STUDIES ON SNAIL, *Cryptozona semirugata* (Beck.) ON MAJOR FIELD CROPS

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INTRODUCTION

Greengram (*Vigna radiata* (L.) Wilczek 2n=22) is the ancient and well known leguminous crop of Asia, belonging to Leguminacea family. The Greengram is one of the thirteen food legumes grown in India and third most important pulse crop of India after chickpea and pigeonpea. Greengram has many common names, *viz.,* mung, moong, mungo, mungbean, goldengram, chickasawpea and oreganpea. In India, the name greengram is more commonly used than mungbean (Chatterjee and Randhawa, 1952). The mungbean is native of India-Burma region of Southeast Asia. It is cultivated extensively in India, Burma and Thailand region of Asia.

India is the largest producer and consumer of pulses in the world accounting for 33 per cent of world area and 22 per cent of world production. At present, in India, mungbean is grown in 34.4 lakh per ha, with a 14 lakh tonnes production with a productivity of 406.98 kg/ha (Anonymous, 2012). In Karnataka, greengram is cultivated in 2.86 lakh/ha, with a total production of 67,426 tonnes. The average productivity is 566 kg per ha (Saraswati *et al*., 2012), which is almost half of the national productivity, thereby indicating that there is wider scope to improve the production potential.

An estimated 200 insect pests that belong to 48 families in Coleoptera, Diptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Orthoptera, Thysanoptera and 7 mites of the order Acarina are known to infest greengram and blackgram (www.intechopen.com). Among rodents, Desert gerbils, *Meriones hurrianae* is a predominant rodent pest of pulses and oilseeds in western Rajasthan and Indian field mouse, *Mus booduga* (Gray) is number two rodent pest in rice and pulses (Navarajan Paul, 2007). Among non insect pests, Snail, *Cryptozona semirugata* (Beck.) has gained major importance on field crops in recent days in transitional belt of northern Karnataka (Giraddi *et al*., 1996).

Molluscs are the second largest invertebrate group in abundance next only to insects (Bouchet, 1992). Land snails constitute about six per cent of the total species on earth (Clark and May, 2002). Globally, nearly 35,000 species of land snails have been described and there may be 30,000 to 60,000 additional species yet to be described (Lydeard *et al*., 2004). They form an important component of the forest ecosystem by recycling nutrients (Graveland *et al*., 1994; Dunk *et al*., 2004) and are the prey base for a number of small mammals, birds, reptiles, amphibians and other invertebrates, including carnivorous snails (Deepak *et al*., 2010).

The distribution and activity of land snails depends on several factors including precipitation, soil pH, soil Ca content, canopy density, *etc.* Calcium availability in the soil is a major limiting factor for their survival as it is required for their shell formation. Several studies have shown that Ca is positively correlated with species richness and density (Burch, 1955; Hotopp, 2002; Aravind, 2005).

Early studies on land snails in India

Indian malacology was pioneered by William Henry Benson (1803–1870), who contributed significantly to our knowledge on Indian land snails in the mid 19th century (Naggs, 1997). The Blanford bothers-William and Henry, Theobald, Pfeiffer, Gude, Godwin-Austen and Beddome, led Indian land snail research until the early 20th century, but Gude and Pfeiffer's research was based entirely on museum material as neither visited India. These malacological pioneers laid the foundation of our knowledge on the taxonomy and distribution of Indian land snails. Following this period of intensive study, there was a drastic decline in studies on Indian land snails .The different snail species recorded from India is tabulated in table 1.

Snail, *Cryptozona semirugata* belongs to the Kingdom: Animalia, phylum: Mollusca, class : Gastropoda, Order : Stylommatophora, Super family: Helicarionoidea and Family : Ariophantidae (Godwin and Austen,1888). Distribution of Ariophantidae include India and south-eastern Asia (Hausdorf, 2000). In this family, the number of haploid chromosomes lies between 21 and 25 and also lies between 31 and 35, but other values are also possible (Barker, 2001).

Their body is asymmetrical, spirally coiled and enclosed in a shell. Snails are legless creatures that glide along on a path of mucus. This mucus dries out and can be seen in the day time as a shiny trail over leaves, fruits and soil. When trails and damage are observed, the snails can often be found on the ground near the injured plants, hiding under decaying plant debris, stones, clods of soil, or logs.

Snails appear as sporadic pests and feed at night in damp places and destroy young shoots and roots of various plants (Balikai, 1999). In Northern dry zone of Karnataka where the annual

Table 1: Different snail species recorded from India

Snail species	Family	Place	Reference
Ariophanta solata	Arionphantidae	Karnataka	Bhat *et al.* (1973)
Indoplanorbis exustus (Deshayes) *Planorbis exustus* Deshayes *Planorbis indicus* Benson	Planorbidae	Bangalore	Subba Rao and Mitra (1979)
Lymnaea lutekola f. succinea (Deshayes) *Limnaea succinea* Deshayes	Lymnaeidae	Assam, Barpeta, Godavari, Jammu and Kashmir, Nilgiris, Palany hills, Tamil Nadu, Uttar Pradesh and West Bengal	Subba Rao and Mitra (1979)
Helix ceylonica Pteiffer *Helix taprobanenis* Dohrn	Arionphantidae	Bombay, south of Narabudda ranging east to Nagpur Western ghats	Subba Rao and Mitra (1979)
Rachis puntatus (Anton) *Bulimus punctatus* Anton *Bulimus solatus* Benson *Rachisellus punctata* Kobalt	Enidae	Maharashtra, Orissa, Tamil Nadu and Uttar Pradesh	Subba Rao and Mitra (1979)
Opeas gracile (Hutton) *Spiraxis gracilis* Blanford *Bulimus indicus* Pfeiffer	Subulinidae	Assam, Bombay, Kashmir, Madras, Poona, Andaman and Nicobar	Subba Rao and Mitra (1979)
Indoplanorbis exustus (Deshayes)	Planorbidae	Bangalore, Karnataka	Subramanya (1983)
Lymnea luteola f. Succinea (Deshayes)	Lymnaeidae		
Ariophanta bistrialis (Beck)	Ariophantidae	Bangalore, Karnataka	Subramanya (1983)
Ariophanta belangeri (D)	Ariophantidae		
Rachis punctatus (Anton)	Enidae		
Glessula dikrangense (G.A)	Glessulidae		
Opeas gracile (Hutton)	Subulinidae		
Cryptozona semirugata (Beck)	Lymnaeidae	Bijapur, Karanataka	Balikai (1999)
Ariophanta sp.	Ariophantidae	Trichur, Ernaculum, Alappuzha and Kottayam of Kerala	Sajitha Kumari and Lyla (2001)

rainfall is less, the snails usually do not out number. Only during exceptional years like 1998 when the rainfall was exceptionally high, their number increase and became real menace to crop plants as they fed voraciously (Balikai, 2008).

Snails frequently inhabit cultivated land and they cause considerable damage to young plants and roots (Efferson, 1968, Fenwick, 1970 and shiff *et al.,* 1973). They make their damp area surrounded by pastures, untrimmed field bunds /over grown slopes. These areas remain moist, afford shelter and provide optimum conditions necessary for increase in number. From here they move on to neighbouring fields at dusk time and return at dawn (Giraddi *et al*., 1996). The heavy incidence of snail, *C. semirugata* on some horticultural crops (4.3 to 95.3%damage) was recorded during September to October, 1998 (Balikai, 2008). The information on the destructive potential of this pest and its management in different field crops is very scanty.

Reddy and Puttaswamy (1984) reported *C. semirugata* on chilli seedlings in the nursery as a pest of occasional importance. Outbreak of snail, *C. semirugata,*at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad during the *Kharif* season of 1993 on various crop seedlings specially on chillies, sunflower, bhendi and cotton was reported (Giraddi *et al*., 1996). The nature of damage caused by this pest was diverse. Small leaves of various plants were completely devoured, while larger leaves were eaten from around the edges. Further in case of marigold, potato and tomato, small branches were cut and found hanging from the plant in addition to their feeding on the leaves. In the recent years the snail (*C. semirugata*) incidence on greengram is on the increase and regularly seen in districts of North Karnataka *viz*., Dharwad, Gadag, Haveri and Belagavi.

Eventhough the snail posses a serious threat to greengram cultivation, comprehensive studies on the snails are lacking. In the absence of detailed information on the pest, to evolve sound and effective management strategies become difficult. Therefore, the present investigation was undertaken with the following objectives :

1) Survey on the population density and extent of damage due to the snail in different crops.
2) Influence of different levels of *Cryptozona semirugata* infestation on plant damage and leaf area consumption in greengram
3) Management of *Cryptozona semirugata* in greengram

REVIEW OF LITERATURE

Attempts have been made to collect literature on various related aspects of the snail, *Cryptozona semirugata* (Beck.) pertaining to the studies undertaken on survey, influence of different levels of *C. semirugata* infestation on plant damage and leaf area consumption in greengram and its management. However, as the available literature on *C. semirugata* is limited, the information on other pest species of snails have also been collected and included in this chapter.

2.1 Survey on the population density and extent of damage by snails in different crops

Bishara *et al.* (1968) found that *Euparypha pisana* (Muller), *Theba pisana* (Muller), *Eobania vermiculata* (Muller), *Rumina decolata* (Linnaeus), *Helicella vestalis* (Pfeiffer) and *Cochlicella acuta* (Muller) were common species of snails in field and orchards of the northern Delta Nile in Egypt.

The population of *Monacha obstructa* (Pfeiffer) in Egyptian clover field, began to increase gradually from the end of March to the middle of April, whenever the suitable temperature and humidity were found (Kady *et al*., 1983).

Subramanya (1983) reported seven species of snails distributed in different parts of Bangalore, they are *Indoplanobia exustus* (Deshayes), *Lymnea luteola f. succinea* (Deshayes), *Ariophanta bistrialis* (Beck), *Ariophanta belangeri* (Deshayes), *Rachia punctatus* (Anton), *Glessula dikrangense* (Godwin-Austen) and *Opeas gracile* (Hutton). Among these, three species are found to be pests *viz*., *O. gracile*, *A. belangeri* and *L.luteola.*

Dutta *et al*. (1984) found that, the faeces of the snail, *C.* s*emirugata* in black pepper garden contained oospores of *Phytophthora palmivora.* El–Okda (1984) stated that *Monacha* sp. and *Oxychilus* sp. were found in Ismaellia Governorate on the Egyptian clover (*Trifolium alexandrium* L.), mango orchards, citrus and ornamental nurseries, in addition to wheat fields. He added that beans, watermelon, maize and tomato were attacked by land snails. Survey conducted by Raut and Ghose (1984) revealed that *Achatina fulica* (Bowdich) from Bijnor, Dhampur and Moradabad, the average population recorded were 19.22, 27.32 and 34.40/m^2, respectively.

Reddy and Puttaswamy (1984) recorded *C. semirugata* as occasional pest on chilli crop.They observed the pest to nibble the leaves of newly formed seedlings and also make burrows in seed beds. Gupta and Doharey (1985) noticed that, the snails were generally active during the rainy season from dusk to dawn. Their activity was maximum from 12 midnight to one am. The seasonal variation of population at Port Blair indicated that snail population recorded in a 25 m^2 plot was maximum during August (153.50/week) and September (121.25/week), and it was minimum during January (14.00/week), February (3.00/week) and March (1.00/week) and nil during April months.

Reddy (1985) reported the soil arthropod pests of chilli from Dharwad during 1980 and 1981. In this, one species of gastropoda was recorded. Investigations of Dutta and Hegde (1987) showed that the snail *C. semirugata* from *Piper nigrum* and *Areca catechu* were highly pathogenic and identified as *P. palmivora* MF4 and *P. meadii*, respectively. Kakoty and Das (1987) reported the snail *A. fulica*, which occurs frequently on tea estates in India and is a potential pest of the tea crop, is described briefly.

The snail, *Cryptozona belangiri* (Deshayes) was reported feeding on chilli in Maharashtra during July 1981. Other slugs and snail pests recorded periodically in India are listed (Patil *et al.,* 1987). Kumari *et al*. (1988) observed that the snail *C. Semirugata* is probably a potent vector of *Phytophthora spp*. in the plantations of South India since the digestive juices have an enhancing effect on oospore germination.

Jagtap *et al*. (1990) worked out the biology of the snail *C. belangiri*, which has become a pest of groundnut in recent days in Maharashtra, India. Wen (1990) accounted the population of *Bradybaena similaris* (Ferrusac) increased during the rainy season (May- September) and decreased during the dry season (October to April) on spongegourd in Taiwan.

Santha kumar and Hegde (1991) noticed that the common garden snail observed in the *Areca catechu* and pepper plantations of Karnataka was *C. semirugata*. Hashem *et al*. (1992) noticed the population fluctuation of the land snails, *T. pisana*, *H. vestalis* and *C. acuta* in citrus orchards. Jagtap *et al.* (1992) reported the total active period of *C. belangiri* varied from 50 to 79 days; snails remained inactive from October to May. The total lifespan of *C. belangiri* ranged between 3 and 5 years.

Srivastava (1992) noticed that the damage to crops by *A. fulica* in Orissa was reported as early as in 1955 and the snail is reported from Anandapur, Baliapal, Balasore and Baripada, the average population being 22.32, 25, 27 and 32/m^2, respectively.

Tillier *et al.* (1993) reported the snail, *A. fulica* is native to East Africa and is now established in American Samoa, Federated States of Micronesia, French Polynesia, Guam, New Caledonia, Northern Marianas, Palau, Papua New Guinea, Vanuatu and Wallis and Futuna. A survey conducted by Ho wai Hoong (1995) revealed that, the largest family of land snails found in Singapore was the Ariophantidae, which comprised eight species. Twelve species of land snails were recorded for the first time in Singapore, bringing the total number of land snails recorded in Singapore to 34 species *viz*., *A. fulica*, *Allopeas clavulinum* (Potiez & Michaud), *Allopeas gracile* (Hutton), *Amphidromus atricallosus perakensis* (Fulton), *Amphidromus inversus* (Müller), *Amphidromus perversus melanomma* (Pfeiffer), *Bradybaena similaris* (Férussac), *Cyclophorus perdix aquila* (Sowerby), *Cyclophorus perdix perdix* (Broderip & Sowerby), *Cyclophorus semisulcatus* (Sowerby), *Diplommatina nevilli* (Crosse), *Ditropopsis koperbergi* (Zilch), *Helicarion perfragilis* (von Moellendorff), *Hemiplecta cymatium* (Pfeiffer), *Hemiplecta humphreysiana* (Lea), *Huttonella bicolor* (Hutton), *Laevicaulis alte* (Férussac), *Lagochilus ciliocinctum* (von Martens), *Liardetia convexoconica* (von Moellendorff), *Liardetia doliolum* (Pfeiffer), *Liardetia indifferens* (Boettger), *Liardetia samoensis* (Mousson), *Mariaella dussumieri* (Gray), *Microparmarion strubelli* (Simroth), *Opeas didyma* (Westerlund), *Opeas pumilus* (Pfeiffer), *Opisthoporus rostellatus* (Pfeiffer), *Parmarion martensi* (Simroth), *Parmarion pupillaris* (Humbert),*Quantula striata* (Gray), *Sarika resplendens* (Philippi), *Semperula maculata* (Templeton), *Subulina octona* (Bruguiere), *Wilhelminaia gratilla* (van Benthem Jutting)

El–Deeb *et al*. (1996) and (2003) surveyed different terrestrial snails on the field crops, vegetables, ornamental plants and in orchards at Kafr El–Shekh and Dakahlia Governorate, Egypt. The results showed that *Succinia putris* (Linnaeus), *E. vermiculata, C. acuta* and *Cepaea nemoralis* (Linnaeus) were commonly recorded on different host plants at Dakahlia Governorate and Kafr El–Shekh.

Sheela Thakur and Rina kumari (1998) from Bihar reported that infestation of *A. fulica* commenced with the onset of monsoon rains and remained active throughout rainy season and started declining gradually from middle of November. Further, the maximum population of Giant African Snail prevailed during August and September (28 to 28.15 per week/54m^2) and minimum during February (2.25 per week/54m^2) and practically nil in January.

The incidence of *C. semirugata* from Bijapur, Karnataka was recorded by Balikai (1999) during September and October in 1998 and the results revealed that the highest number of snails per plant was recorded on *Luffa acutangula* (L.) (8.9) and *Solanum melongena* L. (7.8). *C. semirugata* displayed a host preference for *Beta vulgaris var. bengalensis*, *S. melongena, Trigonella foenum-graecum*, L. *acutangula*, tomatoes, chillies and *Tagetes erecta* L., in comparison with *Clerodendron inerme* L. and *Hibiscus rosa-sinensis* L.

A study conducted by Basavaraju *et al.* (2000) to determine the population density of *A. fulica* on betelvine in 5 villages in Karnataka, India during the *kharif* , 1999 revealed 20-24, 17-21, 11-17, 7-15 and 9-14 snails per vine in Hanagavadi, Belludi, Araganahalli, Nagenahalli and Ramathirtha, respectively. A survey conducted by Tehsin and Sharma (2000) reported that, a few specimens of *A. fulica* were collected in the Panchawati area, Rajasthan, India, on 17 July 1996, which is a voracious feeder and multiplies quickly.

Food preference and consumption of certain vegetable plants and field crops for three land snails: *Monacha cantiana* (Montagu), *S. putris* and *T. pisana* was studied by El- Deeb *et al*. (2001). Results showed that Egyptian clover was the most preferred crop for *M. contiana* followed by lettuce, cucumber, carrot, cabbage and squash, while carrot were the most preferable for *S. putris* followed by Egyptian clover, lettuce, cabbage, cucumber and squash. On the other hand, the lettuce was the most preferable for *T. pisana* followed by cabbage, carrot, cucumber, clover and squash.

A survey conducted by Sajitha-kumari and Lyla (2001) on the pests of orchids in Trichur, Ernakulam, Alappuzha and Kottayam districts of Kerala, India reavealed the different insect pests including non-insect pest, land snail (*Ariophanta sp.*).

Metwally *et al*. (2002) registered six species of terrestrial mollusca belonging to families Helicidae and limacidae on different crops at 23 localities representing 10 districts at Monofia and Gharbia Governorate. These species were *Monacha cartusiana* (Muller), *E. vermiculata* (the Brown

garden snail), *C. acuta* (the conical snail). *M. cartusiana* snail have the upper hand on snail incidence compared to other species.

Achatina fulica prefers to feed on plants in the seedling or nursery stage. Damage by *A. fulica* to the seedling stage can be so severe that farmers change crop species grown. In more mature plants, the type of damage can vary depending on the plant species. Symptoms can range from defoliation to damage of stems, fruits or flowers (Raut and Barker, 2002).

Thirty species of molluscs were found at Cenwanglaoshan Nature Reserve and the surrounding area. Of these, three species belong to the genera *Platyrhaphe, Ptychopoma and Kaliella*. The most abundant species included the snail *O. gracilis*. Several new provincial records were made: *Platyrhaphe hunana* (Gredler), *Chalepotaxis infantilis* (Gredler)*, Girasia hainanensis* (Yen), *O. gracilis*, *Tortaxis mandarinus* (Pfeiffer) *and Euphaedusa aculus* (Benson). Many forest species were present at Cenwanglaoshan, including several indicators of high-integrity forests such as *Chamalycaeus plicilabris* (Moellendorff), *Cryptozona menglunensis* Chen Deniu*, Kaliella pyramidata* (Yen) and *Macrochlamys spiriplana* (Godwin-Austen) (Kadoorie Farm and Botanic Garden, 2003).

According to survey conducted by Sheela Thakur (2003) in three locations of diverse agro climatic conditions in and around Pusa, Bihar, the population of *A. fulica* was maximum during rainy season where population density reached its peak during third week of September (38th Standard Week) at all the locations having an average temperature, relative humidity and rainfall of 29.79^{0}C, 86 per cent and 41.40 mm, respectively. Thereafter population showed a decreasing trend and reached to the lowest density during the third week of December (51st SW) at an average temperature of 21.3^{0}C and relative humidity of 67 per cent. It appeared that an optimum condition of good summer rainfall and increased relative humidity provided favourable environment for the pest.

Achatina fulica is considered a significant pest of agricultural crops. If introduced into the United States, this species may have a high economic impact because of crop damage and the costs of control and survey measures (Venette and Larson, 2004). Rajendra *et al.* (2005) reported land snails of Kodagu district, Karnataka, India. A total of 439 individuals belonging to 9 families, 28 genera and 50 species were collected. *Mariaella dussumieri* is a serious pest causing damage to economically important plantation crops. All the species described are endemic to Western Ghats and Sri Lanka hill ranges.

Javaregowda (2006) studied the seasonal incidence of *A. fulica* in Davanagere and Haveri districts in Betel vine ecosystem. The peak activity of the snail was observed between October and January. Lokma (2007) recorded the lowest number of active snails *H. vestalis* in summer, while the highest one was recorded in spring. Ravikumara *et al*. (2007) reported that, the population of *A. fulica* in arecanut garden occurred throughout the year ranging from 1.00 to 91.25 snails per 10 sq.m.in Shimoga. The highest population (91.25 snails) was observed during second fortnight of September, 2004. The lowest population (1.00 snail) was recorded during first fortnight of February, 2005. *A. fulica* population had highly significant negative correlation with the maximum temperature. During second fortnight of September, 2004 the maximum temperature was only 31.66^{0} C with the highest snail population. Later on population decreased with the increasing maximum temperature. The *A. fulica* showed a highly significant positive correlation with the relative humidity. The highest snail population (91.25 snails) was observed at the optimum RH of 68.3 per cent. With the increasing relative humidity of 85.66 and 81.75 per cent, population was 70.25 and 75.25 snails per 10 m^{2} area, respectively.

Balikai (2008) reported the highest population of snail *C. semirugata*, 257.2 snails/100 sq m during 1998 when second highest rainfall of 1006 mm was recorded in Bijapur, Karnataka.

The main activity season collapsed from February to November for *T. pisana* and *C. acuta*. He added that the land snail, *H. vestalis* proved to be the most abundant species reaching the peak during March to June (Shoieb, 2008). Balikai (2009) recorded a total of 22 insects and non insect pests feeding on ber from extensive ber growing districts of Karnataka, wherein *C. semirugata* was recorded as moderate pest. Survey conducted by Srihata *et al.* (2010) revealed that, the land snails were collected from a square kilometer on Phu No, Kalasin province from thirty-six, 20 × 20 m plots during the rainy season from 31st August to 6th September 2009. In total, 5,607 individuals were found, belonging to 15 species. The most abundant species was *Cryptozona siamensis*; 2,235 individuals (39.86%) were collected.

Balikai *et al*. (2011) reported *C. semirugata* feeding on pomegranate crop in India.

Investigations were made by Vanitha *et al.* (2011) from April 2004 to March 2005 in Coimbatore and Theni districts of Tamil Nadu to record the pest status of vanilla and their natural enemies. Among all, seven gastropods were recorded as pest of vanilla. Among the pests, white grubs and Giant African Snail were found to cause considerable damage to vanilla plants.

Several species of snails are troublesome throughout Ontario in field crops, home gardens, floricultural plantings and greenhouses. The banded wood snail, *Cepaea nemoralis* (Linnaeus), is the most common species of snail (Www. Uoguelph. Ca/Pdc 2003).

2.2 Influence of different levels of *Cryptozona semirugata* infestation on plant damage and leaf area consumption in greengram

Since the literature on the different levels of *Cryptozona semirugata* infestation on plant damage and leaf area consumption in greengram is totally lacking, the related literature is reviewed and presented here.

Tirumala-Rao (1953) reported the nature and extent of snail damage to rice plants in the Northern Circars region of Madras State, India. The snails commonly found in this district are *Viriparus variatus*, *Pila vareus* and *Indoplanorbis exustus* (Deshayes). Snails do most damage to newly transplanted rice in fields which are too low-lying to be properly drained. The stems of the damaged transplants are usually severed by the snails 3-4 inches above their base, below water level. In this way, 10-50 per cent of the transplants may be destroyed.

El-Okda (1980) mentioned that the land mollusca attacked raw succulent vegetables and preferred soggy parts. These pests attacked seeds, seedlings, roots and tuber crops. Then more succulent raw leaf vegetables, fruits and buds were extra ordinarily attacked in addition to flower damage when land mollusca become abundant. These land molluscans also leave unpleasant slimy tracks on the injured parts.

Devaiah *et al.* (1983) noticed that the single snail *C. semirugata* on an average fed 15.57 sq.cm of leaf in a day and the leaves were fed both from margin and centre. The damaged leaves show irregularly cut holes along with black excreta on them on mulberry. Litsinger and Estano (1993) reported that the snail, *Pomacea canaliculata* (Lamarck) is a recently introduced rice pest in Asia. In field experiments in the Philippines, the planting method greatly influenced the period of susceptibility to damage by *P. canaliculata*: wet bed-transplanted 20-day-old seedlings were less damaged than dapog-transplanted 13-day-old seedlings or direct-seeded rice. Seedlings not more than 30 days old were more tolerant of damage than younger seedlings.

Sharma and Agarwal (1989) reported that the Giant African snail as a serious pest on many fruits and vegetable crops, namely banana, beans, brinjal, cabbage, cauliflower, chilli, coconut, coffee, all cucurbits, garlic, knol- khol, okra, lettuce, onion, papaya, tomato and other food crops like maize, paddy, sorghum and sugarcane. Small plants and seedlings were completely eaten by this pest.

A field study conducted by Giraddi *et al.* (1996) at Dharwad, Karnataka, revealed that 30.6, 27.4, 25.4, 10.5, 20.7 and 4.3 per cent of chilli [Capsicum], sunflower, bhendi, soybean, cotton and groundnut seedlings were damaged by *C. semirugata*.

