Rodents and their management of horticultural crops in Karnataka

Mohan I. Naik, Vipin Chaudhary
and Basavadarshan A V

All India Network Project on
Vertebrate Pest Management
University of Agricultural Sciences
GKVK, Bengaluru- 560 065
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Dr. S. Rajendra prasad
Vice Chancellor

Foreword

Karnataka is the second most important state for the production of horticultural crops in the country. The menace of vertebrate pests in horticultural crops especially rodents are at the alarming rate causing 5-14 per cent crop losses. All India Network Project on Vertebrate Pest Management sponsored by ICAR have strived in generating information on rodent population density, extent of crop damage and mitigation strategies for rodents in horticultural crops.

It's a great pleasure to write the foreword to book entitled "Rodents and their management of horticultural crops in Karnataka". This book provides practical information on major rodent pests in horticultural crops of Karnataka, their dynamics, extent of damage and sustainable economic techniques to manage the rodents in horticultural crops of Karnataka.

Rodents are being adaptive and intelligent and increased cropping intensity has made them to develop and elude the man's attempt to eradicate them. This has made our rodent biologists in our university to be continuously engaged in research and to evolve the sustainable management strategies. I am sure that they will succeed in this endeavor.

I am extremely happy to note that Dr. Mohan I Naik, Professor and Head, AINP on Vertebrate Pest Management, have conducted the significant research on bio ecology and integrated management of rodents in various horticultural crops of Karnataka and has taken the technology to reach the farmers.

Date: 23.6.2021
Bengaluru

(Dr. S. Rajendra prasad)

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Dr. Mohan. I. Naik
Professor and Head

Preface

Among the conventional mammalian pests' rodents cause the vulnerable damage to horticultural crops at different stages. The controlling of rodents in horticultural crops requires a depth knowledge on eco biology, population dynamics and quantifying the extent of damage. Thus, this book focuses on the population estimation, extent of damage and integrated management strategies with respect to rodent pests of horticultural crops of Karnataka.

I am confident that this book "Rodents and their management of horticultural crops in Karnataka" will serve as a valuable resource document to create awareness among scientists, students, policy makers, extension functionaries and farmers about rodent outbreaks and management in horticultural gardens of Karnataka.

The efforts made by previous project scientists of our center has provided the necessary information and has to be greatly acknowledged. We would like to sincerely thank Dr. G. Dorairaj, Dr. K. Srihari, Dr. B.K. Guruprasad, Dr. Shakuntala sridhara, Dr. G. Govindaraj and Dr. V Shivayya.

We extend our deep sense of gratitude and thanks to Dr. Rajendra prasad, Vice Chancellor, Dr. Y. G. Shadakshari, Director of Research, University of Agricultural Sciences, Bengaluru, Karnataka for providing constant support to the project and encouragement in bringing out this publication.

We are extremely grateful to the Indian Council of Agricultural Research, New Delhi, Network Coordinating Unit, All India Network project on Vertebrate Pest Management, Central Arid Zone Research Institute, Jodhpur, Rajasthan for providing financial assistance, administrative approval and other necessary facilities for publication.

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(Dr. Mohan. I. Naik)

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INTRODUCTION

The growth of the horticulture sector has been one of the driving forces of overall agricultural development in India. The horticulture sector encompasses various crops such as fruit crops, vegetable crops, ornamental crops, medicinal and aromatic crops, spices, and plantation crops. In Karnataka, the horticulture crop covers 14.8% of the net cultivable area with an annual production of 118.2 lakh tones. Horticulture contributes 40% of the agriculture income and 80% of the agricultural exports in Karnataka and is the second most important states next to Maharashtra for the production of horticultural crops. The agro-climatic suitability provides a unique position for the state to be a natural home for a large number of horticultural crops that can be grown all-round the year. Out of 121.86 lakh ha cultivable areas, nearly 17.64 lakh ha is under horticultural crops accounting for 8 % of the area, contributing to over 136.66 lakh tones. Around 2.46 lakh ha is under fruit crops, and 2.99 lakh ha is under vegetables. Fruits contribute to 73.62 lakh tones while vegetables 6.23 lakh tones. The state leads in the country's area and production of brinjal, tomato, mango, and cut flowers. Horticultural production is hampered by diseases and animal pests. Among the pest, though insect pests occupy the higher position, the rodents are gaining importance for their damage caused in the horticultural crops in recent decades. The high source of nutritious food and vivid vegetative structures and trees provide them habitat for living in the horticultural crops. The crop damage starts from the nursery stage and lasts till the harvesting stage of the crop; however, tubers, fruits, berries and nuts provide them a high source of food materials, the large trees of plantation crops provide them the space for inhabiting and the vegetative structures provide them the fodder for building their nests. Rodents prefer the vegetable, fruit and plantation crops usually, they damage these crops by direct consumption and damaging the vegetative structures by burrowing, gnawing and cutting. Control of rodents in horticultural crops is an arduous task. Though synthetic rodenticides are effective, it is far from satisfactory due to vast vegetative structures, high food source, bait shyness, non-target exposure and consumption of ineffective doses and resistance. In this light, All India Network Project on Vertebrate Pest Management of the University of Agricultural Sciences, GKVK, Bangalore, is conducting research to formulate effective strategies to control rodents in various horticultural crops of Karnataka.

I. Major Rodent Pest in Horticultural crops of Karnataka.

1. The Southern palm squirrel, *Funambulus palmarum* (Linnaeus)

Funambulus palmarum is a medium sized squirrel weighing 80g with a bushy tail belongs to the family Sciuridae. The dorsal side is greyish brown with three white stripes separated by two off-white bands. The tail is white with a blackish mid-portion and the tail tip is whitish. Soft fur covers the small ears. In Karnataka it is distributed throughout the coastal/southern regions. Generally, lives close to human habitation, orchards, gardens, parks and in areas with a fairly good number of trees. It is highly active, playful, arboreal and running around up and down the trees, chirpy and diurnal. They generally consume fruits, nuts, seeds, flowers etc., but being omnivorous, eat insect larvae, beetle, moths etc. *Funambulus. palmarum* causes severe damage to fruits like pomegranate, sapota (Chiku), grapes, guava, zizyphus, pineapple and mango (Plate 1).

