EVALUATION OF NEWER INSECTICIDAL POISON BAITS AGAINST LEPIDOPTEROUS CROP PESTS

Thesis Submitted to the
University of Agricultural Sciences,Dharwad
In Partial fulfillment of the requirements for the
Degree of

MASTER OF SCIENCE (AGRICULTURE)
In
AGRICULTURAL ENTAMOLOGY

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DHARWAD—2007

JULY,2007

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1. INTRODUCTION

The objective of any agricultural research programme is to increase the level of agricultural productivity. The strategy to boost agricultural productivity would be through the adoption of package of practices *viz.* use of high yielding varieties, adequate doses of manures, fertilizers and appropriate plant protection measures. Although, it is very difficult to quantify the contribution of each component, importance of use of insecticides need hardly to be emphasized.

Insecticides were in use from very early times and as early as 200 BC. Boiling a mixture of bitumen and blowing the fumes through grape leaves was advocated to keep away the insects (David and Ananthakrishnan, 2004). The discovery of the insecticidal properties of DDT in 1939 revolutionized the concept of insecticides and insect control. Since then many new chemicals such as organochlorines, organophosphates, carbamates and synthetic pyrethroids have been discovered (David, 2001).

But in a span of six decades after invention of DDT, misuse and ignorance in the use of broad spectrum insecticides resulted into problems like development of resistance to pesticides, secondary pest outbreaks, pest resurgence, bioaccumulation of chemicals in food chain, hazards to non target species etc., much earlier than anticipated. Hence, continuous efforts are being made for safer, selective and ecologically acceptable toxophores and novel methods of application. One such pest management option is use of poison baits.

Poison bait is a mixture of attractive substances, carriers and toxicant. In situations where spraying, dusting or fumigating are not practicable as in case of cutworms and armyworms which pass most of the day underground or in areas of crops too great to be protected by spraying or in windy areas, the idea of incorporating an insecticide into a food based bait is good one (Metcalf and Flint, 1979; Fenemore and Prakash, 1992).

During the 1930's and early 1940's poison baits, using bran or saw dust as carriers, were the most common and economical methods of protecting crops (Shotwell, 1942; Paul, 1942).

However, the use of these baits almost disappeared during the late 1940's following the introduction of organochlorine and organophosphate insecticides (Mukerji *et al.,* 1981). This was mainly because of development of pesticide appliances and different formulations to suite these appliances.

The advantages of chemical insecticides are the availability of the spray equipments and the relatively uniform spread of the chemical over the plant surface, whereas the main disadvantages are destruction of non-target organisms coupled with environmental risk, health hazards and high costs.

In this context, an alternative to aqueous insecticide sprays is the use of a solid carrier such as rice bran or wheat bran impregnated with insecticide that kills insects feeding on it.

Bait formulations provide several advantages over other insecticide application methods. Baits greatly reduce problems encountered with run off and drift from liquid and dust insecticide formulations (Jech *et al.,* 1993). Baits are useful when control programmes are conducted near to water, or in areas where threatened and endangered species occur and where preservation of beneficial species of arthropods is important (Barbara and Pinera, 2003).

Insecticide baits are potentially useful in pest management because of the reduced rate and consequently lower cost of application (Johnson and Henry, 1987). Also, use of bait substantially reduces the overall amount of active ingredient needed and therefore reduces the amount of insecticides present in the environment (Metcalf, 1985, Barbara and Pinera, 2003).

Poisons generally employed in preparing baits during early periods include paris green, sodium fluoride, sodium fluosilicate, metaldehyde, chlordane, toxaphene etc. (Hough and Mason, 1951). Chemicals such as white arsenic, arsenate of soda, arsenite of soda etc. are very likely to burn foliage and are not safe to use in spraying plants but they can be safely used in poison baits (Metcalf and Flint, 1990).

With the invention of organic insecticides, investigations were carried out to substitute the inorganic compounds. The organophosphate and carbamate insecticides in baits such as fonofos, biothion, methomyl (Sechriest and Sherrod, 1977), profenophos, acephate, methyl parathion (Nikolov, 1971), endosulfan (Morgan and French, 1971; Giraddi and Kulkarni, 1987), chlorpyriphos and monocrotophos (Giraddi and Kulkarni, 1987, Ramana *et al.,* 1988 and Viswanadham *et al.,* 1986), carbaryl (Sechriest and Sherrod, 1977, Chandla *et al*., 1977 and Misra *et al*., 1984) etc., pyrethroids such as fenvalerate (Mukerji *et al.,* 1981), permethrin (Phillips *et al.,* 1979) and insect growth regulators such as diflubenzuron (Chacon and Jaramillo, 2003), chlorfluazuron (Peters and Fitzgerald, 2003) etc. were found to give good control of various insect pests.

Severe outbreak of the armyworm, *Mythimna separata* (Walker) (upto 35 larvae/plant) during 1988 in the transitional tract of North-western Karnataka, South India was contained by use of monocrotophos poison bait.

The poison bait containing monocrotophos was found superior giving 98 per cent mortality compared to spraying and dusting of some other chemicals (Hiremath *et al.,* 1992). Also, the poison bait was highly effective in killing a large number of armyworm moths (Hiremath *et al.,* 1990).

Thereafter, monocrotophos became the common toxicant used for baiting purpose in this region.

But, the recent development of keeping of monocrotophos under restricted use in some crops by Central Insecticide Board and Registration Committee (Anon., 2005) and arrival of less toxic insecticides for use in pest management necessitates investigations on efficacy of alternate toxicant molecules to be used in the preparation of poison baits and their effect on non-target organisms.

Therefore, keeping these points in view, a detailed study was taken up both under laboratory and field conditions at the University of Agricultural Sciences, Dharwad to assess the feasibility of using poison baits prepared out of selected chemicals with the following objectives.

1. To evaluate new insecticidal poison baits for their efficacy and preference in the laboratory
2. To assess the efficacy of newer insecticidal poison baits against key lepidopteran pests in crop ecosystems.
3. To assess the effect of poison baits on soil fauna and natural enemies in crop ecosystems.

2. REVIEW OF LITERATURE

Studies made so far on various aspects of use of poison baiting in pest management have been briefly reviewed in this chapter. Literature available on various chemicals used in baits both for laboratory studies and field studies are reviewed. The literature scan suggests that studies on effect of poison baits on soil fauna and natural enemies are scanty. However, the available information is reviewed and presented here.

2.1 Efficacy of poison baits under laboratory conditions

2.1.1 Lepidopteran insects

Delrivero and Planes (1966) carried out laboratory tests in Spain to evaluate the effectiveness of various insecticides suitable for use in baits against larvae of *Spodoptera littoralis* (Fabricius). The insecticides that gave complete mortality within 72 hours were trichlorfon, methidathion, phosalone, aminocarb, diazinon, fenthion, BHC, carbaryl, sodium fluosilicate and barium fluosilicate. Out of these, the last two were the standard toxicants used in baits in Spain against this pest.

Devaiah (1973) conducted studies in the laboratory using last instar larvae of *S. litura.* The baits composed of wheat bran, jaggery and toxicants namely abate, carbaryl, endosulfan, methomyl and trichlorfon. Among these, carbaryl, methomyl and trichlorfon were equally effective and gave 90 per cent mortality.

Dhandapani and Abdulkareem (1983) in their studies with poison balls for red hairy caterpillar found that balls with dipterex insecticide attracted and killed more larvae compared to BHC 50 WP and DDT 50 WP baited balls.

Parasuraman *et al.* (1985) evaluated the effectiveness of different baits to attract the fourth instar larvae of *S. litura.* Wheat flour with 20 per cent molasses attracted more larvae and could maintain their feeding. However, the initial feeding response was not sustained four hour later, where there was a decrease in the larvae attracted to bait.

Viswanadham *et al.* (1986) carried out an experiment on different insecticidal baits at 0.5, 1.0, 1.5 and 2.0 per cent concentrations against *S. litura* under laboratory conditions and noticed the superiority of chlorpyriphos bait over monocrotophos, quinalphos, endosulfan and carbaryl baits. They also reported that rice bran was the most effective carrier which recorded higher mortalities followed by rice fine husk, jowar flour and ragi flour. Further, they reported that rice bran and jaggery at 8:2 ratio were more attractive than at other proportions *viz.,* 8.5: 1.5, 9:1 and 9.5 : 0.5.

El-Nockrashy *et al.* (1986) conducted an experiment in the laboratory about the role of bait formulations on the effectiveness of *Bacillus thuringiensis* Berliner against *S. littoralis*. The baits containing cotton seed kernels extracted with ethanol and acetone-hexane-water were effective in increasing the potency of *B. thuringiensis*. Further, they also reported that the increase in gossypol content decreased the effectiveness of the formulations.

Mohan *et al.* (1989) conducted studies on development and testing of pesticide bait pellets against *S. litura.* Pellets had the following ingredients such as rice bran, jaggery and insecticides like BHC 50 WP, carbaryl 50 WP, Fenthion 80 EC and malathion 50 EC. After a period of two hours all the 25 larvae were attracted and killed in fenthion and malathion pellets, whereas, a mean of 21.43 and 22.68 larvae were killed in BHC 50 WP and carbaryl 50 WP pellets respectively.

2.1.2 Non-lepidopteran insects

Lofgren *et al.* (1963) tested wheat bran, various plant products, vermiculite and various clay granules in Mississippi as carriers in oil baits for use against imported fire ant, *Solenopsis saevissima richteri* Forl. According to them, the most effective formulation consisted of 85 per cent maize cob grits, 15.0 per cent soybean oil and 0.07 per cent mirex.

Adults of field strains of *Blatella germanica* (L.) resistant to dieldrin and bendiocarb were used by Barson (1982) to evaluate two insecticide formulations, 50 per cent boric acid plus 50 per cent porridge oats and 0.25 per cent iodofenphos gel in comparison with gel alone and culture food. After exposure for 24 hours, all cockroaches died within nine days after exposure to boric acid plus oats, whereas with iodofenphos gel some survived after 21 days.

Kepner and Yu (1987) conducted studies to develop an optimal toxic bait for control of molecrickets in Florida using adult female *Scapteriscus acletus* Rehn and Hebard as a model species. They reported that commercially prepared baits with carbaryl 20 per cent, chlorpyriphos 0.5 per cent and trichlorfon five per cent were equally as effective as the malathion four per cent bait applied.

Su and Scheffrahn (1993) evaluated two chitin synthesis inhibitors, hexaflumuron and diflubenzuron in a laboratory choice test for their potential as bait toxicants against the Formosan subterranean termite, *Coptotermes formosanus* Shiraki and the eastern subterranean termite, *Reticulitermes flavipes* (Kollar). They concluded that hexaflumuron is superior to diflubenzuron as a bait toxicant because it was effective over a concentration range of 15.6-62.5 ppm and this range was found to be lethal and non-deterrant for both *C. formosanus* and *R. flavipes*. Diflubenzuron was efficacious for *R. flavipes* and did not appear to be useful as a bait toxicant against *C. formosanus*.

Learmount *et al.* (1996) studied response of strains of housefly, *Musca domestica* Linnaeus, to commercial bait formulations in the laboratory. The bait formulations were Golden Malrin (a.i., methomyl) and Alfacron (a.i. azamethiphos). Golden Malrin was generally effective against the strains tested in no choice tests and gave a minimum of 82 per cent knockdown after exposure for 48 hours. Eight strains gave a reduced knockdown when exposed in choice tests (60 to 87%). They suggested that it is important to use a laboratory method which allows for behavioural differences when monitoring for resistance to insecticides formulated as baits.

Metaweh *et al.* (2002) studied the efficacy of some insecticides as poison baits against fourth nymphal instars of grasshoppers *Euprepocnemis plorans plorans* Charp. and *Heteracris annulosa* Walker. Generally, lambda cyhalothrin revealed higher toxicity than carbosulfan and fenitrothion, against the two species of grasshoppers. However, *H. annulosa* was more susceptible to the toxicants tested than *E. plorans plorans*. Further they reported that carbosulfan poison bait was the least persistent one among the three insecticides.

Chacon and Jaramillo (2003) conducted experiments to study effects of boric acid, fipronil, hydromethylnon and diflubenzuron baits on laboratory colonies of ghost ants, *Tapinoma melanocephalu*m (F.). The colonies were administrated sugar solution baits containing the insecticides and exposed for 21 days. Fipronil caused 100 per cent mortality in all colonies the first week. With boric acid, 100 per cent mortality was attained at the end of third week. Other insecticides could not give 100 per cent mortality of the colonies even after ninth week.

2.2 Efficacy of poison bait in field situations

2.2.1 Lepidopteran insects

Fernald (1914) from southern state of Massachusettes could get excellent results with the bait prepared by mixing one lb paris green, 25 lb bran, two quarts of molasses and water to make thick mash, against *Heliophila unipuncta* Haworth.

Davis and Turner (1918) tested the suitability of saw dust as a substrate of bran in poison baits. The regulation bran mesh composed of one lb poison to 25 lb filler (bran and saw dust), two quarts molasses, six lemons and water as needed, was made up according to three formulae, containing, respectively parisgreen and bran, parisgreen and saw dust and white arsenic and bran. These mixtures were used in a field badly infested with the armyworm. The bait was scattered at the rate of 10 lb per acre. Observations made two days later showed about 75 per cent mortality in saw dust bait area and 100 per cent mortality in the bran bait treated area.