Hanley *et al.* (1996) conducted two experiments in spring and autumn 1992 and examined the effect of mollusc herbivory and gap size on seedling survivorship for four common grassland species *viz*., *Plantago lanceolata* (L.), *Ranunculus acris* (L.), *Senecio jacobaea*(L.) and *Taraxacum officinale* (Wigg) sown into artificially created gaps in plots in a grassland sward. The intensity of mollusc grazing was greatest in autumn, although mollusc grazing in the spring experiment also reduced seedling survival. A close relationship between seedling identity, season and survivorship was found. All four species were adversely affected by the presence of molluscs, although *S. jacobaea* populations were only affected in the spring and *P. lanceolata* in the autumn. While gap size significantly influenced seedling survivorship, this factor had no effect upon mollusc herbivory.

The incidence of *C. semirugata* from Bijapur, Karnataka recorded by Balikai (1999) during September and October in 1998 revealed that the nature of damage caused by *C. semirugata* was diverse. The maximum number of plants were damaged in palak (95.3%), brinjal (90.25%), methi (90.1%) ridgegourd (82.3%) and chillies (80.2%). Percentage leaf area consumption was greatest in *Beta vulgaris* var*. bengalensis* (90.3%) and *Solanum melongena* (85.2%).

Lauenstein (1998), found that the wet conditions resulted in to many problems with snails in

northern Germany. Damage to seeds resulted in low emergence rates. A field survey was carried out in *Ziziphus mauritiana* crops between 1996 and 1998 in Karnataka, India. A total of 22 pests were identified. Of these, *Maconellicoccus hirsutus* (Green), *Perissopneumon tamarindus* (Rao)*, Aubeus himalayanus* (Voss), *Achaea janata* (Linnaeus) *and C. semirugata* were moderate pests, with 31-50 per cent infestation levels (Balikai, 1999). Ordosgoitit (1999) reported the populations of *Orthalicus maracaibensis* (Pfeiffer) were found in field conditions, in Yumare, Yaracuy State, Venezuela, causing serious damages on stems and branches of sweet orange (*Citrus sinensis* L.osbeck) and Tahiti lime (*Citrus latifolia* Tanaka) trees in 1997. Snail damage caused partial necrosis or complete death of infested plants.

A study was conducted by Basavaraju *et al.* (2000) to determine the extent of damage done by *A. fulica* on betelvine in five villages in Karnataka, India during the *kharif* season of 1999. They recorded 60-64, 55-58, 45-50, 40-45 and 38-40 per cent damage from Hanagavadi, Belludi, Araganahalli, Nagenahalli and Ramathirtha, respectively. Sudjono *et al*. (2000) studied the loss of rice due to snail, *P. canaliculata* under field condition, with 12 snails/m^2 causing 10.78 per cent damage and yield reduction of about 15 per cent, in Indonesia. As stated by Barwal and Dhiman (2002) the marigold cultivars recorded the highest percentage of snail-damaged plants, *i.e.* 41.87, 42.77 and 31.77 per cent for Katrain dwarf, Pusa Basanti and Yellow Giant, respectively.

Sanico *et al.* (2002) reported the rice seedlings are often destroyed by golden apple snail (*P. canaliculata*) after transplanting. Two field experiments were conducted to determine the effects of seedling age and seedling number per hill on snail damage, plant growth and grain yield. The first experiment was unsprayed (snail-infested experiment) while the second experiment was sprayed with molluscicide to control snails (snail-free experiment). Increasing seedling age from 2 to 5 weeks resulted in significant reductions in snail damage in terms of missing hills. Increasing seedling number per hill from 1 to 8, 6, 4 and 2 for 2, 3, 4 and 5 week-old seedlings, respectively, also reduced snail damage significantly. In the snail-free experiment, grain yield was not affected significantly when seedling age was increased from 2 to 5 weeks. Increasing seedling number per hill decreased or increased grain yield depending on the season and seedling age. In general, transplanting 4–5 week-old seedlings at one seedling per hill or increasing the number seedlings per hill reduced snail damage in terms of missing hills and minimized yield losses from the snail damage.

Teo (2002) noticed plant damage of 77.77 per cent after one week of transplanting of rice seedlings due to *P. canaliculata.* Yang-Ping Shih *et al.* (2006) revealed that, in the 26 years since from the introduction of the golden apple snail into Taiwan from South America by overseas Chinese from Argentina, the seemingly unstoppable *P. canaliculata* has ravaged the natural ecology of the island and has created huge losses in local agricultural production. The estimated results show that the annual impact of its control and management is $US 175.6 million.

Sunitha (2007) recorded 20 per cent damage to *Capsicum annuum* var *frutescens* due to snail infestation in nursery at Dharwad. Basavaraju *et al*. (2010) reported 8-15 per cent infestation of *A. fulica* on biofuel nursery plants, vegetable crops, garden plants and areca garden. Noor *et al.* (2012) observed that the *P. canaliculata* is widely regarded as worst invasive pest species. It destroyed the young stems and leaves of paddy and consumed 7-24 rice seedlings per day; thus, resulting in extreme damage to the rice growing area.

Giant african snail is a major agricultural pest, feeding on a variety of crops causing significant economic losses. In the US state of Florida it has been estimated that GAS would have caused an annual loss of $US 11 million in 1969 if its population had not been controlled. In India it attained serious pest status, particularly in 1946/47, when it appeared in epidemic proportions in Orissa and caused severe damage to vegetable crops and rice. Plants most likely damaged by the snail are garden flowers and ornamentals, vegetables (especially Cruciferae, Cucurbitaceae and Leguminosae) and immature specimens of breadfruit, cassava and teakwood (www.infonet-biovision.org)

2.3 Management of *Cryptozona semirugata* in greengram

Since the literature on the management of *C. semirugata* on greengram is totally lacking, the related literature is reviewed and presented here.

The ashes or suitable substitutes like saw dust, charcoal, cinders, *etc.*, have been recommended as repellent barrier by many workers. Most often it is suggested that they can be used in combination with copper sulphate. The continued use of ashes may change the soil pH towards alkaline condition (Green, 1911; Hutson, 1920).

Lovett and Black (1920) reported that the soap solution has proved to be only moderately promising in controlling slugs. Beeley (1938) recommended fairly strong bait consisting of one part of calcium arsenate, six parts of slaked lime and two parts of cement by volume with sufficient water to form the consistency of an ordinary concrete mix. This was dried on thin slab, broken in to small pieces and scattered in the areas infested with *A. fulica*. Their attraction for the snails lies in the lime they contain.

Basinger (1940) reported the European brown snail, *E. vermiculata* which often becomes a pest in Californian orange groves by ascending the trees and damaging the young fruits can be controlled by hand broadcasting a poison bait into the tree, on the limbs and on the ground round the tree. To control snails in citrus trees the spray commonly used for brown mottle-leaf of citrus is 2 1/2.lb. zinc sulfate, 1 lb. copper sulfate, 2 lb. hydrated lime, 100 gall water is applied during damp weather, before July if possible. Pangga (1949) combined lime with sulphur and tested it on *A. fulica,* but it proved toxic only to immature stages.

Mariconi (1955) noticed the snails in some parts of Brazil as a serious pest of coffee, stripping the leaves and bark during the night. They can be controlled by spraying the trees with an emulsion consisting of 250 c.c. linseed oil, 250 c.c. skimmed milk and 750 g. metaldehyde in 100 1. water. A single spray is generally sufficient for the season and it should be applied after the first 2 or 3 rains of summer. Peterson (1957) opined that commercial bait in the form of pellet prepared by mixing bran, 1.6 per cent metaldehyde and 5 per cent calcium arsenate which proved to be effective. However pellets degraded soon during the rainy season. Further, snails get paralyzed in 10-15 minutes and die in half to one hour after feeding. Pappas and Carman (1961) opined that metaldehyde at higher dosages, was effective against European brown snail (*H. aspersa*) on lemons, but only partially effective against the snail on Valencia oranges.

Torres (1961) noticed the control with a semi-liquid bait containing metaldehyde. Mariconi (1962) recorded the control of snail in coffee bush by spraying with a mixture of metaldehyde, linseed oil, skimmed milk and water. Ramakrishnan and Pillay (1962) reported a bait of metaldehyde for use in hevea (rubber), rice bran slaked lime and cement in the proportions 1:2:6:6 is recommended. Calcium arsenate baits are less effective. Metaldehyde may also be used as a spray.

Rao (1963) opined that, broadcasting metaldehyde eradicates snails. Nair *et al*. (1968) reported that suspension containing 4, 2 or 1 per cent metaldehyde causes complete mortality of the snail, *A. fulica* in 2 days and 0.5 per cent in 4 days, in field cages 2 per cent dust and 1 per cent suspension gives 93.3 per cent mortality of snails in 24 hours after spraying at Palghat.

Srivastava *et al.* (1968) made observations on the control of *A. fulica* with metaldehyde. According to them, three per cent metaldehyde gave low mortality of snails, whereas five per cent was found effective in giving higher mortality. Regarding the poisoning symptoms, as soon the snails come in contact with metaldehyde pellets, they secreted mucous profusely and become black on exposure to sun and they died soon.

A study conducted by Saxena and Dubey (1970) reveled that use of $CuSo_4$ dust at 5.5 kg/ha against *A. fulica* gave 93 per cent mortality. And same authors working at Tezpur (Assam) on *A. fulica* in addition to other chemicals, used metaldehyde bait at 200 kg/ha. In bait A, they used herbaceous base and in bait B, they used some other bait. They recorded 96 and 98 per cent mortality after 6 hrs of treatment, respectively. They dusted common salt at 200 kg/ha and got 98 per cent mortality of *A. fulica* in 6 hrs after treatment.

Pappas (1971) gave an account of research on molluscicides since 1955. The standard recommendation of tri-calcium arsenate-metaldehyde- bran baits permits good control if careful timing is observed. Bharadwaj (1972) opined that copper sulphate dust (40%) was quite effective but not practicable on a large scale where rains occur. The bait of 5 per cent metaldehyde gave 96.7 per cent kill of *A. fulica.* Bhat *et al.* (1973) noticed the "Snail-kil", a metaldehyde preparation, uniformly broadcasted at 10, 15 or 20 kg per acre gave good control of snails in a coffee plantation.

Field studies conducted by Pappas *et al.* (1973) revealed that, in 2-year trials on the control of *H. aspersa* in grapefruit and tangerine orchards, formetanate, carbofuran, methiocarb and methomyl in apple pomace, with or without metaldehyde, were compared with a proprietary bait containing 5 per cent tricalcium arsenate and 3 per cent metaldehyde. Weather conditions following application in April and May differed markedly in the 2 years, being damp and cloudy in the first year and sunny and warm in the second. The tricalcium arsenate + metaldehyde bait gave the best results in both years and was little affected by the weather. Increases in mortality in the second year ranged between 6

and 41 per cent. The addition of metaldehyde enhanced the effectiveness of all baits except methiocarb. Zectran (4-dimethylamino-3,5-xylyl N-methylcarbamate), which was used in the second year, also gave excellent results with metaldehyde.

Srivastava (1973) suggested to spread five per cent metaldehyde pellets on clean pathways of snails so as to cover as much as pathways to get the highest mortality of Giant African snails. Veeresh *et al.* (1979) reported that application of poison baits containing six per cent lead arsenate or 5 per cent metaldehyde or 3.5 per cent paris green prepared out of wheat bran and gur solution was effective in killing the giant African snails on ornamentals, vegetables and fruit plants with no phytotoxic effect.

The excellent control was obtained with baits of metaldehyde (1-2%) + methiocarb (1%) when distributed around the citrus trees in orchards just outside the periphery, preferably when the snails, *H. aspersa* are active and dry weather is forecast (Pappas and Carman, 1980). Rao *et al.* (1980) reported that, the molluscicidal properties of tobacco (*Nicotiana* sp.) have little practical application due to high production costs.

ElSebae *et al*. (1982) tested locally formulated bran baits containing aldicarb, methomyl or Dupont- 1642 against land snails, *H. vestalis, E. vermiculata* and *T. pisana*. Different wheat and rice brans containing 0.5 per cent aldicarb or methomyl showed high attractant action and toxicity for land snails, represented by their high mortality percentages. Godan (1983) suggested that metaldehyde was most effective when low humidity/high temperature conditions follow ingestion of bait, reflecting the primary role of excess mucus production and desiccation as the mode of action of this molluscicide. Subramanya (1983) recorded 43.07 and 9.23 per cent mortality with 20 kg lime dust and 60 kg tobacco decoction.

In the laboratory, two insecticides, two fungicides and copper sulfate solution were tested against the snail, *A. fulica*. Of these, only copper sulfate caused 100 per cent mortality one week after treatment (Kakoty and Das 1987). Sharma and Agarwal (1989) recommended the use of metaldehyde pellets (5%) at 25 kg per hectare for the control of *A. fulica* effectively. These pellets should be kept around the field. In case of plantation crops the pellets should be kept near the root zone.

Schwartz and Capatos (1990) reported that, metaldehyde paste (4 per cent a.i.) applied to each vine cordon in plots of vineyard in South Africa produced the highest snail mortality (66.2%). Copper sulfate spray with 5 or 10 per cent a.i. gave comparable kill rates, but was phytotoxic to vine leaves and shoots. Wen (1990) opined that metaldehyde 6 G, applied to the bottom of tree trunks and to plant holders, gave the best level of control of *Bradybaena similaris* in the field and remained effective for 21 days in Taiwan.

A new bait (Agtech) comprising an edible matrix incorporating metaldehyde, applied as a coating to an inert core, was tested for the control of slugs and snails on pastures, cabbages and lettuces in New Zealand. The bait (applied at 0. 09, 0.18 and 0.36 kg a.i./ha) gave control of slugs in direct drilled and established pastures comparable to that achieved with Mesurol (methiocarb) and Blitzem (metaldehyde) baits (at 0.2 and 0.81 kg a.i./ha, respectively). These slugs were also controlled by Agtech on lettuces and cabbages and *Helix aspersa* was controlled on lettuces (Barker *et al.,* 1991). In laboratory studies, Dalvi and Dumbre (1992) revealed, spraying or dusting the pesticides BHC [HCH], carbaryl, copper sulfate + lime, quinalphos or endosulfan onto leaves of *Erythrina indica* had little effect in reducing numbers of the snail, *Ariophanta bajadera*.

Shah (1992) reported that the snail *A. fulica* could be killed by sprinkling common salt or leaving them exposed to the sun. Toit and Brink (1992) tested copper sulfate, metaldehyde, methiocarb, copper oxychloride and chlorodane, for the control of *H. aspersa*. The only treatment that reduced snails to a average of less than 2 per tree after 29 weeks was a copper strip around the stem. The strips were 0.127 mm thick and 50 mm wide and they were fastened 500 mm from the ground with a paper-clip. They were still effective 12 months after application and are recommended as a long-term control method. Tillier *et al*.,(1993) suggested the metaldehyde for the control of snail.

Ghamry *et al.* (1994) evaluated fourteen insecticides against low land snails; *M. contiana and E. vermiculata*. Results from bait testes revealed that, methomyl, dithiocarb, carbaryl, chlorpyriphos and dimethoate were effective in killing snails after 12 days under laboratory conditions. The same trend was observed with those insecticides under field conditions also. Giraddi *et al*. (1996) reported that, hand collection of snails and destruction in the early morning hours, treating of crop fields and bunds with insecticidal dusts and banding with insecticidal dust etc, were followed in the control of

snails. Among these, providing of 10 cm wide and 0.5 cm thick banding with malathion 5 per cent dust around crop near the bunds was most effective in the control of snails.

During 1988-92, aldicarb granules and 2.5 per cent metaldehyde (as Snailkill) applied as broadcast (20 g/plant) and 0.01 per cent aldicarb slurry with maida, were molluscicidal when applied to young *Hevea brasiliensis* plants grown at four locations in Kerala, India. Bordeaux paste [Bordeaux mixture] gave repellent activity for 45 days (Jose *et al.,* 1996). Karnatak *et al*. (1998) tested different chemicals against GAS, synthetic pyrethroids were found to be effective. Spraying of decamentrin and fenvalerate 5 per cent gave 100 per cent mortality in a day. Metaldehyde in the form of suspension gave 97.5 per cent mean mortality at 4 per cent concentration and also recorded hundred per cent mortality after 96 hours at 5 per cent spray of sodium chloride. Lauenstein (1998) reported that, at Northern Germany, preventive measures for control of snails include early sowing, increased sowing rates, soil cultivation and liming. The use of molluscicides (metaldehyde, methiocarb and thiodicarb) is discussed.

Basavaraju *et al.* (2000) reported that application of 2.5 per cent metaldehyde pellets was effective in controlling of *A. fulica*. Glen *et al.* (2000) reported that, for control of snail damage in horticultural crops, application of common salt appear to be promising control techniques, either alone or with nematodes. Salmijah *et al.* (2000) recorded 100 per cent mortality of *A. fulica* within 24 hours at 5 per cent metaldehyde bait. Sexena and Mahendra (2000) showed that wet wheat flour was the best bait and dichlorvos was the most potent molluscicide with more than 90 per cent mortality in less than 96 hours.

The effect of a combination of drainage and metaldehyde on feeding damage to direct-seeded rice by the golden apple snail was tested under conditions of high snail density and heavy rainfall. A 10-day drainage immediately following the wet seeding and subsequent 11-day low-level water management was successful in suppressing the snail damage below an acceptable injury level when metaldehyde granules (10%) were applied at a rate of 4 kg/10 acre, 4 days and 10 days after sowing. The analysis of the results of metaldehyde application revealed that the success was mainly due to its effect as feeding arrestant (Suzuki *et al.,* 2000).

Laboratory and field experiments were conducted by Basavaraju *et al.* (2001) in Bangalore during 1999 *kharif* season to study the efficacy of molluscicides against the *A. fulica* infesting betelvine gardens. The treatments comprised: 600 ml monocrotophos 36 SL + 60 kg rice bran + 6 kg jaggery/ha; 600 ml methomyl 12.5 L + 60 kg rice bran + 6 kg jaggery/ha; 600 g carbofuran 3G + 60 kg rice bran + 6 kg jaggery/ha; and 25 kg 2.5 per cent metaldehyde pellets/ha. Metaldehyde pellets and baits prepared with monocrotophos, carbofuran and methomyl gave 100 per cent snail mortality under laboratory conditions. Metaldehyde registered the highest mortality (24.40) against the initial population of 9.5 per plant. The bait prepared with methomyl and carbofuran recorded 18.20 and 17.60 snails per plant, respectively. On the other hand, monocrotophos bait recorded the lowest snail mortality (15.40). The results of field experiments showed that metaldehyde gave excellent control. Metaldehyde application all along the borders of newly-established betelvine gardens was effective against snails. In all the locations, mortality ranged from 49 to 74 per cent.

Wada *et al.* (2001) opined that the application of metaldehyde pellets to *P. canaliculata* after sowing successfully suppressed damage to rice by apple snails, when used in conjunction with 13 or 18 day's drainage after sowing in both light and heavy rain. About 90 per cent of snails were killed by the application of metaldehyde.

Barwal and Dhiman (2002) evaluated different cultivars of marigold, namely Pusa Basanti, Pusa Narangi and Yellow Giant of African marigold, Katrain dwarf of French marigold and Gandhri of *T. minuta*, for their potential to trap *M. glauca* in summer 2001, in Kullu, Himachal Pradesh. Trap crop followed by application of metaldehyde (2%) bait or Snailkill (5 g) at the base of the plant, before the onset of the rainy season was effective in minimizing snail infestation. Henderson & Triebskorn (2002) reported the principal toxic effect of metaldehyde is through stimulation of the mucous gland which cause excessive sliming, leading to death by dehydration. Metaldehyde is broken down into acetaldehyde by sunlight, so pellet should be put in shady places, particularly under the leaves of the affected plants.

Mahrous *et al*. (2002) tested seven pesticides to evaluate their molluscicidal activity as poisonous baits against *M. Cartusiana* in Sharkia Governorate, Egypt. The molluscicidal efficiency of the tested pesticides after 15 day- treatment could be arranged as follows: fenamiphos> sethoxydim> oxamyl> monocrotophos> butachlor> biofly and seed grad. They also reported hand collection of the snails daily and to kill them with a strong solution of common salt or in boiling water is effective. PDCF

(2003) reported the molluscicides such as metaldehyde or methiocarb are available in bait form for use in the control of snails. Metaldehyde is registered for use in vegetable crops, while Methiocarb can be used on ornamentals and lawns only.

Shyam Prasad *et al*. (2004) reported that, Sodium chloride (common table salt) is an effective dehydrating agent; it may be applied as a 12-inch barrier application on the perimeter of known or suspected snail-infested areas; during periods of rain or high relative humidity, salt barriers should be renewed frequently.

Takashi (2004) concluded that an application of bait type metaldehyde showed enough control effects to avoid rice damage by snails even in heavy rain conditions. The stable effects seemed to be due to the active ingredient in the bait type which is dissolved slowly. Abdel-Halim *et al.* (2006) evaluated the molluscicidal efficacy and toxicity of methomyl and other pesticides against glassy clover snails (*M. cartusiana*) under laboratory and field conditions. In clover fields, the efficacy of methomyl was 98.0 per cent, at 5, 6, 13 and 28 days after treatment, respectively in Koom Hamada district and Etay El-baroud research station (Egypt) during 2004-05.

The effect of two natural compounds, Neemix 4.5 per cent (plant extract) and Vertimec 1.8 per cent bio compound (abamectin), in addition to the molluscicidal compound, Cekumeta 5.0 per cent (metaldhyde), were evaluated as a bait or contact (thin film) molluscicide against two land snail species, *M. obstructa* and *E. vermiculata* under laboratory and field conditions of Kafr El-Sheikh Governorate, Egypt. Laboratory results showed that when the three tested compounds were used as a bait, Cekumeta was the most toxic one against the two snail species, followed by Vertimec, while Neemix was the least effective one. On the other hand, *M. obstructa* was more susceptible for Neemix and Vertimec than *E. vermiculata* while vice-versa occurred in case of Cekumeta bait compound. The field results were in agreement with those obtained from the laboratory as Cekumeta bait was the most efficient one against both species, followed with Vertimic and Neemix when applied as baits (Gabr *et al*., 2006).

Javaregowda (2006) tested the various chemicals against the giant african snail. Among these, metaldehyde 2.5 per cent was most effective and registered highest mortality after one day at both the localities tested (30.65 and 43.2%) followed by monocrotophos bait. Hamed *et al.* (2007) evaluated the toxic action of two carbamate molluscicides, methomyl and methiocarb on the digestive gland of the land snail *E. vermiculata* using topical application and baiting technique where in methomyl was found to be more toxic than methiocarb.

A preliminary study was conducted to assess the efficacy of some chemical molluscicides (copper sulfate, zinc sulfate and cypermethrin) against *Indoplanorbis exustus* under natural field conditions. 200 snails were kept in each of 4 plots treated with copper sulfate (4.5 g; 1:50 000 dilution), zinc sulfate (4.5 g; 1:50 000 dilution), cypermethrin (10 per cent w/v, 9 ml; 1:25 000 dilution); 200 untreated snails were also kept in another plot (control). The molluscicidal activity of these agents was determined by counting the number of live and dead snails every 6 h for 96 h. The results showed that copper sulfate and cypermethrin demonstrated 100 per cent snail mortality within 6 h. All the untreated were alive at the end of the study. It is concluded that these agents possess promising molluscicidal properties (Kumar and Prasad, 2007).

The study conducted by Ravikumar *et al*. (2007) during the last week of October 2004 at Yalavatti near Shimoga, Karnataka, on *A. fulica* revealed that, there was no mortality in tobacco leaf extract treatment. The highest mortality of 87.67 per cent was recorded at 6 kg metaldehyde (2.5%) bait per acre and 4 kg metaldehyde (2.5%) bait (87.16%). Dichlorvos bait @ 5 kg per acre gave 25.39 per cent mortality. Mortality in common salt (19.25%), lime powder (19.24%) and iron phosphate @ 3 kg per acre (18.67%) was on par with each other. At fourth day after application mortality ranged from 0 to 73.44 per cent. The highest mortality of 73.44 per cent was recorded at 4 kg metaldehyde (2.5%) bait per acre. At sixth day of application mortality ranged from 0 to 55.71 per cent. No mortality was recorded in lime powder and common salt. The highest mortality of 55.71 per cent was recorded at 6 kg metaldehyde bait per acre,and tobacco leaf extract (1.33 per cent snail mortality) which was the least effective treatment.

Sunitha (2007) reported that, paddy husk 10 kg, jaggery 1.5 kg, monocrotophos 36 S L@ 200 ml mixed and kept it for 24h and broadcasted @2g/plant. Laboratory study conducted by Radwan *et al.* (2008) investigated the lethal toxic action of methomyl and methiocarb on the land snail (*E. vermiculata*) on digestive gland of this snail, using topical application and baiting techniques. The results showed that methomyl exhibited greater efficacy than did methiocarb against the snails in both techniques in Egyptian farms.

The study was designed to investigate the neuropathological effect of the two carbamate pesticides: methomyl and methiocarb on the neurons of the buccal ganglia in the land snail *E. vermiculata* using topical application and baiting technique. Methomyl was found to be more toxic than methiocarb (Essawy *et al.,* 2009). Shevale and Bedse (2009) reported that seven days after application of different poison baits, metaldehyde 2.5 per cent @ 25 kg/ha was found to be most effective (69.3 per cent mortality) on GAS and was closely followed by poison bait consisting of methomyl 40 SP @ 10 g/kg of fermented food bait (wheat bran + jaggery + yeast) (68.1 per cent mortality). Metaldehyde 2.5 per cent with its reduced dose of 5kg/ha along with food bait (wheat bran + jaggery) also showed good efficacy with 40.7 per cent snail mortality and ranked third in order of efficacy. Lime powder @ 100 kg/ha was not effective in controlling the pest.

