	57.30±3.17[a]	58.44±2.52 [a]
II	381.0±7.32	211.56±7.76	261.66±19.69	131.45±10.35	44.47±2.37 [a]	49.76±5.87 [a]
III	357.66±4.01	122.89±4.75	315.66±29.11	120.96±6.61	65.64±4.72 [a]	61.68±6.51 [a]
IV	379.33±13.02	384.75±8.75	310.66±21.65	319.66±7.36	—	—

Values are mean±SE;Values with similar superscript in a column indicate no significant difference at ($P < 0.05$)

Table2: Rodent damage in direct seeded and transplanted basmati rice crops

Block	Cut tillers (%)		Yield loss (kg/0.4ha)		Yield loss saved (kg/0.4ha)	
	DSBR	TBR	DSBR	TBR	DSBR	TBR
I	0.64±0.03 [a]	0.67±0.10 [a]	17.89±4.52 [a]	17.48±1.48 [a]	24.71±1.98	21.00±2.16
II	0.76±0.04 [a]	0.60±0.13 [a]	19.93±3.40 [a]	23.20±3.40 [a]	22.67±2.52	15.28±1.76
III	0.43±0.03 [a]	0.37±0.06 [a]	10.32±1.44 [a]	12.32±3.89 [a]	32.28±3.90	26.16±2.14
IV	1.61±0.09 [b]	1.09±0.10 [b]	42.60±7.16 [b]	38.48±4.36 [b]	-	-

Values are mean±SE;Values with different superscripts in a column indicate significant difference at $P<0.05$

Table 3: Live burrow count before and after treatment in direct seeded basmati rice crop

Block	Live burrow/0.4 ha before treatment		Live burrow/0.4 ha after treatment	
	B. bengalensis	*M. booduga*	*B. bengalensis*	*M. booduga*
I	8.66 ± 1.45	3.66 ± 0.98	4.00 ± 0.45	2.33 ± 0.98
II	6.00 ± 0.81	5.00 ± 0.82	3.33 ± 0.27	1.66 ± 0.28
III	10.66 ± 0.27	7.33 ± 0.98	3.00 ± 0.82	1.66 ± 0.31
IV	9.33 ± 1.52	3.00 ± 0.48	7.66 ± 0.70	3.66 ± 0.75

Values are mean ± SE

Table 4: Live burrow count before and after treatment in transplanted basmati rice crop

Block	Live burrow/0.4 ha before treatment		Live burrow/0.4 ha after treatment	
	B. bengalensis	*M. booduga*	*B. bengalensis*	*M. booduga*
I	8.00 ± 1.42	6.00 ± 0.47	5.00 ± 1.25	2.66 ± 0.98
II	6.66 ± 0.27	4.33 ± 0.72	4.66 ± 0.27	2.00 ± 0.51
III	10.33 ± 1.52	5.66 ± 1.27	3.33 ± 1.09	2.33 ± 0.27
IV	7.33 ± 0.47	3.66 ± 0.72	9.00 ± 1.47	5.66 ± 0.92

Values are mean ± SE

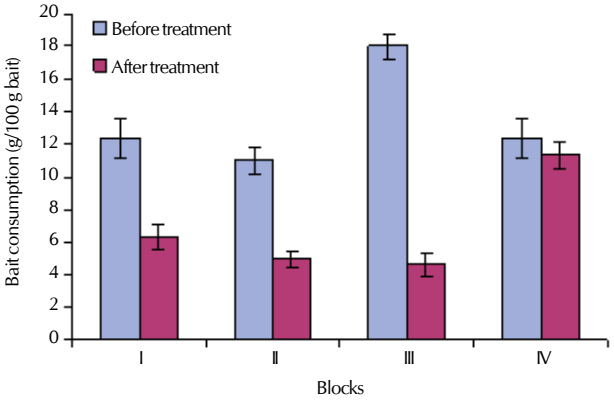

Figure 1: Total live burrow count in treated and untreated blocks of direct seeded basmati rice crop before and after treatment

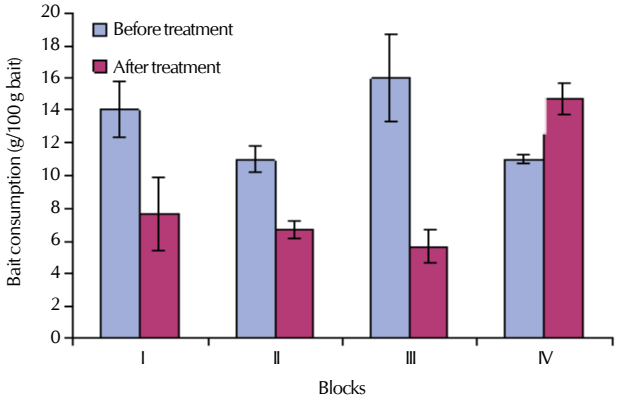

Figure 2: Total live burrow count in treated and untreated blocks of transplanted basmati rice crop before and after treatment

had been carried out, but the difference in control success among the three treated blocks was found to be non-significant.