Plate 1: The Southern palm squirrel, *Finambulus palmarum* (Linnaeus)

2. The Indian porcupine, *Hystrix indica* (Kerr.)

The crested porcupine is the largest rodent species in Karnataka, measuring 680-750mm in length and weighing 11-18 kg. The neck and upper back are covered with excited the hair stand erect to form a prominent crest. The body is clothed with alternating dark brown and white quills and the tail is covered by short and broad quills. Short, coarse, black hairs thinly cover the ventral surface. In Karnataka, it is mostly predominant in Western Ghats regions and rocky area of plain lands. Porcupines are nocturnal with an acute sense of smell. Porcupines are known to be chiefly herbivorous, feeding on succulent tubers, bulbs, ripe fruits and bark of trees. Grain, vegetables of all kinds and roots are also consumed. They can be very destructive to gardens and cultivated crops by tunneling beneath the walls and hedges to access the food. They cause considerable yield loss to potato, sweet potatoes, ripe melons, onion, carrots, etc., apart from this, it is known for exhibiting girdling behaviour in coconut plantations (Plate 2).

Plate 2: The Indian porcupine, *Hystrix indica* (Kerr.)

3. The Indian gerbil, *Tatera indica* (Hardwicke)

Belonging to the family muridae as rats and mice, but in a different sub family, gerbilliane, the Indian gerbil is distinctly different from rats by its tail, hind feet, ears and eyes. The tail, unlike the naked type in rats and mice is covered with hair, which terminates at the tip as a tuft. The hind feet are longer than fore feet. Eyes are large and ears are round. Generally light brown in colour, varying from sandy brown to grey on the dorsal side and pure to off white ventrally. Feet are white, in colour. A light brown band runs along each side of the tail. In Karnataka it is mostly distributed in dry regions. Main food is grains, leaves and grasses. When density is high, they are destructive to almost all kinds of cultivated crops at every stage and are also known to hoard food in their burrows During lean season they eat roots, leaves and fruits of wild plants. It is a severe pest of vegetables and fruits (Plate 3).

Plate 3: The Indian gerbil, *Tatera indica* (Hardwicke)

4. The soft furred field rat, *Millardia meltada* (Ryley)

The *Millardia meltada* belongs to the family muridae weighs 40-60g, with soft fur. Body colour is light to dark grey dorsally with foot and belly being off white. Tail is similar to body colour with dark grey above and pale below (Plate 4). In Karnataka in his distributed in almost all regions. Nocturnal in habitat. *Millardia meltada* is a severe pest of vegetables and fruits.

5. **The Brown spiny mouse, *Mus platythrix (Bennet)*.**

Mus platythrix body weight ranges 20-30g with the fur composed of entirely flattened spines. The dorsal fur is coarser than the belly. The colour is sandy to brown dorsally and white ventrally. The colour pattern is sharp and distinct. In Karnataka it is distributed in all the districts and is found in crop fields, prefers, rocky and gravely habitat. The mouse is burrow-dwelling and nocturnal. The burrow opening is characterized by the arrangement of pebbles in concentric circles and is a serious pest of vegetable crops (Plate 5).

6. **The India field mouse, *Mus booduga* (Gray)**

M. booduga is a tiny mouse weighing 10-12g belongs to the family muridae. Dorsal fur varying in colour from pale sandy in the desert regions to dark brown to greyish in most regions. Ventrum is white. *Mus booduga* is found in crop fields especially irrigated ones. It is fossorial and nocturnal and burrow opening is characterized by scooped soil at the entrance with small pebbles. It is a pest of vegetables and some fruit crops (Plate 6).

Plate 4: The soft furred field rat, *Millardia meltada* (Ryley)

Plate 5: The Brown spiny mouse, *Mus platythrix (Bennet)*

Plate 6: The India field mouse, *Mus booduga* (Gray)

7. **The House rat, *Rattus rattus* (Linnaeus).**

It is a medium sized rat weighing 150-200g belongs to the family Muridae. *R. rattus* is also called as roof rat, black rat and ship rat. It is characterized by long tail, slender body and pointed snout as well as the belly. The dorsal fur is mostly blackish in commensal forms, ranging from yellow to brown black with pale white belly and leaves in plantation crops, especially coconut and areca nut (Plate 7).

8. **The lesser bandicoot rat, *Bandicota bengalensis* (Gray).**

The lesser bandicoot is robust with a round head and a broad muzzle weighing 200-350g. the body is covered with coarse fur which forms black-tipped piles on the dorsal side. The colour on the dorsal side is dark brown but may be blackish, pale brown or reddish. Feet are dark but digits are paler. Tail is entirely dark and paler below occasionally the belly is grey and rarely whitish. It is completely a fossorial and nocturnal rodent and considerable amount of food is hoarded inside the borrows. The lesser bandicoot is a severe pest of many vegetables and coconut nurseries. Their burrows were also reported from cashew, pineapple, cardamom, pepper, yam and rubber plantations of Karnataka (Plate 8).

Plate 7: The House rat, *Rattus rattus* (Linnaeus)

Plate 8: The lesser bandicoot rat, *Bandicota bengalensis* (Gray).

RODENT DAMAGE IN HORTICULTURAL CROPS OF KARNATAKA.

1. **Fruit crops:** fruits crops experience a vulnerable level of crop damage. The rodents preferred the ripened berries and damaged them by direct consuming and they also damaged the inflorescence and vegetative structures by burrowing, gnawing and cutting. In fruit crops, *Funambulus palmarum* was the predominant rodent pest (Figure 1 and 2).

a) **Mango:** In mango *Funambulus palmarum* and *Rattus Rattus* were the predominant rodent pests. The average crop damage and rodent density were 6.8 per cent and 15.9 LBC/ha, respectively. The peak rodent damage was observed in the fruit formation stage. The rodents damaged the ripened berries by direct consumption and damaged the un ripened fruits and inflorescence by gnawing.

b) **Sapota (Chikku):** The average crop damage was 3.9 per cent with 18.5 LBC/ha rodent density. *Funambulus palmarum* and *Rattus Rattus* were the predominant rodent species, and they caused the damage by feeding the ripened fruits.

c) **Guava:** In guava *Funambulus palmarum* was the predominant rodent pest and it was followed by *Rattus rattus*, *Bandicota bengalensis* and *Tatera indica*. The rodents damaged the fruits by direct feeding, and during the nursery stage, the rodents damaged the vegetative structures by gnawing. The average crop damage was 4.9 per cent and rodent density was 17.1 LBC/ha.