The control of round snail in cereal, pulse and oilseed crops apply low rates of metaldehyde for densities up to 80 round snails (>7mm in diameter) per square metre. For conical snails, repeated applications at a lower rate are probably more efficient than a one-off full rate (Anonymous, 2011). Scot Nelson (2012) noticed that application of kerosene and common salt may effectively control *A. fulica*, but these are not registered as agricultural pesticides in Hawaii.

Use of metaldehyde 2.5 per cent DP- SNAILKIL® 2.5 per cent Bait –2kg/ac., impregnate gunny bag with 15 per cent salt solution and place the gunny bags at random in the field (approximate : 10/ acre), dust powered salt over the snail wherever it is possible and methomyl poison baits (Rice bran - 1 kg, Jaggery - 0.2 kg, methomyl 40 SP - 100g) are effective in controlling of snails and use cabbage leaves/split papaya stems as attractant (http://www.agritech.tnau.ac.in). In East Africa, sprinkling the snail habitats and / or around crop base with table salt in dry seasons, has proven effective in controlling of Giant African Snails (www.infonet-biovision.org). Biopesticides *viz.,* metal salt-based molluscicides as snail baits and snail pellets. These are derived from iron phosphate, copper sulfate and aluminium sulfate. However, these baits should be daily removed from orchards and destroyed whereas sodium chloride (common table salt) is an effective dehydrating agent. It may be applied as a inch barrier application on the perimeter of known/ suspected snail infested area (www.intechopen.com).

MATERIAL AND METHODS

The investigations on the contemplated objectives were carried out during *kharif* 2012 at Department of Agricultural Entomology and Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad on medium black soil while, the survey work was undertaken in farmer's fields, on snails attacking different crops and also on per cent damage done by snails.

Dharwad is situated in the transitional tract of Karnataka (Zone-8) at $15^{0}26^{1}$ north latitude and $75^{0}07^{1}$ east longitude with an altitude of 678 meters above Mean Sea Level (MSL). The mean annual rainfall is about 751.10 mm distributed over a period of seven to eight months (April to November) with two peaks occuring in July and October. The period of March to May is very hot with mean maximum temperature ranging between 33 to 37°C. Similarly, during December and January, which are cooler months with mean minimum temperature, ranging between 11.00 and 21.74°C, the relative humidity fluctuates between 40 and 85 per cent. The details of materials used and the methodology adopted during the course of investigation are described here under.

3.1 Survey on the population density and extent of damage due to the snail in different crops

The snail infestation became a threat in recent days in the transitional belt of the region. Hence, an area of operation for this study was confined to the selected villages of the Dharwad taluk to record the population density and extent of damage due to the snail in different cropping ecosystems by conducting fixed plot and roving survey.

3.1.1 Roving Survey

3.1.1.1 Method of survey

The roving survey was made at fortnightly interval during cropping period in Dharwad taluk in the villages *viz.*, Narendra, Chikkamalligwad, Kamlapur and Hebbali farm to know the status of snail infestation in different cropping ecosystems from June, 2012. The different ecosystems included agriculture and horticulture crops. The population density of snails were estimated by counting the number of snails per 25 m^2 area from five randomly selected spots in the field on different crops as well as on bunds of 5 m running length and the average population load per 25 m^2 area was computed in different crops.

The damage potentiality was worked out by scoring the number of seedlings damaged and expressed in terms of per cent seedlings devoured/damaged.

$$\text{Per cent damage} = \frac{\text{Number of infested plants}}{\text{Total number of plants observed}} \times 100$$

3.1.2 Fixed spot survey

The population dynamics studies on snail was undertaken in the main campus of UAS, Dharwad at weekly interval on different major crops grown in MARS, Dharwad. The observations on snail population was made at weekly interval. The population count were estimated by counting the number of snails per 25 m^2 area from five randomly selected spots in the field as well as on bunds of 5 m running length and the average population load per 25 m^2 area and 5 m running length was computed in different crops. Further, the damage potentiality was worked out by scoring the number of seedlings damaged and expressed in terms of per cent seedlings devoured/damaged.

$$\text{Per cent damage} = \frac{\text{Number of infested plants}}{\text{Total number of plants observed}} \times 100$$

From the field collected snails, representative snail specimens were preserved properly in 70 per cent alcohol and also only shells were sent for identification to Dr. R.Venkitesan, Scientist "C", Zoological Survey of India, Southern Regional Centre, Chennai and got identified. Comparative data on the incidence of *Cryptozona semirugata* (Beck) on different crops was observed.

3.1.2.1 Correlation Co-efficient between snails and weather parameters

Correlation studies was made by correlating the mean density of snail population with the meteorological parameters like, mean maximum and minimum temperature, average relative humidity and total rainfall during the approximate developmental period at MARS, Dharwad (Appendix-I).

3.2 Influence of different levels of *Cryptozona semirugata* infestation on plant damage and leaf area consumption in greengram under caged condition

To assess the infestation of snail, *C. semirugata* on plant damage and leaf area consumption in greengram, a cage experiment was conducted during 1st week of July, 2012 by adopting two factorial complete randomized design. Green gram variety, NVL-1 (Naval) (Nirmal moong) was sown in plastic troughs (65 × 45 × 30 cm). About 54 plastic troughs were used for the experimentation in the shade house and in each trough hundred seedlings were maintained. The crop was raised by following all recommended package of practices except the plant protection schedule. Each trough was covered by thin muslin cloth (1m width × 1 m breadth × 2.5 m height).

The experiment consisted of eighteen treatments which were replicated thrice. Care was taken to remove all the insect pests and snails if any from trough before enclosing cloth cages (Plate 1) at seven days after sowing. Then known numbers of uniform sized snails were released treatment wise at 7, 15 and 30 days after sowing (DAS) to assess the extent of plant damage (Plate 2) and leaf area consumption. The plants were confined to cages for 30 days. All the treatments were covered with muslin cloth to avoid escape of snails from the plots.

3.2.1 Collection of snails

Snails were collected early in the morning between 7 am and 8 am. Field collected snails were kept in bin and snails were provided with soybean and mulberry leaves and covered with muslin cloth. Food was changed twice a day till completion of experiment. Egg masses were collected every day. Hatched out young snails were allowed to feed on fresh soybean leaves twice a day, as these crops were easily available near experimental plot. As the snails grew they were transferred to another container, bigger and uniform sized snails were taken for further studies.

3.2.2 Details of the treatments used for infestation by snail, *Cryptozona semirugata*

Treatment details

First factor

P_1- Releasing of zero snails (control)

P_2 - Releasing of two snails

P_3 - Releasing of four snails

P_4 - Releasing of six snails

P_5 - Releasing of eight snails

P_6 - Releasing of ten snails

Second factor

D_1 - 7 days after sowing

D_2 - 15 days after sowing

D_3 - 30 days after sowing

Treatment combinations:

T_1 - P_1D_1 (Releasing of zero snails after 7 days after sowing) (control)

T_2 - P_1D_2 (Releasing of zero snails after 15 days after sowing) (control)

T_3 - P_1D_3 (Releasing of zero snails after 30 days after sowing) (control)

T_4 - P_2D_1 (Releasing of two snails after 7 days after sowing)

T_5 - P_2D_2 (Releasing of two snails after 15 days after sowing)

Plate 1 : Experiment on estimation of damage due to snail under shade condition

Plate 2 : Snail damage to greengram plant in cage house

T_6 - P_2D_3 (Releasing of two snails after 30 days after sowing)

T_7 - P_3D_1 (Releasing of four snails after 7 days after sowing)

T_8 -P_3D_2 (Releasing of four snails after 15 days after sowing)

T_9 - P_3D_3 (Releasing of four snails after 30 days after sowing)

T_{10} - P_4D_1 (Releasing of six snails after 7 days after sowing)

T_{11}- P_4D_2 (Releasing of six snails after 15 days after sowing)

T_{12} –P_4D_3 (Releasing of six snails after 30 days after sowing)

T_{13} - P_5D_1 (Releasing of eight snails after 7 days after sowing)

T_{14} - P_5D_2 (Releasing of eight snails after 15 days after sowing)

T_{15} - P_5D_3 (Releasing of eight snails after 30 days after sowing)

T_{16} - P_6D_1 (Releasing of ten snails after 7 days after sowing)

T_{17} - P_6D_2 (Releasing of ten snails after 15 days after sowing)

T_{18} - P_6D_3 (Releasing of ten snails after 30 days after sowing)

3.2.3 Plant damage and leaf area consumption were calculated by using the following formulae

$$\text{Per cent seedlings damaged /devoured} = \frac{\text{No. of seedlings damaged}}{\text{Total number of seedlings}} \times 100$$

Per cent leaf area consumption was calculated by taking the leaves from five randomly selected plants from each treatment were used for the estimation of leaf area. Leaf area was computed at 7, 15 and 30 DAS by using disc method (Stickler *et al.,* 1961) and expressed as cm^2 $plant^{-1}$. Later, per cent plant damage and leaf area consumption data was transformed to arc sine transformation for reliable analysis and the data was subjected to statistical analysis.

3.3 Management of the snail in green gram

Field investigations were carried out to study the effect of different treatments to manage pest in green gram. The experiment was conducted during *Kharif*, 2012 at the MARS, UAS Dharwad. It was laid out in a Randomized Complete Block Design (RCBD) with eleven treatments and each treatment was replicated thrice with a plot size of 2.1 x 3 m leaving gang way of one meter around the plots. The green gram variety, Shining moong was sown during 1st week of July (5-7-2012) at a spacing of 30 x 10cm. Later, yellow polythene sheet of 200 guage was inserted vertically around the plot/treatment basin to the depth of 15 cm to avoid migration of snails during experimentation from one treatment to another (Plate 3). The treatment details are presented in table 2.

3.3.1 Preparation of poison bait

One kg of wheat bran was kept in plastic basin, to which 10 gms of jaggery mixed in 50 ml of water and the jaggery solution so prepared was sprinkled on wheat bran. Later the remaining quantity of water was added and mixture was mixed thoroughly.

3.3.2 Preparation of tobacco decoction and its dilutions

Tobacco waste-1 kg, water-10 lt, soft soap-500 gms. It was prepared by boiling tobacco waste in water till a dark coloured liquid was obtained and to this soft soap was added. The stock solution was diluted six to ten times with water and strained before spraying.

3.3.3 Imposition of treatments

Metaldehyde 2.5 % (pellets) which is available as ready to use molluscicide was broadcasted at the rate of 5 kg /ha and also fenvalerate, malathion, lime dust and bleaching powder were applied to heap of weed (Plate 4). Tobacco decoction was applied as spray to the crop and common salt as dehydrating agent.

Table 2: Details of treatments imposed under field condition for the management of snail, *Cryptozona semirugata*

Treatment details:

Treatments	Dosage/ha
Metaldehyde 2.5% (Pellets)	5 kg
Copper sulphate	60 kg bait (100 g/kg bait)
Methomyl 40 SP	60 kg bait (10 g/ kg bait)
Monocrotophos 36 SL	60 kg bait (10 ml/ kg bait)
Fenvalerate 0.4 D	25 kg
Malathion 5 D	25 kg
Common crystal salt	25 kg
Lime powder (Dust)	25 kg
Tobacco decoction	10% solution
Bleaching powder	25 kg
Untreated control	-

Plate 3 : General view of the experimental plot

Plate 4 : Weed heap placed in the experimental field in management studies

Copper sulphate, methomyl 40 SP and monocrotophos 36 SL were mixed with bait trap (60 kg/ha) and these baits were applied in the field during the evening hours on bunds or near the organic waste to attract and kill the snails. The observations were taken at 1, 3, 7 and 10 days after treatment. As there were no natural infestation of snails in field because of low rainfall period, the snails were artificially released. Twenty snails were realeased during first application, Whereas fifteen snails were released during second and third application. Number of dead snail count was taken at early in the morning between 7 am and 8 am. Second and third round of application was given at 10 days interval. The population count data was transformed to arc sine transformation for reliable analysis and the data was subjected to statistical analysis. Later the per cent decline in snail population was worked out in different treatments.

3.3.4 Yield and quality parameters

At harvest the pods from individual plots were taken separately and the yield was recorded for the plot and yield data was computed to quintals per hectare and were analysed and subjected to DMRT

3.3.5 Cost economics

The cost of cultivation for each treatment was worked out by taking into consideration the price of inputs prevailing in the market. Net profit per ha was calculated by deducting the cost of cultivation from gross income. The benefit cost ratio was worked out as follows

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

EXPERIMENTAL RESULTS

Results of the investigation on the survey of the population density and extent of damage due to snail, *Crypotozona semirugata* (Beck) in different cropping ecosystems, influence of different levels of snail infestation on plant damage and leaf area consumption and its management in greengram are elucidated in this chapter.

4.1 Survey on the population density and extent of damage due to the snail in different crops

4.1.1 Roving survey

An intensive roving survey on the population density and extent of damage by the snail, *C. semirugata* was undertaken on the farmers field during 2012 in major snail incidence villages of Dharwad *viz.*, Narendra, Hebbali farm, Kamlapur and Chikkamalligwad. The fields were visited at fortnightly interval on major field crops grown in village by the farmers. Observations were made on the population density and extent of damage in different crops. The data pertaining to survey are presented here under.

The roving survey on the incidence level of *C. semirugata* on major crops grown in different villages revealed that, irrespective of the locations maximum population of snails was noticed during 28th Std week on bund, field near bund (FNB) and also inside the field.

Among different locations, snail population was more in Hebbali Farm followed by Narendra and Kamlapur village. Across the locations, the snail population was maximum on bund followed by FNB and inside the field.

4.1.1.1 Hebbali Farm (Black soil)

4.1.1.1.1 Number of snails

The scanning of the data reveals that the population of snails were more during 28th standard week on soybean (8.00 to 11.2 per 25 m^2) followed by cotton (6.60 to 10.40 per 25 m^2) on bund. The snail population was more in FNB (10.40 per 25 m^2) on cotton and 11.20 per 25 m^2 on soybean than inside the field (6.60 per 25 m^2 on cotton and 8.00 per 25m^2 on soybean) (Table 3).

During 32nd standard week, the population was 8.00 per 25m^{2}on cotton and 9.20 per 25m^2 on soybean field near bund, whereas the population inside the field was less which ranged from 6.00 to 6.80 per 25m^{2}on cotton and soybean, respectively.

The least number of snails were observed during 24th std week on FNB (3.20 and 4.00 per 25m^2) and inside the field (2.00 and 2.60 per 25m^2) on cotton followed by soybean, respectively.

4.1.1.1.2 Per cent plant damage

The per cent damage to soybean and cotton in field near bund was more (16.12 to 26.29 per cent) compared to inside the field (5.40 and 10.24 per cent) on cotton and soybean during early stage of crop (24th std week). As crop age advances, the per cent plant damage decreases. The minimum per cent damage was observed during 34th std week on soybean followed by cotton on FNB (0.00 and 0.87 per cent) and inside the field (0.00 and 0.30 percent).

4.1.1.2 Narendra village (Black soil)

4.1.1.2.1 Number of snails

The survey data in Narendra village indicated that mean number of snails per 5m row on bund, and per 25m^2 on FNB and inside field was nil from 18 to 22 std week. However, the population of snail and per cent damage started from 24th std week (Table 3).

The maximum number of snails were observed during 28th std week where in soybean recorded maximum number of snails (10.00 per 25 m^2) which was followed by maize + redgram, cotton, groundnut and sorghum (8.80, 8.20, 5.80 and 5.20 per 25 m^2, respectively) near field bund. While the population inside the field was more on soybean during 28th std week, soybean was followed by maize + redgram, cotton, groundnut and sorghum (jowar) which recorded 6.80, 5.40, 5.00 and 4.40 per 25 m^2, respectively.

Table 3: Roving survey on the incidence of snail, *Cryptozona semirugata* on major crops grown on black soil in different villages

MSW	Crop	Hebbali Farm					Narendra village					Kamlapur village				
		Number of snails			Per cent plant damage		Number of snails			Per cent plant damage		Number of snails			Per cent plant damage	
		Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB	Inside field	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB	Inside field	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB	Inside field
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	Cotton	5.80	3.20	2.00	16.12	5.40	-	-	-	-	-	-	-	-	-	-
	Soybean	6.40	4.00	2.60	26.79	11.24	6.40	4.40	1.80	23.85	8.76	2.80	1.80	0.80	18.14	6.63
	Groundnut	-	-	-	-	-	3.80	2.60	1.00	18.59	6.54	2.20	0.80	0.40	16.16	6.13
	Potato	-	-	-	-	-	3.00	2.20	0.80	19.27	8.46	-	-	-	-	-
	Chilli	-	-	-	-	-	-	-	-	-	-	3.20	2.20	1.20	14.59	7.91
	Mean	**6.10**	**3.60**	**2.30**	**21.45**	**8.32**	**4.40**	**3.07**	**1.20**	**20.57**	**7.92**	**2.73**	**1.60**	**0.80**	**16.30**	**6.89**
26	Cotton	12.40	6.60	3.60	12.03	5.40	-	-	-	-	-	-	-	-	-	-
	Soybean	13.20	6.80	4.20	23.47	9.65	8.60	5.80	4.20	19.89	7.58	5.20	3.00	2.00	15.15	4.42
	Groundnut	-	-	-	-	-	4.80	3.20	2.20	13.83	5.81	4.00	1.60	1.60	13.51	5.72
	Potato	-	-	-	-	-	3.80	3.20	2.80	15.31	3.40	-	-	-	-	-
	Redgram	-	-	-	-	-	5.80	4.00	3.80	17.14	6.52	-	-	-	-	-
	Pea	-	-	-	-	-	5.80	3.60	3.00	11.09	8.36	4.40	2.60	2.20	14.32	4.98
	Jowar (sorghum)	-	-	-	-	-	-	-	-	-	-	3.80	1.40	1.20	10.09	4.56
	Groundnut+Coriander	-	-	-	-	-	-	-	-	-	-	4.20	1.80	1.80	12.51	5.00
	Chilli	-	-	-	-	-	-	-	-	-	-	7.80	3.40	2.40	15.40	4.72
	Mean	**12.80**	**6.70**	**3.90**	**17.75**	**7.53**	**5.76**	**3.96**	**3.20**	**15.45**	**6.33**	**4.90**	**2.30**	**1.87**	**13.50**	**4.90**
28	Cotton	15.20	10.40	6.60	8.26	4.20	11.40	8.20	5.40	13.30	5.72	-	-	-	-	-
	Soybean	16.40	11.20	8.00	17.11	4.71	14.80	10.00	7.60	12.60	5.23	10.00	5.40	3.00	12.82	4.02
	Groundnut	-	-	-	-	-	8.60	5.80	5.00	11.29	4.59	8.40	3.60	2.20	11.51	5.54
	Jowar	-	-	-	-	-	6.80	5.20	4.40	8.28	4.84	5.60	2.80	2.00	8.65	3.94
	Maize+ Redgram	-	-	-	-	-	13.00	8.80	6.80	10.72	4.15	-	-	-	-	-
	Pea	-	-	-	-	-	-	-	-	-	-	6.00	4.40	2.20	8.21	3.77
	Mean	**15.80**	**10.80**	**7.30**	**12.69**	**4.45**	**10.92**	**7.60**	**5.84**	**11.24**	**4.91**	**7.50**	**4.05**	**2.35**	**10.30**	**4.32**

Contd…..

MSW	Crop	Hebbali Farm					Narendra village					Kamlapur village				
		Number of snails			Per cent plant damage		Number of snails			Per cent plant damage		Number of snails			Per cent plant damage	
		Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB	Inside field	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB	Inside field	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB	Inside field
30	Cotton	13.60	6.40	4.20	3.48	2.20	7.80	5.80	5.00	9.36	3.36	-	-	-	-	-
	Soybean	14.20	7.60	4.80	9.37	1.44	10.00	7.40	5.40	10.92	3.98	-	-	-	-	-
	Jowar	-	-	-	-	-	6.00	4.80	3.40	7.75	3.90	4.60	1.80	1.00	4.61	2.59
	Pea	-	-	-	-	-	-	-	-	-	-	4.80	3.20	1.60	6.27	3.53
	Groundnut	-	-	-	-	-	-	-	-	-	-	4.40	2.80	1.20	8.54	3.78
	Mean	**13.90**	**7.00**	**4.50**	**6.42**	**1.82**	**7.93**	**6.00**	**4.60**	**9.34**	**3.75**	**4.60**	**2.60**	**1.27**	**6.47**	**3.30**
32	Cotton	14.00	8.00	6.00	2.17	1.59	10.00	7.60	5.40	3.76	1.44	-	-	-	-	-
	Soybean	15.00	9.20	6.80	0.00	0.00	13.40	8.80	7.20	3.26	0.60	8.80	4.80	2.80	2.24	0.80
	Groundnut	-	-	-	-	-	7.40	5.20	4.00	3.83	1.82	6.60	3.00	1.80	1.80	1.20
	Potato	-	-	-	-	-	6.40	4.00	3.80	5.22	1.24	-	-	-	-	-
	Maize	-	-	-	-	-	5.20	3.60	3.00	6.30	2.13	-	-	-	-	-
	Maize+ Redgram	-	-	-	-	-	12.00	8.20	6.60	7.19	3.61	-	-	-	-	-
	Groundnut+Redgram	-	-	-	-	-	8.00	4.40	3.60	4.40	1.93	-	-	-	-	-
	Jowar	-	-	-	-	-	-	-	-	-	-	5.00	2.40	1.60	1.51	0.40
	Mean	**14.50**	**8.60**	**6.40**	**1.09**	**0.80**	**8.91**	**5.97**	**4.80**	**4.85**	**1.82**	**6.80**	**3.40**	**2.07**	**1.85**	**0.80**
34	Cotton	8.40	3.60	2.40	0.87	0.30	4.40	2.80	2.60	2.80	0.80	-	-	-	-	-
	Soybean	9.20	5.00	2.80	0.00	0.00	7.60	4.80	3.40	0.20	0.00	4.40	2.60	1.40	0.00	0.00
	Maize	-	-	-	-	-	3.60	2.40	2.00	0.60	0.00	-	-	-	-	-
	Potato	-	-	-	-	-	3.20	2.60	1.40	0.80	0.20	-	-	-	-	-
	Greengram	-	-	-	-	-	8.00	5.40	3.80	0.20	0.00	-	-	-	-	-
	Peas	-	-	-	-	-	4.00	4.60	1.20	0.00	0.00	-	-	-	-	-
	Tomato	-	-	-	-	-	3.20	1.20	1.20	0.00	0.00	-	-	-	-	-
	Groundnut	-	-	-	-	-	-	-	-	-	-	3.80	1.20	1.20	0.40	0.20
	Jowar	-	-	-	-	-	-	-	-	-	-	3.00	0.80	1.00	0.20	0.00
	Mean	**8.80**	**4.30**	**2.60**	**0.43**	**0.15**	**4.86**	**3.40**	**2.23**	**0.66**	**0.14**	**3.73**	**1.53**	**1.20**	**0.20**	**0.07**

MSW – Meterological standard week FNB- Field near bund

The mean minimum number of snails were found during 24th standard week both on FNB (3.07) and inside the field (1.20).

4.1.1.2.2 Per cent plant damage

The per cent damage by the snail on FNB and inside the field was maximum during 24th std week on soybean (23.85 per cent) followed by potato and groundnut (19.27 and 18.59 per cent, respectively) on FNB, whereas inside the field the damage was more on soybean (8.76 per cent), followed by potato and groundnut (8.46 and 6.54 per cent, respectively).

The mean minimum per cent damage was found during 34th std week where in cotton recorded higher per cent damage (2.80) followed by potato, maize, greengram, soybean, peas, tomato which recorded 0.80, 0.60, 0.20, 0.20, 0.00, 0.00 per cent, respectively on FNB. The per cent damage inside the field was more on cotton (0.80 per cent), followed by potato (0.20 per cent) and nil on other crops.

4.1.1.3 Kamlapur village (Black soil)

4.1.1.3.1 Number of snails

The mean maximum population was observed during 28th std week (5.40, 4.40, 3.60 and 2.80 snail per 25 m^2, respectively) on soybean, pea, groundnut, and sorghum on FNB and was 3.00, 2.20, 2.20 and 2.00 snails per 25 m^2, respectively in soybean, pea, groundnut and sorghum inside the field (Table 3).

This was followed by 32nd week, where in soybean, groundnut and jowar recorded 4.80, 3.00 and 2.40 per 25m^2 on FNB and 2.80, 1.80 and 1.60 per 25m^2 on same crops inside the field.

The lowest snail population was recorded at 34th and 24th std week. At 34th standard week, soybean, groundnut and sorghum recorded 2.60, 1.20 and 0.80 snails per 25 m^2 on FNB and (1.40, 1.20 and 1.00 per 25m^2) inside the field, respectively. At 24th week, chilli, soybean and groundnut recorded 2.20, 1.80 and 0.80 per 25 m^2, respectively on FNB and inside the field (1.20, 0.80 and 0.40 snails per 25 m^2, respectively).

4.1.1.3.2 Per cent plant damage

The mean per cent plant damage recorded during survey in Kamlapur was maximum at 24th and 26th week. At 24th week, the highest per cent plant damage of 16.30 per cent was recorded on crops grown near field bund compared to 6.89 per cent on crops grown inside the field.

During 26th std week once again the highest mean damage to the plants of 13.5 per cent was seen on crops grown in field near bunds compared to 4.9 per cent on crops grown inside the field. Later on the per cent damage to the plants by snails gradually declined on different crops grown both in fields near bund and also inside the field.

It is interesting to note that the incidence of snail on major crops grown in red soil in Narendra and Chikkamalligwad villages throughout the crop growth period was nil.

4.1.2 Fixed plot survey

The fixed plot survey study was carried out during *kharif*, 2012 at MARS, University of Agricultural Sciences, Dharwad on black soil. During the course of study the mean number of snail and the per cent plant damage, untill crop duration, were recorded on major crops grown in MARS, Dharwad and results are presented here under.