Dahms and Fenton (1942) reported the use of a poison bait for control of the armyworm, *Cirphis unipuncta* Haworth on wheat crop. According to them, a bait of two quarts of sodium arsenate per 100 lb wheat bran moistened with water gave good control of armyworm.

Scott (1945) found that *C. unipuncta* in wheat and barley was controlled by broadcasting 20 to 30 lb bait of bran and parisgreen (100:3 or 100:4) per acre, reducing the infestation by 90 per cent in 72 hours.

Tunblad (1947) reported that bait consisting of wheat bran, cryolite, sugar and water (50:3:2:40) gave over 90 per cent mortality of larvae of *Agrotis segetum* (Schiff.) attacking the young stocks of apple and other fruit trees in Sweden. The bait was distributed along the rows in the evening and the plants were surrounded by dead larvae in the next day morning.

The out break of cutworm *Euxoa segetum* (Schiffmuller) in ragi and cotton fields was effectively controlled by poison bait than drenching with insecticides. The quantity of bait per acre was prepared by mixing dry bran (8 seers), jaggery (2 lb) and moistened by sprinkling water. To this, sodium silicofluoride (1 lb) was added and the whole mixture was thoroughly mixed and applied in ragi and cotton fields at evening time to avoid the drying effect of the sun. After 24 hours, 62.5 per cent mortality was obtained in both fields as compared to drenching insecticides (Usman, 1953).

Kamel and Shoeb (1958) worked on different insecticidal baits in cotton seedlings, against *Agrotis ipsilon* (Hufnagel). The bait consisting of bran, molasses, water with toxicant was properly mixed and broadcasted in cotton seedling. It was observed that dieldrin bait (17.1 oz) was most effective (100%) followed by endrin (18.6 oz).

Hsu *et al.* (1958) reported that *Heliothis armigera* (Hubner) on cotton was controlled by five per cent DDT dust and a 50 per cent DDT wettable powder diluted 1:300 in water were the best treatments. Although, poison bait of soybean cake containing BHC was very effective against last instar larvae.

Sechriest and Moore (1968) evaluated wheat bran and apple-pomace baits on wheat for the control of armyworms, *Pseudaletia separata* [Haworth] and found out that apple-pomace was found to be more attractive than wheat bran.

Sechriest (1968) found trichlorfon, abate, ethyl parathion, mirex, TED and carbaryl as effective toxicants in bait formulations against *A. ipsilon* infesting corn crop.

Yonce and Gentry (1970) reported that jar traps containing Tween-20, terpenyl acetate, brown sugar and water were found to attract adults of oriental fruit moth, *Grapholitha molesta* (Busck) and also attracted large numbers of adults of lesser peach tree borers, *Synanthedon pictipes* (Grote and Robinson) and small numbers of adults of peach tree borers, *Sanninonidea exitiosa* (Say) and dogwood borers, *Thamnosphecia scitula* (Harris).

Among the 15 compounds tested against granulate cutworm, *Feltia subterranea* (F.) on peanuts in Georgia in bait formulations, abate, monocrotophos, dursban, dyfonate, trichlorfon, methyomyl and monitor gave greater than 90 per cent control of cutworms within 24 hours after application (Morgan and French, 1971).

Erfurth (1973) reported that poison bait consisting of wheat bran, sugar and trichlorfon was more effective against *A. segetum* and *Agrotis exclaminations* (Linnaeus) infesting potatoes in East Germany.

Creighton *et al.* (1973) reported that the bait containing CSM (a high protein food containing processed maize-meal, deflattened soybean flour, non-fat dried milk, refined soybean oil and mixture of minerals and vitamins) and methomyl at 0.25 lb toxicant/acre was effective against *Heliothis zea* (Boddie) on tomato in South Carolina.

Yokoi *et al.* (1975) reported the behavioural differences among larvae of Noctuids (*A. ipsilon*, *S. litura* and *Momestra brassicae* (L.)) when the commercial Japanese bait, Nekiriton was used. When the granular bait containing one per cent trichlorfon was placed on the soil surface, it was most effective against *A. ipsilon* and least effective against *M. brassicae*. Whereas, when applied to leaves of Chinese cabbage, it was less effective against *S. litura*.

Sechriest and Sherrod (1977) evaluated six insecticides in pelleted bait formulations in the field for control of larvae of *A. ipsilon*, attacking seedling corn. Biothion at 0.34 kg a.i./ha, fonofos at 1.12 kg a.i./ha, methomyl at 0.17 kg a.i./ha, chlorpyriphos at 0.34 kg a.i./ha trichlorfon at 1.12 kg a.i./ha and carbaryl at 0.84 kg a.i./ha controlled the black cutworm larvae when applied soon after seedling emergence.

Gholson and Showers (1979) conducted experiments on the feeding behaviour of black cutworm, *A. ipsilon* on seedling corn in presence of organic baits in green house and observed that fifth and sixth instars fed more on corn seedlings when baits were absent than in the presence of baits. They have also reported that apple grape, grape and bran pellets were the most attractive of all the materials tested in baits.

Third to fifth instar larvae of *S. litura* was effectively controlled by spreading out the bait based on lindane (1 kg of a 25% dust), wheat bran (100 kg) and water (50 liters), before dusk at the rate of 70-80 kg/ha (Gharib, 1979).

Abdulkareem and Viswanathan (1980) recommended poison baiting for the control of *S. litura*. The contents were rice bran (5 kg), jaggery or molasses (0.5 kg), carbaryl 50 per cent WP (0.5 kg) and water (3 litres).

Petrik (1981) advocated the use of poison baits in sugar beet field against winter moth, *A. segetum,* exclamation mark moth, *A. exclamationis* and other noctuids. William and Showers (1982) reported that a mixture of bran, grape and apple grape was found to be attractive to black cutworm (*A. ipsilon*) larvae when seven bait materials were tested.

Baits of five per cent carbaryl in wheat bran or kibbled wheat of 10 kg/ha was found superior to three commercial baits for larvae of *A. ipsilon* (Hill *et al.,* 1983).

Jayaraj (1983) stated that under field conditions, the full grown larvae of *S. litura* hiding inside the soil crevices during day time, were found to be attracted to wheat flour bait or rice bran bait with 20 per cent molasses.

Ascher and Rubin (1983) carried out experiments with wheat bran bait for the control of *S. littoralis*. They observed that, in the field, the effectiveness of 0.1 per cent chlorpyriphos decreased from 100 per cent mortality to 85 per cent within 16 days and to 53.4-56 per cent within 26 days.

Moustafa (1983) carried out experiments using different carriers on the performance of baits with fenvalerate and chlorpyriphos used for the control of *A. ipsilon*. Maize cob pith was more attractive and effective carrier than groundnut shell or wheat bran. Further, he reported higher toxicity of the baits on moist than dry soil.

Parasuraman *et al.* (1985) conducted studies to test the effectiveness of different baits to attract larvae of *S. litura* in cotton ecosystem. They found that a maximum of 34.9 larvae were attracted to wheat flour with 20 per cent molasses 16 hours after the bait was placed. They suggested that insecticides and nuclear polyhedrosis virus in bait preparation containing wheat flour with 20 per cent molasses might prove useful in controlling *S. litura*.

Dhandapani and Abdulkareem (1986) conducted experiments in the field for the control of red headed hairy caterpillar, *A. albistriga* on the efficacy of various insecticides *viz.,* carbaryl, DDT, acephate and trichlorfon as toxicants with rice bran as base and jaggery as attractant in the bait and suggested to use the bait with trichlorfon in the integrated control of this pest.

Giraddi and Kulkarni (1987), worked on insecticidal baits (Fenthion, endosulfan, monocrotophos and quinalphos) with 500 g jaggery, 40 kg wheat bran in five litres of water per hectare. According to them quinalphos bait properly mixed and dried under shade for one hour and applied against armyworm, *Mythimna separata* (Walker) larvae in sorghum at Dharwad was more effective followed by monocrotophos bait.

Dhandapani *et al.* (1987) reported the effectiveness of poison bait with fenpropathion and trichlorfon for the control of *S. litura*.

Lampert and Southern (1987) evaluated various formulations and methods of application of *B. thuringiensis* var. *Kurstaki* Berliner and acephate for control of the tobacco budworm, *Heliothis virescens* (F.) on flue-cured tobacco and hand applied baits were found to be the most effective.

Ramana *et al.* (1988) reported 0.01 per cent chlorpyriphos + 1.0 per cent chlorpyriphos bait (rice bran and jaggery at 4:1), 0.05 per cent chlorpyriphos + 0.05 per cent chlorpyriphos bait and 0.05 per cent monocrotophos + 0.05 per cent monocrotophos bait to be effective in descending order against *S. litura* in groundnut. However, fenvalerate was the most economical chemical which resulted in the highest net profit.

As a continuation of the experiments conducted in the laboratory, Mohan *et al.* (1989) conducted studies using poison pellets in a cauliflower field severely infested with *S. litura*. From an area of two cents a mean number of 17, 23.5, 40 and 47.5 larvae were attracted and killed by the BHC 50 WP, carbaryl 50 WP, fenthion 80 EC and malathion 50 EC pellets.

Ramaprasad *et al.* (1989) assessed five insecticide bait formulations against *S. litura* in tobacco nurseries and found that the later instars can be effectively and economically controlled by the application of endosulfan or monocrotophos or chlorpyriphos or fenvalerate or quinalphos at 1/3rd of their recommended dose by mixing with rice bran and jaggery at the ratio of 4:1 and with the application rate of 31.25 kg/ha.

Kulkarni (1989) carried out an experiment on different insecticidal sprays and bait formulations in *kharif* and summer seasons against *S. litura* in groundnut crop. In *kharif* season, NPV was found highly effective in reducing the larval populations followed by monocrotophos spray and monocrotophos bait. During summer the mortality of the pest was highest in mocrotophos spray followed by methamidophos spray, chlorpyriphos bait and decamethrin bait.

Hiremath *et al.* (1990) taking advantage of an army worm outbreak at Dharwad, carried out poison bait experiments. Application of poison bait containing monocrotophos was found superior (98% larval mortality within 24 hours) compared to sprays with 0.05 per cent monocrotophos (97.83%), endosulfan (73.6%), chlorpyriphos (75.43%), decamethrin (73.2%) or application of BHC dust (64.33%) and carbofuran 3G (86.53%) in suppressing *M. separata* population. Further, based on economics and safety measures, it was recommended that the poison bait @ 25.0, 37.5, 50.0, 75.0, 100.0 and 125.0 kg/ha has to be used when the population is 0-5, 6-10, 11-15, 16-20, 21-25 and 25-30 larvae/plant respectively.

In another study, Hiremath *et al.* (1992) found out the mass trapping technique for the armyworm moths by using fermented bait of monocrotphos (stored for 48 hours). The application of such bait resulted in 98 per cent kill of larvae and 70 per cent of moths.

Chandrasekhar (1992) evaluated the efficacy of seven insecticides against *S. litura* infesting potato crop. Among the insecticides tried, monocrotophos poison bait, chlorpyriphos and quinalphos treatment registered with lesser tuber loss on weight basis. On number basis also, monocrotophos poison bait gave maximum control.

Giraddi (1992) reported that monocrotophos and diflubenzuron poison bait were effective in the management of cotton cutworms, Agrotis spp., though methomyl soil drench was significantly superior treatment.

Mallapur (1993) conducted to test the efficacy of some of the chemicals and bioagents against *M. separata*, by applying them mainly through bait formulations. Fenvalerate dust exhibited its superiority over others (87-100 % reduction). However, the cost benefit ratio was highest in monocrotophos bait (1:15) followed by chlorpyriphos bait (1:12). Further, he suggested imposition of NPV spray or removal of top dried leaf portions followed by poison bait application as the management strategy for *M. separata*.

Hiremath (1993) found that poison bait consisting of 250 ml monocrotophos, four kg jaggery, 50 kg rice bran and six to eight litres of water, was significantly superior to endosulfan spray in suppressing the larval population of *M. separata* on sorghum and maize, *S. litura* on groundnut and sunflower and *H. armigera* on bengalgram and cotton. The bait was effective in killing the adults of these pests. Also, increasing of jaggery content by two times (8 kg) was found superior. Among the carriers evaluated, the rice bran was found to be most effective.

On the contrary, the bait application was not found superior (64.85%) in the control of either early or late instar larvae of horn caterpillar, *Agrius convolvuli* (L.) on greengram at Dharwad. Instead, spraying of insecticides namely monocrotophos 0.108 per cent and quinalphos 0.062 per cent proved superior and registered high larval mortality of 87.74 and 87.53 per cent, respectively (Nagaraja, 1993).

Studies conducted for evaluating the combination effect of poison bait and *B. thuringiensis* revealed its less efficacy in controlling pests of greengram. However, among all the treatments bait formulation with monocrotphos alone emerged as superior with larval mortality of *A. convolvuli* (51.29%) and *P. orichalcea* (35.03%) recording yield of 452.96 kg/ha (Chougala, 1994).