Mango

Sapota (Chikku)

Guava

Pomegranate

Plate 9: Rodent damage in fruit crops

d) **Pomegranate:** In pomegranate, the crop damage was 6.8 per cent and the rodent density was 29.5 LBC/ha. The rodent species complex included the *Funambulus palmarum*, *Rattus rattus*, *Bandicota bengalensis* and *Tatera indica*. The fruits were directly consumed by the rodents and rodent damage was also recorded during the flowering stage by damaging the flowers at the peduncle. In the nursery stage the rodents damaged the vegetative parts by gnawing.

e) **Grapes:** In grape garden *Funambulus palmarum* and Rattus Rattus were the prevalent rodent species and they were followed by *Bandicota bengalensis* and *Millardia meltada*. The rodent was present from the nursery state to the harvesting stage of the crop. The average crop damage was 7.4 per cent and rodent density was 22.5 LBC/ha. The rodents damaged the vegetative parts and directly fed the ripened berries. In some grape gardens, damage to drip irrigation pipes by gnawing was also noticed.

f) **Pineapple:** Pineapple is seriously prone to rodent damage the rodent damage was recorded from nursery to fruit harvesting stage. The crop damage was 9.2 per cent and rodent density was 39.6 LBC/ha. The rodent damaged the vegetative parts and directly fed the berries. Among the rodent pests *Bandicota bengalensis* was predominant and it was followed by *Millardia meltada, Mus booduga,* and *Tatera indica*.

g) **Papaya:** *Funambulus palmarum* and *Rattus Rattus* were the predominant rodent pest's and the average damage was 3.7 per cent and rodent density was 12.9 LBC/ha. The rodents damaged the mature fruits by direct consuming.

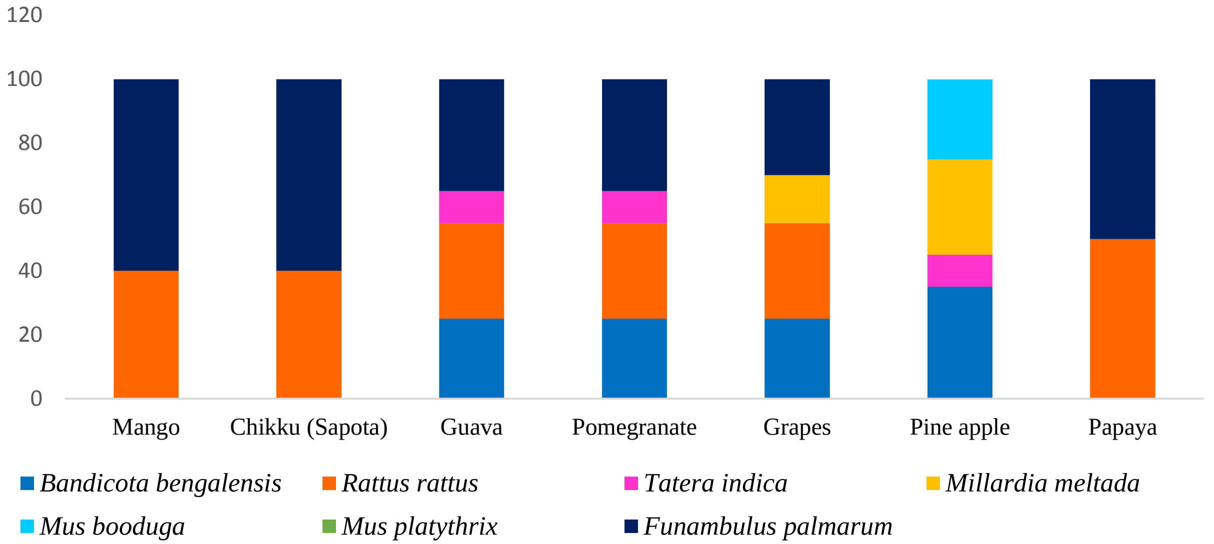

Figure 1: Rodent species composition in fruit crops of Karnataka.

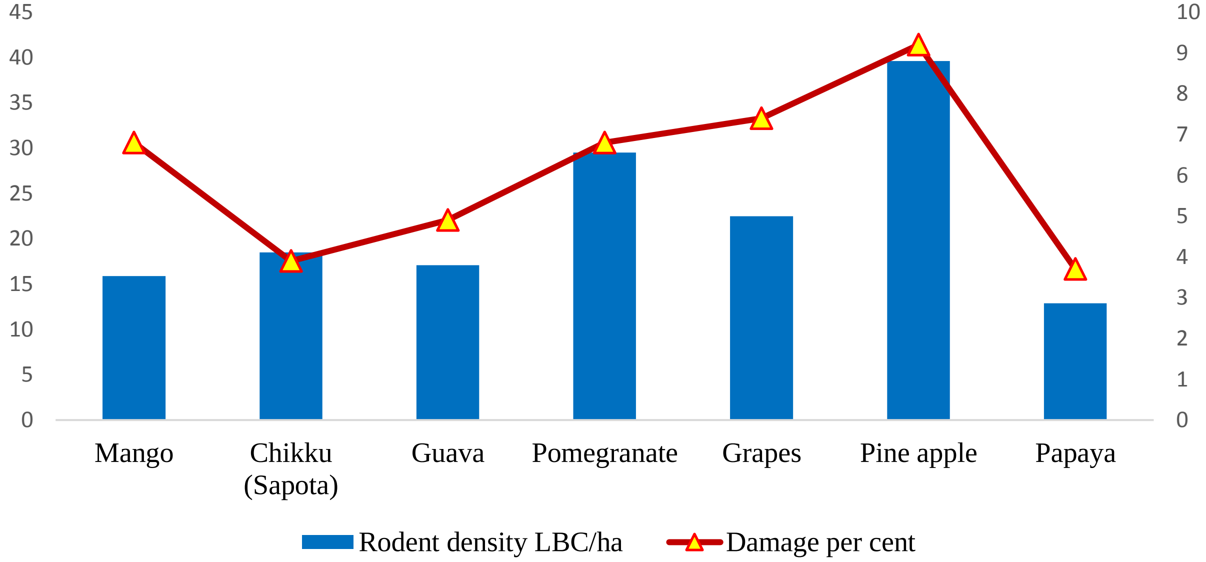

Figure 2: Rodent density and damage in fruit crops of Karnataka

Grapes **Grapes**

Pine apple

Papaya

Plate 10: Rodent damage in fruit crops

2. Vegetable Crops.

Vegetable crops are seriously prone to rodent damage. The rodents highly preferred the tubers (Guards, potato, sweet potato, tapioca) than the fruits (beans, onion, cabbage, capsicum). The rodents were observed from the nursery state to the harvesting stage of the crop. However, in vegetable crops the *Bandicota bengalensis* was the predominant rodent pest (Figure 3 and 4).

a) **Carrot:** In carrot, the average damage was 8.7 per cent and rodent density was 26.2 LBC/ha, among the rodent pests, *Millardia meltada* and *Bandicota bengalensis* were predominant and it was followed by *Tatera indica*, *Mus booduga* and *Mus platythrix*. The peak rodent activity was recorded in the maturity and harvesting stage. The rodents damaged the mature tubers by direct feeding.

b) **French bean:** The rodent species complex included the *Bandicota bengalensis, Mus platythrix* and *Millardia meltada*. The crop damage was 4.5 per cent and rodent density was 21.6 LBC/ha. The rodents damaged the sown seeds, damaged the vegetative structures by gnawing and consumed the mature fruits.

c) **Cabbage and Cauliflower:** In cabbage, the crop damage was 6.8 percent and rodent density was 26.3 LBC/ha. *Bandicota bengalensis* was the predominant rodent pest and was followed by *Mus platythrix*, *Mus booduga* and *Tatera indica*. The rodents damage the crop by burrowing and damaging the vegetative structures and direct feeding.