The mean number of snails per 5m row on bund, and 25 m^2 on FNB and inside field was nil from 18 to 22nd std week on every crop. However, the population of snail and per cent damage started from 24th std week on all the crops grown in MARS, Dharwad.

4.1.2.1 Maize

4.1.2.1.1 Number of snails

From table 4 it is clear that, snail population on maize was more during 29th standard week and up to 37th standard week the snails were persisted in field from 23rd standard week.

Table 4: Incidence of *Cryptozona semirugata* on maize in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	7.20	2.20	0.60	9.30	4.32
24	4.20	1.80	0.20	5.77	1.60
25	9.80	2.60	0.80	8.48	4.94
26	6.20	2.20	0.40	5.37	3.08
27	10.20	2.40	1.40	2.40	1.83
28	6.80	1.40	0.60	2.18	1.24
29	13.80	2.60	2.20	1.40	0.80
30	10.20	0.60	0.40	0.70	0.37
31	7.40	0.80	0.20	0.42	0.16
32	12.20	1.40	4.60	0.37	0.10
33	6.40	2.40	0.80	0.19	0.00
34	5.20	2.00	0.40	0.00	0.00
35	6.80	2.80	2.80	0.00	0.00
36	9.20	3.60	2.60	0.00	0.00
37	2.80	3.20	2.00	0.00	0.00
Mean	**7.89**	**2.13**	**1.33**	**3.32**	**1.84**

FNB- Field near bund

The snail population on bund was more which ranged from 2.80 to 13.80 per 5m row length. The population of snail was comparatively low in maize field near bund which ranged from 0.60 to 3.60 per $25m^2$ in different standard weeks. The population of snail on maize crop inside the field was lowest, which ranged from 0.20 to 4.60 per $25m^2$ compared to FNB.

4.1.2.1.2 Per cent plant damage

The damage to maize crop was more near field bund which ranged from 0.00 to 9.30 per cent per $25m^2$, while it was minimum inside the field which ranged from 0.00 to 4.32 per cent per $25m^2$.

In general, the damage to maize crop by snail gradually declined from 23^{rd} standard week with advancement of crop age. At the fag end of the cropping season the damage was nil on maize crop as the crop matured and became unpalatable to the snail.

4.1.2.2 Greengram

4.1.2.2.1 Number of snails

The data presented in table 5 on the incidence of *C. semirugata* on greengram revealed that the first appearance of snails was noticed during 23^{rd} std week and persisted in field up to 32^{nd} std week.

The snail population on bund was more which ranged from 4.20 to 11.60 per 5m row length. Whereas the population of snails was comparatively low in greengram field near bund which ranged from 1.20 to 5.40 per $25m^2$ in different standard weeks. The population of snail on greengram crop inside the field was lowest which ranged from 0.20 to 4.40 per $25m^2$ compared to FNB.

4.1.2.2.2 Per cent plant damage

The per cent plant damage to greengram crop was more near field bund which ranged from 0.60 to 21.00 per cent per $25m^2$, while it was minimum inside the field which ranged from 0.02 to 7.90 per cent per $25m^2$. In general, the damage to greengram crop by snail (Plate 5) gradually declined from 23^{rd} std week with advancement of crop age. At the fag end of the cropping season the damage was nil on greengram crop as the crop matured and became unpalatable to the snail.

4.1.2.3 Blackgram

4.1.2.3.1 Number of snails

The mean maximum snail population on blackgram crop was observed during 29^{th} standard week. The population on bund was ranged from 4.60 to 13.20 per 5m row length. The population of snail was comparatively low in black gram field near bund which ranged from 0.60 to 3.60 per $25m^2$. Whereas lowest snail population was found inside the field (0.20 to 3.00 per $25m^2$) than on bund and FNB (Table 6).

4.1.2.3.2 Per cent plant damage

On blackgram crop the damage was maximum near field bund which ranged from 0.00 to 20.60 per cent per $25m^2$, while it was minimum inside the field which ranged from 0.00 to 7.10 per $25m^2$.

4.1.2.4 Sunflower

4.1.2.4.1 Number of snails

Similar trend was observed here also. During 29^{th} std week the mean population of snail was ranged from 3.60 to 13.20 per 5m row on bund and on FNB it varied from 1.20 to 4.00 per 25 m^2 and inside the field (0.40 to 3.80 per $25m^2$), respectively. The minimum population was found during 24^{th} std week (3.60 per 5m row) on bund and (1.20 and 0.40 per 25 m^2) on both FNB and inside field, respectively (Table 7).

4.1.2.4.2 Per cent plant damage

The damage to the plant during its early stage was 19.31 and 4.65 per cent per $25m^2$ in FNB and inside the field, respectively. As the crop duration advances the per cent damage goes on decreased (*i.e* during 32^{nd} std week). While at last week of crop duration (35^{th} std week) the damage was 0.00 per cent per 25 m^2 on both FNB and inside the field, respectively.

Table 5: Incidence of *Cryptozona semirugata* on greengram in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	6.80	1.60	1.20	21.00	7.90
24	4.20	1.20	0.20	16.30	3.80
25	7.60	2.60	2.00	19.67	7.60
26	5.80	1.20	0.80	18.96	6.50
27	9.80	3.40	2.80	7.90	2.90
28	5.40	2.00	1.40	4.40	1.00
29	11.60	5.40	4.40	1.73	0.20
30	6.20	1.80	1.20	0.60	0.00
31	6.20	1.80	1.00	0.00	0.00
32	10.20	3.00	2.40	0.00	0.00
Mean	**7.38**	**2.40**	**1.74**	**11.32**	**4.27**

FNB- Field near bund

Plate 5 : Greengram plants fed by snail

Table 6: Incidence of *Cryptozona semirugata* on blackgram in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	5.20	0.60	0.20	20.60	7.10
24	4.60	0.80	0.20	13.93	2.54
25	8.20	1.20	1.00	16.77	7.69
26	5.00	0.80	0.40	18.18	5.51
27	8.60	2.00	1.80	7.85	1.91
28	5.60	1.20	0.80	3.26	1.38
29	13.20	3.60	3.00	1.73	0.70
30	8.60	0.80	0.60	0.12	0.00
31	6.40	1.60	1.40	0.00	0.00
32	10.20	2.80	2.80	0.00	0.00
33	5.40	3.00	2.40	0.00	0.00
Mean	**7.36**	**1.67**	**1.33**	**10.31**	**3.83**

FNB- Field near bund

Table 7: Incidence of *Cryptozona semirugata* on sunflower in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	5.20	1.40	0.60	19.31	4.65
24	3.60	1.20	0.40	13.83	1.64
25	8.20	1.80	1.00	16.01	5.25
26	5.00	1.40	0.80	14.58	4.53
27	8.60	3.20	0.80	6.83	1.65
28	5.60	1.60	0.60	3.50	0.88
29	13.20	4.00	3.80	1.84	0.44
30	8.60	1.40	0.60	0.30	0.15
31	6.40	1.60	0.40	0.30	0.00
32	10.20	2.40	1.60	0.20	0.00
33	5.40	2.60	2.00	0.00	0.00
34	4.60	2.20	1.60	0.00	0.00
35	6.40	3.60	2.20	0.00	0.00
Mean	**7.00**	**2.18**	**1.26**	**7.67**	**2.30**

FNB- Field near bund

4.1.2.5 Groundnut

4.1.2.5.1 Number of snails

From table 8 it is clear that, during 29th std week the mean maximum number of snails were recorded. The population was ranged from 3.20 to 11.40 per 5m row length on bund, while on FNB and inside field the population of snail was (0.80 to 4.80 per 25m^2) and (0.20 to 3.80 per 25m^2), respectively. The mean minimum population of snails were observed during 34th std week which recorded 2.20 and 1.60 snails per 25 m^2 on FNB and inside field, respectively.

4.1.2.5.2 Per cent plant damage

The damage during 1st week of crop sown (*i.e* 23rd std week) recorded 14.51 and 6.90 per cent per 25 m^2 on field and FNB, respectively. While during 32nd std week, the damage (Plate 6) was 0.81 and 0.20 per cent per 25 m^2 on field and FNB, respectively. During harvesting stage of crop (36th std week) the per cent damage was nil on both FNB and inside the field, respectively.

4.1.2.6 Sesamum

4.1.2.6.1 Number of snails

During 29th std week, the mean maximum number of snail was found on FNB and inside the field (4.60 and 2.00 per 25 m^2, respectively). The mean minimum snail number was recorded during 24th std week on FNB (0.20 per 25 m^2) and was 0.40 per 25m^2 inside the field, respectively (Table 9).

4.1.2.6.2 Per cent plant damage

The damage was found maximum during 23rd std week which recorded 11.10 and 5.60 per cent per 25 m^2 on FNB and inside field, respectively. The mean minimum damage was observed during 31st std week (0.30 and 0.10 per cent per 25 m^2) on FNB and inside field, respectively.

4.1.2.7 Soybean

4.1.2.7.1 Number of snails

From the data presented in table 10, it is clear that the snail population was maximum during 36th std week (13.00 per 5m row on bund) and (5.80 and 4.80 per 25m^2 on FNB and inside field). The population gradually decreased with decrease in rainfall *i.e* during 34th std week (3.20 per 5m row on bund) and (2.20 and 1.80 per 25 m^2) on FNB and inside field, respectively.

4.1.2.7.2 Per cent plant damage

It is clear from the table 10, the per cent damage (Plate 7) was maximum during first week of crop (23rd std week) which was ranged from 0.02 to 20.80 per cent per 25m^2 on FNB and (0.12 to 7.60 per 25m^2) inside the field. The damage gradually decreased during 34th std week (0.02 and 0.00 per cent per 25 m^2) on FNB and field, while during harvesting stage the per cent damage was (0.00) on both FNB and inside the field per 25 m^2.

4.1.2.8 Cotton

4.1.2.8.1 Number of snails

The data presented in table 11 on the incidence of *C. semirugata* on cotton crop revealed that the first appearance of snails was noticed during 23rd standard week and persisted in field up to 46th standard week.

The snail population on bund was more which ranged from 1.00 to 16.00 per 5m row length. Whereas the population of snails was comparatively low in cotton field near bund which ranged from 0.20 to 6.60 per 25m^2 in different standard weeks. The population of snail on cotton crop inside the field was lowest which ranged from 0.20 to 5.20 per 25m^2 compared to FNB.

4.1.2.8.2 Per cent plant damage

The damage to cotton crop was more near field bund which ranged from 0.10 to 16.50 per cent per 25m^2, while it was minimum inside the field (0.20 to 8.00 per cent per 25m^2).

Table 8: Incidence of *Cryptozona semirugata* on groundnut in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	7.60	1.40	0.60	14.51	6.90
24	4.60	0.80	0.20	9.32	2.18
25	4.80	2.20	1.00	13.72	4.88
26	6.20	1.40	0.40	13.00	3.50
27	9.20	3.60	3.20	9.67	2.21
28	4.40	2.80	2.20	4.22	0.82
29	11.40	4.60	3.60	3.96	0.30
30	6.40	1.80	0.80	2.87	0.80
31	5.60	2.20	1.60	1.67	0.30
32	9.80	3.00	3.60	0.81	0.20
33	7.20	2.20	1.20	0.00	0.00
34	3.20	2.20	1.60	0.00	0.00
35	10.60	3.80	2.40	0.00	0.00
36	10.60	5.80	3.80	0.00	0.00
Mean	**7.25**	**2.70**	**1.87**	**7.37**	**2.20**

FNB- Field near bund

Plate 6 : Snail damaging on groundnut

Table 9: Incidence of *Cryptozona semirugata* on sesamum in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	6.80	1.20	0.40	11.10	5.60
24	3.80	0.20	1.60	5.80	2.65
25	7.40	2.20	1.00	10.50	5.27
26	6.40	1.00	1.00	5.17	3.19
27	9.60	3.00	1.60	3.90	1.70
28	5.40	1.80	0.60	3.30	1.50
29	11.40	4.60	2.00	2.60	1.20
30	6.40	2.00	1.20	2.20	0.90
31	5.80	1.80	0.80	0.30	0.10
32	10.20	2.20	1.20	0.00	0.00
33	6.80	1.80	1.20	0.00	0.00
34	2.80	2.60	1.60	0.00	0.00
Mean	**6.90**	**2.44**	**1.42**	**4.98**	**2.45**

FNB- Field near bund

Table 10: Incidence of *Cryptozona semirugata* on soybean in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	7.20	2.20	1.60	20.80	7.60
24	4.60	2.00	1.20	14.60	3.40
25	8.20	3.40	3.00	21.00	7.40
26	6.80	2.40	1.80	19.20	6.50
27	9.40	4.60	4.20	16.37	3.66
28	5.40	2.40	1.80	10.58	1.99
29	12.40	6.20	5.00	7.42	1.77
30	6.80	2.80	2.20	5.20	0.40
31	6.40	2.20	1.80	4.29	0.37
32	10.80	3.80	3.00	1.46	0.12
33	7.20	2.60	2.20	0.82	0.00
34	3.20	2.20	1.80	0.02	0.00
35	11.20	4.20	3.60	0.00	0.00
36	13.00	5.80	4.80	0.00	0.00
Mean	**8.04**	**3.34**	**2.70**	**10.14**	**3.32**

FNB- Field near bund

Plate 7 : Snail damage to soybean seedlings

Table 11: Incidence of *Cryptozona semirugata* on cotton in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	6.20	1.40	0.60	16.50	8.00
24	4.80	1.20	0.30	12.40	2.00
25	7.60	2.80	1.20	16.10	8.00
26	6.20	4.20	1.40	14.30	7.60
27	8.20	3.80	2.40	11.70	6.10
28	6.80	2.20	1.00	6.70	3.00
29	11.60	5.60	4.00	6.50	2.60
30	5.40	2.20	1.00	6.20	2.10
31	5.40	1.60	0.80	5.19	1.10
32	9.40	3.40	2.20	3.96	0.80
33	7.00	2.20	0.80	2.90	0.40
34	3.80	0.80	0.00	2.57	0.60
35	10.00	3.60	2.40	2.71	0.24
36	10.20	4.60	3.20	2.77	0.19
37	5.80	2.00	1.20	3.08	0.34
38	2.20	0.40	0.00	0.30	0.31
39	16.00	6.20	4.60	0.10	0.20
40	11.20	6.60	5.20	0.00	0.00
41	9.40	4.60	3.40	0.00	0.00
42	2.80	0.80	0.20	0.00	0.00
43	6.40	2.20	1.00	0.00	0.00
44	7.60	5.20	4.00	0.00	0.00
45	1.00	0.20	0.00	0.00	0.00
46	1.20	0.20	0.00	0.00	0.00
Mean	**6.92**	**2.83**	**2.04**	**6.70**	**2.56**

FNB- Field near bund

4.1.2.9 Chilli

4.1.2.9.1 Number of snails

From the table 12, it is evident that the snail population was maximum on bund which varied from 4.80 to 15.20 per 5m row length, while the population of snails was comparatively low in chilli field near bund which ranged from 1.20 to 4.00 per $25m^2$ in different standard weeks.

The population of snail on chilli crop inside the field was lowest which ranged from 0.20 to 3.20 per $25m^2$ compared to FNB.

4.1.2.9.2 Per cent plant damage

The damage to chilli crop was more near field bund which ranged from 0.27 to 23.10 per cent per $25m^2$, whereas it was minimum inside the field which ranged from 0.54 to 9.13 per cent per $25m^2$.

4.1.2.10 Onion

4.1.2.10.1 Number of snails

The data presented in table 13 on the incidence of *C. semirugata* on onion revealed that the first appearance of snails were noticed during 23^{rd} standard week and persisted in field up to 34^{th} standard week.

The snail population on bund was more which ranged from 4.40 to 14.60 per 5m row length, whereas the population of snail was comparatively low in onion field near bund which ranged from 1.00 to 3.50 per $25m^2$ in different standard weeks. The population of snail on onion crop inside the field was lowest which ranged from 0.20 to 2.80 per $25m^2$ compared to FNB.

4.1.2.10.2 Per cent plant damage

The damage to onion (Plate 8) was more near field bund which ranged from 0.16 to 5.90 per cent, while it was minimum inside the field which ranged from 0.12 to 3.23 per cent.

4.1.2.11 Tomato

4.1.2.11.1 Number of snails

From table 14, it is revealed that the maximum number of snails was found on bund which ranged from 3.80 to 14.60 per 5m row length, this was followed by field near bund which ranged from 0.80 to 3.20 per $25m^2$. Whereas the population of snail was lowest on tomato crop which ranged from 0.20 to 2.40 per $25m^2$ compared to FNB

4.1.2.11.2 Per cent plant damage

The damage to tomato crop was more near field bund which ranged from 0.22 to 25.77 per cent per $25m^2$, while the per cent damage to plant was minimum inside the field which ranged from 0.10 to 4.81 per cent per $25m^2$.

4.1.3 Comparative analysis of incidence of *Cryptozona semirugata* in different crops

The comparative analysis on the incidence of snail, *C. semirugata* on different crops indicated that there was no much variation in the number of snail recorded per 5m row length on different crops (Table 15).

The snail population in field near bund in different crops also did not vary very much which ranged from 1.67 to 3.34 per $25m^2$. The snail population inside the field in different crops ranged from 0.88 to 2.04 per $25m^2$ with a maximum of 2.04 per $25m^2$ in cotton and a minimum of 0.88 per $25m^2$ in tomato.

With regard to per cent plant damage in different crops in fields near bund revealed greater variation which ranged from 3.32 to 11.32 per cent. The data clearly indicates that greengram was very much preferred (11.32 per cent) closely followed by blackgram (10.31 per cent), soybean (10.14 per cent) and chilli (9.07 per cent). While the other crops like maize (3.32 per cent), tomato (3.39 per cent), onion (3.61 per cent) and sesamum (4.98 per cent) were least preferred. The per cent plant damage on different crops inside the field did not vary very much which ranged from 1.84 to 4.45 per cent.

Table 12: Incidence of *Cryptozona semirugata* on chilli in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	7.40	1.60	0.60	23.10	9.13
24	5.20	1.20	0.20	14.51	3.56
25	10.20	2.60	1.80	21.35	7.83
26	6.40	1.60	0.80	10.27	7.29
27	10.40	3.80	3.20	5.40	3.78
28	6.40	2.80	1.40	4.05	2.43
29	15.20	4.00	3.20	1.62	1.08
30	8.80	1.40	0.40	1.08	0.54
31	7.40	1.60	0.80	0.27	0.00
32	12.40	2.60	1.60	0.00	0.00
33	5.60	2.20	1.00	0.00	0.00
34	4.80	1.40	0.40	0.00	0.00
Mean	**8.35**	**2.23**	**1.28**	**9.07**	**4.45**

FNB- Field near bund

Table 13: Incidence of *Cryptozona semirugata* on onion in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	7.00	2.40	1.20	5.90	3.23
24	4.40	1.60	0.80	3.22	2.37
25	9.40	2.40	2.00	6.13	3.69
26	5.80	1.00	0.00	5.79	3.33
27	9.60	2.80	1.20	4.93	1.98
28	6.20	2.20	1.00	2.17	0.81
29	14.60	3.40	2.80	0.63	0.12
30	8.60	1.20	0.20	0.16	0.00
31	7.20	3.50	0.80	0.00	0.00
32	11.80	2.20	2.20	0.00	0.00
33	6.00	2.60	1.00	0.00	0.00
34	4.60	2.00	0.80	0.00	0.00
Mean	**7.93**	**2.27**	**1.27**	**3.61**	**2.21**

FNB- Field near bund

Plate 8 : Snails in onion field

Table 14: Incidence of *Cryptozona semirugata* on tomato in MARS, Dharwad

Meterological Standard week	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
18	-	-	-	-	-
19	-	-	-	-	-
20	-	-	-	-	-
21	-	-	-	-	-
22	-	-	-	-	-
23	6.80	2.00	0.80	5.77	4.81
24	3.80	1.40	0.20	2.47	1.59
25	9.40	2.20	1.20	7.04	5.17
26	5.80	0.80	0.20	7.41	3.72
27	9.60	2.40	1.20	5.03	2.94
28	6.20	1.80	0.40	3.12	1.76
29	14.60	2.80	2.00	1.77	0.88
30	8.60	0.80	0.20	0.65	0.22
31	7.00	0.80	0.00	0.44	0.10
32	11.80	1.80	0.60	0.22	0.00
33	6.00	2.00	1.00	0.00	0.00
34	4.60	1.60	0.40	0.00	0.00
35	6.40	3.20	2.40	0.00	0.00
Mean	**7.73**	**1.81**	**0.88**	**3.39**	**2.35**

FNB- Field near bund

Table 15: Comparative data on the mean incidence of *Cryptozona semirugata* on different crops

Crops	Number of snails			Per cent plant damage	
	Bund (Per 5m row length)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)	FNB (Per 25 m^2)	Inside field (Per 25 m^2)
Maize	7.89	2.13	1.33	3.32	1.84
Green gram	7.38	2.40	1.74	11.32	4.27
Blackgram	7.36	1.67	1.33	10.31	3.83
Cotton	6.92	2.83	2.04	6.70	2.56
Chilli	8.35	2.23	1.28	9.07	4.45
Soybean	8.04	3.34	2.70	10.14	3.32
Groundnut	7.25	2.70	1.87	7.37	2.20
Sesamum	6.90	2.44	1.42	4.98	2.45
Sunflower	7.00	2.18	1.26	7.67	2.30
Onion	7.93	2.27	1.27	3.61	2.21
Tomato	7.73	1.81	0.88	3.39	2.35

FNB- Field near bund

4.1.4 Correlation Co-efficient between snails and weather parameters during *kharif*, 2012

Snail population was positively and significantly correlated with rainfall, maximum and minimum RH, irrespective of the crops whereas it was negatively and significantly correlated with maximum and minimum temperature (Table 16).

4.2 Influence of different levels of *Cryptozona semirugata* infestation on plant damage and leaf area consumption in greengram during *kharif*, 2012

The results of infestation on plant damage and leaf area consumption in green gram due to *C. semirugata* in caged condition with different levels of snail released at 7, 15 and 30 days after sowing (DAS) are presented in the table 17.

4.2.1 Per cent plant damage

The per cent plant damage in different treatments with differential levels of snails released indicated that the mean per cent plant damage decreased (42.89 to 26.14 per cent) with advancement of crop age from 7 to 30 DAS. Similarly mean per cent plant damage at different levels of snail population ranged from 24.76 to 61.52 per cent being highest (61.52 per cent) at ten snails per treatment and lowest (24.26 per cent) at two snails per treatment. However in control where the crop was caged without releasing any snails did not record any damage.

The data from table 17 also indicated that, there was increase in the plant damage as the snail number per treatment increased from 2 to 10 which ranged from 23.67 to 98.67 per cent at 7 DAS

At 15 DAS, the damage varied from 16.67 to 73.00 per cent in the treatments where 2 to 10 snails were released per treatment. However, the minimum plant damage was noticed at 30 DAS (13.00 to 43.67 per cent). The per cent plant damage decreased with advancement of crop age.

4.2.2 Per cent leaf area consumption

With regard to mean per cent leaf area consumption, it decreased (44.41 to 38.30 per cent) with advancement of crop age from 7 to 15 DAS. Likewise per cent leaf area consumption increased from 30.88 to 66.79 per cent with increase in the number of snails released from 2 to 10 being highest in treatment where 10 snails per treatment were released. However in control no damage was seen to the leaves in the crop which was completely protected from snail damage by caging.

The maximum leaf area consumption was observed at initial stage of snail release *i.e.,*7 DAS, but at later stages the consumption of leaf area decreased at all pest densities (2 to 10 snail per treatment). At 7 DAS, the per cent leaf area consumption varied from 37.96 to 72.53. The maximum leaf area consumption was observed with 10 snail per treatment (72.53 per cent) followed by 8 snail per treatment (61.42 per cent), 6 snail per treatment (48.15 per cent), 4 snail per treatment (46.41 per cent), 2 snail per treatment (37.96 per cent) and no damage under control (0.00 per cent).

At 15 DAS, the per cent leaf area consumption varied between 34.69 to 67.59 per cent. The maximum per cent consumption was observed in the treatment with 10 snails per treatment (67.59 per cent) followed by 8, 6, 4 and 2 snails per treatment (57.89, 46.79, 44.20 and 34.69 per cent, respectively). However, there was no damage in control treatment.

The data obtained at 30 DAS on per cent leaf area consumption ranged from 0.00 to 60.24 per cent. The maximum damage was recorded in treatment with 10 snails per treatment (60.24 per cent) followed by 8 snails per treatment (54.54 per cent). Whereas, the other treatments (6,4 and 2 snails per treatment) recorded 43.69, 39.34, 32.00 per cent, respectively. However, no damage was found in control treatment.

4.3 Management of snail, *Cryptozona semirugata* on greengram

Data recorded on the efficacy of different treatments against the snail, *C. semirugata* are presented in tables 18 to 21.