2.2.2 Non-lepidopteran insects

In continuation of the studies conducted in the laboratory on the efficacy of various carrier materials like wheat bran, vermiculite, clay granules etc., a field test was conducted using the best proven combination consisting of 85 per cent maize cob grits, 15 per cent soybean oil and 0.07 per cent mirex against the imported fire ant, *S. seavissima richteri.* Such baits gave more then 95 per cent control of the ants at the rate of 5-20 lb (1.7 to 6.8 g insecticide per acre (Lofgren *et al.,* 1963).

Field tests with small cages were used to determine if a reduced concentration of carbaryl in a flaky wheat bran bait and a reduced rate of application of the bait could still yield satisfactory control of mormon cricket, *Anabrus simplex* Haldeman on range land. A reduction from 5% a.i. to 2% a.i. in concentration yielded no statistical difference in mortality. The tests indicated that control with bait could be achieved with 60 per cent less carbaryl and a reduction in rate of application as great as 75% (Foster *et al.,* 1979).

All the major species of grasshoppers except *Amphitornus coloradus* (Thomas) and *Camnula pellucida* (Scudder) were found susceptible to the wheat bran bait with carbaryl (0.56%) as toxicant in the grassland (Onsager *et al.,* 1980). Mukerji *et al.* (1981) reported efficacy of dimethoate mixed with flaky wheat bran bait, among four insecticides tested against third instar grasshopper populations composed mostly of *Melanoplus sanguinipes* (Fab.) followed by fenvalerate compared to propoxur and pyridaphenthion.

Hislop *et al.* (1981) conducted experiments on the control of walnut husk fly, *Ragoletis suavis completa* (Cress) in walnut orchard and found out the superiority of bait formulation compared to sprays. Further, they also reported that the application to half the canopy with bait containing fenvalerate was more effective than application to only quarter canopy area.

Johnson and Henry (1987) reported that the wheat bran baits treated with either low dosages (80 g/ha) of insecticides like carbaryl and dimethoate or with *Nosema locustae* Canning were effective to reduce the grasshoppers including *Melanopsis arginipes* (Fabricius) and *M. inlantilis* (Scudder) in road side vegetation in Alberta.

Metcalf *et al.* (1987) evaluated dry cucurbitacin containing baits for controlling diabroticite beetles in sweet corn and cucurbits and found that methomyl, carbofuran, carbaryl and bendiocarb baits at 0.1 per cent were more effective than the pyrethroids permethrin, cypermethrin, fenvalerate and flucythrinate at 0.01%. Isofenphos was the most effective of the organophosphorous insecticides.

Bait mixtures containing boric acid and protein hydrolysate proved to be effective against *Bactrocera tau* Walker (Sunandita and Gupta, 2001). Montiel and Jones (2002) recommended protein bait spraying with sprayable protein (1 ml of protein hydrolysate) against *B. oleae* (Gmelin).

2.3 Effect of poison baits on soil fauna, natural enemies and other beneficials

Petrik (1981) advocated to spare the natural enemies of pests feeding on the sugarbeet plants by the use of baits.

George *et al.* (1992) studied the effects of 2% carbaryl bran bait applied for grasshopper control, on non-target birds, mammals and insects in western north Dakota. They found that bird density did not differ two, 10, 21 days and one year after application.

The poison bait consisting of monocrotophos as toxicant was found safe to honey bees on sunflower (Hiremath, 1993).

Carbaryl bran bait (2% a.i.) was reported to be non-lethal to adult or immature alfalfa leaf cutting bee, *Megachile rotundata* (F.) when delivered at doses higher than those likely to be encountered in treated plants (Peach *et al.,* 1994).

3. MATERIAL AND METHODS

The evaluation of poison baits, was carried out both in the laboratory of Department of Agricultural Entomology and in field at the Water and Landuse Management Institute (WALMI), Dharwad and Main Agricultural Research Station (MARS), UAS, Dharwad during the year 2006. The experimental location lies in the transitional belt at $15^0\,17^{'}$ North latitude and 70^0 05’ East longitude and at an altitude of 731.8 m above mean sea level (MSL). Materials used and the techniques employed during the course of investigations for conducting each experiment are presented below.

3.1 Preparation of poison baits

For the bait preparation, the procedure adopted by Hiremath *et al.* (1990) was used but with alterations in terms of the toxicant chemical.

According to the procedure followed by Hiremath *et al.* (1990), poison bait consisted of 50 kg rice bran, 250 ml monocrotphos 36 SL and four kg jaggery dissolved in eight litres water (for 1 ha). 50 kg of rice bran was spread on the hard ground floor and four kg of jaggery was dissolved in two litres of water and sprinkled on the bran evenly. Later, the required quantity of poison was dissolved in two litres of water and sprinkled on the bran. Afterwards, four litres of water was poured into the mixture and stirred properly. Later, this mixture was transferred to gunny bags and kept for 48 hours for fermentation.

Similarly, the ingredients required for preparing 100 g and two kg baits for laboratory and field experiments, respectively were taken and poison baits were prepared and used for the experiments.

3.1.1 Evaluation of new insecticidal poison baits for their efficacy and preference in the laboratory

Evaluation of poison baits in laboratory was carried out in two experiments. The larvae required for conducting the experiments were reared in the laboratory as per the methodology given under 3.1.1.1.

3.1.1.1 Rearing of larvae in the laboratory

Larvae of *Mythimna separata* (Walker) were collected from the field and reared in the laboratory (Plate 1) in large plastic containers. After the fifth moult, a thin layer of sandbed was placed inside each container in order to provide suitable condition for pupation. After five to six days, emerging moths were collected and were released into a 30 cm x 30 cm x 30 cm wooden cage with glass sliding front. A cloth sieve was provided on one side. 20 per cent sucrose soaked in cotton swab was provided as adult food. Dry leaf pieces of sorghum were kept inside the cage for egg laying. After egg laying, dried leaves with eggs were taken out and kept for hatching. The neonate larvae were released in plastic boxes with meshed lid @ 25 larvae/box. As the growth progressed, the larvae were transferred to large plastic containers. The fourth instar larvae were used for the experiments.

3.1.1.2 Experiment No. I : Evaluation of newer insecticides in poison baits for efficacy against *M. separata*

For the study, poison baits using five different chemicals were used in addition to monocrotophos poison bait as standard check.

Since there is no standardized recommendation available on the rate of new chemicals to be used in bait preparations, it is empirically calculated based on their dosage recommended for spray application (Anon., 2004) and considering the spray volume required per acre as 200 litres.

Poison baits each weighing 100 g were prepared at three levels of concentrations of all the five chemicals. The three concentrations of each chemical were selected such that the concentrations were 75, 50 and 25 per cent of the recommended dosages of the chemicals.

a) Rearing of field collected larvae

b) Pupae of *M. separata*

c) Oviposition by *M. separata*

d) Eggs of *M. separata*

Plate1: Rearing of Mythimna separate (walker) in laboratory

Table 1 : Chemicals used for the preparation of poison baits for laboratory experiments

Insecticides	Recommended dosages for sprays	Amount of chemicals required for preparing 100g of poison bait		
		75%	50%	25%
Profenophos 50EC	2 ml/l	1.5 ml	1 ml	0.5 ml
Chlorpyriphos 20 EC	2 ml/l	1.5 ml	1 ml	0.5 ml
Indoxacarb 14.5SC	0.5 ml/l	0.375 ml	0.25 ml	0.125 ml
Spinosad 45SC	0.2 ml/l	0.15 ml	0.1 ml	0.05 ml
Lambda cyhalothrin 5EC	2 ml/l	1.5 ml	1 ml	0.5 ml
Monocrotophos 36 SL	0.5 ml/100 g*			

* - Dosage in poison bait which was the standard check

There were three replications for each concentration of all the chemicals. Details of the treatments are furnished in Table 1.

After the preparation, poison baits were kept in small gunny bags for 48 hours for ensuring fermentation. Later poison baits were spread into plastic boxes with meshed lid and the lab reared fourth insar larvae of *M. separata* were released into it @ 15 larvae/box. 100 g mixture of rice bran and jaggery without insecticide was also kept as control.

Observations were taken on number of dead larvae at 12, 24, 48 and 72 hours after the release of larvae into the boxes containing poison baits.

3.1.1.3 Experiment No. 2 : Preference of larvae towards poison baits

The studies were carried out in a specially designed insect cage of size 3m $\times$ 3m in greenhouse prepared out of muslin cloth (Plate 2). Poison baits weighing 100g each were prepared following the standard methodology, using all the chemicals tried in experiment no. 1 (at 75% of recommended dosage). The laboratory reared larvae of *M. separata* (100 no.s) were introduced simultaneously to the poison baits by keeping them in the centre of cage. The behavioural pattern and movement of larvae towards each poison bait indicating any attraction was recorded. Also, dispersal patterns of the larvae and settlement on baits for

Table 2 : Chemicals used for the preparation of poison baits for field experiments

Insecticides	Recommended dosages for sprays	Quantity of insecticide used in 2kg bait
Profenophos 50EC	2 ml/l	30 ml
Chlorpyriphos 20 EC	2 ml/l	30 ml
Indoxacarb 14.5SC	0.5 ml/l	7.5 ml
Spinosad 45SC	0.2 ml/l	3 ml
Lambda cyhalothrin 5EC	2 ml/l	30 ml
Monocrotophos	250 ml/50 kg*	10 ml

* - Dosage in poison bait which was the standard check

Plate 2: Muslim cloth cage used for assessing larval preference to poison baits

feeding were observed. The study was repeated for two times to assess the behaviour precisely.

3.2 Evaluation of newer insecticide molecules for use in poison baits in various crop ecosystems

Experiments were laid out at the Water and Land Management Institute (WALMI), Dharwad and Main Agricultural Research Station (MARS), Dharwad to evaluate the efficacy of newer insecticide molecules for use in poison baits in four crop ecosystems. The crop ecosystems selected were of groundnut targeting *Spodoptera* litura (Fab.), sorghum for *M. separata*, chickpea and pigeonpea for *Helicoverpa armigera* (Hub.). The experiments were conducted in standing crops during *kharif* (groundnut and sorghum) and *rabi* (pigeonpea and chickpea) seasons of 2006.

From the treatments given in Table 1, the concentrations which proved best for each insecticide in laboratory were selected and evaluated in the above mentioned crop ecosystems. The experiment was conducted in a randomized block design with four replications. The plot size was 20 m × 20 m. Monocrotophos poison bait, suggested by Hiremath *et al.* (1990) was included as the standard check along with an untreated check. Details of the treatments are furnished in Table 2.

In the field, the baits were broadcasted above the plant height, so as to ensure deposition on plant and soil surface as well, depending on the type of pest. The application of the bait was done during evening hours, when the pest activity was high. Prior to the application of the bait the initial count of the larvae were taken from replicated spots measuring 2.0 m x 2.0 m in each crop.

Further, observations on various crops were recorded on larvae and adults collected from four spots measuring 2 m × 2 m per spot at random in each experimental plot. Mortality counts were taken at 24, 48 and 72 hours and seven days after application.

3.3 Effect of poison baits on soil fauna in various crop ecosystems

The impact of poison baits on the natural enemies and soil fauna like earthworms, ground beetles etc. was evaluated in the field by observing for natural enemies and soil fauna that got attracted and killed. The observations were recorded from four spots measuring 2.0 m × 2.0 m per spot at random in each experimental plot, after the application of poison baits.

4. EXPERIMENTAL RESULTS

The results of the investigations on the evaluation of poison baits for their efficacy against target pests in laboratory and crop ecosystems at UAS, Dharwad during 2006 are presented in this chapter. The effects of the poison baits on the natural enemy fauna are also presented here under.

4.1 Evaluation of new insecticidal poison baits for their efficacy and preference in the laboratory

The evaluation of poison baits in the laboratory was carried out in two experiments. The results of the experiments conducted using the laboratory reared larvae of *Mythimna separata* (Walker) are presented under 4.1.1 and 4.1.2.

4.1.1 Experiment No 1 : Evaluation of newer insecticides in poison baits for efficacy against *M. separata*

Poison baits prepared using the chemicals as given in Table 1 were spread into plastic boxes with meshed lid and the laboratory reared fourth instar larvae of *M. separata* were released into it @ 15 larvae/box. The mortality percentages were recorded at 12, 24, 48 and 72 hours after the treatment (Table 3).

At 12 hours after treatment, chlorpyriphos at 75 per cent of recommended dosage recorded significantly highest mortality (73.30%) and it was on par with the standard check monocrotophos (71.53%). Spinosad at 75 per cent of recommended dosage (66.60%), lambda cyhalothrin at 75 per cent of recommended dosage (60%), the latter being on par with chlorpyriphos at 50 per cent of recommended dosages (60%), were to follow. Spinosad at 50 per cent of recommended dosage (51.6%), profenofos at 75 per cent and 50 per cent of recommended dosages (51.06 and 48.80%), indoxacarb at 75 per cent of recommended dosage (48.89%), lambda cyhalothrin at 50 per cent of recommended dosage (48.80%) and chlorpyriphos at 25 per cent of recommended dosage (46.6%) found to show moderate efficacy and were on par with each other. Indoxacarb at 25 per cent of recommended dosage (35.55%) was found inferior and was on par with profenofos at 25 per cent of recommended dosage (40%) and lambda cyhalorthin at 25 per cent of recommended dosage (40%).