Carrot

Sweet potato

Okra

Bottle guard

Plate 11: Rodent damage in vegetable crops

d) **Beet root:** In beet root the crop damage was 5.4 per cent and the rodent density was 32.8 LBC/ha. *Bandicota bengalensis* was the predominant rodent pest fallowed by *Mus platythrix* and *Tatera indica*. The rodents damaged the beetroots by direct consuming the mature tubers.

e) **Capsicum:** In Karnataka capsicum is cultivated in the field and poly house conditions however, *Funambulus palmarum* was predominant and it was followed by *Bandicota bengalensis* and *Mus platythrix*. The rodents damaged the mature fruits by direct feeding.

f) **Cucumber:** In cucumber damaged, the average damage was 4.6 per cent and the density was 28.9 LBC/ha. The rodents damaged the mature and tender tubers. They also damaged the vegetative structures by burrowing, gnawing and cutting. Hoarding of vegetative structures was also observed. Among the rodent pests *Bandicota bengalensis* was predominant and was followed by *Mus booduga*, and *Mus platythrix.*

g) **Potato and Sweet potato:** *Bandicota begalensis, Millardia meltada* and *Mus booduga* were the predominant rodent pest species observed. The average damage was 8.7 per cent and the rodent density was 38.7 LBC/ha. The potatoes are seriously prone to rodent damage. The rodents damaged the tubers by direct feeding, and they also damaged the vegetative structures by burrowing and gnawing.

h) **Tomato:** In tomatoes, the rodents damaged the vegetative parts and consumed the ripened berries. The damage was 6.4 per cent and the rodent density was 16.8 LBC/ha. Among the rodent pests, *Bandicota bengalensis* and *Funambulus*

Cucumber

Brinjal

French bean

Beet root

Plate 12: Rodent damage in vegetable crops

palmarum were predominant and it was followed by *Tatera indica* and *Mus platythrix.*

i) **Pumpkin:** Pumpkin is highly vulnerable to rodent damage. The average damage per cent was 11.4 per cent and the average density was 58.1 LBC/ha. *Bandicota bengalensis* was the predominant rodent species and it was followed by *Mus platythrix* and *Millardia meltada*. The rodents damage the tubers by directly feeding and damaging the vegetative structures by burrowing, gnawing, and cutting.

j) **Okra:** *Bandicota bengalensis* was the predominant rodent species in okra the average rodent density was 33.4 and damage was 7.1 percent the rodents damaged the fruits by feeding and they also damage the vegetative structures by cutting and hoard the vegetative parts in the burrows. *Millardia meltada, Mus platythrix* and *Tatera indica* were also observed in okra.

k) **Brinjal:** In brinjal *Funambulus palmarum* was the predominant rodent pest and *Tatera indica* and *Bandicota bengalensis* followed it. The rodents preferred and damaged the mature fruits and in the vegetative stage they damaged the vegetative parts and flowers at peduncle region by burrowing and gnawing. The average damage was 1.6 per cent and rodent density was 20.1 LBC/ha.

l) **Guards**: Among the guard's rodents preferred the bottle guard, ash guard, ridge guard. They damaged the tubers by feeding and damaged the vegetative structures by cutting, gnawing, and burrowing. They also hoarded the vegetative structures. The average damage was 5.8 per cent and rodent density was 38.7 LBC/ha. Among the rodent species complex, *Bandicota bengalensis* was predominant and it was followed by *Millardia meltada, Tatera indica,* and *Mus platythrix.*