Table 16: Correlation coefficient between snail, *Cryptozona semirugata* and weather parameters on different crops during *Kharif*, 2012

Parameters	Maize	Green gram	Black gram	Sunflower	Groundnut	Sesamum	Soybean	Cotton	Chilli	Onion	Tomato
Rainfall	0.87**	0.92**	0.94**	0.93**	0.87**	0.90**	0.84**	0.56**	0.85**	0.87**	0.87**
Max. RH	0.67**	0.87**	0.83**	0.68**	0.69**	0.71**	0.75**	0.39*	0.73**	0.70**	0.84**
Min. RH	0.15*	0.89**	0.54**	0.21*	0.02*	0.36*	0.09*	0.28*	0.45*	0.38*	0.35*
Max. temp.	-0.68*	-0.87*	-0.80*	-0.74*	-0.78*	-0.74*	-0.76*	-0.37*	-0.64*	-0.68*	-0.66*
Min. temp.	0.26*	-0.45*	0.14*	0.26*	0.44*	0.16*	0.39*	0.30*	0.04*	0.11*	0.12*

* Significant at P=0.05 Max.- Maximum Temp.- temperature
** Significant at P=0.01 Min.- Minimum RH- Relative humidity

Table 17: Greengram plant damage due to *Cryptozona semirugata* at different stages of crop growth under shade condition with different levels of release of snails

Treatments	Per cent plant damage				Per cent leaf area consumption			
Duration (D) → / No. of Snails released (S) ↓	7 DAS	15 DAS	30 DAS	Mean	7 DAS	15 DAS	30 DAS	Mean
2	23.67 (29.10)	16.67 (24.07)	13.00 (21.12)	24.76	37.96 (37.86)	34.69 (32.42)	32.00 (28.12)	34.88
4	35.67 (36.65)	34.33 (35.85)	21.33 (27.50)	33.33	46.41 (52.49)	44.20 (48.63)	39.34 (40.23)	43.32
6	54.33 (47.47)	44.33 (41.73)	25.67 (30.42)	39.87	48.15 (55.52)	46.79 (53.14)	43.69 (47.75)	46.21
8	74.33 (59.55)	55.67 (48.24)	35.33 (36.46)	48.08	61.42 (77.09)	57.89 (71.78)	54.54 (66.34)	57.95
10	98.67 (84.55)	73.00 (58.67)	43.67 (41.34)	61.52	72.53 (90.97)	67.59 (85.45)	60.24 (75.33)	66.79
Control (without release of snails)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Mean	42.89	34.76	26.14		44.41	41.86	38.30	44.41
	S.Em.±		**CD@1%**		**S.Em.±**		**CD@1%**	
D	0.33		1.27		0.34		1.30	
S	0.47		1.79		0.48		1.84	
DxS	0.81		3.10		0.83		3.18	

Figures in the parenthesis are arc sine transformed values
DAS= Days after sowing D= Duration of plants S= Number of snails released D×S= Interaction between duration of plants and number of snails.

4.3.1 First application

During first application as there was no natural infestation of snails in greengram field, the sufficient number of *C. semirugata* were collected from farmer's fields and uniform sized snails were released at 20 per each treatment.

The per cent mortality of snails at 1 DAT indicated that metaldehyde was highly effective in controlling the snail (Plate 9) by recording 92.67 per cent mortality followed by common crystal salt (83.33 per cent) (Plate 10) , copper sulphate (70.33 per cent) (Plate 11) and bleaching powder (68.33 per cent) (Plate 12). Tobacco decoction (0.67 per cent) and fenvalerate (0.67 per cent) were totally ineffective in controlling the snails as they were on par with untreated control (0.33 per cent) (Plate 13). These were followed by malathion (3 per cent) and lime powder (6.25 per cent) as evident from table 18.

The efficacy of different treatments remained exactly same at 3, 5 and 7 DAT. The cumulative mean per cent mortality in different treatments revealed that metaldehyde was found highly effective by recording maximum of 94.17 per cent mortality being significantly superior to all other treatments. The next best treatments were common crystal salt (87.83 per cent), copper sulphate (72.33 per cent) and bleaching powder (69.92 per cent). However, tobacco decoction was ineffective in controlling the snails as it was statistically on par with untreated control. Both insecticidal dust *viz.*, fenvalerate 0.4 dust and malathion 5% dust were also ineffective in controlling the snails.

4.3.2 Second application

During second application, the snail *C. semirugata* were collected from fields and uniform sized snails were released at 15 per each treatment as there was no natural infestation of snails in greengram field.

The per cent mortality of snails at 1 DAT revealed that metaldehyde was highly effective in controlling of snail by recording 93.67 per cent followed by common crystal salt (88.67 per cent), copper sulphate (71.00 per cent) and bleaching powder (68.67 per cent). Tobacco decoction (0.33 per cent) and fenvalerate (0.67 per cent) were totally ineffective in controlling the snails as they were on par with untreated control (0.33 per cent). These were followed by malathion (3.67 per cent). Lime powder (7.33 per cent) and monocrotophos (10.37 per cent) were less effective showing on par with each other (Table 19).

Similar trend was observed at 3, 5 and 7 DAT. The cumulative mean per cent mortality in different treatments observed that the metaldehyde was found highly effective (95.58 per cent) being significantly superior to all other treatments. The next best treatments were common crystal salt (89.67 per cent) and copper sulphate (71.92 per cent). Whereas tobacco decoction (0.33 per cent) and fenvalerate (0.67 per cent) were ineffective in controlling the snails as these were statistically on par with untreated control (0.33 per cent).

4.3.3 Third application

Similar observations were noticed on third round of application also. Wherein, metaldehyde (94.00 per cent) and common crystal salt (86.56 per cent) were emerged as best treatments at 1 DAT. Whereas fenvalerate (0.33 per cent) and tobacco decoction (0.33 per cent) were not at all effective in controlling of snails as they were on par with untreated control (0.33 per cent) (Table 20).

The efficacy of different treatments remained exactly same at 3, 5 and 7 DAT. The cumulative mean per cent mortality in different treatments revealed that metaldehyde (94.75 per cent) was found highly effective and significantly superior to all other treatments. This was followed by common crystal salt (89.59 per cent) and copper sulphate (72.42 per cent). However, tobacco decoction (0.50 per cent) and fenvalerate (0.50 per cent) were totally ineffective for control of snail as it was statistically on par with untreated control (0.33 per cent).

The comparative data of all the three applications noticed highest cumulative mean in treatment metaldehyde (94.83 per cent mortality) followed by common crystal salt, copper sulphate and bleaching powder (89.03, 72.22 and 70.08 per cent mortality, respectively). Whereas, fenvalerate (0.47) and tobacco decoction (0.50) recorded least per cent of cumulative mean (Table 21).

4.3.4 Yield

The grain yield of greengram (var. shining moong) as influenced by different treatments recorded from 3.32 to 6.39 q/ha. Metaldehyde 2.5% pellets was found highly effective in recording highest grain yield of 6.39 q/ha being statistically on par with common crystal salt (6.3q/ha) and bleaching powder (5.88q/ha) (Table 22).

Table 18: Evaluation of different treatments against *Cryptozona semirugata* under field condition at 15DAS (1st application)

Treatments	Dosage	Per cent mortality				Cumulative Mean
		1 DAT	3 DAT	5 DAT	7 DAT	
Metaldehyde 2.5% pellet	5 kg/ha	92.67 (74.43)[a]	94.00 (75.85)[a]	94.33 (76.24)[a]	95.67 (78.00)[a]	94.17 (76.12)[a]
Copper sulphate	100 g/kg bait	70.33 (57.00)[c]	72.33 (58.27)[c]	73.00 (58.70)[c]	73.67 (59.14)[c]	72.33 (58.27)[c]
Methomyl 40 SP	10 g/kg bait	46.00 (42.70)[e]	46.67 (43.09)[e]	47.67 (43.66)[e]	51.33 (45.76)[e]	47.92 (43.81)[d]
Monocrotophos 36 SL	10 ml/kg bait	10.67 (19.06)[f]	11.67 (19.97)[f]	11.33 (19.66)[f]	11.33 (19.66)[f]	11.25 (19.59)[e]
Fenvalerate 0.4 dust	25 kg/ha	0.67 (3.83)[i]	1.00 (5.74)[i]	1.00 (5.74)[i]	1.00 (5.74)[i]	0.92 (5.48)[h]
Malathion 5 dust	25 kg/ha	3.00 (9.88)[h]	4.00 (11.54)[h]	4.33 (12.00)[h]	4.33 (12.00)[h]	3.92 (11.41)[g]
Common crystal salt	25 kg/ha	86.33 (68.32)[b]	87.33 (69.21)[b]	88.33 (70.11)[b]	89.33 (70.95)[b]	87.83 (69.64)[b]
Lime powder	25 kg/ha	6.25 (14.38)[g]	6.59 (14.80)[g]	7.43 (15.75)[g]	7.43 (15.75)[g]	6.93 (15.17)[f]
Tobbaco decoction	10% solution	0.67 (3.83)[i]	0.67 (3.83)[ij]	0.67 (3.83)[ij]	0.67 (3.83)[ij]	0.67 (3.83)[hi]
Bleaching powder	25 kg/ha	68.33 (55.76)[d]	69.33 (56.39)[d]	70.67 (57.21)[d]	71.33 (57.64)[d]	69.92 (56.74)[c]
Untreated Control	-	0.33 (1.91)[i]	0.33 (1.91)[j]	0.33 (1.91)[j]	0.33 (1.91)[j]	0.33 (1.91)[i]
S.Em ±		1.23	1.07	1.15	1.13	1.02
CD @ 5 %		3.65	3.17	3.4	3.36	3.01

Note: Figures in the parentheses are arc sine transformed values.
Means followed by same letters do not differ significantly by DMRT at 0.05% level
DAT- Days after Treatment DAS- Days after sowing

Plate 9 : Mortality of snails due to metaldehyde application

Plate 10 : Mortality of snails due to effect of salt on heap of weed

Plate 11 : Mortality of snails due to effect of copper sulphate bait

Plate 12 : Effect of bleaching powder on snails over heap of weed

Plate 13 : Green gram seedlings damage by snail *Cryptozona semirugata* in field

Table 19: Evaluation of different treatments against *Cryptozona semirugata* under field condition at 25DAS (2st application)

Treatments	Dosage	Per cent mortality				Cumulative Mean
		1 DAT	3 DAT	5 DAT	7 DAT	
Metaldehyde 2.5% pellet	5 kg/ha	93.67 (75.43)[a]	95.33 (77.54)[a]	96.67 (79.60)[a]	96.67 (79.60)[a]	95.58 (77.90)[a]
Copper sulphate	100 g/kg bait	71.00 (57.42)[c]	71.67 (57.84)[c]	72.00 (58.05)[c]	73.00 (58.70)[c]	71.92 (58.00)[c]
Methomyl 40 SP	10 g/kg bait	45.89 (42.64)[e]	46.67 (43.09)[e]	47.11 (43.34)[e]	47.11 (43.34)[e]	46.69 (43.10)[d]
Monocrotophos 36 SL	10 ml/kg bait	10.37 (18.75)[f]	10.80 (19.16)[f]	11.00 (19.33)[f]	11.00 (19.33)[f]	10.79 (19.15)[e]
Fenvalerate 0.4 dust	25 kg/ha	0.67 (3.83)[h]	0.67 (3.83)[h]	0.67 (3.83)[h]	0.67 (3.83)[h]	0.67 (3.83)[g]
Malathion 5 dust	25 kg/ha	3.67 (10.96)[g]	4.67 (12.42)[g]	4.67 (12.42)[g]	4.67 (12.42)[g]	4.42 (12.07)[f]
Common crystal salt	25 kg/ha	88.67 (70.33)[b]	89.33 (70.94)[b]	90.00 (71.57)[b]	90.00 (71.57)[b]	89.67 (71.26)[b]
Lime powder	25 kg/ha	7.33 (15.66)[f]	8.00 (16.77)[f]	8.33 (15.75)[f]	8.33 (16.77)[f]	8.00 (16.41)[e]
Tobbaco decoction	10% solution	0.33 (1.91)[h]	0.33 (1.91)[h]	0.33 (3.83)[h]	0.33 (1.91)[h]	0.33 (1.91)[g]
Bleaching powder	25 kg/ha	68.67 (55.96)[d]	69.33 (56.38)[d]	71.00 (57.43)[d]	74.33 (58.59)[d]	70.83 (57.31)[c]
Untreated Control	-	0.33 (1.91)[h]	0.33 (1.91)[h]	0.33 (1.91)[h]	0.33 (1.91)[h]	0.33 (1.91)[g]
S.Em ±		1.26	1.18	1.32	1.26	1.15
CD @ 5 %		3.73	3.49	3.90	3.73	3.42

Note: Figures in the parentheses are arc sine transformed values.
Means followed by same letters do not differ significantly by DMRT at 0.05% level
DAT- Days after Treatment DAS- Days after sowing

Table 20: Evaluation of different treatments against *Cryptozona semirugata* under field condition at 35DAS (3st application)

Treatments	Dosage	Per cent mortality				Cumulative Mean
		1 DAT	3 DAT	5 DAT	7 DAT	
Metaldehyde 2.5% pellet	5 kg/ha	94.00 (75.85)[a]	94.33 (76.27)[a]	95.33 (77.58)[a]	95.33 (77.58)[a]	94.75 (76.82)[a]
Copper sulphate	100 g/kg bait	72.00 (58.05)[c]	72.00 (58.07)[c]	72.67 (58.48)[c]	73.00 (58.70)[c]	72.42 (58.32)[c]
Methomyl 40 SP	10 g/kg bait	46.44 (42.96)[e]	47.11 (43.34)[e]	47.11 (43.34)[e]	47.56 (43.60)[e]	47.06 (43.31)[d]
Monocrotophos 36 SL	10 ml/kg bait	9.67 (18.09)[f]	10.00 (19.16)[f]	11.00 (19.36)[f]	11.00 (19.36)[f]	10.42 (18.81)[e]
Fenvalerate 0.4 dust	25 kg/ha	0.33 (1.91)[i]	0.33 (1.91)[i]	0.67 (3.83)[i]	0.67 (3.83)[i]	0.50 (3.26)[h]
Malathion 5 dust	25 kg/ha	3.00 (9.97)[h]	3.33 (10.50)[h]	3.67 (11.02)[h]	3.67 (11.02)[h]	3.42 (10.64)[g]
Common crystal salt	25 kg/ha	86.56 (68.49)[b]	88.67 (70.34)[b]	91.44 (73.05)[b]	91.67 (73.31)[b]	89.59 (71.18)[b]
Lime powder	25 kg/ha	6.33 (14.51)[g]	6.33 (14.51)[g]	7.00 (15.32)[g]	7.33 (15.68)[g]	6.75 (14.94)[f]
Tobbaco decoction	10% solution	0.33 (1.91)[i]	0.33 (1.91)[i]	0.67 (3.83)[i]	0.67 (3.83)[i]	0.50 (3.26)[h]
Bleaching powder	25 kg/ha	67.67 (55.36)[d]	69.33 (56.40)[d]	70.33 (57.00)[d]	70.67 (57.21)[d]	69.50 (56.49)[c]
Untreated Control	-	0.33 (1.91)[i]	0.33 (1.91)[i]	0.33 (1.91)[i]	0.33 (1.91)[i]	0.33 (1.91)[h]
S.Em ±		1.23	1.22	1.10	1.19	1.06
CD @ 5 %		3.63	3.61	3.24	3.51	3.14

Note: Figures in the parentheses are arc sine transformed values.
Means followed by same letters do not differ significantly by DMRT at 0.05% level
DAT- Days after Treatment DAS- Days after sowing

Table 21: Comparative data of all the three applications in management of snail, *C. semirugata*

Treatments	Dosage/ha	Cumulative mean (Per cent mortality)
Metaldehyde 2.5% pellet	5 kg	94.83
Copper sulphate	60 kg bait (100 g/kg bait)	72.22
Methomyl 40 SP	60 kg bait (10 g/kg bait)	47.22
Monocrotophos 36 SL	60 kg bait (10 ml/kg bait)	10.82
Fenvalerate 0.4 dust	25 kg	0.47
Malathion 5 dust	25 kg	3.92
Common crystal salt	25 kg	89.03
Lime powder	25 kg	7.22
Tobbaco decoction	10% solution	0.50
Bleaching powder	25 kg	70.08
Untreated Control	-	0.33

All the treatments were significantly superior to untreated control. However, minimum grain yield of 3.32 q/ha was recorded in untreated control.

4.3.5 Cost economics

The analysis of cost economics in the management of snails as influenced by different treatments revealed that highest net returns of Rs. 25,328/- was recorded in common crystal salt followed by metaldehyde (Rs. 23,156/-), copper sulphate (Rs. 21,739), bleaching powder (Rs. 21,591) and methomyl (Rs. 20,659). With regard to BC ratio, highest BC ratio of 3.03 was recorded in common crystal salt compared to all other treatments. Whereas in the remaining treatments the BC ratio ranged from 2.13 to 2.59 (Table 23).

Table 22: Grain yield of greengram as influenced by different treatments

Treatments	Dosage/ha	Yield (kg/ plot)	Yield (q/ ha)
Metaldehyde 2.5%	5 kg	0.43^{a}	6.39^{a}
Copper sulphate	60 kg bait (100 g/kg bait)	0.35^{bc}	5.90^{b}
Methomyl 40 SP	60 kg bait (10 g/kg bait)	0.34^{cd}	5.64^{c}
Monocrotophos 36 SL	60 kg bait (10 ml/kg bait)	0.32^{cde}	5.41^{d}
Fenvalerate 0.4 D	25 kg	0.28^{f}	4.68^{f}
Malathion 5 D	25 kg	0.30^{ef}	4.97^{e}
Common crystal salt	25 kg	0.38^{b}	6.30^{a}
Lime powder	25 kg	0.31^{def}	5.19^{de}
Tobbaco decoction	10% solution	0.28^{f}	4.74^{f}
Bleaching powder	25 kg	0.35^{bc}	5.88^{b}
Untreated Control	-	0.20^{g}	3.32^{g}
S.Em±	-	0.0019	0.23
CD @ 5%	-	0.0056	0.69

Means followed by same letters do not differ significantly (P=0.05) by DMRT

Table 23: Cost economics as influenced by different treatments

Treatments	Dosage/ha	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs /ha)	B:C ratio
Metaldehyde 2.5%	5 kg	38355.56	15200.00	23155.56	2.52
Copper sulphate	60 kg bait (100 g/kg bait)	35378.67	13640.00	21738.67	2.59
Methomyl 40 SP	60 kg bait (10 g/kg bait)	33859.00	13200.00	20659.00	2.57
Monocrotophos 36 SL	60 kg bait (10 ml/kg bait)	32472.00	14820.00	17652.00	2.19
Fenvalerate 0.4 D	25 kg	28105.33	13175.00	14930.33	2.13
Malathion 5 D	25 kg	29837.67	13700.00	16137.67	2.18
Common crystal salt	25 kg	37778.00	12450.00	25328.00	3.03
Lime powder	25 kg	31138.33	12250.00	18888.33	2.54
Tobbaco decoction	10% solution	28429.67	12700.00	15729.67	2.24
Bleaching powder	25 kg	35266.00	13675.00	21591.00	2.58
Control	-	19943.00	12000.00	7943.00	1.66

Price of greengram per quintal during season was Rs. 6000 B:C ratio- Benefit cost ratio

DISCUSSION

Pest complex in any crop is not static in time and space, particularly in the context of its economic significance in crop production. The post-green revolution period which exhibited phenomenal growth in production also witnessed an increase in pest problems, wherein several new pests emerged and the existing ones became more severe. One such pest on greengram is snail, *Cryptozona semirugata* (Beck). In recent days snail, *C. semirugata* has gained major importance on field crops in transitional belt of Karnataka. Snails appear as sporadic pests and feed at night in damp places and destroy young shoots and roots of various plants. In Northern dry zone of Karnataka where the annual rainfall is less, the snails usually do not out number. Only during exceptional years like 1998 when the rainfall was exceptionally high, their number increased and became real menace to crop plants as they fed voraciously.

It is necessary to understand the details about, survey on the population density and extent of damage due to the snail, *C. semirugata* in different cropping ecosystems, influence of different levels of *C. semirugata* infestation on plant and leaf area consumption and devising economically and environmentally sound management strategies in greengram are discussed here under with related literature.

5.1 Survey on the population density and extent of damage due to the snail *Cryptozona semirugata* in different crops

5.1.1 Roving survey

Surveys measuring both the distribution and abundance of a pest can be used to assess the relative level of pest infestation and pest migration. A survey can identify areas of relatively high infestation and may show up seasonal patterns of occurrence in different locations. Such seasonal patterns may be related to differences in environmental conditions and may provide some understanding of factors influencing pest population dynamics, levels of infestation and or environmental factors in particular regions may be shown to be indicative of impending pest out breaks.

Field based monitoring can also be carried out to follow the progress of population development of a predefined number of pests or action threshold. This may be any number of pests from one and may indicate that pesticide application necessary.

In the present study the roving survey conducted in Hebbali Farm, Narendra and Kamlapur villages revealed the activity of snail, *C. semirugata* from 24th to 34th std. week on different crops grown by the farmers *viz.,* cotton, soybean, groundnut, potato, chilli, redgram, jowar, peas, tomato and maize. Further, the per cent plant damage was more initially during 24th standard week which coincided with seedling stage of different crops in all the villages surveyed (Fig. 1- 3).

The per cent plant damage decreased with the advancement of crop age. The literature on the activity of *C. semirugata* on different crops is very scanty. However, the pest is seen only in recent years in certain pockets of Dharwad district on different crops.

The present findings are in agreement with the study of Gupta and Doharey (1985); Sheela Thakur and Rina Kumari (1998) and Ravi Kumar *et al.* (2007) who also reported the activity of snail, *Achatina fulica* Bowdich during rainy season. In all the areas surveyed the snail population was maximum on bund, followed by field near bund and inside the fields which may be due to the presence of more moisture retention capacity, undisturbed soil without any insecticidal application on bund and immediate availability of food/ shelter (grass) after the first showers received in June are some of the probable reasons for higher population on bund.

The study also indicated non occurrence of snail *C. semirugata* in red soil areas of Narendra and Chikamalligwad throughout the cropping period which may be due to more percolation of water, less moisture holding capacity and granular texture of red soil.

5.1.2 Fixed plot survey

The comparative data on the incidence of *C. semirugata* based on fixed plot survey on different crops revealed that the population of snails were more on bund followed by FNB and inside the field. It may be because of more moisture retention capacity, undisturbed soil without any insecticidal application on bund and also immediate availability of food/ shelter (grass) after the first showers received in June are some of the probable reasons for higher population on bund (Fig. 4).

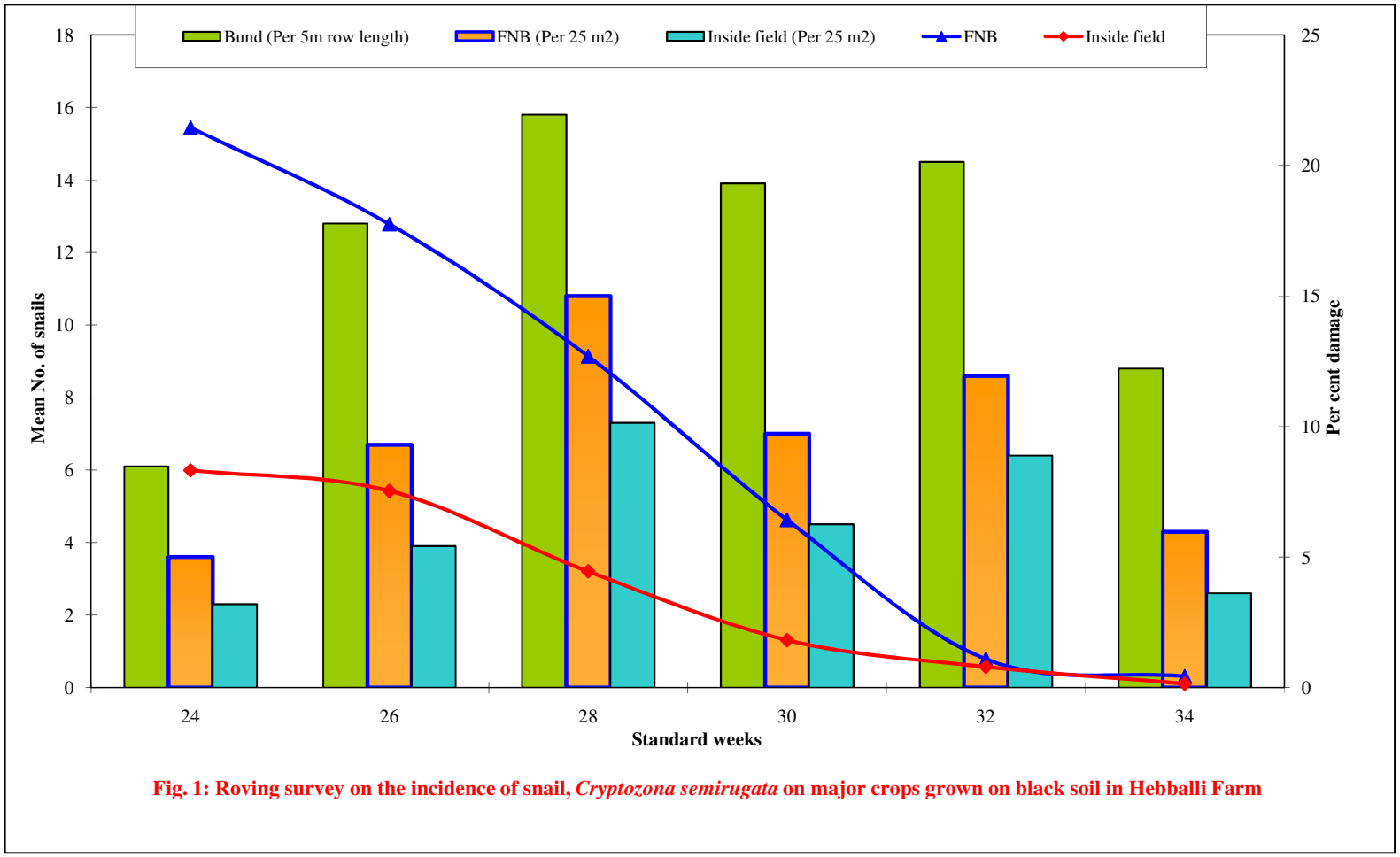

Fig. 1: Roving survey on the incidence of snail, *Cryptozona semirugata* on major crops grown on black soil in Hebballi Farm

Fig 1 : Roving survey on the incidence of snail, *Cryptozona semirugata* on major crops grown on black soil in Hebballi Farm