However, all the three concentrations of the chemicals i.e., 75, 50 and 25 per cent were significantly superior to control, where no mortality of the larvae was observed.

Among the three levels of concentrations tested, 75 per cent of recommended dosage of each chemical emerged as superior over other two levels of concentrations except in the case of profenofos where 50 per cent of recommended dosage (48.80%) and 75 per cent of recommended dosage (51.60%) were on par with each other.

After 24 hours of exposure of larvae to the baits, significantly highest mortality was recorded by chlorpyriphos at 75 per cent of recommended dosage (93.30%). This was found superior to rest of the treatments including the standard check, monocrotophos (88.80%). Next to follow were profenofos at 75 per cent of recommended dosage (80.00%), chlorpyriphos at 50 per cent of recommended dosage (82.20%) and spinosad at 75 per cent of recommended dosage (80.00%). Moderate efficacy was shown by lambda cyhalothrin at 75 per cent of recommended dosages (73.3%) and spinosad at 50% of recommended dosages (66.6%), but these treatments were significantly different from each other. Eventhough, indoxacarb at 25 per cent of recommended dosage recorded least mortality (46.60%) followed by spinosad at 25 per cent of recommended dosage (51.07%), they were significantly superior to control. All the chemicals tested were found to show significantly higher mortality at 75 per cent of their recommended dosages in the bait formulation vis-à-vis other two dosages.

At 48 hours after treatment, chlorpyriphos at 75 per cent of recommended dosage maintained its superiority by recording 100 per cent mortality, while the standard check monocrotophos recorded 97.76 per cent mortality. Next to follow was lambda cyhalothrin at 75 per cent of recommended dosage (93.30%) followed by profenofos at 75% of

Table 3: Effect of different insecticide poison baits against fourth instar larvae of *M. separata*

Treatments	Conc. of poison bait*	12 hrs	24 hrs	48 hrs	72 hrs
Profenofos 50 EC	25	40 (39.25)gh	53.3 (46.92)gh	73.3 (58.92)hi	93.3 (75.04)bcd
	50	48.80 (44.35)e	57.76 (49.5)fg	86.6 (68.56)def	95.53 (79.85)abc
	75	51.06 (45.64)e	80 (63.47)c	93.3 (73.04)cd	97.76 (84.66)ab
Chlorpyriphos 20 EC	25	46.6 (43.07)ef	60 (50.79)f	80 (63.47)gh	95.53 (79.85)abc
	50	60 (50.79)d	82.2 (65.17)c	88.83 (70.72)cde	100 (89.47)a
	75	73.3 (58.92)a	93.3 (75.04)a	100 (89.47)a	100 (89.47)a
Indoxacarb 14.5 SC	25	35.55 (36.59)h	46.6 (43.07)i	60 (50.79)j	86.6 (68.56)d
	50	44.4 (40.53)fg	53.3 (46.94)gh	80 (63.47)gh	93.3 (75.03)bcd
	75	48.89 (44.35)e	60 (50.79)f	86.6 (68.56)def	95.53 (79.85)abc
Spinosad 45 SC	25	37.76 (37.93)gh	51.07 (45.64)hi	66.6 (54.72)ij	93.3 (75.04)bcd
	50	51.06 (45.64)e	66.6 (54.72)e	82.2 (65.17)fg	95.53 (79.85)abc
	75	66.6 (54.72)bc	80 (65.17)c	91.02 (72.88)cd	100 (89.47)a
Lambda cyhalothrin 5 EC	25	40 (39.25)gh	53.3 (46.92)gh	66.6 (54.73)ij	88.83 (70.72)cd
	50	48.8 (44.35)e	60 (50.79)f	84.4 (66.86)efg	95.53 (79.85)abc
	75	60 (52.10)cd	73.3 (58.92)d	93.3 (75.04)c	100 (89.47)a
Monocrotophos 36 SL (Standard check)		71.53 (57.52)ab	88.8 (70.72)b	97.76 (85.04)b	100 (89.47)a
Control (rice bran + jaggery)		0 (0.074)i	0 (0.074)j	0 (0.074)k	0 (0.074)e

Figures in paranthesis are means of angular transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - 25, 50 and 75 per cent of the recommended quantity of the insecticide for spray

recommended dosage and spinosad at 75 per cent of recommended dosage (91.02%). The latter treatments were on par with chlorpyriphos at 50 per cent of recommended dosage (83.30%) which in turn was on par with profenofos at 50 per cent of recommended dosage (86.60%) and indoxacarb at 75 per cent of recommended dosage (86.60%). The least efficacy was registered in indoxacarb treatment at 25 per cent of recommended dosage (60.00%) which was on par with lambda cyhalothrin and spinosad at 25 per cent of their recommended dosages (66.60%).

Among the three levels of concentrations tested, 75 per cent of recommended dosage of each chemical registered significantly higher mortality except in the case of profenofos where mortality at 75 per cent of recommended dose (93.30%) of the chemical was on par with the mortality caused by 50 per cent of recommended dosages (86.60%) of the chemical.

At 72 hours after treatment, chlorpyriphos at 75 and 50 per cent of recommended dosages, spinosad at 75 per cent of recommended dosage and lambda cyhalothrin at 75 per cent of recommended dosage were found superior giving cent per cent mortality which were on par with the standard check, monocrotophos.

Next to follow were profenofos at 50 per cent of recommended dosage, chlorpyriphos at 25 per cent of recommended dosage, indoxacarb at 75 per cent of recommended dosage, spinosad at 50 per cent of recommended dosage and lambda cyhalorthin at 50 per cent of recommended dosage (95.53%). The least efficacy was shown by indoxacarb at 25 per cent of recommended dosage (86.60%). However, it was significantly superior to control.

At 72 hours after treatment imposition, all the three levels of concentrations of the chemicals were found to give almost equal level of mortality. In case of profenofos, 75 per cent of recommended dosage and 50 per cent of recommended dosage found to show no significant difference in mortality. The latter was on par with mortality at 25 per cent of recommended dosage.

In case of chlorpyriphos, all the three levels of concentrations were on par with each other. Indoxacarb showed non-significant difference between 75 per cent of recommended dosage and 50 per cent of recommended dosage, but 25 per cent recommended dosage was significantly inferior to 75 per cent of recommended dosage. Spinosad and lambda cyhalothrin also followed the same trend.

4.1.2 Experiment No. 2 : Preference of larvae towards poison baits

To study the behavioural pattern and attraction of larvae, five poison baits at 75 per cent of their recommended dosages for each chemical were evaluated in the laboratory of department of agricultural entomology, UAS, Dharwad along with monocrotophos bait as standard check. Rice bran and jaggery were mixed and prepared as bait formulation, without adding any chemical, to keep as untreated check. After fermentation for 48 hours, the baits were kept along the periphery within the muslin cloth cage and larvae (100 no.s) were released into the middle of the cage.

Immediately after release, larvae were seen to move towards the periphery (Fig. 1a), with the movement patterns being very random. Many of the larvae appeared attracted to one or the other bait and oriented their movement towards all the baits, but some of the larvae seemed to move aimlessly. A number of larvae were found crawling into the space between two adjacent baits (Fig. 1b).

Eventually, all the larvae were found feeding on the baits. Interestingly, lambda cyhalothrin bait appeared to show some repellent action. Some of the larvae, which initially seemed to get attracted towards lambda cyhalothrin bait, moved away from it after initial feeding. In the case of other baits also, to and fro movements were observed, yet it was not as apparent as in the case of lambda cyhalothrin.

No bait could sustain feeding by larvae even after 15 minutes of release. Larvae were found shifting their feeding to adjacent baits on both sides, intermittently. But, no larvae were found going to a bait other than its adjacent bait.

Since the larvae were found moving in an irregular fashion and seen to feed from multiple baits, the mortality resulted in this case could not be accounted due to a particular chemical in bait formulation. Hence, the counts of larvae in each bait formulation at various time intervals were taken without considering whether they are dead or alive.

The counts taken at 15 minutes after release showed a uniformity in number of larvae feeding on each bait. However, lambda cyhalothrin showed a slightly less number (12.0) of larvae. All other baits showed larval feeding in a range of 14.33-15.67 (Table 4).

At 30 minutes after release, almost same trend was observed. At this point, lambda cyhalothrin showed almost the same number of larvae compared to other bait formulations.

During the time between the first and the second observations, larvae continued the random movement but in a more restricted manner (Fig. 1c). The larvae were moving from one bait to another but were not found moving to the periphery of the experimental arena unlike what they did just after the release. After 30 minutes of release no much movement of larvae between the baits was noticed.

At 60 minutes after release, four baits showed same number of larvae as that seen at 30 minutes after release. Spinosad and indoxacarb showed an increase in number of larvae while lambda cyhalothrin showed a reduction from the count recorded at 30 minutes after release.

At 16 hours after release, no change in larval count was observed from the one recorded at 60 minutes after release. Looking to the overall movement pattern of larvae towards the poison baits in case study, it could be indicated that the larvae did not exhibit any specific preference to a particular toxicant in the bait.

4.2 Field evaluation of newer insecticide molecules for use in poison baits in crop ecosystems

With a view to assess the efficacy of new chemicals as a possible substitute for monocrotophos in poison baits, experiments were carried out in four crop ecosystems, *viz.,* groundnut, sorghum, pigeonpea and chickpea, targeting key lepidopterous insect pests. Observations were taken at 24, 48, 72 hours and seven days after application of baits.

4.2.1 Evaluation of fermented poison baits in groundnut ecosystem

Poison baits were applied on the standing crop of groundnut (Plate 3) at WALMI, Dharwad. The results on the mortality of larvae and adults of *Spodoptera litura* (Fab.) are presented below.

4.2.1.1 Effect of poison baits on larvae of *S. litura* in groundnut ecosystem

The population counts on the crop taken before application of poison bait was non-significant as evident from Table 5. However the post treatment counts soon after a day of treatment imposition were found significant indicating differential efficacy of the treatments. Chlorpyriphos bait was found to be highly effective with 5.25 mean number of dead larvae, followed by monocrotophos bait (4.0), the standard check (Plate 4). The latter was found as effective as profenofos bait (3.25), which in turn was at par with spinosad bait (2.5). Lambda cyhalothrin was the least effective chemical in the bait (1.25) but it was on par with indoxacarb (2.0).

At 48 hours after treatment, the same trend was noticed as seen at 24 hours after treatment.

At 72 hours after treatment, chlorpyriphos bait recorded the highest number of dead larvae (6.5) in the treated plots. The next best treatments were monocrotophos (5.0), profenofos(4.75) and spinosad (4.0) baits. Spinosad bait was on par with indoxacarb bait (3.25) which in turn was on par with lambda cyhalothrin bait (2.75). There was no mortality of any larvae seen in control.

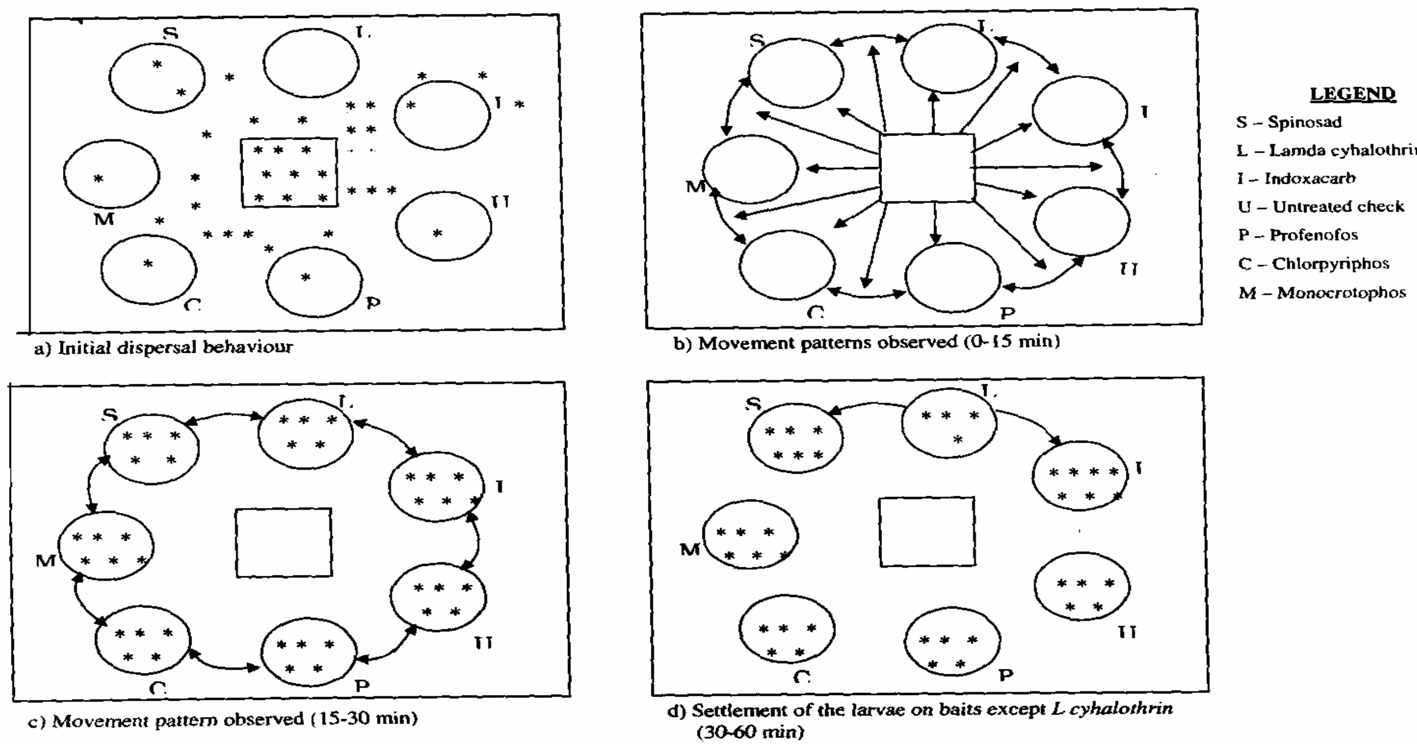

Fig. 1 : Dispersal behaviour and movement pattern of larvae *M. separata* observed under choice conditions within the insect cages