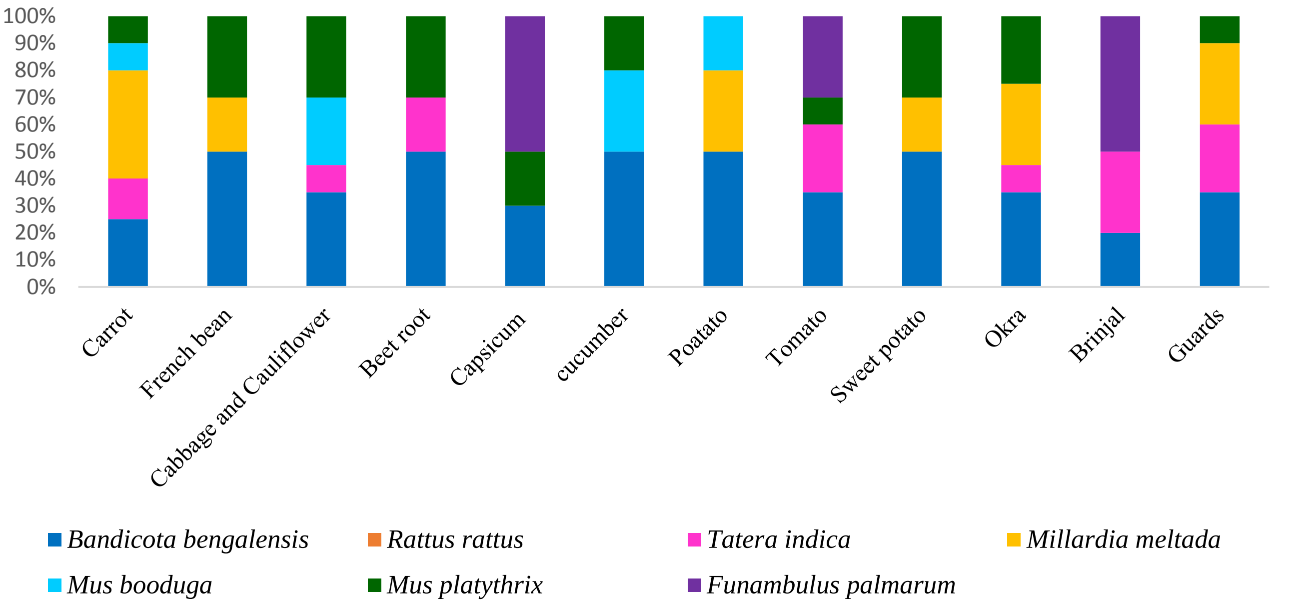

Figure 3: Rodent species composition in Vegetable crops of Karnataka

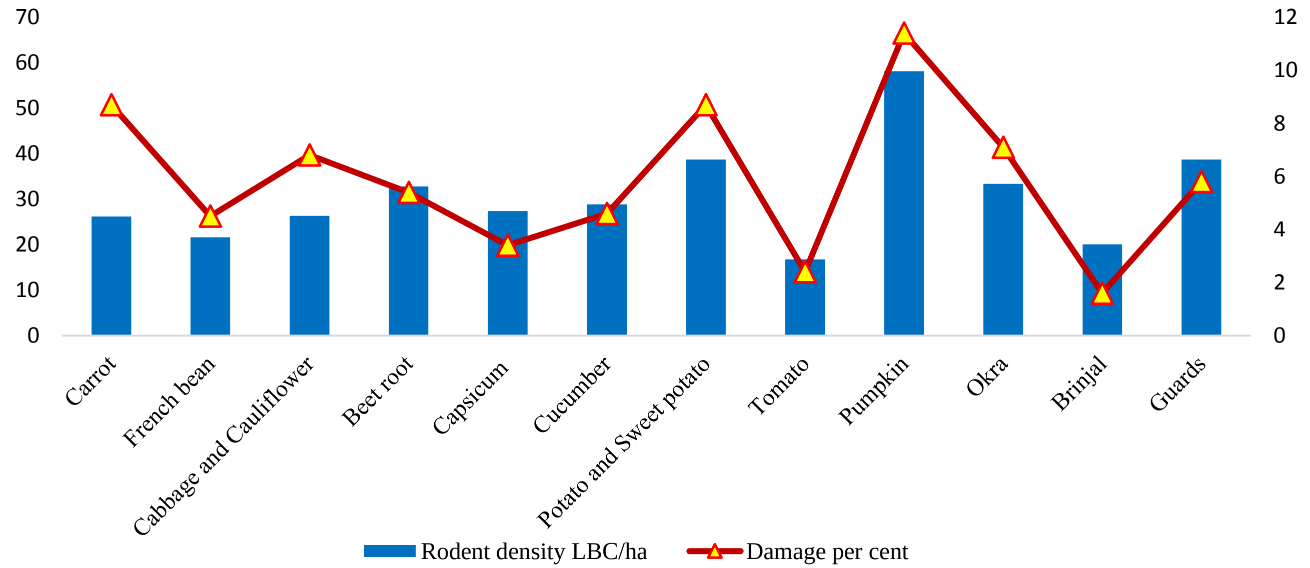

Figure 4: Rodent density and damage in Vegetable crops of Karnataka

Pumpkin

Capsicum

Potato

Tomato

Plate 13: Rodent damage in vegetable crops

C) **Coffee:** Coffee plantations are also critically prone to rodent damage among the rodents *Millardia meltada*, *Bandicota bengalensis* and *Funambulus palmarum* were dominant and the average crop damage was 11.3 per cent and rodent density was 15.9 LBC/ha. The rodents damaged the mature berries and also vegetative structures by cutting, burrowing and gnawing.

c) **Cocoa:** In cocoa plantations, *Funambulus palmarum* followed by *Ratts rattus* and *Bandicota bengalensis* were the predominant rodent pests the rodents damaged the mature pods by direct feeding. Squirrels cause damage to the cocoa pods in the center, while the rats cause damage near the peduncle. The average crop damage was 5.4 per cent and the rodent density was found to be 23.8 LBC/ha.

d) **Banana:** In banana plantations, the crop damage by the rodents was founded to be 3.5 per cent and the rodent density was 19.6 LBC/ha. *Bandicota bengalensis* followed by *Funambulus palmarum* and *Rattus rattus* were the predominant rodent species. The rodents damaged the tubers in the vegetative stage by gnawing and consuming mature fruits in the ripening stage.

e) **Cashew nut:** Cashew crop also suffers from rodent damage. The rodent infestation lasts from the nursery stage to the harvesting stage of the crop. The rodents damaged the vegetative structures, inflorescence and mature fruits of the crop. The average crop damage was 2.5 per cent and the rodent density was 12.8 LBC/ha. *Bandicota bengalensis*, *Funambulus palmarum*, and *Rattus rattus* were the predominant rodent pests.

Coffee

Areca nut

Coconut

Banana

Plate 14: Rodent damage in plantation crops

4. Spices crop.

Spices crop such as pepper and cardamom also experienced rodent damage. The rodents damaged inflorescence, vegetative structures and matured fruits. In the spices crop, *Funambulus palmarum* was the predominant rodent pest (Figure 5 and 6).

a) **Cardamom:** in cardamom, the capsules are highly exposed to rodent damage an average of 6.7 per cent crop damage and rodent density of 20.5 LBC/ha was observed. The rodents damaged the mature and developing capsules and among the rodent pests *Funambulus palmarum*, *Rattus rattus* and *Bandicota bengalensis* were the predominant rodent pests.

b) **Pepper:** In pepper the rodents damaged the inflorescence and unripened berries. The average crop damage was 3.6 per cent and the rodent density was 19.8 LBC/ha. Among the rodent pests *Rattus rattus*, *Funambulus palmarum* and *Bandicota bengalensis* were the predominant rodent pests.

5. **Flowers:**

The flower crops are also exposed to crop damage; rodent damage was observed in vegetative and flowering stages. *Bandicota bengalensis* was the predominant rodent pest (Figure 5 and 6).

a) **Chrysanthemum:** in chrysanthemum, the rodents damage the vegetative structure by burrowing, cutting and hording the vegetative structures. The average crop damage was 2.1 per cent and rodent density was 18.5 LBC/ha. *Bandicota bengalensis* followed by *Millardia meltada* and *Mus platythrix* were the rodent species observed.

b) **Polyanthus lily:** Both in field and poly house conditions the crop experienced the crop damage, the rodents damaged the crop by burrowing and cutting the vegetative structures. An average crop damage of 3.6 per cent was observed with 19.3 LBC/ha. *Bandicota bengalensis* followed by *Rattus rattus*, *Mus platythrix* and *Mus booduga* were the predominant rodent pests.

c) **Mari gold:** In marigold *Funambulus palmarum* and *Rattus rattus* were the predominant rodent pests. The rodents damaged the vegetative structure by burrowing and cutting average crop damage of 1.8 per cent, and 15.6 LBC/ha rodent density was observed.


Plate 15: Squirrel feeding guava and pomegranate

Cashew nut

Cocoa

Chrysanthemum

Polyanthus lily

Plate 16: Rodent damage in plantation and flower crops

Table 1: Rodent density, damage and rodent species composition in horticultural crops of Karnataka.