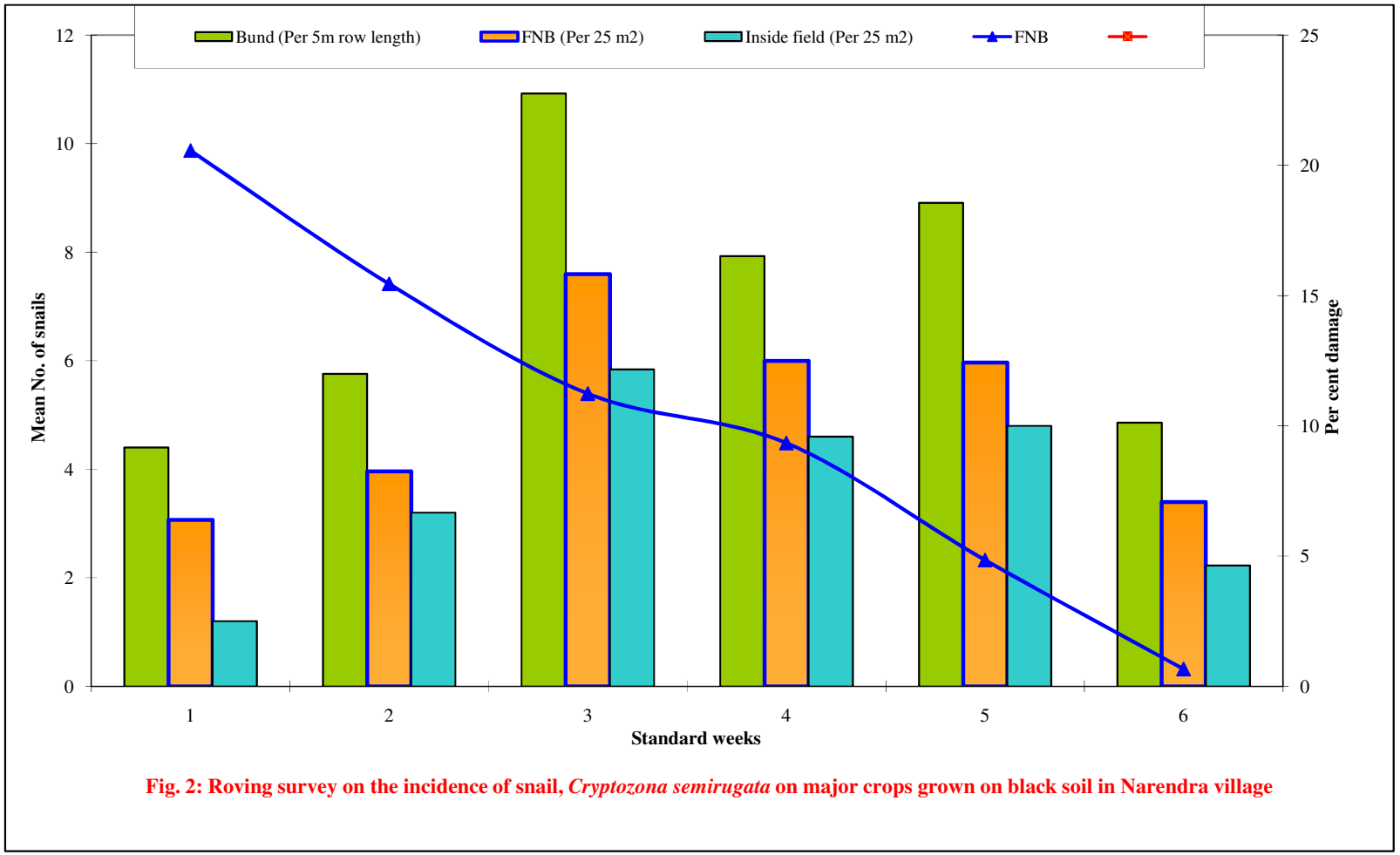

Fig. 2: Roving survey on the incidence of snail, *Cryptozona semirugata* on major crops grown on black soil in Narendra village

Fig 2 : Roving survey on the incidence of snail, *Cryptozona semirugata* on major crops grown on black soil in Narendra village

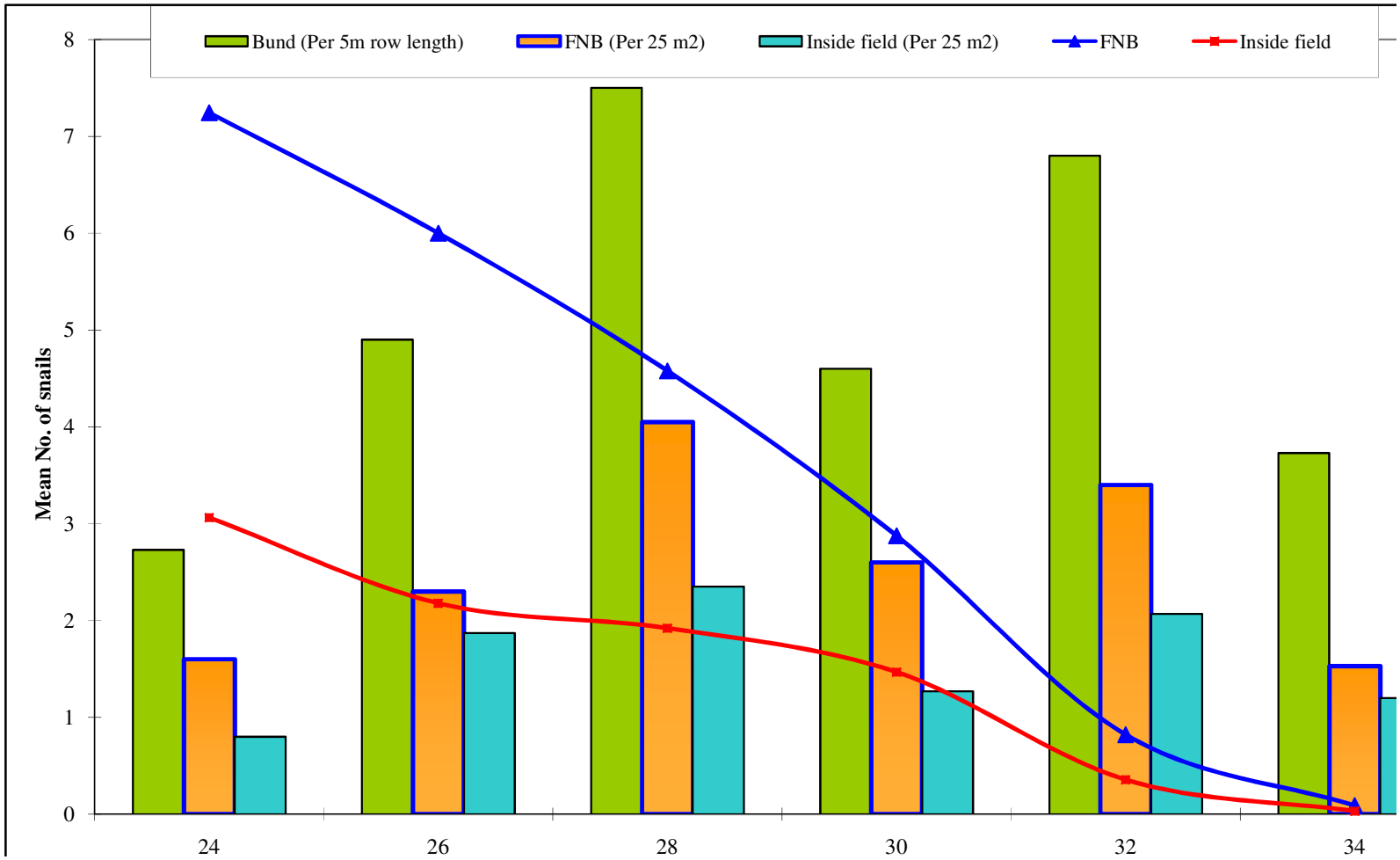

Fig 3 : Roving survey on the incidence of snail, *Cryptozona semirugata* on major crops grown on black soil in Kamalapur village

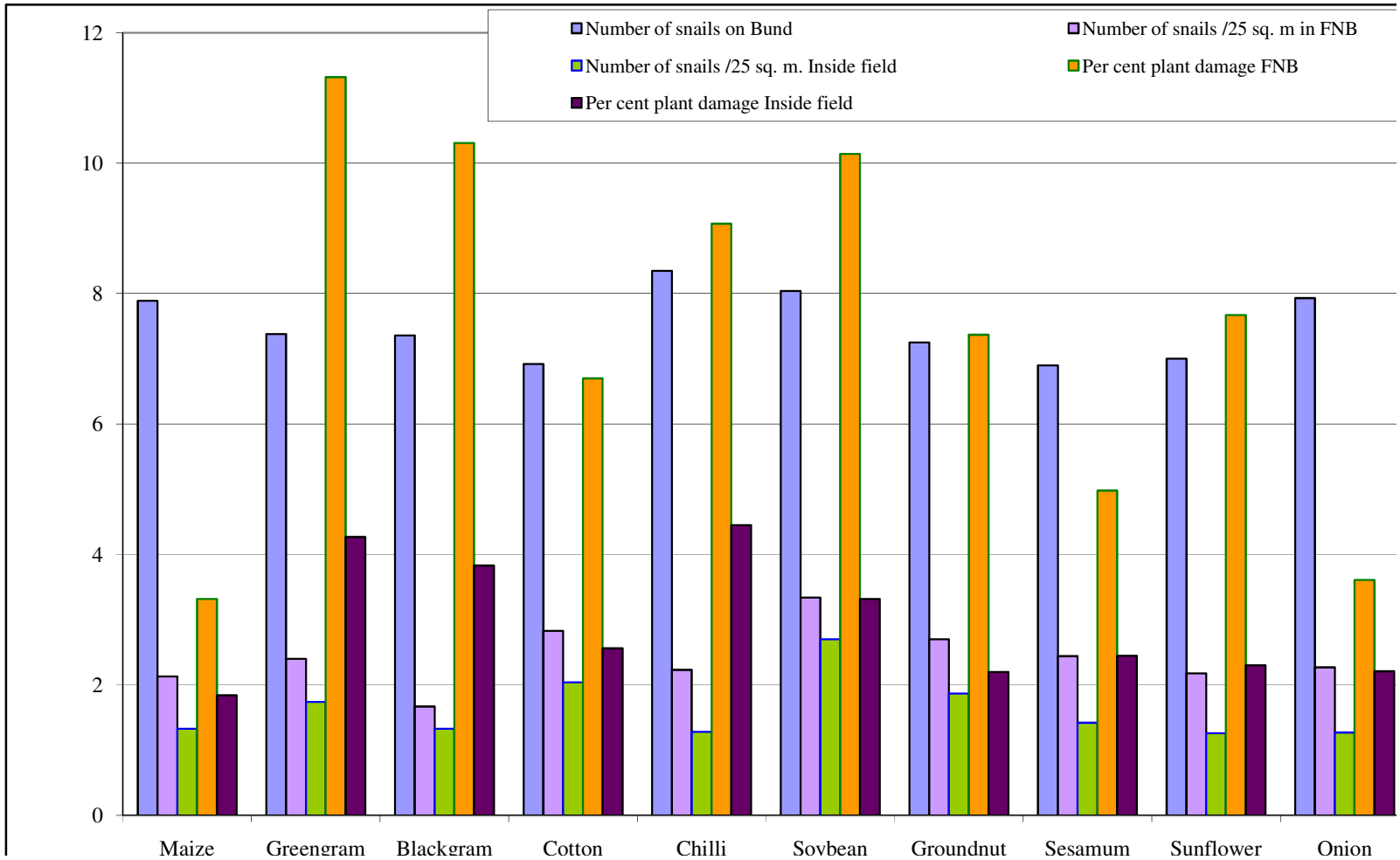

Fig 4 : Comparative data on the incidence of *Cryptozona semirugata* on different crops

Snail will come out when its requirement fulfills with the high rainfall day, cloudy weather and maximum relative humidity during rainy season. After emergence, the snails will search for its food and prefer grasses on bunds which will be always available on bunds when there are no crops near bund.

Giraddi *et al.* (1996) also reported higher population of snail, *C. semirugata* at MARS, Dharwad on bunds than in crop fields which agrees with the present investigation.

In the present study population was more on different crops near field bund than far inside the field. This may be because the snails which are found on bund on large number immediately after first showers would spend less energy for migrating from bund to cropped area and thus more population was found near bund area than inside the field.

The present findings agrees with the work of Giraddi *et al*.(1996) who also reports less population of snails found near field bund than bund which agrees with present findings.

In the present study the patterns of damage caused by *C. semirugata* on different crops varied. The per cent plant damage was more on green gram, black gram, soybean and chilli, both near field bund and inside the field. Similar observations were also made by Giraddi *et al*. (1996) who reported higher population of the snail on bund (1.40 to 14.70 per m^2) than crop fields (0.12 to 3.70 per m^2). They also reported that chilli (30.6 per cent) was most preferred crop than others.

5.1.3 Correlation Co-efficient between snails and weather parameters during *kharif*, 2012

Correlation studies between snail and weather parameters revealed that snail population was positively and significantly correlated with rainfall, maximum and minimum RH, irrespective of the crops whereas it was negatively and significantly correlated with maximum and minimum temperature (Fig. 5).

The results pertaining to correlation studies by *C. semirugata* on different crops is totally lacking. Hence the present results are compared with the work of Ravi Kumar *et al*. (2007) on *A. fulica.* They reported positive and significant correlation between *A. fulica* and weather parameters *viz.,* rainfall, maximum and minimum relative humidity. Negative and significantly correlate with maximum and minimum temperature.

5.2 Influence of different levels of *Cryptozona semirugata* infestation on plant damage and leaf area consumption in greengram during *kharif*, 2012

In the present investigation, there was increase in the plant damage and leaf area consumption as the snail number increased from 2 to 10. At the early stage of crop growth (7 DAS), the damage was more compared to later stages (15 and 30 DAS) (Fig.6a and 6b).

The reviews pertaining to per cent plant damage and per cent leaf area consumption by *C. semirugata* in green gram ecosystem are totally lacking. In the absence of relevant literature it is inferred that the plant damage was more at early stage of crop growth which may be due to soft and succulent nature of the plants. With the advancement in crop age there was decrease in the damage by snail which may be due to hard and fibrous nature of the plant becoming unpalatable to the snail.

However, Litsinger and Estano (1993) and Teo (2002) also reported higher damage by snail *Pomacea caniculata* Lamarck on young seedlings of rice (7 to 13 days old) than older seedlings (30 days old) is in agreement with present finding.

5.3 Management of snail, *Cryptozona semirugata* in greengram

Based on the results obtained on the efficacy of different treatments from all the three applications (comparative data) it is inferred that broadcasting of metaldehyde (2.5%) pellets in the field proved highly effective (94.83 per cent mortality) compared to all other treatments in recording highest mortality (Fig. 7).

The several authors *viz*., Rao (1963); Nair *et al*.(1968); Basavaraju *et al*. (2000); Basavaraju *et al*. (2001); Barwal and Dhiman (2002); Javaregowda (2006); Ravi Kumar *et al*. (2007) and Shevale and Bedse (2009) also reported the superiority of metaldehyde in controlling snails in different crops which agrees with present findings.

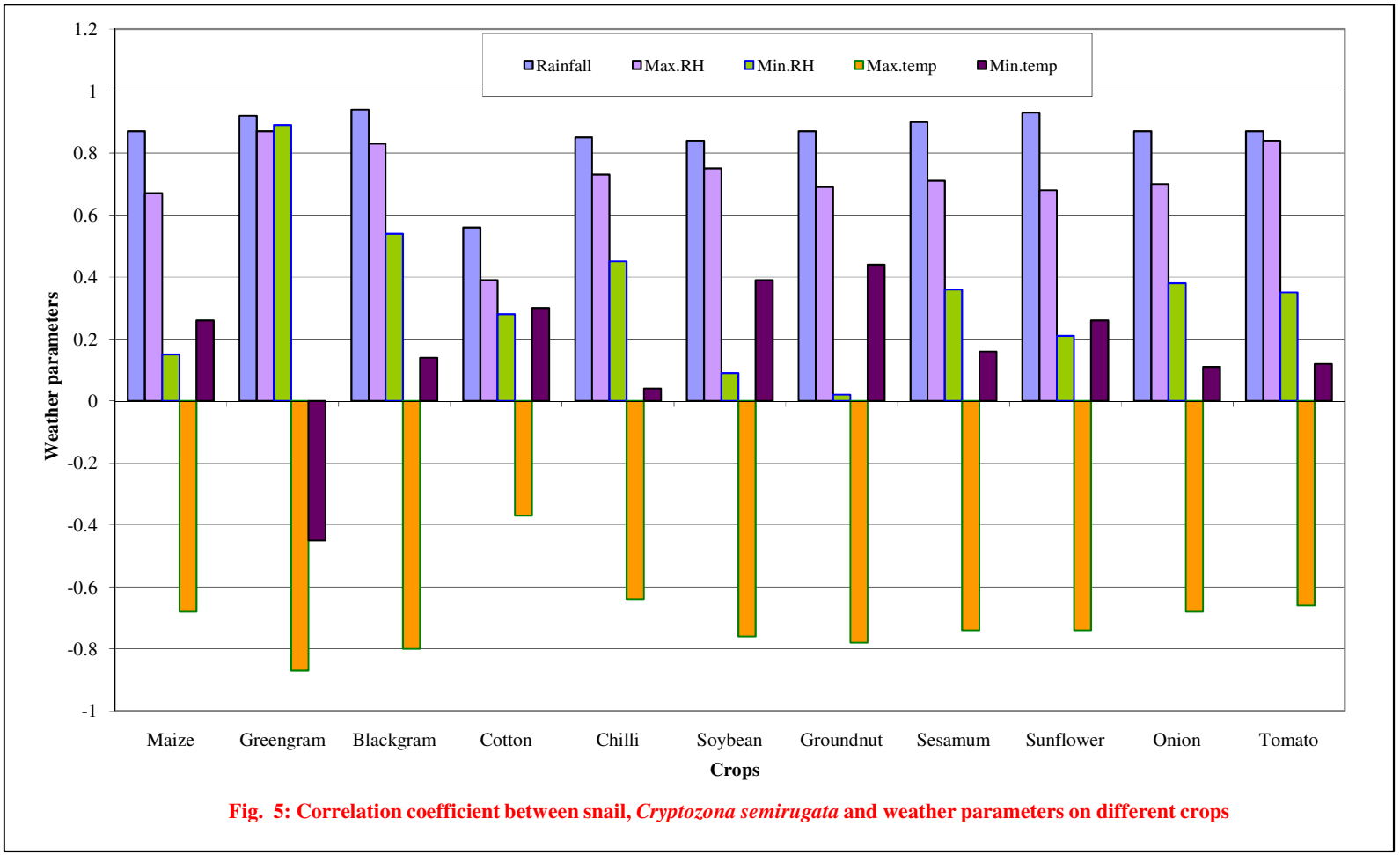

Fig. 5: Correlation coefficient between snail, *Cryptozona semirugata* and weather parameters on different crops

Fig 5 : Correlation coefficient between snail, *Cryptozona semirugata* and weather parameters on different crops

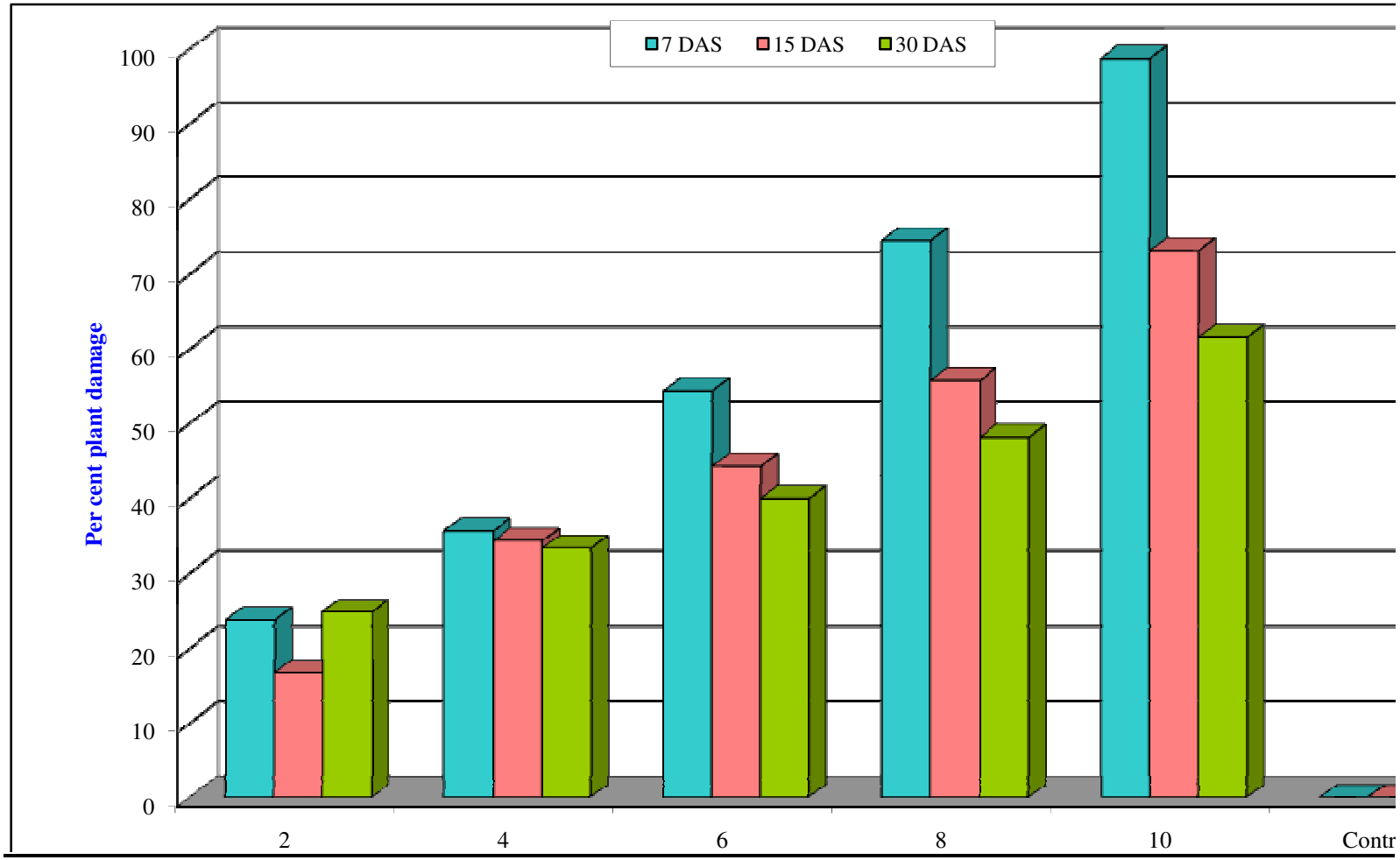

Fig 6a : Greengram per cent plant damage due to *Cryptozona semirugata* at different stages of crop growth under shade condition with different levels of release of snails

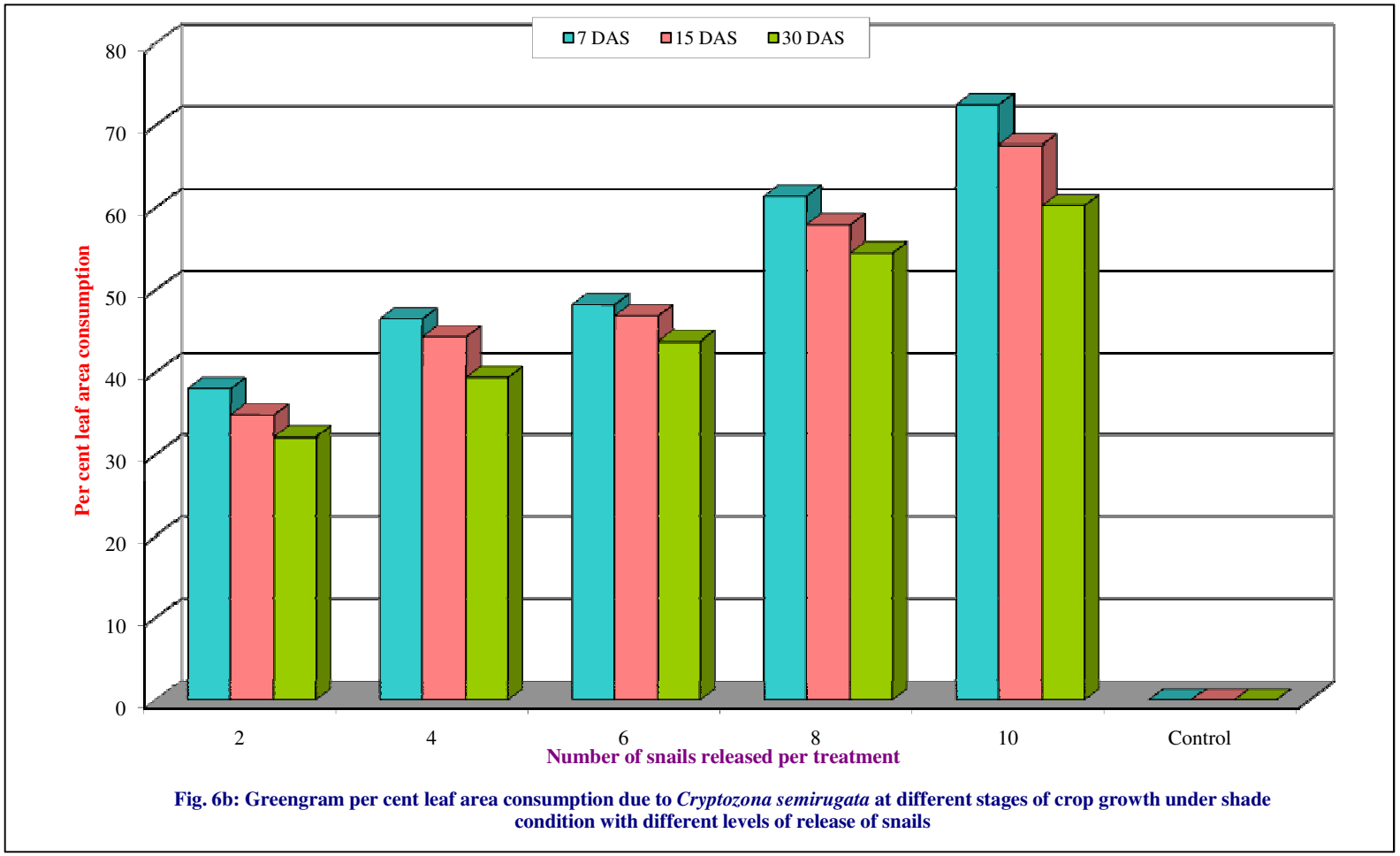

Fig. 6b: Greengram per cent leaf area consumption due to *Cryptozona semirugata* at different stages of crop growth under shade condition with different levels of release of snails