Fig1:Dispersal behaviour and movement pattetrn of larvae M.separata observed under choice conditions within the insect cages

Table 4 : Feeding pattern of larvae under choice conditions in the insect cages

Treatments	Number of larvae (dead/alive) in baits at			
	15 min	30 min	60 min	16 hours
Profenofos 50 EC	14.67	15.67	15.67	15.67
Chlorpyriphos 20 EC	15.33	14.00	14.00	14.00
Indoxacarb 14.5 SC	14.33	16.33	16.67	16.67
Spinosad 45 SC	14.67	14.33	15.67	15.67
Lambda cyhalothrin 5 EC	12.00	14.00	12.33	12.33
Monocrotophos 36 SL	15.00	13.00	13.00	13.00
Untreated control (Rice bran + jaggery)	14.33	13.67	13.67	13.67

Table 5: Evaluation of fermented poison baits against larvae of *S. litura* in Groundnut

Treatments	Pre-treatment count*	Mean number of dead larvae at*			
		24 hrs	48 hrs	72 hrs	7 days
Profenofos 50 EC	5 (2.34)a	3.25 (1.933)bc	4.0 (2.115)bc	4.75 (2.284)b	5.75 (2.495)b
Chlorpyriphos 20 EC	4.25 (2.12)a	5.25 (2.396)a	6.25 (2.597)a	6.5 (2.641)a	7.0 (2.73)a
Indoxacarb 14.5 SC	4.75 (2.28)a	2.0 (1.564)de	2.75 (1.798)d	3.25 (1.924)cd	3.5 (1.996)d
Spinosad 45 SC	4.5 (2.23)a	2.5 (1.726)cd	3.25 (1.924)cd	4.0 (2.115)bc	4.5 (2.233)c
Lambda cyhalothrin 5 EC	4 (2.12)a	1.25 (1.314)e	2.5 (1.726)d	2.75 (1.798)d	3.25 (1.933)d
Monocrotophos 36 SL	4.5 (2.23)a	4.0 (2.115)b	4.5 (2.233)b	5.0 (2.340)b	6.0 (2.55)ab
Untreated control (Rice bran + jaggery)	4 (2.12)a	0 (0.707)f	0 (0.707)e	0. (0.707)e	0 (0.707)e

Figures in parantheses are $\sqrt{x+0.5}$ transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - from 4 sq. m area

At seventh day of application, chlorpyriphos bait registered the highest number of dead larvae (7.0), followed by monocrotophos bait (6.0), the latter being on par with profenofos bait (5.75). The next best treatment was spinosad bait (4.5). Lambda cyhalothrin (3.25) and indoxacarb (3.5) baits were found statistically inferior to other treatments. In untreated control, again no dead larvae were noticed indicating that mortality of larvae in other treatments was due to the effect of toxicant.

4.2.1.2 Effect of poison baits on adults of *S. litura* in groundnut ecosystem

At 24 hours after treatment, significantly highest number of dead adults were found in chlorpyriphos bait (6.0) followed by monocrotophos bait (5.25) (Plate 4) and being at par with each other. The next best treatment was profenofos bait (2.5) followed by spinosad bait (1.75) and were on par with each other. Lambda cyhalothrin bait (0.5) proved to be significantly inferior to all the treatments but on par with indoxacarb bait (0.75). In untreated control, no dead moths were seen (Table 6).

The same trend was followed at 48 hours after treatment except in profenofos (2.75) and spinosad (2.0) baits showing significant difference between each other. In this case, profenofos bait emerged superior to spinosad bait, while lambda cyhalothrin (1.0) and indoxacarb (1.25) baits were found to be inferior. No death of adult was observed in untreated control.

At 72 hours after treatment, chlorpyriphos bait maintained its superiority (6.25) and was on par with the standard check monocrotophos bait (5.5). The next best treatment was profenofos bait (3.25) followed by spinosad (2.25) and indoxacarb (1.75) baits, the latter two being on par with each other. Lambda cyhalothrin exhibited comparatively poor efficacy in attracting and killing the moths. In the untreated control, no moths were attracted.

At seven days after treatment, the highest number of dead adults were observed in chlorpyriphos bait (7.5) which was on par with monocrotophos bait (6.5) and differed significantly from rest of the treatments. Profenofos (4.25) and spinosad (4.0) baits which were on par with each other were to follow in efficacy. These treatments differed significantly from indoxacarb (3.0) and lambda cyhalothrin (2.5) baits which registered the lowest number of dead adults. Untreated control exhibited no mortality of adults.

4.2.2 Evaluation of poison baits in sorghum ecosystem

Poison baits were applied on the standing sorghum crop at grand growth stage (Plate 5). The results on the mortality of larvae and adults of *M. separata* are presented below.

4.2.2.1 Effect of poison baits on larvae of *M. separata* in sorghum ecosystem

Almost a uniform pest distribution was (16 to 20.25/4 m^2) noticed prior to treatment imposition (Table 7). Among the five chemicals tried in baits, at 24 hours after application, chlorpyriphos bait proved superior killing 9.0 larvae of *M. separata* per 4 sq. m area. Standard check, monocrotophos bait recording mortality of 9.5 was on par with it (Plate 6). Profenofos (5.75) and spinosad (5.5) being on par to each other and indoxacarb (3.25) were the other good ones in efficacy. Lambda cyhalothrin bait recorded the least efficacy by causing mortality to only 2.25 larvae, but it was significantly superior to untreated control with no mortality of larvae.

At 48 hours after application, almost same trend was noticed as that seen at 24 hours with chlorpyriphos (9.25) showing superiority over other chemicals and being on par with the standard check, monocrotophos (10.75).

At 72 hours and seven days after treatment, chlorpyriphos and monocrotophos baits being on par, were significantly superior to rest of the treatments. Profenofos and spinosad baits were to follow the above ones killing 8.25 and 7.25; 8.75 and 8.0 larvae respectively at 72 hours and seven days after treatment imposition.

Table 6: Evaluation of fermented poison baits against adult moths of *S. litura* in Groundnut

Treatments	Mean number of dead adults at*			
	24 hrs	48 hrs	72 hrs	7 days
Profenofos 50 EC	2.5 (1.726)b	2.75 (1.798)b	3.25 (1.933)b	4.25 (2.171)b
Chlorpyriphos 20 EC	6 (2.449)a	6.25 (2.498)a	6.25 (2.597)a	7.5 (2.827)a
Indoxacarb 14.5 SC	0.75 (1.095)c	1.25 (1.314)d	1.75 (1.492)c	3.0 (1.861)c
Spinosad 45 SC	1.75 (1.492)b	2.0 (1.581)c	2.25 (1.654)c	4.0 (2.115)b
Lambda cyhalothrin 5 EC	0.5 (0.966)cd	1.0 (1.225)d	1.25 (1.314)d	2.5 (1.726)c
Monocrotophos 36 SL	5.25 (2.396)a	5.5 (2.447)a	6.0 (2.55)a	6.5 (2.644)a
Untreated control (Rice bran + jaggery)	0 (0.707)d	0 (0.707)e	0 (0.707)e	0 (0.707)d

Figures in parantheses are $\sqrt{x+0.5}$ transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - from 4 sq. m area

Plate3: Field view of experimental groundnut crop

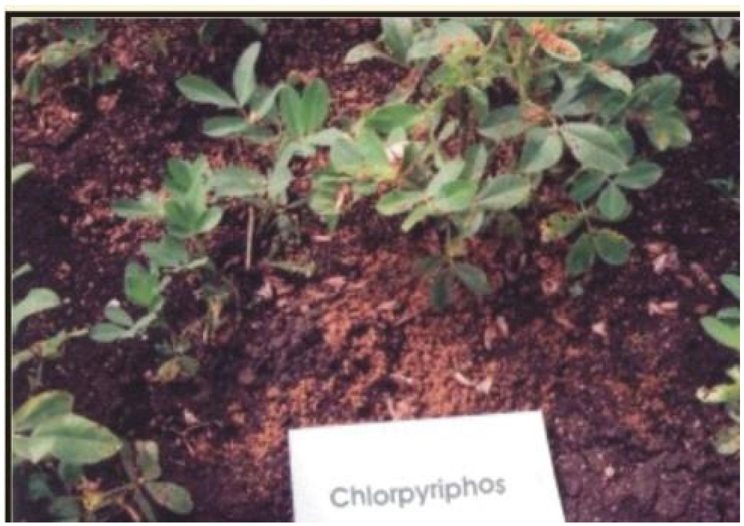

Plate:4 Larvae and adult moths of spodopetera litura Fab.attracted to poison bait

4.2.2.2 Effect of poison baits on adults of *M. separata* on sorghum

At 24 hours after treatment, chlorpyriphos bait registered highest efficacy by attracting and killing 5.75 adults from an area of $4m^2$. It was on par with standard check, monocrotophos (6.5) bait (Plate 6). The next best treatment was spinosad (1.25) bait which was on par with lambda cyhalothrin (1.0) bait, with the latter being on par with indoxacarb (0.75) bait, which was found inferior among the treatments (Table 8).

At 48 hours after treatment, chlorpyriphos (6.25) bait was found to be superior to rest of the chemicals except the standard check monocrotophos (7.25) bait. These treatments were on par to each other, while spinosad (1.75), indoxacarb (1.5) and lambda cyhalothrin (1.25) baits being on par were inferior in efficacy.

At 72 hours after treatment, also almost same trend was seen.

At seven days after treatment, none of the five chemicals tried could give efficacy that was comparable to standard check, monocrotophos bait (8.0). Among the chemicals, chlorpyriphos (6.75) proved superior over rest of the treatments, followed by profenofos (4.25) and spinosad (3.75). Whereas, lambda cyhalothrin recorded the least mortality (2.0). There was no attraction of moths in untreated control.

4.2.3 Evaluation of poison baits in chickpea ecosystem

Poison baits were applied on chickpea crop at pod formation stage (Plate 7). The results on the mortality of larvae and adults of *Helicoverpa armigera* (Hubner) are presented below.

4.2.3.1 Effect of poison baits on larvae of *H. armigera* in chickpea

A uniform pest distribution (4.75 to $5.5/4m^2$ area) was observed prior to treatment imposition (Table 9). At 24 hours after treatment, chlorpyriphos bait caused mortality of highest number of larvae (2.0) and was comparable to the standard check, monocrotophos (1.5) bait. Profenofos bait found to be the next best treatment (1.0) followed by spinosad bait (0.5).

At 48 hours after treatment, chlorpyriphos (2.5) and monocrotophos (2.25) baits recorded significantly superior efficacy over other treatments. The next best treatments were profenofos (1.25) and spinosad (0.75) baits and were on par with each other.

After 72 hours of the treatment, no increase in number of dead larvae was observed and at seven days after treatment it showed the same number of dead larvae as that seen at 72 hours after treatment. At 72 hours after treatment, chlorpyriphos (2.75) and monocrotophos (2.50) baits recorded the highest number of dead larvae and were on par with each other.

4.2.3.2 Effect of poison baits on adults of *H. armigera* in chickpea

At 24 hours after application, chlorpyriphos bait recorded the highest mortality of adults (0.75) (Plate 8). Other treatments were on par with each other. At 48 hours after application, chlorpyriphos (1.0) and monocrotophos (1.0) baits registered significantly higher mortality of adults vis-à-vis untreated control. Other treatments could give only negligible mortality (Table 10). At 72 hours after treatment, chlorpyriphos (1.5) bait recorded highest number of dead adults, followed by monocrotophos (1.25), profenofos (1.0), spinosad (0.75), indoxacarb (0.75) and lambda cyhalothrin (0.5) baits which were on par with each other. Untreated control, registered no adult mortality.

At seven days after treatment, chlorpyriphos (1.75) and monocrotophos (1.5) baits resulted into highest mortality of moths followed by profenofos bait (1.0) which was on par with the above mentioned treatments. The latter treatment was on par with spinosad (0.75), indoxacarb (0.75) and lambda cyhalothrin (0.5) baits. The bait lambda cyhalothrin failed to attract significant number of adults proving its poor efficacy.