	Crop	Rodent density LBC/ha	Damage per cent	Species composition
Fruit crops	Mango	15.9	06.8	Fp>Rr
	Chikku (Sapota)	18.5	03.9	Fp>Rr
	Guava	17.1	04.9	Fp>Rr>Bb>Ti
	Pomegranate	29.5	06.8	Fp>Rr>Bb>Ti
	Grapes	22.5	07.4	Fp=Rr>Bb>Mme
	Pine apple	39.6	09.2	Bb>Mme>Mb>Ti
	Papaya	12.9	03.7	Fp=Rr
Vegetable crops	Carrot	26.2	08.7	Mme>Bb>Ti>Mb=Mp
	French bean	21.6	04.5	Bb>Mp>Mme
	Cabbage and cauliflower	26.3	06.8	Bb>Mp>Mb>Ti
	Beet root	32.8	05.4	Bb>Mp>Ti
	Capsicum	27.4	03.4	Fp>Bb>Mp
	Cucumber	28.9	04.6	Bb>Mb>Mp
	Potato and sweet potato	38.7	08.7	Bb>Mme>Mb
	Tomato	16.8	06.4	Bb>Fp>Ti>Mp
	Pumpkin	58.1	11.4	Bb>Mp>Mme
	Okra	33.4	07.1	Bb>Mme>Mp>Ti
	Brinjal	20.1	01.6	Bb>Mme>Ti
	Guards	38.7	05.8	Bb>Mme>Ti>Mp
Plantation crops	Coconut	26.8	15.8	Rr>Fp>Bb
	Areca nut	21.6	13.9	Rr>Fp>Bb
	Coffee	15.9	11.3	Mme>Bb>Fp
	Cocoa	23.8	05.4	Fp>Rr>Bb
	Banana	19.6	03.5	Bb>Fp>Rr
	Cashew nut	12.8	02.5	Bb>Fp=Rr
Spices	Cardamom	20.5	06.7	Fp>Rr>Bb
	Pepper	19.8	03.6	Rr>Fp>Bb
Flower crops	Chrysanthemum	15.5	02.1	Bb>Mme>Mp
	Polyanthus lily	19.3	03.6	Bb>Rr>Mp>Mb
	Mari gold	15.6	01.8	Fp=Rr

4. Management of rodents in coffee plantations

In India, Karnataka alone shares 71 per cent of coffee production. seven coffee plantations were selected out of which five plantations were treated with commercially available rodenticides Zn_3P_2 (2%) bait**,** bromadiolone (2%) bait and bromadiolone (cake) and new rodenticides (Difenacoum cake, and Flocoumafen cake) whereas, in the 6th plantation snap trap @ 54 per ha was employed with sanitation measures and rest of the plantation was treated as control where no treatments were taken up. Rodent density (LBC per ha) and Rodent index (RI) were recorded prior and 15 days after the treatment. The results indicated that the per cent reduction in RI and LBC per ha was highest (81.90, 66.47%, respectively) in treatment where the placement of snap trap @ 54 per ha with sanitation measures were followed. In case of rodenticides application all the treatments performed well with the per cent reduction of RI and LBC/ha in Zn_3P_2(2%) baiting (74.16& 52.87%, respectively)**,** Bromadiolone (2%) baiting (69.70, 54.65%, respectively), Bromadiolone cake (70.29, 46.59%, respectively). Whereas the new rodenticides Difenacoum cake (73.27, 52.47%, respectively), and Flocoumafen cake (75.22, 56.69%, respectively) performed equally with old rodenticides in suppressing the rodents over pre- treatment. The predominance of *Funambulus palmarum*, *Rattus rattus*, *Bandicota bengalensis* and *Mus booduga* in the plantation were recorded (Table 2). The above result also conveys that trapping of migrated rodents and decreasing the habitat by maintaining sanitation alone decreased the rodent damage and among the rodenticides the efficacy of new rodenticides was on par with commercially available older rodenticides for rodent management.

Table 2: Management of rodents in coffee plantations

Sl. No.	Treatment	Pre-treatment		Post treatment (15 DAA)		Reduction or increase in RD over pre-treatment (%)	Reduction or increase in RI over pre-treatment (%)
		RD (LBC/ha)	RTI	RD (LBC/ha)	RTI		
1	**Zn_3P_2 (2%) baiting**	19.14	39.50	9.02	10.20	52.87	74.16
2	**Bromadiolone (2%) baiting**	16.56	38.12	7.51	11.55	54.65	69.70
3	**Difenacoum cake**	20.45	40.23	9.72	10.75	52.47	73.27
4	**Bromadiolone cake**	21.68	38.17	11.58	11.34	46.59	70.29
5	**Flocoumafen cake**	17.85	34.08	7.73	8.44	56.69	75.22
6	**Snap trap @ 54 / ha with Sanitation**	18.25	37.33	6.12	6.75	66.47	81.90
7	**Untreated control**	19.55	39.33	21.23*	41.46*	08.59*	5.43*
Species composition: *Funambulus palmarum*, *Rattus rattus*, *Bandicota bengalensis* and *Mus booduga*.							

(*Increased over the pre-treatment)

- RD= Rodent density, LBC/ha = Live burrow counts / hectare.
- RTI = Rodent Trap Index = (((Number of rodents caught/Number of Traps Placed) x 12 / (Number of days traps are set)) X 7).

5. Efficacy of bait placement for rodent management in Areca plantation.

In Karnataka among the plantation crops Areca nut is the chief economic crop. According to Previous studies a damage per cent of 10-15 have been recorded due to rodent infestation and usually they damage the inflorescence, tender and ripened nuts. In the management of rodent's rodenticide application may fail due to neophobia, shyness, resistance and improper bait placement. In many instances rodents often spend the time on the crown of areca tree than on the ground. Hence an alteration in bait placement could enhance the efficacy of rodenticide. In the present studies the rodenticides were placed on the inflorescence to know its effectiveness in areca plantations. Out of seven plantations in three plantations treatments were placed on crown region of areca and three plantations were baited near the base of the plant and in burrows, while rest of the plantation was considered as the control where no baits were placed. The study was conducted for three years (2014-2016). The average RI (rodent infestation) and average per cent nut damage was recorded prior to treatment and 15 days after the treatment. The results indicated that (Table 3) with placement of poison baiting on the crown region resulted in overall reduction of RI and reduction in nut damage per cent by 83.62, and 93.50 per cent compared with 24.25 and 37.15 per cent when treatments were placed in burrow or base of the plant indicating that placement of treatment plays an important role in the management of rodents in Arecanut. However, among the treatments, all the three treatments i.e. baiting with Bromadiolone, Bromadiolone cake placement and baiting with Zn_3P_2 performed equally with reduction in RI of 85.77, 84.72 and 80.37 and reduction of nut damage was 93.85, 93.78 and 92.88 per cent, respectively (Table 3).

Table 3: Efficacy of bait placement for rodent management in areca plantation.

