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Efficacy of rodenticide bait application for rodent pest management in potato crop

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Abstract
The experiment was conducted in four blocks of potato crop with each block consisting of three replications of 0.4 ha. The rodent control was carried out in block I (paper baiting of 2% Zinc phosphide @ 1 kg/ha at tuber maturation stage after application of last irrigation), block II (paper baiting of 0.005% Bromodialone @ 1 kg/ha at tuber maturation stage after application of last irrigation) and block III(paper baiting of 2% Zinc phosphide @ 1 kg/ha at tuber maturation stage after application of last irrigation followed by paper baiting of 0.005% Bromodialone @ 1 kg/ha at pre-harvesting stage). Block IV was kept as control. The percent control success of 57.56 ± 4.13 and 59.67±3.92 with respect to same and control fields, respectively; the minimum percent damage to potatoes (4.00±2.31); yield loss (11.60±6.94 kg/ha) and post-harvest burrow count (13.33±0.83/ha) was recorded in block III thus indicating that two treatments first with zinc phosphide at tuber maturation stage followed by bromadiolone after an interval of 15 days were maximum effective in controlling rodent population in potato crop.

Keywords: potato crop, rodents, zinc phosphide, bromadiolone

Introduction
Potato (*Solanum tuberosum*) is an important food crop throughout the world. It is used as vegetable, livestock feed and for manufacturing starch, alcoholic beverages and other processed products in industries. The major potato growing states in India are Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Gujarat and Madhya Pradesh. In Punjab, 87.4 ha area is covered under potato production which is raised for fresh market and seed purpose. The state has established itself as a seed producing state of potato. The best time for sowing of potato in Punjab is last week of September to middle of October for the autumn crop and the second fortnight of January for the spring crop. However, the date of sowing in September would much depend upon the temperature prevailing at that time [1].

There are 103 species and 89 subspecies of rodents under 46 genera belonging to 7 families which have been reported in India [2]. The economic injury caused by rodent pests is much higher than that caused by any other pest. Rodents inflict serious damage at all the growth stages of crops from sowing to harvesting as well as during storage. Though a pragmatic estimate of the damage caused by rodents is difficult to make due to the varied approaches and methods used in evaluating damage, approximately 10-20% damage have been recorded due to rodents [3].

Rodents cause more damage at the seedling and the ripening stages of the crops, so control operations must be planned accordingly. Rodents cause considerable economic losses in staple crops, particularly tuber crops and cereals [4]. The damage caused by lesser bandicoot rat to fruits and vegetables especially potatoes and sweet potatoes is more pronounced as due to their fossorial nature, they damage roots of these plants and become difficult to control [5]. In addition, they also hoard the tubers in their burrows.

There is no information regarding control of rodents in potato crop with rodenticide application in Punjab. Thus, trials on determining the efficacy of different rodenticide applications for rodent pest management in potato crop were conducted at farmer's fields in village Nangal, Tehsil Phillaur, District Jalandhar.

Materials and Methods
Location for experiment: The experiment was conducted in total 4.8 ha area of potato crop in village Nangal, Tehsil Phillaur of District Jalandhar during 2015-16. The area was divided into four blocks I, II, III and IV with each block consisting of three replicated fields of 0.4 ha area.

Pre-census: Prior to treatment of blocks, pre-census bait consumption (g/100g) was recorded in all the fields for two days by placing plain bait @ 1kg/ha at 40 paper bait points/0.4 ha. The bait consisted of mixture of cracked wheat, powdered sugar and vegetable oil in ratio of 96:2:2.

Treatment: After taking pre census, rodent control was carried out in blocks I, II and III. Block IV was kept as untreated control. In blocks I and II, rodenticide application was carried out once at tuber maturation stage (105 days after sowing) after application of last irrigation with 2% zinc phosphide and 0.005% bromadiolone, respectively @ 1 kg/ha. In block III, first baiting was carried out with 2% zinc phosphide at tuber maturation stage after application of last irrigation and second with 0.005% bromadiolone at 15 days interval @ 1 kg/ha each. Baits (2% zinc phosphide and 0.005% bromadiolone) were kept on 40 points per 0.4 ha area by placing 10g of bait on pieces of paper arranged in a grid with line to line and point to point distances of 10 m. Bait points were concealed under potato plants to prevent consumption by non-target animals.