Table 7: Evaluation of fermented poison baits against larvae of *M. separata* in sorghum

Treatments	Pre-treatment count*	Mean number of dead larvae at*			
		24 hrs	48 hrs	72 hrs	7 days
Profenofos 50 EC	18.25 (4.03)a	5.75 (2.495)b	7 (2.736)b	8.25 (2.95)b	8.75 (3.032)b
Chlorpyriphos 20 EC	18.75 (4.09)a	9.00 (3.080)a	9.25 (3.352)a	12.25 (3.569)a	13.25 (3.706)a
Indoxacarb 14.5 SC	16 (4.06)a	3.25 (1.924)c	4 (2.108)c	5.25 (2.391)c	5.5 (2.439)c
Spinosad 45 SC	20.25 (4.25)a	5.5 (2.444)b	6 (2.539)b	7.25 (2.783)b	8 (2.913)b
Lambda cyhalothrin 5 EC	19 (4.11)a	2.25 (1.564)d	3 (1.861)c	4 (2.115)d	4.25 (2.117)d
Monocrotophos 36 SL	19.75 (4.15)a	9.5 (3.122)a	10.75 (3.463)a	13 (3.671)a	13.75 (3.773)a
Untreated control (Rice bran + jaggery)	17.75 (4.07)a	0 (0.707)e	0 (0.707)d	0 (0.707)e	0 (0.707)e

Figures in parantheses are $\sqrt{x+0.5}$ transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - from 4 sq. m area

Table 8: Evaluation of fermented poison baits against for efficacy adult moths of *M. separata* in sorghum

Treatments	Mean number of dead adults at*			
	24 hrs	48 hrs	72 hrs	7 days
Profenofos 50 EC	2.75 (1.798)b	3.5 (1.996)b	3.75 (2.059)b	4.25 (2.117)c
Chlorpyriphos 20 EC	5.75 (2.498)a	6.25 (2.597)a	6.25 (2.597)a	6.75 (2.688)b
Indoxacarb 14.5 SC	0.75 (1.095)d	1.5 (1.403)c	2.0 (1.581)bc	2.75 (1.798)d
Spinosad 45 SC	1.25 (1.314)c	1.75 (1.492)c	2.75 (1.798)bc	3.75 (2.042)c
Lambda cyhalothrin 5 EC	1.0 (1.225)cd	1.25 (1.314)c	1.25 (1.314)c	2.0 (1.564)e
Monocrotophos 36 SL	6.5 (2.644)a	7.25 (2.783)a	8.0 (2.913)a	8.0 (2.913)a
Untreated control (Rice bran + jaggery)	0 (0.707)e	0 (0.707)d	0 (0.707)d	0 (0.707)f

Figures in parantheses are $\sqrt{x+0.5}$ transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - from 4 sq. m area

Plate5: Field view of experimental sorghum crop

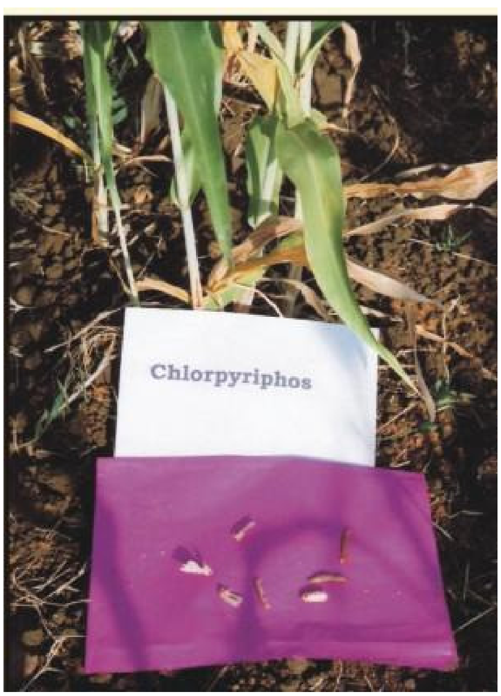

Plate 6: Larvae and adult moths of Mythimna separate (walker) Attracted to poison baits

Table 9: Evaluation of fermented poison baits against larvae of *H. armigera* in chickpea

Treatments	Pre-treatment count*	Mean number of dead larvae at*			
		24 hrs	48 hrs	72 hrs	7 days
Profenofos 50 EC	4.75 (2.28)a	1.0 (1.225)bc	1.25 (1.314)b	1.25 (1.314)b	1.25 (1.314)b
Chlorpyriphos 20 EC	5.25 (2.39)a	2.0 (1.581)a	2.5 (1.726)a	2.75 (1.798)a	2.75 (1.798)a
Indoxacarb 14.5 SC	5.25 (2.39)a	0.5 (0.966)cde	0.5 (0.966)bc	1.0 (1.225)b	1.0 (1.225)b
Spinosad 45 SC	5 (2.34)a	0.5 (1.095)bcd	0.75 (1.095)b	1.25 (1.314)b	1.25 (1.314)b
Lambda cyhalothrin 5 EC	4.75 (2.28)a	0.25 (0.837)de	0.5 (0.966)bc	0.75 (1.095)b	0.75 (1.095)b
Monocrotophos 36 SL	5.5 (2.44)a	1.5 (1.403)ab	2.25 (1.654)a	2.5 (1.726)a	2.5 (1.726)a
Untreated control (Rice bran + jaggery)	5.25 (2.39)a	0 (0.707)e	0 (0.707)c	0 (0.707)c	0 (0.707)c

Figures in parantheses are $\sqrt{x+0.5}$ transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - from 4 sq. m area

Plate7: Field view of experimental chickpea crop

Plate 8: Larvae and adult moths of Helicoverpa armigera Hub. Attracted to poison baits

4.2.4 Evaluation of poison baits in pigeonpea ecosystem

Evaluation of poison baits on pigeonpea was undertaken at pod formation stage. Poison baits were applied on standing crop of pigeonpea (Plate 9). The results on the mortality of larvae and adults of *H. armigera* are presented below.

4.2.4.1 Effect of poison baits on larvae of *H. armigera* in pigeonpea

The counts taken one day prior to application of baits showed almost uniform distribution of pest population on the crop (Table 11). At 24hours after the treatment imposition, chlorpyriphos bait recorded maximum number (1.5) of dead larvae followed by the standard check, monocrotophos (1.0) and were on par with each other (Plate 10). Profenofos (0.5) and spinosad (0.5) baits were on par with monocrotophos bait, while lambda cyhalothrin bait proved to be inferior, indicating its poor efficacy.

At 48 hours after treatment, chlorpyriphos (1.75) bait and the check monorotophos bait (1.75) emerged as the best treatments and they were on par with each other followed by spinosad bait (1.0). Profenofos bait showed moderate efficacy (0.75) and was on par with spinosad bait, while indoxacarb (0.5) and lambda cyhalothrin (0.25) baits failed to attract significant numbers of larvae.

After 48 hours of treatment, no increase in dead larvae number was observed and at 72 hours and seven days after treatment, there was no additional mortality to that seen at 48 hours after treatment.

4.2.4.2 Effect of poison baits on adults of *H. armigera* in pigeonpea ecosystem

At 24 hours after application of bait, no treatment was found to be significantly superior over control. This showed the poor efficacy of bait formulations in attracting and killing adult moths of *H. armigera*. However, all treatments except indoxacarb bait could attract and kill adult moths ranging from a meager 0.25 to 0.75 per 4 sq. m area. Indoxacarb as well as untreated control could not attract any adult moths (Table 12).

At 48 hours after treatment, chlorpyriphos bait recorded highest mortality (1.0) (Plate 10) and was on par with other treatments. The same trend was observed at seven days after treatment. No increase in mortality of adult moths was observed except in monocrotophos bait.

At seven days after treatment, chlorpyriphos (1.25) bait recorded highest mortality and was significantly superior to untreated control and indoxacarb. Other treatments were on par with chlorpyriphos in attracting and causing mortality.

4.3 Effect of poison baits on soil fauna in various crop ecosystem

The variation in mode of action of poison bait formulations when compared to insecticidal sprays necessitated their evaluation for effect on natural enemies of pests and soil fauna, the result of which in various crop ecosystems are presented below.

4.3.1 Effect of poison baits on soil fauna in groundnut ecosystem

Poison baits were applied in the standing crop of groundnut at WALMI, Dharwad. At 24 hours after application of bait, a few ground beetles were found dead in plots treated with chlorpyriphos, monocrotophos and profenofos baits with their number ranging from 0.25 to 0.5 per $4m^2$ area. No other plot showed mortality of ground beetles. At 48, 72 hours and seven days after treatment no increase in mortality was observed. Other beneficials *viz.,* earthworms, honey bees were not attracted to the baits.

4.3.2 Effect of poison baits on soil fauna in sorghum ecosystem

Poison baits were applied in standing crop of sorghum at WALMI, Dharwad. Observations made one day prior to the application of baits showed the presence of *Chrysoperla* sp. and coccinellids in the sorghum ecosystem. But after treatment imposition, no *Chrysoperla* was found attracted or killed in any of the bait treatments. However, some coccinellid beetles were found attracted and were found dead in monocrotophos treatment

Table 10: Evaluation of fermented poison baits against adults moths of *H. armigera* in chickpea

Treatments	Mean number of dead adults at*			
	24 hrs	48 hrs	72 hrs	7 days
Profenofos 50 EC	0.25 (0.837)b	0.5 (0.966)abc	1.0 (1.225)abc	1.0 (1.225)ab
Chlorpyriphos 20 EC	0.75 (1.225)a	1.0 (1.225)a	1.5 (1.403)a	1.75 (1.492)a
Indoxacarb 14.5 SC	0.25 (0.837)b	0.5 (0.966)abc	0.75 (1.095)bc	0.75 (1.095)b
Spinosad 45 SC	0.5 (0.966)ab	0.75 (1.095)ab	0.75 (1.095)bc	0.75 (1.095)b
Lambda cyhalothrin 5 EC	0.0 (0.707)b	0.25 (0.837)bc	0.50 (0.966)c	0.5 (0.966)bc
Monocrotophos 36 SL	1.0 (0.966)ab	1.0 (1.225)a	1.25 (1.314)ab	1.5 (1.403)a
Untreated control (Rice bran + jaggery)	0.0 (0.707)b	0 (0.707)c	0 (0.707)d	0 (0.707)c

Figures in parantheses are $\sqrt{x+0.5}$ transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - from 4 sq. m area

Table 11: Evaluation of fermented poison baits against larvae of *H. armigera* in pigeonpea

Treatments	Pre-treatment count*	Mean number of dead larvae at*			
		24 hrs	48 hrs	72 hrs	7 days
Profenofos 50 EC	1.75 (1.49)a	0.5 (0.966)bc	0.75 (1.095)bc	0.75 (1.095)bc	0.75 (1.095)bc
Chlorpyriphos 20 EC	2 (1.56)a	1.5 (1.403)a	1.75 (1.492)a	1.75 (1.492)a	1.75 (1.492)a
Indoxacarb 14.5 SC	2.5 (1.73)a	0.25 (0.837)c	0.5 (0.966)bcd	0.5 (0.966)bcd	0.5 (0.966)bcd
Spinosad 45 SC	2.25 (1.68)a	0.5 (0.966)bc	1 (1.225)ab	1 (1.225)ab	1 (1.225)ab
Lambda cyhalothrin 5 EC	2 (1.56)a	0.25 (0.837)c	0.25 (0.837)cd	0.25 (0.837)cd	0.25 (0.837)cd
Monocrotophos 36 SL	2.25 (1.68)a	1.0 (1.225)ab	1.75 (1.492)a	1.75 (1.492)a	1.75 (1.492)a
Untreated control (Rice bran + jaggery)	2.25 (1.68)a	0 (0.707)c	0 (0.707)d	0 (0.707)d	0 (0.707)d

Figures in parantheses are $\sqrt{x+0.5}$ transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - from 4 sq. m area

Plate9: Field view of experimental pigeonpea crop

Plate 10: Larvae of Helicoverpa armigera (Hub.) attracted to poison baits

Table 12 : Evaluation of fermented poison baits against adult moths of *H. armigera* in pigeonpea

Treatments	Mean number of dead adults at*			
	24 hrs	48 hrs	72 hrs	7 days
Profenofos 50 EC	0.5 (0.966)a	0.5 (0.966)ab	0.5 (0.966)ab	0.5 (0.966)ab
Chlorpyriphos 20 EC	0.75 (1.095)a	1.0 (1.225)a	1.0 (1.225)a	1.25 (1.314)a
Indoxacarb 14.5 SC	0.0 (0.707)a	0.25 (0.837)ab	0.25 (0.837)ab	0.25 (0.837)b
Spinosad 45 SC	0.25 (0.837)a	0.5 (0.966)ab	0.5 (0.966)ab	0.5 (0.966)ab
Lambda cyhalothrin 5 EC	0.5 (0.966)a	0.75 (1.095)ab	0.75 (0.966)ab	0.75 (1.095)ab
Monocrotophos 36 SL	0.5 (0.966)a	0.5 (0.966)ab	0.75 (1.095)ab	0.75 (1.095)ab
Untreated control (Rice bran + jaggery)	0.0 (0.707)a	0.0 (0.707)b	0.0 (0.707)b	0 (0.707)b

Figures in parantheses are $\sqrt{x+0.5}$ transformed values
Means in the column followed by same alphabet do not differ significantly by DMRT
* - from 4 sq. m area

(0.25 /4 sq. m) along with ground beetles (0.5 /4 sq. m). Here also, baits did not attract any earthworms or honey bees.