Fig 6b : Greengram per cent leaf area consumption due to *Cryptozona semirugata* at different stages of crop growth under shade condition with different levels of release of snails

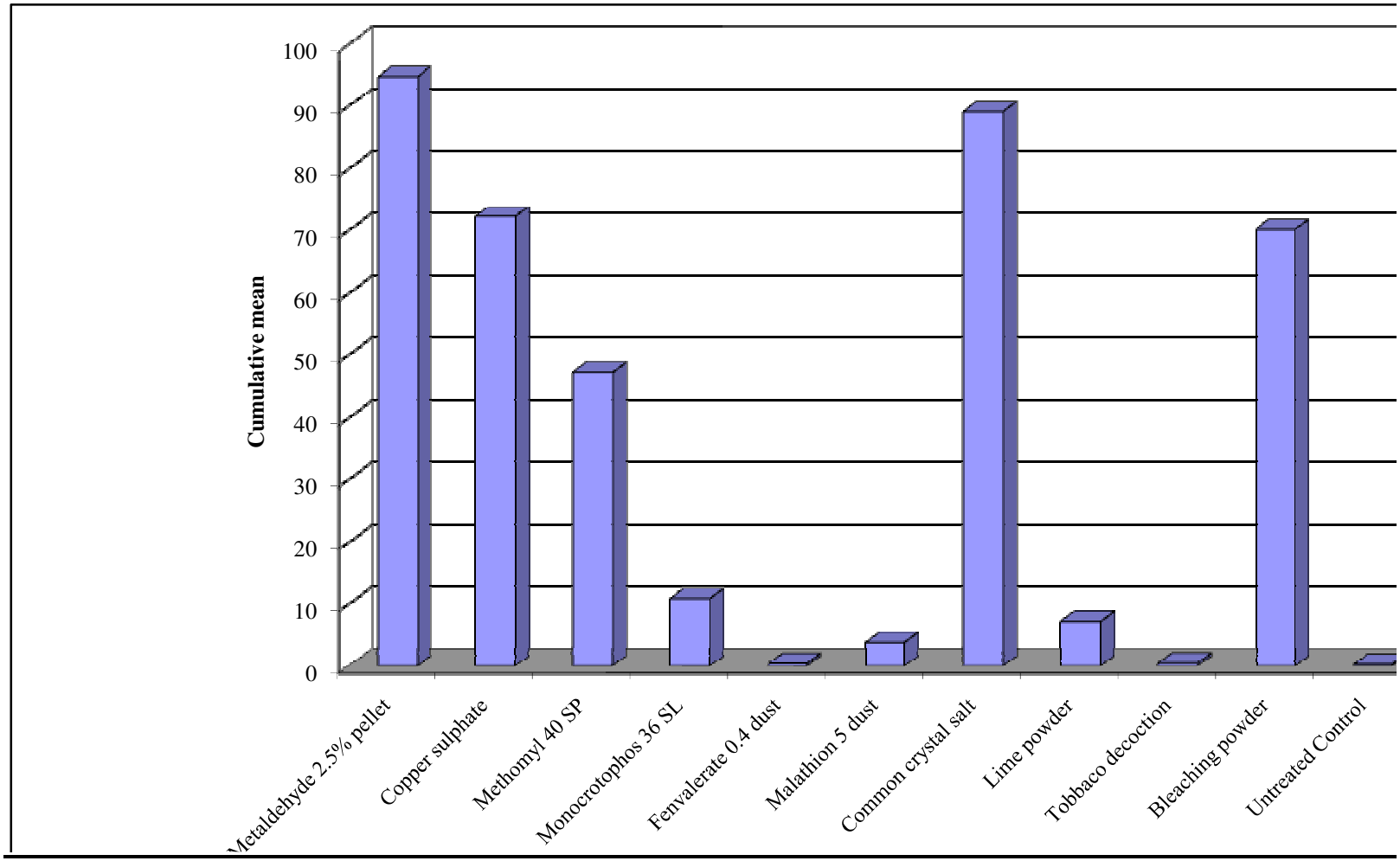

Fig 7 : Comparative data on the efficacy of different treatments in the management of snail, *Cryptozona semirugata*

The next best treatment in the present study was common crystal salt (89.03 per cent mortality) sis supported by the reports of Saxena and Dubey (1970); Shah (1992); Karnatak *et al.* (1998); Glen *et al.* (2000); Mahrous *et al.* (2002) and Shyam Prasad *et al.* (2004).

In the present study copper sulphate (72.22 per cent mortality) was also proved effective in controlling the snail which was also documented with the findings of Saxena and Dubey (1970); Bharadwaj (1972); Kakoty *et al.* (1987); Schwartz and Capatos (1990) and Kumar *et al.,* (2007) in different crops.

However, lime powder and tobacco decoction were found ineffective in controlling the snails which is supported by the findings of Subramanya (1983); Ravi Kumar *et al.* (2007); Shevale and Bedse (2009)

5.3.1 Yield

In the present study highest grain yield was noticed in metaldehyde and common crystal salt (6.39 and 6.30 q/ha, respectively). These were followed by application of copper sulphate (5.90 q/ha) and bleaching powder (5.88 q/ha) (Fig. 8).The results of the present study on the efficacy of these treatments in recording highest yield of green gram cannot be compared in the absence of relevant literature.

5.3.2 Cost economics

Highest net returns of Rs. 25,328/ha and Rs. 23,155/ha was realised in common crystal salt and metaldehyde with a BC ratio of 3.03 and 2.52 respectively (Fig. 9). The results of the present findings cannot be compared in the absence of related literature.

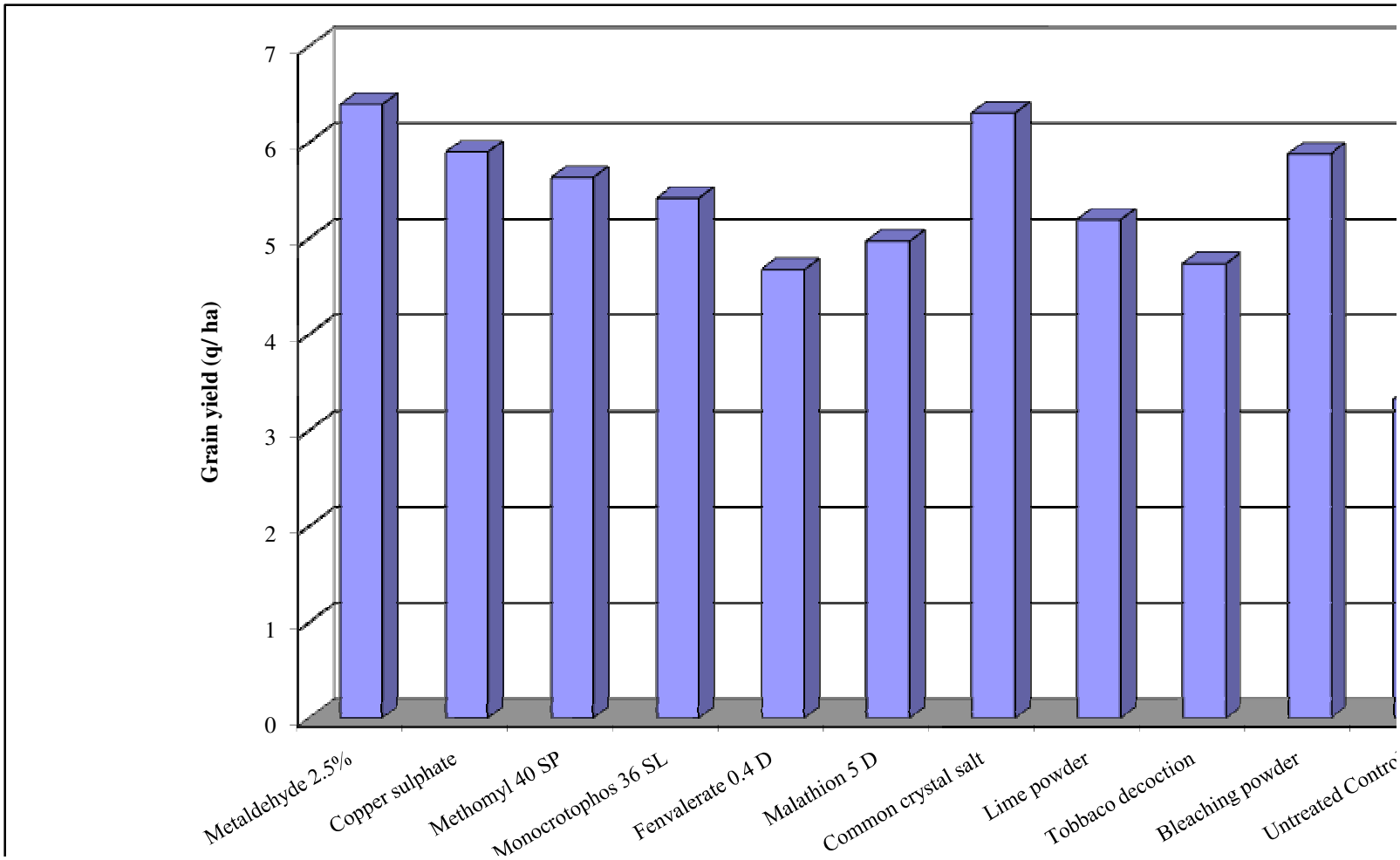

Fig 8 : Grain yield of greengram as influenced by different treatments

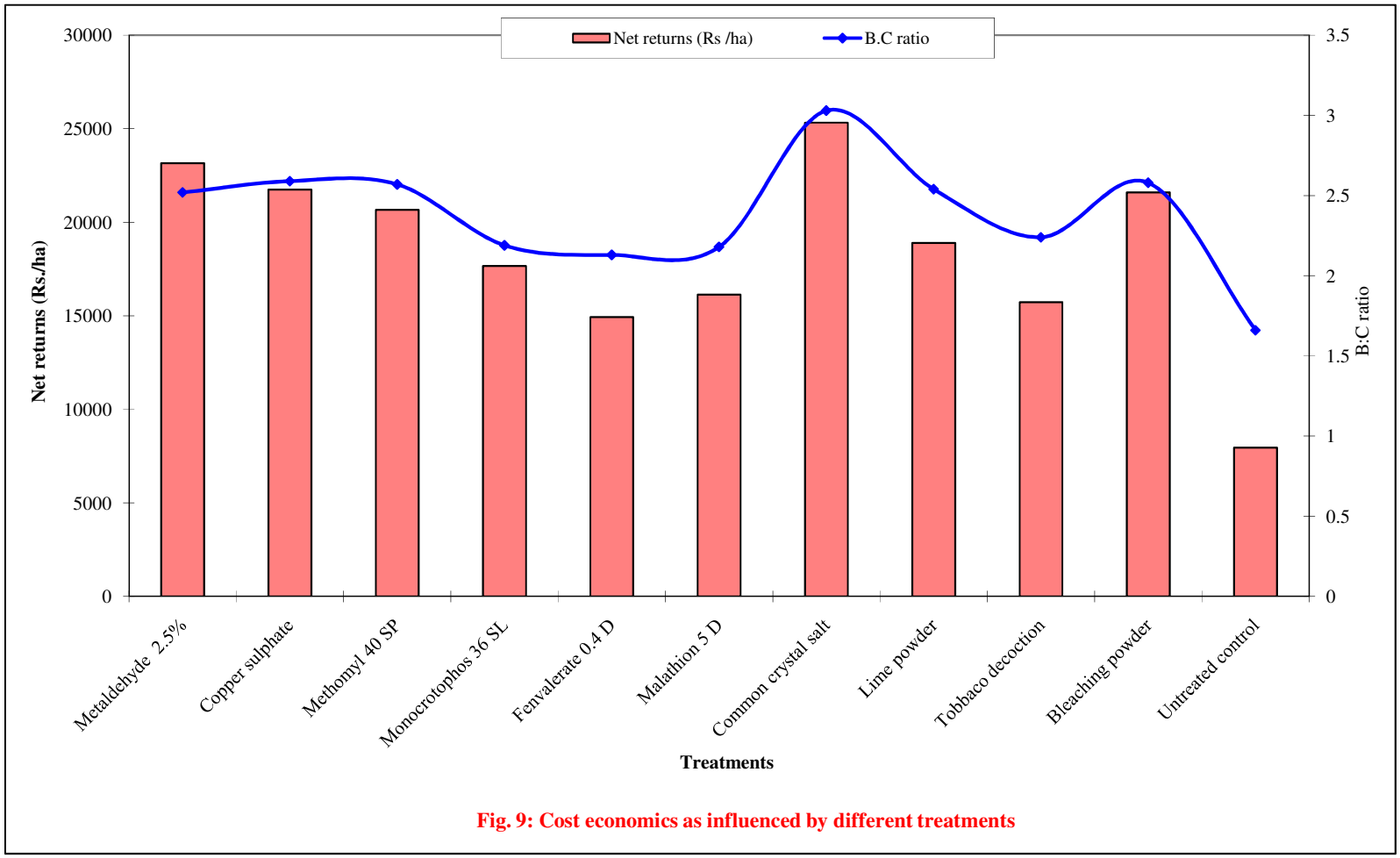

Fig. 9: Cost economics as influenced by different treatments

Fig 9 : Cost economics as influenced by different treatments

SUMMARY AND CONCLUSIONS

Investigations on the survey of population density and extent of damage due to snail, *Crypotozona semirugata* (Beck) in different cropping ecosystems, influence of different levels of *C. semirugata* infestation on plant damage and leaf area consumption in greengram and its management in greengram have been summarized below.

Survey was under taken in four villages of Dharwad taluks *viz*., Narendra, Chikkamalligwad, Kamlapur and Hebballi Farm, during *Kharif* 2012. Among the villages surveyed under roving survey though the first occurance of snail was seen in 24th std. week and continued up to 34th std. week in black soil, the peak activity was found during 28th std. week on all the villages, irrespective of the crops. The mean maximum number of snails was found during 28th std. week in Hebbali Farm (15.80 per 5 m row length, 10.80 and 7.30 per 25 m^2) followed by Narendra (10.92 per 5 m row length, 7.60 and 5.84 per 25 m^2). Kamlapur village noticed (7.50 per 5 m row length, 4.05 and 2.35 per 25 m^2) on bund, field near bund and inside field, respectively.

The mean per cent plant damage on different crops in all the villages were highest during 24th std. week (21.45 and 8.32 per 25 m^2) at Hebbali Farm, followed by Narendra (20.57 and 7.92 per 25 m^2) and Kamlapur (16.30 and 6.89 per 25 m^2) on FNB and inside field, respectively. Later it declined gradually with the advancement of crop growth. The population of snails was more on bund compared to field near bund and also inside the field in all the std. weeks in all the villages surveyed.

In Narendra and Chikkamalligwad villages all the crops grown in red soil area was totally free from snail incidence.

The comparative data on the fixed plot survey revealed that the snail population was more on bund (6.9 to 8.35 per 5 m row length) than fields near bund (1.67 to 3.34 per 25 m^2) and inside the field (0.88 to 2.70 per 25 m^2). The per cent plant damage was more in fields near bund (3.32 to 11.32 per cent per 25 m^2) compared to inside field (1.84 to 4.45 per cent per 25 m^2). Based on the per cent plant damage it can be summarised that higher per cent plant damage in field near bund and inside field recording more on greengram (11.32 and 4.27 per cent), blackgram (10.31 and 3.83 per cent), soybean (10.14 and 3.32 per cent) and cotton (9.07 and 4.45 per cent), respectively were highly preferred than other crops grown in the surveyed areas.

Correlation between snails and weather parameters revealed that snail population was positively and significantly correlated with rainfall, maximum and minimum RH, irrespective of the crops whereas it was negatively and significantly correlated with maximum and minimum temperature.

Investigations on the influence of different levels of *C. semirugata* infestation on plant damage and leaf area consumption in greengram noticed the per cent plant damage and per cent leaf area consumption increased with increase in snail population from 2 to 10 at all the three different days after sowing. The per cent plant damage at 7 DAS (23.67 to 98.67 per cent) was more compared to 15 and 30 DAS (16.67 to 73.00 and 13.00 to 43.67 per cent). Whereas, per cent leaf area consumption was also more during 7DAS (37.96 to 72.53 per cent) compared to 15 and 30 DAS (34.69 to 67.59 per cent and 32.00 to 60.24 per cent), respectively.

Management of snail, *C. semirugata* in greengram revealed metaldehyde (94.83%), common crystal salt (89.03%), copper sulphate (72.22%) and bleaching powder (70.08%) proved highly effective in recording higher per cent mortality. Whereas tobacco decoction (0.5%) and lime powder (7.22%) proved least effective. The insecticides *viz*., monocrotophos 36 SL (10.82%), two dust formulations *viz*., fenvalerate 0.4%D (0.47%) and malathion 5%D (3.92%) proved ineffective in controlling the snail.

Highest grain yield of 6.39 q/ha was registered with metaldehyde 2.5% and also common crystal salt (6.30 q/ha). This was followed by copper sulphate (5.90 q/ha) and bleaching powder (5.88 q/ha). While untreated control registered minimum grain yield of 3.22 q/ha

Cost economics of different treatments revealed that common crystal salt and metaldehyde 2.5% registered highest net returns of Rs. 25,328/- and Rs. 23,155/-, respectively compared to untreated control which registered lowest net returns of Rs. 7943/- when the pest was not controlled. The higher BC ratio of 3.03 was obtained from common crystal salt compared to all other treatments. Whereas in the remaining treatments the BC ratio ranged from 2.13 to 2.59.

Future line of work

1. Biology and off seasonal survival of *C. semirugata* in relation to soil types
2. Assesment of crop loss due to *Cryptozona semirugata* in major crops under field condition
3. Evaluation of ecofriendly management approaches in managing *C. semirugata*

REFERENCES

AbdelHalim, K. Y., AbouElKhear, R. K. and Hussein, A. A., 2006, Molluscicidal efficacy and toxicity of some pesticides under laboratory and field conditions. *J. Agric. Sci.,* 14(2) : 861-870.

Aravind, N. A., 2005, Ecology of Land Snails of Western Ghats. *PhD Thesis*, Department of Applied Zoology, Mangalore University, Mangalore, pp. 182.

Balikai, R. A., 1999, Incidence of snail, *Cryptozona Semirugata* (Beck) on some horticultural crops in Northern Karnataka. *Pest Mgmt. Hort. Ecosys*, 5(1) : 70-71.

Balikai, R. A., 1999, Pest scenario of ber (*Zizyphus mauritiana* Lamarck) in Karnataka. *Pest Mgmt. in Hortl. Ecosys.,* 5(1) : 67-69.

Balikai, R. A., 2008, Potential of snails as crop pests in Northern dry zone of Karnataka. *Intl. J. Agric. Sci.,* 4(1) : 394-396.

Balikai, R. A., 2009, Insect pest status of ber (*Zizyphus Mauritiana* Lamarck) in India and their management strategies, *Acta Horticulturae*, 840 : 461-474.

Balikai, R. A., Kotikal, Y. K. and Prasanna, P. M., 2011, Status of pomegranate pests and their management strategies in India. *Acta Horticulturae*, 890 : 569-583.

Barker, G. M., 2001, Gastropods on land : Phylogeny, Diversity and Adaptive Morphology. *The Biology of Terrestrial Molluscs*. Cabi Publishing. Pp. 139 and 142.

Barker, G. M., Pottinger, R. P., Lloyd, J. M., Addison, P. J., Firth, A. C. and Stewart, A. P., 1991, A novel bait formulation for slug and snail control. *Proc. of the Forty Fourth New Zealand Weed and Pest Control Conference.* Pp.195-200.

Barwal, R. N. and Dhiman, M. R., 2002, Evaluation of marigold, *Tagetes spp*. cultivars as trap crop for the temperate snail, *Macrochlamys glauca* Pfr. *Pest Mngt. in Hortic. Ecosys.,* 8(2) : 133-134.

Basavaraju, B. S., Girish, A. C., Thyagaraj, N. E. and Chakravarty, A. K., 2010, Giant African Snail, *Achatina fulica* Bowdich. A menace in Hassan district, Southern Transitional Zone of Karnataka. A survey paper presented : *34th Annual Conf.of Ethological Society of India and Colloquium on Ethology from Organism down to Ethobomolecule*.

Basavaraju, B. S., Kulapati Hipparagi, Chinnamadegowda, C. and Krishnamurthy, N., 2001, Management of Giant African Snail in betelvine garden. *Curr Res.* 30(78) : 116-118.

Basavaraju, B. S., Kulapati Hipparagi, Gowda, C. L., Jamagandi and Murthy, N. K., 2000, Preliminary survey on the incidence of *Achatina fulica* Bowdich in Davanagere district. *Curr. Res.,* 29 : 129.

Basinger, A. J., 1940, Brown snail infestations. *Calif Citrogr*., 25 : 226.

Beeley, F., 1938, The Giant Snail, *Achatina fulica* suggestions for control. *J. Rubb. Res. Inst.,* 8 : 1309.

Bhardwaj, A. K., 1972, Testing of pesticides against the Giant African Snail, *Achatina fulica* Bowdich. *Indian J. Entomol.,* 34(1) : 42-45.

Bhat, P. K., Shamanna, H. V. and Viswanathan, P. R. K. 1973, Control of Snail (*Ariophanta solata*) with 'snail-kill'. *Indian Coffee,* 77 : 349-350.

Bishara, S. I., Hassan, M. S. and Kalliny, A. S. (1968), Studies on some land snails injurious to agriculture in U.A.R. Revue de zoologie et de botanique africaines Lxx VII (3-4): 239-252.

Bouchet, P., 1992, Extinction and preservation of species in the tropical world : What future for molluscs? *American Conchocologist*, 20 : 20-24.

Burch, J. B., 1955, *How To Know the Eastern Land Snails.* Wm. C. Brown, Dubuque, p. 214.

Chatterjee, D. and Randhawa, G. S., 1952, Standardized names of cultivated plants in India on cereals, pulses, vegetables and spices. *Indian J. Hortic.,* 9 : 64-84.

Clark, J. A. and May, R. M. 2002, Taxonomic bias in Conservation Research. *Science.* 297 : 191–192.

Dalvi, C. S. and Dumbre, R. B., 1992, Chemical control of snails, *Ariophanta bajadera* (Peiffer). *Indian J. Entomol.,* 54(1) : 70-72.

Deepak, V., Vasudevan, K. and Pandav, B.., 2010, Preliminary observation on the diet of the cane turtle (*Vijayachelys silvatica*). *Hamdaryad,* 34 : 166–168.

Devaiah, M. C., Rajashekhargouda, R. and Suhas Yelshetty, 1982-83, A new snail pest*, Cryptozona semirugata* (Beck) (Stylommatophora : Ariophantidae) of mulberry and other cultivated plants. *Indian J. Seric.,* 21-22 : 64-66.

Dunk, J. R., Zielinski, W. J and Preisler, H. K., 2004, Predicting the occurrence of rare mollusks in northern California forests. *Ecological Applications,* 14: 713–729.

Dutta, P. K., Hegde, R. K. and Anahosur, K. H., 1984, An assured *in vitro* technique for the germination of oospores of *Phytophthora palmivora*. *Curr. Sci*., 53(12) : 655-656.

Dutta, P. K. and Hegde, R. K., 1987, Studies on two Phytophthora diseases (koleroga of arecanut and black pepper wilt) in Simoga District, Karnataka State. *Plant Pathology Newsletter*.5(1-2): 29.

Efferson, J.N., 1968, Arice seed farm in Central America. *Rice Journal*, 71: 6-9.

ElDeeb, H. I, ElGhamry, E. M, ElHwashy, N. and Essa, N., 1996, Relative abundance of some land snails in certain governorate of Egypt. *J. Agric. Sci. Mansoura Univ.,* 21(8) : 2977-2983.

ElDeeb, H. I., Foda, M. E., Zedan, H. and Edress, N. M., 2001, Bait preference and food consumption of some land snails in Egyptian new reclaimed lands. *J. Envrt. Sci.,* 3 : 90-104.

ElDeeb, H. I., Zidan, Z. H., Fouad, M. M. and Asran, F. D., 2003, Survey of terrestrial snails and their malacophagous insects at three governorates in Egypt. *Egyptian J. Applied Sci.,* 18 : 355-361.

ElOkda, M. K., 1980, Land snails of economic importance on vegetable at Alex and Ria and Neighboring region. *Agric. Res. Review,* 58 : 79-85.

ElOkda, M. K., 1984, Land mollusca infestation and chemical control in Elismaelia Governorate. *Agric. Res. Review*, *Egypt,* 62 : 87-92.

ElSebae, A. H., ElOkda, M. M. K. and Marei, A. S., 1982, Local formation of three Carbamated Oxims as Terrestrial Molluscicides. *Agric. Res. Rev.,* 60 : 85-91.