Post-census: After 15 days of treatment in all the blocks, post-census bait consumption (g/100g) was recorded by placing plain bait for two days @ 1kg/ha at 40 paper bait points/0.4 ha.

Control success: From the data on pre and post census bait consumptions, efficacy of rodenticide treatments was evaluated by determining reduction in rodent activity with respect to same field as well with respect to untreated control fields by the formulae used in earlier studies [6].

Pre-harvest rodent damage: The incidence of pre-harvest rodent damage in treated and untreated fields was assessed by randomly selecting 5 samples of $4m^2$ area per field of 0.4 ha and counting total number of potatoes damaged by rodents. From each field of treated and untreated blocks, 5 plants were selected at random for counting number of potatoes/plant. Also total number of plants/$4m^2$ was counted to determine the total number of potatoes/$4m^2$. Percent potatoes damaged were calculated as follows:

$$\text{Potatoes damaged (\%)} = \frac{\text{No. of potatoes damaged/4m}^2}{\text{Total no. of potatoes/4m}^2} \times 100$$

From each field at pre-harvest stage, ten potatoes were collected at random and their yield was determined to calculate the average yield/potato (g). Yield loss (kg/ha) in all fields was calculated by multiplying number of potatoes damaged/ha with average yield/potato.

Burrow census: Survey of live rodent burrows was conducted during different growth stages of potato crop in the fields of all blocks. Burrows of different rodent species were determined on the basis of characteristic burrow entrances [7, 8].

Statistical analysis: The data was interpreted as mean±S.E. of three replications and subjected to paired Student's t-test to draw the conclusions. Values were considered significant at 5% level.

Results and Discussion

The rodents started building up their burrows in potato crop fields at the tuber maturation stage i.e. 105 days after sowing and started damaging the crop, so first paper baiting was done at tuber maturation stage in all the potato crop fields.

Control success: The rodent control success in three different blocks of potato crop with respect to same field and control field was found to be 38.70±3.22 and 42.33 ± 2.96 in block I, 46.45±0.75 and 49.13± 0.59 in block II and 57.56 ± 4.13 and 59.67±3.92 in block III, respectively indicating maximum control success in block III (Table 1).

Pre-harvest rodent damage: The maximum percent potato damage and yield loss (19.25±2.03 and 256.8±27.46 Kg/ha) was recorded in block IV where no treatment was done (Table 2). The earlier studies reported severe yield losses, ranging from 18.0 to 71.0% in potato crop [9]. The minimum percent potato damage (4.00±2.31) and yield loss (11.60±6.94 kg/ha) was found in block III having first application of zinc phosphide followed second application of bromadiolone and the yield loss in this block was significantly ($P \leq 0.05$) less from that in block I (64.46±35.57 kg/ha) and block II (66.44±34.03 kg/ha). Reduction in rodent damage in treated fields from that of untreated ones resulted in save in yield loss of 190.36 to 245.20 kg/ha with net benefit of Rs. 324.72 to 399.40 per hectare with maximum saved yield loss and benefit in block III (Table 2).

Burrow count: The major rodent species found inhabiting potato crop fields in present study as identified based on characteristic burrow entrances were lesser bandicoot rat, *Bandicota bengalensis*, field mouse, *Mus booduga*, Indian gerbil, *Tatera indica* and soft furred field rat, *Millardia meltada*. The potato crop in Punjab is generally irrigated at 7-10 days interval during initial growth stages [1] as the crop responds better to frequent irrigation because of shallow root system. Thus, during early stages of crop growth, though few rodent burrows were seen but no damage was observed prior to tuber maturation stage. In later stages of crop growth when tuber maturation started (in the month of January) and irrigation was reduced, the rodents started building up their burrows and causing damage (Figure 1). Moreover, at this time no or little food was available to rodents in the surrounding wheat crop fields.