4.3.3 Effect of poison baits on soil fauna in chickpea ecosystem

Poison bait treatment was done on standing crop of chickpea at WALMI, Dharwad. Pre treatment observations showed presence of coccinellid beetles in chickpea ecosystem but none of them were found killed due to bait application. However, chlorpyriphos (0.25 /4 sq. m) and moncorotophos (0.25 /4 sq. m) showed mortality of ground beetles at 24 hours after treatment imposition. Thereafter, no increase in mortality was observed. No mortality of earthworms or bees was found in the treated plots.

4.3.4 Effect of poison baits on soil fauna in pigeonpea ecosystem

Poison baits were applied on standing crop of pigeonpea at MARS, Dharwad. At 24 hours after the application of bait no mortality of soil fauna or natural enemies was observed in any of the treated plots. However, at 48 hours after treatment, mortality of coccinellid beetles was observed in plots treated with chlorpyriphos (0.25 /4 sq. m). Thereafter, no increase in mortality was observed. In this case also, no mortality of earthworms nor attraction of bees to baits was seen.

5. DISCUSSION

The investigations on efficacy of some of the newer insecticides in poison baits in laboratory and in crop ecosystems were conducted to find out suitable insecticides for poison baits as the present recommended chemical monocrotophos 36 SL has been kept under restricted use due to its toxicity. The information on the various aspects *viz.,* efficacy of the new chemicals v/s target pests in laboratory and field, insecticide induced preference and behavioural pattern of larvae towards baits and effect of poison baits on soil fauna were investigated. The salient findings are discussed in the light of earlier works and presented here under.

5.1 Evaluation of new insecticidal poison baits for their efficacy and preference in the laboratory

As this investigation was carried out in two parts, the various aspects investigated are also discussed accordingly i.e., experiment no. 1 : effect of newer insecticides in poison baits against larvae of *Mythimna separata* (Walker) and experiment no. 2 : preference of larvae of *M. separata* towards poison baits.

5.1.1 Experiment no. 1 Evaluation of newer insecticides in poison baits for efficacy against *M. separata*

The primary objective of carrying out this experiment was to know the effect of some newer insecticides against larvae of *M. separata* for which in the management programme use of poison baits has been an integral part for many years. Besides, chemicals were tried in poison baits at reduced dosages than the recommended, to evaluate their efficacy at low dosages with a view to reduce the environmental load of the insecticides and thus the possible hazards by them.

Data on the efficacy of poison baits in causing mortality of *M. separata* larvae (Table 3) showed that all the tested insecticides were effective against the target insect and mortality of larvae increased with increase in time of exposure at all the concentrations. Chlorpyriphos at 75 per cent of recommended dosage was significantly superior over all other treatments at 12, 24 and 48 hours after exposure of larvae to the baits. The treatment gave cent per cent mortality of larvae at 48 hours after exposure which was unattainable by any other chemical treatments within that time period. Among the dosages tried, 75 per cent of recommended dosage was highly effective than the other two concentrations tried, i.e., 25 and 50 per cent of recommended dosage. At 50 per cent of recommended dosage, chlorpyriphos gave cent per cent mortality of the larvae at 72 hours after exposure to bait. Whereas, 25 per cent of recommended dosage could not produce cent per cent mortality even after 72 hours of exposure. This clearly indicates the effectiveness of chlorpyriphos at 75 per cent of recommended dosage. There are no reports available on the efficacy of chlorpyriphos bait on the larvae of *M. separata* under laboratory conditions. However, Viswanadham *et al.* (1986) reported efficacy of chlorpyriphos bait against *Spodoptera litura* (Fab.) under laboratory conditions. They could get cent per cent mortality of larvae when exposed for 48 hours to chlorpyriphos bait and they also observed increase in mortality with increase in time of exposure. Similar results were also observed by Chandrasekhar (1992) using spray of chlorpyriphos under laboratory conditions against *S. litura*.

A newer molecule, spinosad at 75 per cent of recommended dosage gave cent per cent mortality of larvae at 72 hours after exposure. At 75 per cent of recommended dosage, it invariably gave significantly superior results than the other two dosages tested (25 and 50%), at different intervals except 72 hours after exposure. The use of this molecule in bran bait formulation is seemingly a new one in insect pest management except for the report of use against snails (Gabr *et al.,* 2006). However, spinosad is reported to be used in bait sprays against fruit flies (Mc Quate *et al.,* 2005).

The synthetic pyrethroid, lambda cyhalothrin also gave cent per cent mortality at 72 hours after exposure at 75 per cent of recommended dosage which was observed to be the best among the three levels of concentrations tested. There are no reports of use of this chemical in bait formulations under laboratory conditions. However, its mode of action as good contact poison and moderate activity as stomach poison is well documented (Ray, 1991), which attributed for its efficacy as a poison bait in the present study.

Profenofos and indoxacarb also could give good results when applied at 75% of recommended dosages. Incidentally, it was observed that there was no significant variation between 50 per cent of recommended dosage and 75 per cent of recommended dosage of profenofos at 12, 48 and 72 hours after exposure of larvae to the baits. But observations made 24 hours after exposure, which was empirically fixed as the reference point for selecting best dosage for field study, showed 75 per cent of recommended dosage as superior and hence this dosage was selected for field study. Indoxacarb could not give 100 per cent mortality of larvae even after exposure to 72 hours. Use of indoxacarb in bran bait formulation against lepidopterous pest appears new to science. However, Cook *et al.* (2004) observed 100 per cent mortality of *Spodoptera exigua* (Hub.) (beet armyworm) under laboratory conditions after 10 days of exposure when treated with indoxacarb in spray formulation.

The standard check, monocrotophos bait consistently gave higher mortality at all the intervals and was next only to chlorpyriphos (75% of recommended dosage) in giving maximum mortality. Similar trend was reported by Chandrasekhar (1992) from Bangalore, under laboratory conditions against *S. litura* where cent per cent mortality was observed at 72 hours of exposure of larvae to the monocrotophos poison bait. But Viswanadham *et al.* (1986) from Bapatla observed 100 per cent mortality of larvae of *S. litura* at 48 hours after exposure of larvae to the monocrotophos poison bait. The variation of this result from the present investigation may be due to test insect and the change in the bait composition. They used a rice bran-jaggery proportion of 8:2 with high concentration of monocrotophos (2%) whereas in the present study, rice bran and jaggery was in the proportion of 25:2 and monocrotophos was at a lower concentration (1%). Kadapatti (1993) observed that monocrotophos poison bait failed to inflict mortality on fourth instar larvae of *Spilosoma obliqua* (Walker) at 48 hours after exposure which is contradictory to earlier reports and present results. This could be due to the change of insect species involved in this experiment.

In the current investigation, 75 per cent of recommended dosage of all the chemicals tested were found to result into good mortality of larvae of *M. separata*. The chemicals such as chlorpyriphos, spinosad and lambda-cyhalothrin at 75 per cent of recommended dosage proved effective in bringing about cent per cent mortality of larvae. This throws light on possibilities of using these chemicals in bait formulations at reduced dosages which would prove environment friendly and cost effective at the same time. The possibility of using insecticides in reduced dosages for poison baiting was first demonstrated by Foster *et al.* (1979) who advocated to use 2 per cent of carbaryl instead of 5 per cent in flaky wheat bran bait against mormon crickets. Similar trial was conducted by Viswanadham *et al.* (1986) under laboratory conditions, using different levels of concentration of chlorpyriphos (0.5, 1.0, 1.5 and 2.0%) in bait. Eventhough, cent per cent mortality of *S. litura* was obtained in all these concentrations, they recommended use of chlropyriphos at 0.5 per cent concentration with a view to reduce the pesticide load.

The absence of mortality in the untreated control boxes clearly indicated that the toxicity of insecticides was responsible for larval mortality in the boxes with treated baits.

Success of poison baiting largely depends on the ability of a particular bait to attract the target pest towards the source rather than its ability to cause mortality to it. As this experiment was carried out in confinement, larvae had no choice other than feeding on the bait into which they were released. Hence, it can be considered as a forced feeding rather than one with a choice. Therefore, another experiment to study the behavioural pattern and attraction of larvae towards bait was conducted, results of which are discussed under 5.1.2.

5.1.2 Preference of larvae towards poison baits

The experiment was set up within a muslin cloth cage with a view to ward off external interferences and to restrict the movement of larvae within the experimental arena.

Larvae were found moving out towards the baits after their release. But initially the movement was very random and was not in any definite direction or pattern, instead, the larvae were found moving in all directions. However, soon they started orienting themselves towards different poison baits, proving the ability of the baits in attracting them. But baits could not sustain the feeding initially and the larvae were found moving from one bait to another. The movements started to decline at 10 minutes after release. However, lambda cyhalothrin bait appeared to be less preferred by the larvae soon after their exposure to bait, the reason for which could not be understood clearly. It is not clear whether reduced preference of larvae to lambda cyhalothrin bait was due to properties of the chemical or due to any inherent repellent property. However, there are reports indicating that toxicity of lambda cyhalothrin may vary according to not only the concentration of the active ingredient but also according to the solvent vehicle (Miester, 1992). Use of lambda cyhalothrin as toxicant chemical in bran bait was reported by Metaweh *et al.* (2002) against grasshopper species. However, they had neither used jaggery or any other attractant nor fermented the bait mixture.

But as time lapsed (30 minutes after release) lambda cyhalothrin showed almost the same number of larvae feeding on it as the other baits (Table 4). At 16 hours after release, no change in larval count was observed from the one recorded at 60 minutes after release. This was due to lack of further movement of larvae after they had settled at 60 minutes after release on the baits, suggesting initiation of toxic effects of the chemicals on the larvae.

Parasuraman *et al.* (1985) during a study to test the effectiveness of different baits to attract larvae of *S. litura* under laboratory conditions, observed the movement of larvae from one bait to another till they settled in the most preferred bait. This is in line with the present observations where multidirectional movement of larvae was noticed even upto 60 minutes after exposure to baits. It could be concluded from the present study that the bait mixtures irrespective of chemicals do not have any differences among themselves, in their effect in attracting larvae to them. This is in agreement with the work of Hiremath *et al.* (1990) who reported that attraction of larvae of *M. separata* to poison baits was triggered by some strong aroma produced by the fermentation of jaggery in the bait mixture.

The laboratory studies indicated that all the poison baits were toxic to the test insect, though the degree varied. Secondly, the in house cage study, done to know whether larvae are attracted to any specific toxicant, revealed no such responses by the test insect. To study the effect of each poison baits against target pests under the natural ecological conditions, field studies were then conducted on various crop ecosystems, results of which are discussed under 5.2.

5.2 Evaluation of newer insecticidal poison baits for efficacy in crop ecosystems

The laboratory studies conducted on the test insect *M. separata* proved the efficacy of the chemicals at 75 per cent of the recommended dosage vis-à-vis 50 and 25 per cent of dosages. Hence, in field evaluation, this concentration was set as the standard and according to that poison baits were prepared using each chemical.

5.2.1 Efficacy of poison baits against *S. litura* in groundnut

5.2.1.1 Larval mortality

In the present investigation, five chemicals along with monocrotophos (standard check) were evaluated in poison baits for their efficacy against *S. litura*. The results (Table 5) revealed that chlorpyriphos bait was the most effective ones against *S. litura* causing mortality of 5.25 larvae per 4 sq. m area within a day of application of bait v/s that was observed in monocrotophos bait treated plots (4.0). It was significantly superior to rest of the poison baits. The number of dead larvae increased steadily from 24 hours to 7 days after application in chlorpyriphos treated plots. An average of 7.0 larvae were found dead in chlorpyriphos at seven days after application. These results clearly indicated the efficacy of chlorpyriphos bait in causing mortality to larvae of *S. litura* (Fig. 2). The results also indicated that chlorpyriphos in bait may be sustaining its toxicity even after seven days of its application. This was followed by monocrotophos (6.0), profenofos (5.75), spinosad (4.5) and lambda cyhalothrin (4.5) baits at seven days after application.

Kulkarni (1989) reported chlorpyriphos bait as quite effective in controlling *S. litura* in groundnut, where he observed 63.77 to 72.14 per cent reduction of larval population over check during *kharif* and summer. Ramana *et al.* (1988) reported that use of chlorpyriphos bait at 0.5% and 1.0% resulted into 47.94% and 52.60% reduction of larvae over control respectively in *rabi* groundnut when applied against *S. litura*. The earlier reports by Patel and Chari (1983) on tobacco, Balasubramanian and Balasubramanian (1984) on castor, Balasubramanian *et al.* (1985) and Chandrasekhar (1992) on potato indicated the efficacy of chlorpyriphos as v/s *S. litura*. This lends support to the present findings

The organophosphorous compound profenofos in the present study proved its efficacy in bait against *S. litura* by causing mortality to as many as 5.75 larvae at 7 days after treatment from an area of 4 m^2. Efficacy of profenofos bait for the control of cutworms is on record (Nikolov, 1981).

The microbial product spinosad was moderately effective and caused mortality to the larvae to the tune of 2.5 to 4.5 larvae from 4 sq m area at 24 hours and seven days after application of baits. As spinsoad is reported to be effective against caterpillars in general (Dandale *et al.,* 2000), the moderate efficacy in the present study might be possibly due to the variation in method of application adopted.