Essawy, A. E., Abdelmeguied, N. E., Radwan, M. A., Hamed, S. S. and Hegazy, A. E., 2009, Neuropathological effect of Carbamate Molluscicides on the land Snail*, Eobania vermiculata*. *Cell Biol. Toxic*., 25(3) : 275-290.

Fenwick, A., 1970, The development of snail control methods on an irrigated sugarcane estate in Northern Tanzania. *Bulletin of world health organization*, 42: 589-596.

Gabr, W. M., Youssef, A. S. and Khidr, F. K., 2006, Molluscicidal effect of certain compounds against two land snail species, *Monacha obstructa* and *Eobania vermiculata* under laboratory and field conditions. *Egyptian J. Agric. Res., ,* 84(1) : 43-50.

Ghamry, E. M., Amer, K. Y. and Wilson, B. M., 1994, Screening test of some insecticides against two land snails, *Monacha cantiana* and *Eobania vermiculata* in Sharkia Governorate. *Zagazig J. Agric. Res.,* 21 : 1539-1545.

Giraddi, R. S., Kulkarni, K. A. and manjunath, M., 1996, Outbreak of snail, *Cryptozona semirugata* (Beck) on field crops. *Karnataka J. Agric. Sci.,* 9(3) : 533-534.

Glen, D. M., Wiltshire, C. W., Hughes, L., Ester, A., Rozen, K. Van., Castillejo, J., Iglesias, J., Speiser, B., Coupland, J. and Gwynn, R., 2000, The use of slug parasitic nematodes and other techniques for control of slug and snail damage in horticultural crops. The BCPC *Conf.*: Pests and diseases, *Proc. of an International Conf.held at the Brighton Hilton Metropole Hotel, Brighton*, 1 : 345-350.

Godan, D., 1983, *Pest slugs and snails : Biology and control*. 2nd edn. Springer-Verlag, Berlin, Heidelberg, NewYork..

Godwin, A. B. and Austen, H. H.,1888, *Land and freshwater mollusca of India*, including South Arabia, Baluchistan, Afghanistan, Kashmir, Nepal, Burmah, Pegu, Tenasserim, Malay Peninsula,

Ceylon, and other Islands of the Indian Ocean, supplementary to messrs. Theobald and Hanley's Conchologia Indica. Taylor & Francis, London, 1(6) : 207-257. PP. 253.

Graveland, J. R., Van der Wal, J. H., Van Balen and Van Noordwijk, A. J., 1994, Poor reproduction in forest passerines from decline of snail abundance on acidified soils. *Nature.,* 368: 446–448.

Green, E. E., 1911, The wondering of a Gigantic African Snail. *Zoologist* (London), 4th series, 15 : 41-45.

Gupta, G. P. and Doharey, K. L., 1985, In : non insect pest and predators. *All India Scientific Writers Society*, New Delhi.

Hamed, S. S., Abdelmeguied, N. E., Essawy, A. E., Radwan, M. A. and Hegazy, A. E., 2007, Histological and ultrastructural changes induced by two Carbamate Molluscicides on the digestive gland of *Eobania vermiculata*. *J. Biol. Sci.,* 7(6) : 1017-1037.

Hanley, M. E., Fenner, M. and Edwards, P. J., 1996, Mollusc grazing and seedling survivorship of four common grassland plant species : The role of gap size, species and season. *Acta Oecologica*, 17(4): 331-341.

Hashem, A. G., Nakhla, J. M. and Tadros, A. W., 1992, The seasonal fluctuation in the land snails population on citrus trees in the Northern Reclaimed lands. *AlAzhar J. Agric. Res.*, 16 : 325-337.

Hausdorf, B., 2000, Biogeography of the limacoidea sensu lato (Gastropoda : Stylommatophora): vicariance events and longdistance dispersal. *J. Biogeography*, 27(2): 379-390.

Henderson, H. and Triebskorn, R., 2002, Chemical control of terrestrial gastropods. *Cab International*, *Molluscs as Crop Pests,* pp. 31.

Ho Wai Hoong, 1995, A review of the land snail fauna in Singapore. *The Raffles Bulletin Zool.*, 43(1): 91-113.

Hotopp, K. P., 2002, Land snails and soil calcium in central Appalachian Mountain forest. *South Eastern Naturalist* : 27–44.

Hutson, J. C., 1920, The African snail (*Achatina fulica*). *Tropical Agric.*, 55 : 217-285.

Jagtap, A. B., Mali, M. S. and Moholkar, P. R., 1990, Snail : A new pest of groundnut in Maharashtra. *Groundnut News*, 2(1) : 67.

Jagtap, A. B., Mali, M. S., Moholkar, P. R. and Khaire, V. M., 1992, Biology of snail infesting groundnut and various crops in Maharashtra. *J. Maharashtra Agril. Univ.,* 17(2) : 249-251.

Javaregowda, 2006, Incidence of Snail, *Achatina fulica* (Bowdich) in betel vine and its management, *Pest Mgmt. in Hortl. Eco.,* 12(1) : 41-46.

Jose, V. T., Nehru, C. R. and Jayarathnam, K., 1996, Management of slugs and snails on young rubber. *Indian J. Natural Rubber Res.,* 9(1) : 32-35.

Kadoorie Farm and Botanic Garden, 2003, *Report of rapid biodiversity assessments at cenwanglaoshan nature reserve,* Northwest Guangxi, China, 1999 and 2002. South China Forest Biodiversity Survey Report Series : No. 27., *Hong Kong Sar*, pp. 27.

Kady, M. M., Ghanim, A. A., ElAdl, A. A. and Nassar, O. A., 1983, Seasonal abundance of the terrestrial snail *Monacha obstructa* and its chemical control. *J. Agric. Sci. Mansoura Univ.,* 8 : 377-383.

Kakoty, N. N. and Das, S. C., 1987, The Giant African Snail, *Achatina fulica* Bowdich a non arthropod pest. *Two and A Bud.,* 34(12) : 33-35.

Karnatak, A. K., Srivastava, R. M. and Kanaujra, K. R., 1998. Management of Giant African Snail, *Achatina fulica* Bowdich, Tarai region of Uttar Pradesh. *Indian J. Eco.,* 25 : 81-83.

Kumar, R. R. and Prasad, K. D., 2007, Control of *Indoplanorbis exustus* snail with chemical and herbal molluscicidal agents. *Prog. Res.*, 2(12) : 173-174.

Kumari, P. S., Hegde, R. K., Basarkar, P. W., Srinivasan, C. N. and Srikant Kulkarni, 1988. Role of enzymes in the gut region of the garden snail (*Cryptozona semirugata* Beck.) on the germination of oospores of *Phytophthora* spp. *Indian J. Pl. Pathol.,* 6(1) : 49-51.

Lauenstein, G., 1998, Field slugs and snails. *Kartoffelbau*, 49 : 158-163.

Litsinger, J. A. and Estano, D. B., 1993, Management of the golden apple snail, *Pomacea canaliculata*(Lamarck) in rice. *Crop Prot.,* 12(5) : 363-370.

Lokma, M. H. E. (2007), Studies on some terrestrial gastropods inguious to field crops at Sharkia governorate. *M. Sc. Thesis Faculty of Agriculture Zagazig University,* Egypt. Pp. 147.

Lovett, A. L. and Black, A. B., 1920, The grey garden slug with notes on allied forms. *Oregon Agriculture College Experimental Station Bulletin*, 170 : 1-48.

Lydeard, C., Cowie R. H., Ponder. W. F., Bogan. A. E., Bouchet. P., Clark S. A., Cummings K. S., Frest. T. J, Gargominy. O., Herbert D. G, Hershler. R, Perez. K. E., Roth. B., Seddon. M., Strong. E. E. and Thompson. F. G., 2004, The Global Decline of Non-marine Molluscs. *BioScience,* 54 : 321–330

Mahrous, M. E., Ibrahim, M. H. and AbdElAal, E. M., 2002, Control of certain land snails under field conditions in Sharkia Governorate. *Egyptian J. Agric. Res.,* 29 : 1041-1045.

Mariconi, F. A. M., 1962, Snails and the coffee bush. *Bol. Super Serv. Cafe.,* 37(420) : 68.

Mariconi, F. De. A. M., 1955, Snails as pests of coffee. *Folha Da Manha*, 30(338) : 378.

Metwally, A. M., Zedan, H. A., ElSaeid, A. B. and ElAkra, T. M. M., 2002, Ecological studies on certain land snails in Monofia and Gharbia Governorate. *Proc. of 2nd International Conference, Plant Protection Research Institute*, Cairo, Egypt : 65-79.

Naggs, F, 1997, William Benson and the study of land snails of British India and Ceylon. *Archives of Natural History* 24 : 37–88.

Nair, M. R. G. K., Das, N. M. and Abraham, J., 1968, Use of metaldehyde as dusts and sprays to control the Giant African Snail, *Achatina fulica* Bowdich. *Indian J. Entomol.,* 30(1) : 58-60.

Navarajan Paul, 2007*, Insect Pests and their Management*, Indian Agricultural Research Institute, New Delhi.

Noor, H. M. S., Dachyar Arbaina, Mohamed Z. M. D., Nilawati Pilusb and Rohaina Nawic, 2012, Distribution and management of *Pomacea canaliculata* in the northern region of Malaysia : Mini review. *APCBEE Procedia,* 2 : 129-134

Ordosgoitti, F. A., 1999, Citrus snail pests in Yumare, Yaracuy State, Venezuela. *Agronomia Tropical Maracay,* 49(4) : 517-525.

Pangga, G. A., 1949, A Priliminary report on the biology and control of the Giant African snail, *Achatina fulica* (Fer.) *Philippines J. Agric.,* 14 : 337-347.

Pappas, J. L. and Carman, G. E., 1980, New treatment programs for brown snail control. *Citrograph*, 65(8) : 235-238.

Pappas, J. L., 1971, Control of european brown garden snail in citrus. *Citrograph*, 56(7) : 225-228.

Pappas, J. L. and Carman, G. E., 1961, Control of European brown snail in citrus groves in Southern California with Guthion and Metaldehyde sprays. *J. Econ. Ent.,* 54 : 15-26.

Pappas, J. L., Carman, G. E. and Wood, G. F., 1973, Weather effects on baits for controlling European brown garden snails in citrus. *California Agric.*, 27(11) : 13-15.

Patil, D. T., Patil, A. K. and Airi, D. S., 1987, New record of snail infesting French bean, groundnut and chilli crops in Kolhapur, Maharastra State, *Current Res. Rep.,* 3(2) : 12.

Peterson, G. D., 1957, Studies on the control of Giant African Snail on Guam. Hilgardia, 26(6) : 643-648.

Radwan, M. A., Essawy, A. E., Abdelmeguied, N. E., Hamed, S. S. and Ahmed, A. E., 2008, Biochemical and Histochemical studies on the digestive gland of *Eobania vermiculata* snails treated with Carbamate pesticides. *Pesticide Biochem. Physiol,* 90(3) : 154-167.

Rajendra, Mavinkurve, G., Sandhya, Shanbhag, P. and Madhyastha, N. A., 2005, Descriptions of few land molluscs from Kodagu district of Karnataka. *India Records of the Zoological Survey of India,* 105(12) : 117-125.

Ramakrishnan, T. S. and Pillay, P. N. R., 1962, Snails and slugs. *Rubb. Bd. Bull.* 6 : 268.

Rao, B. S., 1963, Pests of leguminous covers in malaya and their control. *Plant Bull Rrim.,* (68) : 18-26.

Rao, V. P., Chowdary, V. D. and Narayana, R., 1980, Effect of aqueous tobacco extract on the bioenergetic parameters of the host Snail, *Lymnaea luteola. Proc. of the 10th International Congress of Tropical Medicine and Malaria*.

Raut, S. K. and Barker, G. M., 2002, *Achatina fulica* Bowdich and other achatinidae as pests in tropical Agriculture. *Molluscs as crop pests*, Cab International.

Raut, S. K. and Ghose, K. C., 1984, Pestiferous land snails of India. *Zool. Surv. India Tech. Monog.,* 11 : 151.

Ravikumara, Mahan, I. N., Manjunath, M. and Pradeep, S., 2007, Evaluation of attractant waste material and bait for the management of Giant African Snail, *Achatina fulica* Bowdich. *Karnataka J. Agric. Sci.,* 20(2) : 288-290.

Ravikumara, Mahan, I. N., Manjunath, M. and Pradeep, S., 2007, Seasonal incidence of Giant African Snail, *Achatina fulica* Bowdich (Gastropoda : Achatinidae) in areca ecosystem. *Karnataka J. Agric. Sci.,* 20(1) : 157-158.

Reddy, D. N. R. and Puttaswamy, 1984, Pest infesting chilli (*Capsicum annuum* L.) in the nursery. *Mysore J. Agric. Sci.,* 18 : 122-125.

Reddy, D. N. R., 1985, Soil arthropods associated with chilli (*Capsicum annuum* L.). *J. Soil Biol. Ecol.,* 5(1) : 72-77.

Sajitha Kumari and Lyla, K. R., 2001, A survey of the pest of orchids. *J. Trop. Agric.,* 39 : 32-34.

Salmijah, S., Chan, M. K., Kong, B. H., Makimum, A. and Ismail, B. S., 2000, Development of resistance in *Achatina fulica* Fer. And *Badyaena similaris* Fer. towards metaldehyde. *Pl. Prot. Qrt.,* 15 : 2-5.

Sanico, A. L., Peng, S., Laza, R. C. and Visperas, R. M., 2002, Effect of seedling age and seedling number per hill on snail damage in irrigated rice. *Crop Protection*, 21 : 137–143.

Santha Kumar, P. and Hegde, R. K., 1991, Study on the germination of oospores of *Phytopthora palmivora*. *Indian Phytopathology,* 44 : 3.

Saraswati Poudel Acharya, Basavaraja, H., Kunnal, L. B., Mahajanashetti, S. B. and Bhat, A. R. S., 2012, Growth in area, production and productivity of major crops in Karnataka. *Karnataka J. Agric. Sci.,* 25(4) : 431-436.

Saxena, B. N. and Dubey, D. N., 1970, Field trials on the control of land snails. *Pesticides*, 4(5) : 20-23.

Schwartz, A. and Capatos, D., 1990, An evaluation of chemicals for the toxicity to brown snail *(Helix aspersa* Muller) on grapevines. *South African J. Enol. Vitic.*, 11(1) : 55-58.

Scot Nelson, 2012, Injuries caused by the Giant African Snail to papaya. *Miscellaneous pests.* pp. 6.

Sexena, R. M. and Mahendra, V. K., 2000, An introduction to Giant African Snail, *Achatina fulica*, its destructive ability and an attempt to control by using bait technique. *Flora and Fauna Jhansi*, 6 : 27-28.

Shah, N. K., 1992, Management of Giant African Snail. *Indian Farming,* 41 : 21.

Sharma, D. D. and Agarwal, M. L., 1989, Save your crops from Giant African Snail. *Indian Farming,* 38 : 15-22.

Sheela Thakur and Rina Kumari, 1998, Seasonal behavior of Giant African Snail, *Achatina fulica* in Bihar. *J. Ecotoxicology and Envtl. Monitoring,* 8 : 153-160.

Sheela Thakur, 2003, Population dynamics of Giant African Snail, *Achatina fulica* Bowdich (Stylommatophora : Achatinidae) in North Bihar. *J. Appl. Zool. Res.,* 14 : 151-154.

Shevale, B. S. and Bedse, V. L., 2009, Evaluation of different poison baits for the management of Giant African Snail, *Achatina fulica* Bowdich. *Pest Mgmt. in Hortl. Eco.,* 15(2) : 147-149.

Shiff, C.J., Clarke, V.de V., Evans, A. C. and Barnish, G., 1973, Molluscicide for the control of Schistomomiasis in irrigation schemes. *Bulletin Of World Health Organization*, 48: 299-307.

Shoieb, M. A., 2008, Occurrence and distribution of terrestrial mollusks in Suez Canal Governorates and South of Sinai, *Egyptian J. Agric. Res.,* 86 : 989-994.

Shyam Prasad, G., Singh, D. R., Senani and Medhi, R. P., 2004, Ecofriendly way to keep away pestiferous Giant African Snail, *Achatina fulica* Bowdich from nursery beds. *Curr. Sci.,* 87(12) : 1657-1659.

Srihata, S., Tumpeesuwan, C. and Tumpeesuwan, S., 2010, Species diversity, abundance and habitats of land snails in a square kilometer on Phu No, Kalasin Province. *J. Sci. and Tech.* 29(4) : 359-371.

Srivastava, P. D., 1973, The Giant African Snail an its control, *Indian Forming*, 23: 33-36.

Srivastava, P. D., 1992, Problem of land snails in Agriculture : A study of the Giant African Snail. Concept Publishing Company, New Delhi, pp. 234.

Srivastava, P. D., Srivastava, Y. N. and Singh, J., 1968, Observation on the control of *Achatina fulica* Bowdich with metaldehyde. *J. Entomol.,* 30 : 175-176.

Sticker, F. C., Wearden, S. Pauli, A. W., 1961, Leaf area determination in grain sorghum. *Agron. J.*, 53: 187-188.

Subba Rao, N. V. and Mitra, S. C., 1979, On land and fresh water mollusks of Pune district, Maharashtra. *Rec. Zoological Survey,* 75 : 1-37.

Subramanya, K. B., 1983, Studies on the snails with special reference to Giant African Snail, *Achatina fulica* (Bowdich) (Gastropoda : Achatinidae), *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India), pp. 67.

Sudjono, S. M., Triman, B. and Henderish, S., 2000, Integrated pest management on the golden apple snail on rice field. In Indonesian Report to Armp Ii, pp. 16.

Sunitha, T. R., 2007, Insects pests of *Capsicum annuum Var. Frutescens* (L) and their management, *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

Suzuki, Y., Matsumura, M., Arimura, K., Urano, S., Wada, T., Yusa, Y. and Ichinose, K., 2000, Management of the golden apple snail, *Pomacea canaliculata* (Lamarck), by drainage and metaldehyde application in direct sown rice under heavy rainfall conditions. *Proc. of the Association for Plant Protection of Kyushu*. 46 : 94-97.

Takashi Wada, 2004, Strategies for controlling the apple Snail, *Pomacea canaliculata*(Lamarck) (Gastropoda : Ampullariidae) in Japanese direct sown paddy fields. *Jarq* 38(2) : 75-80.

Tehsin, R. H. and Sharma, S. K., 2000, First record of Giant African land Snail, *Achatina fulica* from Rajasthan. *Zoos' Print J.*, 15(3) : 231.

Teo, S. S., 2002, Selecting plants with molluscicidal properties for the control of the golden apple Snail *Pomacea canaliculata* (Lamarck). *3rd International Conf.on Biopesticides*, Kuala Lumpur, Malaysia, pp. 22-26.

Tillier, S., Jackson, G. V. H. and Macfarlane, R., 1993, Giant African Snail, 2nd Edition. Pest Advisory Leaflet South Pacific Commission. (6) : pp. 4

Tirumala Rao, V., 1953, Snail damage to paddy in the Northern Circars and their control. *Madras Agric. J.,* 40(10) : 44-52.

Toit, WJDu and Brink, T., 1992, Efficacy of different treatments against the brown snail, *Helix aspersa* Muller on citrus in South Africa. *Fruits Paris*, 47(6) : 657-660.

Torres DeMello, A., 1961, Snail pests of coffee. *Bol. Super Serv. Cafe.,* 36 : 45

Vanitha, K., Karappuchamy. P. and Sivasubramanian, P., 2011, Pests of Vanilla (*Vanilla planifolia* Andrews) and their natural enemies in Tamil Nadu, India. *International Journal of Biodiversity and Conservation*., 3(4): 116-120.

Veeresh, G. K., Rajagopal, D. and Puttarudraiah, M., 1979, First record of Giant African Snail, *Achatina fulica* Bowdich (Mollusca : Gastropoda) as a serious pest of ornamental crops in Bangalore. *Curr. Res.,* 8 : 202-204.

Venette, R. C. and Larson, M., 2004, Mini risk assessment : Giant African Snail, *Achatina fulica* Bowdich [Gastropoda : Achatinidae]. *Cooperative Agricultural Pest Survey Program*.

Wada, T., Yusa, Y., Ichinose, K., Kanno, H., Matsumura, M., Arimura, K. and Urano, S., 2001, Control of the apple snail, *Pomacea canaliculata*, in direct sown paddy fields, using drainage and molluscicide applications. *Kyushu Plant Prot. Res.,* 47 : 58-64.

Wen, H. C., 1990, Seasonal occurrence and chemical control of *Bradybaena similaris* on spongegourd. *J. Agric. Res. China,* 39(3) : 228-233.

Yang Ping shih, ChenYuhui, LeeWuchung and ChenYahui, 2006, Golden apple snail management and prevention in Taiwan. *Global Adv. Ecol. Mngt. Golden Applesnails.* pp. 169-179.

Websites visited

anonymous, 2011, *www. Coretext. Com. Au*.

anonymous, 2012, *http: //www.Agropedia.Com.*

http : //www.Agritech.Tnau.Ac.In

www. Intechopen.Com.

www. Uoguelph.Ca/Pdc 2003

www.Infonet-biovision. Org

Appendix I : Weekly meteorological data recorded during experimentation period

MSW	Rainfall (mm)	Temperature (°C)		Relative Humidity (%)	
		Mean Maximum	Mean Minimum	Mean Maximum	Mean Minimum
18 (May 1 to 5)	00.0	35.9	20.3	72.7	46.8
19 (May 6 to 12)	02.6	34.7	21.2	70.4	50.1
20 (May 13 to 19)	00.8	37.0	21.9	71.0	51.6
21 (May 20 to 26)	00.4	36.3	22.1	73.6	47.3
22 (May 27 to June 2)	00.0	34.2	21.9	72.9	51.3
23 (June 3 to 9)	14.6	31.3	21.8	78.4	63.7
24 (June 10 to 16)	00.0	31.0	21.3	82.9	64.1
25 (June 17 to 23)	15.6	28.7	20.7	85.3	72.4
26 (June 24 to 30)	13.2	27.6	20.7	85.7	80.1
27 (July 1 to 7)	29.2	26.6	20.7	88.4	82.3
28 (July 8 to 14)	08.0	28.8	20.8	85.6	77.6
29 (July 15 to 21)	48.4	26.6	20.9	89.6	87.0
30 (July 22 to 28)	24.8	27.0	21.0	89.4	81.0
31 (July 29 to Aug. 4)	19.6	26.7	20.4	87.6	78.8
32 (Aug. 5 to 11)	39.2	26.4	20.8	92.7	88.8
33 (Aug. 12 to 18)	14.4	28.1	20.2	84.3	76.0
34 (Aug. 19 to 25)	07.6	28.3	20.6	87.9	76.0
35(Aug. 26 to Sept.1)	15.8	26.3	20.3	91.7	86.7
36 (Sept.2 to 8)	26.0	26.9	20.6	91.6	89.3
37 (Sept.9 to 15)	04.8	27.5	20.2	88.3	81.3
38 (Sept.16 to 22)	01.2	28.6	18.8	77.4	73.7
39 (Sept.23 to 29)	51.8	30.7	19.0	81.3	71.6
40 (Sept.30 to Oct 6)	43.2	27.3	20.5	89.0	84.0
41 (Oct 7 to 13)	37.6	30.5	18.4	71.1	58.9
42 (Oct 14 to 20)	00.0	31.2	17.0	57.6	36.1
43 (Oct 21 to 27)	08.4	29.8	17.9	77.7	54.7
44 (Oct 28 to Nov 3)	34.5	27.6	17.8	77.1	60.1
45 (Nov 4 to 10)	00.0	30.1	20.1	85.0	59.4
46 (Nov 11 to 17)	01.2	28.9	13.5	59.9	42.1
47 (Nov 18 to 24)	00.0	25.8	12.2	54.0	40.1
48 (Nov 25 to Dec 1)	00.0	30.5	16.2	69.3	47.2
49 (Dec 2 to 8)	00.0	29.8	16.6	70.4	47.7
50 (Dec 9 to 15)	44.1	28.9	16.3	70.5	50.2

MSW- Meteorological Standard Week

STUDIES ON SNAIL, *Cryptozona semirugata* (Beck.) ON MAJOR FIELD CROPS

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ABSTRACT

The roving survey on the incidence level of *Cryptozona semirugata* (Beck.) on major crops grown in different villages revealed that, irrespective of the locations maximum population of snails and mean per cent plant damage was noticed during 28th Std week and 24th std. week, respectively in black soil in Hebbali Farm followed by Narendra and Kamlapur village. Across the locations, the snail population was maximum on bund followed by field near bund (FNB) and inside the field during the cropping period in all the villages surveyed. In Narendra and Chikkamalligwad villages where all the crops grown in red soil area were totally free from snail incidence.

The comparative data on the fixed plot survey showed that the snail population was more on bund than FNB and inside the field. The per cent plant damage was more in FNB compared to inside field. Based on the per cent plant damage greengram (11.32 and 4.27 per cent) was highly preferred crop than other crops grown in the surveyed areas. Snail population was positively and significantly correlated with rainfall, maximum and minimum RH, irrespective of the crops. The per cent plant damage and per cent leaf area consumption increased with increase in snail population from 2 to 10 per treatment at 7, 15 and 30 at days after sowing. The per cent plant damage and per cent leaf area consumption at 7 DAS was more compared to 15 and 30 DAS.

Metaldehyde (94.83%), common crystal salt (89.03%), copper sulphate (72.22%) and bleaching powder (70.08%) proved highly effective in recording higher per cent mortality of snail in field experiment. Highest grain yield of 6.39 q/ha was registered with metaldehyde 2.5%. Common crystal salt revealed highest net returns of Rs. 25,328/- with a BC ratio of 3.03 compared to all other treatments.