After harvest of potato crop, the maximum rodent burrow count (64.18±3.00/ ha) was observed in block IV and the minimum in block III (13.33±0.83/ ha) (Table 3). The field mouse, *M. booduga* was found to be the predominant rodent species followed by *B. bengalensis*, *T. indica* and *M. meltada*. The rodents had hoarded potato tubers in their burrows for future use. Previous studies on spring crop of potato have reported that *B. bengalensis* activity started soon after the planting of potato crop was over during March-April, when they fed upon mother tubers resulting in poor germination and from June till harvest, they damaged developing tubers [9].

Present study thus indicates that two rodenticide treatments, first with 2% zinc phosphide at tuber maturation stage after about 105 days of sowing and second with 0.005% bromadiolone after an interval of 15 days were maximum effective in control of rodents in potato crop. These observations are in accordance with earlier studies which reported that double baiting treatments comprising zinc phosphide and bromadiolone accomplished significantly higher reduction of rodent population as well as crop damage than that with single baiting treatments conducted with either of the two rodenticides [10].

As there is variation in maturity period of different varieties of potato crop cultivated in Punjab, the first baiting with 2% zinc phosphide should be done after 7-10 days of last irrigation at tuber maturation stage as this is the time when rodents buildup their burrows and damage the potato tubers. The second poison baiting with 0.005% bromadiolone should be done at interval of 10-15 days after first poison baiting. These two applications will help the farmers in effective management of rodents in potato crop fields thereby raising their farm income.

Table 1: Effect of different treatments on rodent control in potato crop

Block	Plain bait consumption (%)		Control success (%)	
	Pre-census	Post-census	wrt same field	wrt control field
I	89.00±1.66	53.92±1.75	38.70±3.22^{a}	42.33±2.96^{a}
II	94.58±5.42	50.67±3.17	46.45±0.75^{b}	49.13±0.59^{b}
III	87.33±6.36	37.58±6.53	57.56± 4.13^{c}	59.67±3.92^{c}
IV	88.33±1.67	92.83±1.64	--	--

Values are mean±S.E.
Values with different superscripts a-c in a column differ significantly at $P \leq 0.05$

Table 2: Effect of different treatments on rodent damage in potato crop

Block	Damaged potatoes (%)	Yield loss (kg/ha)	Yield loss saved (kg/ha)	Net benefit (Rs/ha)
I	5.95± 3.53^{a}	64.46± 35.57^{a}	192.34	349.68
II	5.18± 2.52^{a}	66.44± 34.03^{a}	190.36	324.72
III	4.00± 2.31^{a}	11.60± 6.94^{b}	245.20	399.40
IV	19.25± 2.03^{b}	256.8± 27.46^{c}	-	-

Values are mean±S.E.
Values with different superscripts a-c in a column differ significantly at $P \leq 0.05$
Cost of potato: Rs 2/Kg, Cost of single treatment of 2% zinc phosphide/ha = Rs 35/- and cost of single treatment of 0.005% bromadiolone/ha = Rs 56/-

Table 3 : Post harvest burrow count/ha in different blocks of potato crop

Block	Mb	Bb	Ti	Mm	Total
I	9.18± 1.65^{a}	5.83± 2.20^{a}	1.65± 1.65^{a}	0.83± 0.83^{a}	18.33± 3.00^{a}
II	9.18± 0.83^{a}	5.00± 1.45^{a}	5.83± 0.83^{b}	0.83± 0.83^{a}	20.83± 2.20^{a}
III	5.83± 0.83^{b}	3.33± 0.83^{a}	4.18± 0.83^{b}	0^{a}	13.33± 0.83^{b}
IV	24.18± 6.00^{c}	15.83±3.00^{b}	14.18±1.68^{c}	10.00±2.88^{b}	64.18± 3.00^{c}

Values are mean±S.E.
Values with different superscripts a-c in a column differ significantly at $P \leq 0.05$
Mb-*Mus booduga*, Bb-*Bandicota bengalensis*, Ti- *Tatera indica*, Mm-*Millardia meltada*

Fig 1: Rodent damage at tuber maturation stage of potato crop

Conclusion

The two treatments of rodenticide application i.e. paper baiiting with zinc phosphide at tuber maturation stage of potato crop followed by paper baiting with bromadiolone after an interval of 15 days were maximum effective in controlling rodent population in the crop.

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