Sl No.	Treatment	Rodent Infestation (RI)		Reduction in (RI)	Mean Reduction in (RI)	Per cent nut damage		Reduction in nut damage (%)	Mean Reduction in nut damage (%)
		Pre-treatment	15 DAT			Pre-treatment	15 DAT		
Treatments in the crown region									
1	**Baiting with Zn_3P_2 (2%)**	15.90	3.10	80.37	83.62	1.65	0.13	92.88	93.50
2	**Bromadiolone cake placement**	16.77	2.57	84.72		1.68	0.11	93.78	
3	**Baiting with Bromadiolone**	15.72	2.26	85.77		1.59	0.10	93.85	
Treatment in burrows and base of the plant									
1	**Baiting with Zn_3P_2 (2%)**	15.04	12.25	18.51	24.45	1.82	1.17	36.54	37.15
2	**Bromadiolone cake placement**	14.04	10.06	28.37		1.85	1.16	38.40	
3	**Baiting with Bromadiolone**	15.04	12.96	26.48		1.94	1.24	36.52	
	Control	15.64	17.31*	10.64*		1.79	2.06*	11.14*	

(*Increased over the pre-treatment)

RI= ((Number of trees with fallen nut / Total number of trees) X100)

Nut damage per cent= ((Number of damage nuts / Total number of nuts) X RI)

6. Management of rodents in grape garden

Grape is one of the important horticultural crops of Karnataka. Which is grown for its fruit and wines preparation. It is grown in an area of 43,800 ha. with a production of 4,30,560 tonnes. Apart from many other pests, rodents are also causing considerable economic damage to grape fruits and drip irrigation system. To find out an effective management practices to control or to minimize rodent damage, a study was undertaken up at Srirampura village of Chikkaballapura district during the year 2012-13. Five plots of one hectare. Grape garden area was selected for present study and imposed the following different treatments i.e., i) Robon cake @ 1 pc/burrow, ii) Snap trap @ 1/30sq ft, iii) Poison baiting with 2% ZnP iv) Glue trap at 15ft distance only in border, v) Untreated check. Before imposing the treatment and after the treatment rodent density in terms of LBC per ha and percent damage (Table 4).

The observation made before and after impose of treatments on rodent density and per cent damage. Before impose of treatments the population density was ranging 25 to 32 per ha. and the predominant species was Bandicota bengalensis follow (73.68 LBC by Melardia meltada, Tatera indica and. Mus booduga. The per cent damage was 6.75 to 8.25. The observation made after 10 days of imposing the treatments. The per cent reduction in population and damage was registered maximum in poison baiting (73.68 LBC & 72.72% respectively) followed by snap trap (60.98 LBC & 60.00%) and least in glue trap (34.48 & 30%).

Table 4: Rodent management in grape garden

Sl No.	Treatment	Before treatment						After treatment						% reduction over pre treatment	
		Rodent density (LBC/ha)					Per cent damage	Rodent density (LBC/ha)					Per cent damage	Rodent density	Rodent damage
		B.b.	***Mme***	***T.i***	***Mb***	**Total**		***B.b***	***Mm***	***T.i***	***M.b***	**Total**			
1	Robon cake @ 1 pc/burrow	30.66	3.33	8.66	4.66	47.31	6.75	11.66	2.66	4.33	1.66	20.31	3.25	57.00	51.85
2	Snap trap @ 1/30sq ft	28.33	5.66	8.33	8.66	50.98	7.50	8.66	4.33	3.66	4.33	20.98	3.00	58.84	60.00
3	Poison baiting with 2% ZnP	31.66	8.33	9.66	8.33	57.98	8.25	7.66	2.33	2.66	2.33	14.98	2.25	74.16	72.72
4	Glue trap at 15ft distance only in border	25.33	4.66	12.33	7.66	49.98	7.25	20.33	2.66	8.33	3.66	34.98	4.75	30.00	34.48
5	Untreated check	23.33	3.66	7.66	6.33	40.98	6.25	25.33	3.66	8.33	5.33	42.65	6.50	-	-

7. Management of rodents by cultural / mechanical methods in cardamom

An experiment was taken up at Kumta, North Kanara to overcome the problems of rodents in cardamom. Then were 5 treatments (Table 5) with 4 replications. The observations were recorded on 30, 60, 90, and 110 days old panicles. From the observation it was found that rodents preferred (6.68%) 110 days old compound which a yellowish in color and fully matured. The young and fleshy capsules (1.61% incidence) of the five treatments over lapping of panicles + covering with thorny plant broaches and changing the position of brooches at 15 days interval recording significantly least damage if 2.87 per cent and 3.71 per cent at 90 and 110 days old panicles respectively, and which is on par with timely picking of capsules with 3.95 per cent and 2.87 per cent rodent damage at 90 and 110days old panicles, respectively. While, other treatments (over lapping of panicles and overlapping with covering of thorny bushes) were on per but superior over control.

Table 5: Management of rodents in cardamom by cultural / mechanical methods

Treatment	Capsule infestation by rodents (%)			
	30 DOP	60 DOP	90 DOP	110 DOP
1. Overlapping of panicle	2.10 (8.30)b	2.32 (8.74)b	5.82 (13.96)c	7.47 (8.74)b
2. Overlapping of panicles + covering with thorny plant branches	1.24 (6.38)a	1.44 (7.07)a	4.42 (12.09)b	5.97 (14.14)b
3. Overlapping of panicles + covering with thorny plant branches and changing position of Branches at 15 days interval.	1.04 (5.84)a	1.18 (6.37)a	2.87 (9.77)a	3.17 (10.26)a
4. Timely picking	-	-	2.87 (9.77)a	3.95 (11.46)a
5. Control	2.06 (8.24)b	4.82 (12.74)c	8.53 (16.96)d	12.82 (20.77)c
Mean	1.61	2.44	4.90	6.68
S.Em. -/+	0.24	0.44	0.44	0.87
CD (5 %)	0.74	1.36	1.35	2.67
CV(%)	19.86	20.00	17.32	18.67

Figures in parenthesis indicate angular transformed values, DOP=Days old panicle

8. **Operational trail on trunk banding technology for rodent management in coconut.**

Coconut is known to be vulnerable for rodents throughout the year. The rodents cause considerable damage by feeding on the tender nuts. The major species which attacks the coconut are *Rattus rattus, Funambulas palmarum* and *Bandicota bengalensis.* The non-burrowing species like *Rattus rattus and Funambulas palmarum* are usually climb on the trunk of coconut tree and establish their colony on the crown itself and other burrowing species v*iz…* *Bandicota bengalensis.* are responsible for causing damage in nursery and trees by opening burrows in root zones. Therefore, to overcome rodent problem it is better to cover trunk with slippery materials. Hence, an experiment was started up at Agricultural Research Station Arasikere to compare the efficiency of zinc sheets with polythene wrapper of thicker gauge against rodent damage and also about their longevity and cost: benefit ratio. The polythene wrappers and zinc sheets were wrapped, mechanically on 20 years old coconut trees in one-hectare area each. The observations on the number of trees affected/ha, number of tender nuts affected / ha was counted on day of wrapping the trunk (pre-count) and at an interval of 2, 4, 6, 12 & 18 months (Table 6). The initial data indicated that both polythene wrappers and zinc sheets were on par with respect to damage prevention by rodents compared to control. From the result it was found that both zinc sheets and polythene wrappers prevented rodent damage and performed better. The zinc sheets are relatively costly. The initial cost of wrapping polythene was only 2000/- per ha whereas cost of zinc sheets was 6000/- per ha, the cost benefit ratio was 1:3 (Table 7). At the end of 18 months the viability of polythene sheets was 42 per cent as against zinc sheet which is 100 per cent.