This was also supported by lower per cent cut tillers and yield loss in treated fields of both DSBR and TBR crops. The per cent cut tillers in treated blocks of DSBR fields ranged from 0.43 ± 0.03 to 0.76 ± 0.04 compared to 1.61 ± 0.09 untreated block. Similarly, per cent cut tillers in treated blocks of TBR fields ranged from 0.37 ± 0.06 to 0.67 ± 0.10 compared to 1.09 ± 0.10 in untreated block. Yield loss (kg/0.4ha) in DSBR fields recorded in blocks I, II, III and IV was 17.89 ± 4.52, 19.93 ± 3.40, 10.32 ± 1.44 and 42.60 ± 7.16, respectively. Similarly, in blocks belonging to TBR fields, the per cent yield loss recorded was 17.48 ± 1.48, 23.20 ± 3.40, 12.32 ± 3.89 and 38.48 ± 4.36, respectively (Table 2). Cut tillers and yield loss in treated blocks were found to be significantly ($P < 0.05$) low than found in untreated blocks. In DSBR, yield loss saved (kg/0.4ha) ranged from 22.67 ± 2.52 to 32.28 ± 3.90, similarly in TBR fields the yield loss (kg/0.4ha) ranged from 15.28 ± 1.76 to 26.16 ± 2.14. Higher save in yield loss was observed in block III as compared to other treated blocks (Table 2). Babbar et al., (2014) also recorded minimum per cent cut tillers and yield loss (kg/hectare) in rice crop after treatment with rodenticides i.e. from 0.30-0.70 per cent and 30.30-65.90 kg/hectare, respectively in treated blocks as compared to control blocks (1.10 -1.50 per cent and 87.0-162.0 kg/hectare) in Jalandhar and Kapurthala districts of Punjab. Earlier, Anonymous (1991) recorded yield losses of 1.09-17.47% in rice crop due to rodent damage in Punjab.

The predominant rodent species in both types of fields recorded was *B.bengalensis* followed by *M. booduga* (Tables 3 and 4). Dutta and Sharma (2007) also found among different habitats *B. bengalensis*as the most abundant (43.75%) rodent species in rice fields as compared to other species. Initially, before treatment in DSBR crop, the mean number of burrows/0.4 ha of *B. bengalensis* and *M. booduga* ranged from 6.00-10.66 and 3.00-7.33, respectively in all the four blocks. Similarly, in TBR fields, the burrows of two species before treatment ranged from 6.66-10.33 and 4.33-5.66, respectively. After treatment, burrows were found reduced to 3.00 to 4.00 and 1.66 to 2.33, respectively in treated blocks of DSBR and from 3.33 to 5.00 and 2.00-2.66, respectively in treated blocks of TBR. After treatment, the mean number of total burrows/0.4 ha in all the three treated blocks of DSBR and TBR were found reduced significantly ($P < 0.05$) from that found before treatment (Figs 1 and 2). In untreated block of DSBR, there was no significant difference in initial number of total burrows and those found at the end of experiment, whereas in TBR, increase in burrows was observed.

Direct seeding helps to reduce water consumption by about

2.25 million liters/ha as it eliminates raising of saplings in a nursery, puddling, manual transplanting and maintenance of 4-5 inches of standing water at the base of the transplanted crop (Mann *et al*., 2004; Joshi *et al*., 2013). There was more problem of rodents in DSBR crop as rodents make more burrows inside the field than on bunds due to dry fields as compared to TBR crop.

Present study thus suggests the conduction of two rodenticide treatments *i.e.* burrow baiting at vegetative stage and paper baiting at reproductive stage of the crop with recommended doses of rodenticides to reduce rodent population and save yield loss in both direct seeded and transplanted basmati rice crops as higher per cent control success and lower per cent cut tillers along with yield loss was recorded in fields having combination of these treatments. By doing so, a farmer can increase his farm income and can play an important role in sustainability of food security.

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