Table 6: Comparison of polyethylene wrappers v/s zinc sheets for the management of rodents in coconut.

Treatments	No. of plants affected/ha							No. of nuts affected/ha							Viability of trunk banding (%)	Initial cost/ha (Rs.)
	Pre count	Months After						Pre count	Months After							
		2	4	6	12	18	24		2	4	6	12	18	24		
Polythene wrapper	14	0	0	0	0	0	6	23	0	0	0	0	0	26	0	2000
Zinc sheets	15	0	0	0	0	0	0	24	0	0	0	0	0	0	100	6000
Control	13	14	17	16	21	24	28	21	24	29	28	184	286	302	-	-

Plate 18: Trunk banding technique in coconut plantation for rodent management

Table 7: Details of cost/materials for estimating C: B Ratio for polythene wrappers and zinc sheets for the management of rodents in coconut

No. of trees / ha	=	100
Zinc sheets required / tree	=	3 Sq. ft.
Zinc sheets required / ha	=	300 Sq. ft.
Cost of sheets required / ha	=	300 x 15 = Rs. 4500/- (@ 15 Sq. ft)
Instillation charge	=	Rs. 1500/-
Total cost	=	Rs. 6000/-
Polythene sheets required / tree	=	3. Sq.ft.
Polythene sheets required / ha	=	300 Sq.ft.
Cost of sheets required / ha	=	300 x 2.50 = Rs. 750/- (@ 2.50 Sq. ft)
Instillation charge	=	1250/-
Total cost	=	2000/-
Total amount gained due to treatments	=	551 x Rs. 5 = Rs. 2755

9. Rodent management in pepper plantations

An experimental was taken up at Mudgire, Chikkamagalur (district) in order to manage rodents with 6 treatments and 4 replications. The treatments included the Zinc phosphide (2%) baiting followed by Bromadiolone baiting, Bromadiolone baiting followed by Zinc phosphide baiting, placement of snap trap @ 54/ha, 2% Zinc phosphide baiting alone and Bromadiolone baiting alone.

Out of these treatments Snap trap @54/ha was found effective with 95.85 per cent incidence reduction (Table 8) [Zn_3P_2 followed by Bromodiolone baiting, Bromodiolone followed by Zn_3P_2 baiting, snap trap @ 54/ha, was followed by Zn_3P_2 bait (once), and Bromodiolone bait (once)] followed by Zn_3P_2 baiting followed by bromodiolone baiting and bromodiolone baiting followed by Zn_3P_2 baiting with a reduction of 94.66 and 90.73 per cent incidence over pretreatments. However, in control there was an increase of 54.98 per cent incidence.

Table 8: Rodent management in Pepper plantations

Sl. no	Treatments	Pre-count		After first application			After second application		
		LBC/ ha	Per cent incidence on berries	LBC/ha	Per cent incidence on berries	Per cent decrease in incidence over Pre-count	LBC /ha	Per cent incidence on berries	Per cent decrease in incidence over Pre-count
1	Zinc phosphide (2%) baiting followed by Bromodiolone bait	25.23	2.62	7.87	0.68	74.05	2.0	0.14	94.66
2	Bromodiolone bait followed by Zinc phosphide bait	31.56	3.13	6.15	0.65	79.23	3.0	0.29	90.73
3	Snap trap @ 54/ha	24.15	2.17	4.65	0.39	82.03	2.0	0.09	95.85
4	Zinc phosphide (2%) bait (once)	27.41	2.82	8.58	0.99	64.89	-	-	-
5	Bromodiolone bait	34.54	2.33	5.01	0.44	81.12	-	-	-
6	Control	28.41	2.71	31.06	2.89	+6.64	34.0	4.20	+54.98

10. Rodent management in carnation ornamental plants in Poly House conditions.

The management of rodents in poly house agriculture (carnation ornamental plants at flowering stage) was conducted at Bettadabyrapura in Doddaballapura Talluk of Bangalore rural district during the year 2010-11. The experiment conducted with the following treatment i) Burrow fumigation with chili powder 20g / burrow, ii) Bromodiolone, Roban cake application 1 pc. / burrow, iii) Poison baiting with Zinc phosphate followed by Bromodiolone, iv) Snap trap @ 1/30sq ft, v) Live trap @ 1/30sq ft , vi) Untreated check.

The observation was made before and after imposing of treatments on different species, of rodent density and percent damage. The population density was made before treatment on the basis of live burrow count and damage in percentage. The major species was *Bandicota bengalensis* followed by *Mus booduga and Tatera indica.* The percent damage was ranging from 7.8 to 8.92.

Further the observation made after 10 days of imposing the treatments the highest per cent reduction is population density and damage was registered in poison baiting and snap trap treatments followed robon cake, burrow fumigation and live trap (Table-9).

Table 9. Rodent management in carnation ornamental plants in Poly House conditions

Sl No.	Methods	Before treatment					After treatment					% reduction over pre treatment	
		Rodent density (ha)				Per cent damage	Rodent density (LBC/ha)				Per cent damage	Damage control	Rodent density
		B.b	***M.b***	***T.i***	**Total**		***B.b***	***M.b***	***T.i***	**Total**			
1.	Burrow fumigation with chilli powder @ 20g/burrow	15	8	3	26	8.5	4	8	1	13	2.52	70.35	50.00
2.	Robon cake @ 1 pc/burrow	12	2	2	16	7.8	3	1	1	5	2.35	69.82	68.75
3.	Poison baiting with Znp @ 2% followed by Bromodiolone	11	4	6	18	8.75	3	1	1	5	2.15	75.43	72.22
4.	Snap trap @ 1/30sq ft	9	2	2	13	7.98	3	-	1	4	1.75	78.07	69.23
5.	Live trap @ 1/30sq ft	8	3	1	22	8.92	8	1	-	9	3.25	36.56	59.09
6.	Untreated check	15	2	4	21	8.52	16	2	4	22	8.75	-	-

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