The poison baits, indoxacarb and lambda cyhalothrin were relatively less effective in causing mortality to the larvae. There are no reports on the efficacy of these poison baits, but report by Cook *et al.* (2004) indicating high efficacy of indoxacarb compared to profenofos against *S. exigua* and excellent results with lambda cyhalothrin against many lepidopterous insects like brinjal shoot and fruit borer and shoot and capsule borer of cardamom as sprays are on record (Mathirajan *et al.,* 2000). But in the current study, lambda cyhalothrin proved to be ineffective possibly due to the change in mode of application and the reduced dosage used.

Monocrotophos poison bait, standard check was highly effective in controlling the larval population which was next only to chlorpyriphos bait. The mortality obtained in monocrotophos bait treated plots was to the tune of 4.0-6.0 larvae per 4 sq. m area. Such findings on efficacy of monocrotophos bait are on record (Ramana *et al.,* 1988, Kulkarni, 1989 and Hiremath, 1993) against *S. litura* in groundnut ecosystem. Also, the effectiveness of monocrotophos spray has been reported by Chari and Patel (1972) on tobacco, Reddy *et al.* (1985) on groundnut and Rao and Ahmed (1985) on chillies against *S. litura*. These reports corroborate the present investigation on efficacy of monocrotophos bait.

5.2.1.2 Adult mortality

The highest adult attraction and subsequent mortality was observed in plots treated with chlorpyriphos bait followed by plots treated with monocrotophos bait (Table 6). At seven days after application, a maximum number of 7.5 adults were attracted and found dead in chlorpyriphos v/s monocrotophos (6.5), profenofos (4.25), spinsoad (5.0), indoxacarb (3.0) and lambda cyhalothrin (2.5) baits (Fig. 3). The efficacy of various baits in attracting and bringing about mortality of adult moths was of the order of chlorpyriphos > monocrotophos > profenofos > spinosad > indoxacarb > lambda cyhalothrin, at 48 hours after treatment. There is no much information available on the efficacy of fermented baits in attracting adults of lepidopterous insects except the works by Hiremath *et al.* (1990) and Hiremath (1993). Hiremath *et al.* (1990) noticed an average mortality of 5.66 moths of *S. litura* per 4 sq. m area in sorghum by the application of monocrotophos bait. Whereas, Hiremath (1993) obtained mortality of 7.06 moths per 4 sq. m 10 days after application of baits in groundnut which is comparable with the present results where 6.5 moths per 4 sq. m was observed at 7 days after treatment imposition. Adult attraction and subsequent mortality in plots treated with bait formulations made out of profenofos, spinosad, indoxacarb and lambda cyhalothrin is a new documentation to the entomological science.

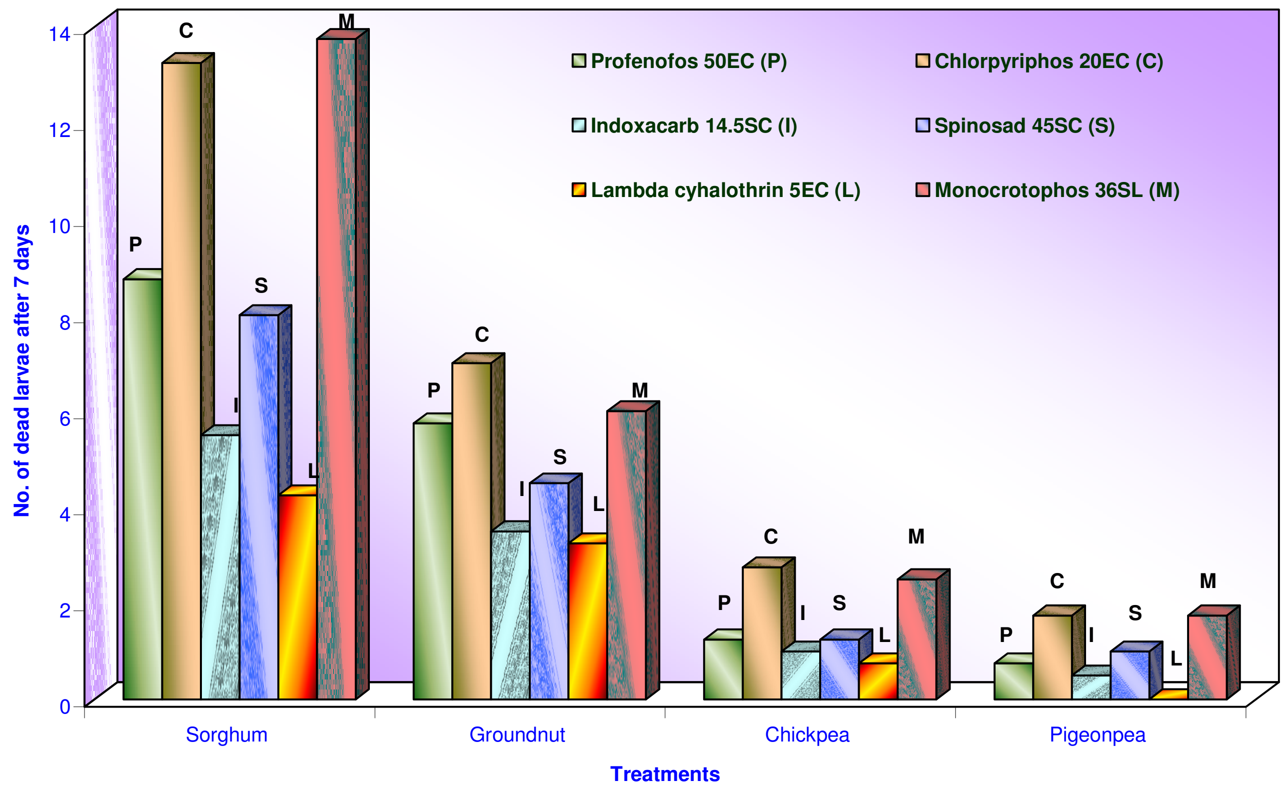

Fig. 2 : Evaluation of poison baits against larvae in sorghum, groundnut, chickpea and pigeonpea

Fig 2: Evaluation of poison baits against larvae in sorghum groundnut, chichpea and pigeonpea

5.2.2 Evaluation of poison baits against *M. separata* in sorghum

5.2.2.1 Larval mortality

The data obtained (Table 7) clearly indicates that chlorpyriphos bait and monocrotophos bait are equally effective in causing mortality to larvae of *M. separata* in sorghum ecosystem, registering maximum mortality of 13.25 and 13.75 larvae per 4 sq. m, respectively at seven days after treatment imposition (Fig. 2). Both chlorpyriphos and monocrotophos baits were superior over all other treatments at each time interval of observations. Efficacy of monocrotophos bait against *M. separata* in sorghum in the present study corroborates the works of Giraddi and Kulkarni (1987), Hiremath *et al.* (1990), Hiremath (1993) and Mallapur (1993). Further, the efficacy of monocrotophos against the target pest is in agreement with Kalode *et al.* (1972), Deol *et al.* (1981) and Singh and Deol (1988).

Efficacy of chlorpyriphos bait against larvae of *M. separata* is in accordance with earlier report by Mallapur (1993) who obtained >60% mortality of larvae in sorghum environment. The results obtained in the present investigation on the efficacy of chlorpyriphos are also comparable with the works of Mittal *et al.* (1980), Mathur and Upadhyay (1982), Singh and Deol (1988) and Hiremath *et al.* (1992), though the mode of application differed.

The poison baits next to follow in the order of efficacy were profenofos and spinsoad which recorded 8.75 and 8.0 dead larvae per 4 sq m area respectively at seven days after application. There are no reports available on the efficacy of these chemicals against larvae of *M. separata*. However, Nikolov (1981) reported the efficacy of profenofos in baits against cutworms. Spinosad is reported to have both contact and stomach activity which is a primary requisite to be effective as a bait toxicant. But, the moderate efficacy observed in the present investigation might be due to reduced dosages of chemical used in the bait.

Indoxacarb and lambda cyhalothrin baits were found to be significantly inferior to other treatments, even though these chemicals were reported to be highly effective as lepidoptericides (Bheemanna and Patil, 1999, Mathirajan *et al*., 2000). The variation may be due to method of application adopted as well as due to the difference in target insect.

5.2.2.2 Adult mortality

Chlorpyriphos bait emerged as the best among the five chemicals tested, which proved its superiority recording highest number of dead adults (8.0 per 4 sq. m area) at seven days after application (Table 8). At other time intervals, chlorpyriphos and monocrotophos baits were on par with each other in terms of number of dead adults per 4 sq. m area. The adult mortality observed in the treated plots was of the order of monocrotophos > chlorpyriphos > profenofos > spinosad > indoxacarb > lambda cyhalothrin at seven days after treatment (Fig. 3). Mass killing of armyworm moths by using fermented monocrotophos poison bait was for the first time reported by Hiremath *et al.* (1990) who obtained mortality of *M. separata* adults to the tune of 20.61 numbers per sq. m area. The higher number of dead adults obtained in this study v/s the present investigation could be attributed to the difference in the initial pest population. In the report indicated above, initial population of larvae was as large as 35 per plant but it varied from 16 to 20.25 per 4 sq. m area in the present study, which might be the possible reasons for low population of adult moth attracted in the present study. However, the present results corroborate the work of Hiremath (1993) who obtained comparable adult mortality (6.26 per 4 sq. m area) of *M. separata* at five days after treatment, in maize using monocrotophos bait.

Other baits also were able to cause mortality of moths but to a lesser extent than monocrotophos and chlorpyriphos. In untreated check, there was no mortality of moths, indicating that attraction and mortality of moths in other treatments were due to effect of toxicant.

5.2.3 Evaluation of poison baits against *Helicoverpa armigera* (Hubner) in chickpea

5.2.3.1 Larval mortality

At 24 hours after treatment imposition, chlorpyriphos bait proved to be superior over other treatments followed by monocrotophos bait (Table 9). Chlorpyriphos showed a slight increase in larval mortality at each time interval except at seven days after treatment, whereas monocrotophos showed increase in mortality only upto 48 hours after treatment.

The remaining treatments profenofos, spinosad, indoxacarb and lambda cyhalothrin baits showed poor efficacy in attracting and killing larvae of *H. armigera*. There is no information on efficacy of these chemicals in poison baits. However, Dhawan *et al.* (1991), Dandale *et al.* (2002), Yelshetty *et al.* (1999) and Mathirajan *et al.* (2000) observed high efficacy of these chemicals against larvae of *H. armigera* but the mode of application was spraying.

The superior treatments, monocrotophos and chlorpyriphos, also could not result into substantial mortality of the larvae (2.5 and 2.75 per 4 sq. m area respectively) (Fig. 2). Hiremath *et al.* (1990) and Hiremath (1993), using monocrotophos bait reported the poor efficacy of bait formulations in causing mortality to *H. armigera* when compared to chemical sprays.

5.3.2.2 Adult mortality

The highest adult mortality was observed in chlorpyriphos and monocrotophos treated plots followed by spinosad plots, seven days after treatment imposition (Table 10). However, counts obtained were very less which suggests the poor efficacy of bait formulations to attract adult moths of *H. armigera* in chickpea ecosystem (Fig. 3). This result is in agreement with the work by Hiremath (1993) in chickpea where 0.27 adults were found dead one day after treatment imposition.

5.2.3 Evaluation of poison baits against *H. armigera* in pigeonpea

5.2.3.1 Larval mortality

In general, poison baits showed less efficacy in causing mortality to larvae in pigeonpea when compared to its efficacy in other crop ecosystems (Fig. 2). However, the baits could cause mortality of larvae to a less extent but many a times the mortality counts failed to differ significantly from untreated check, proving its inefficacy. However, chlorpyriphos bait at seven days after treatment registered significantly highest mortality (1.75) as compared to other baits (0.25 to 1.00). Monocrotophos the check, however was on par with chlorpyriphos in efficacy (Table 11). These results are in agreement with the study conducted by Hiremath (1993) in pigeonpea ecosystem where monocrotophos poison bait was found inferior to endosulfan spray.

Earlier reports indicated spinosad, profenofos, indoxacarb and lambda cyhalothrin in sprays as very effective against pigeonpea pod borer (Dhawan *et al.,* 1991, Dandale *et al.,* 2002, Yelshetty *et al.,* 1999 and Mathirajan *et al.,* 2000).

5.2.3.2 Adult mortality

All treatments except the untreated check could attract and cause mortality to adult moths of *H. armigera* (Table 12). Seven days after treatment imposition, chlorpyriphos bait emerged superior over other treatments followed by monocrotophos bait (Fig. 3). Hiremath *et al.* (1990) obtained an adult mortality of 0.73 with monocrotophos bait and Hiremath (1993) 0.60 per 4 sq. m in pigeonpea ecosystem against *H. armigera* which are comparable with the present results where 0.75 adult mortality was noticed in monocrotophos bait treated plots.

5.3 Effect of poison baits on natural enemies and soil fauna

In general, the effect of poison baits on soil fauna and natural enemies in the crop ecosystems was very much negligible compared to the pest numbers. Application of poison baits in groundnut ecosystem resulted into mortality of some ground beetles in plots treated

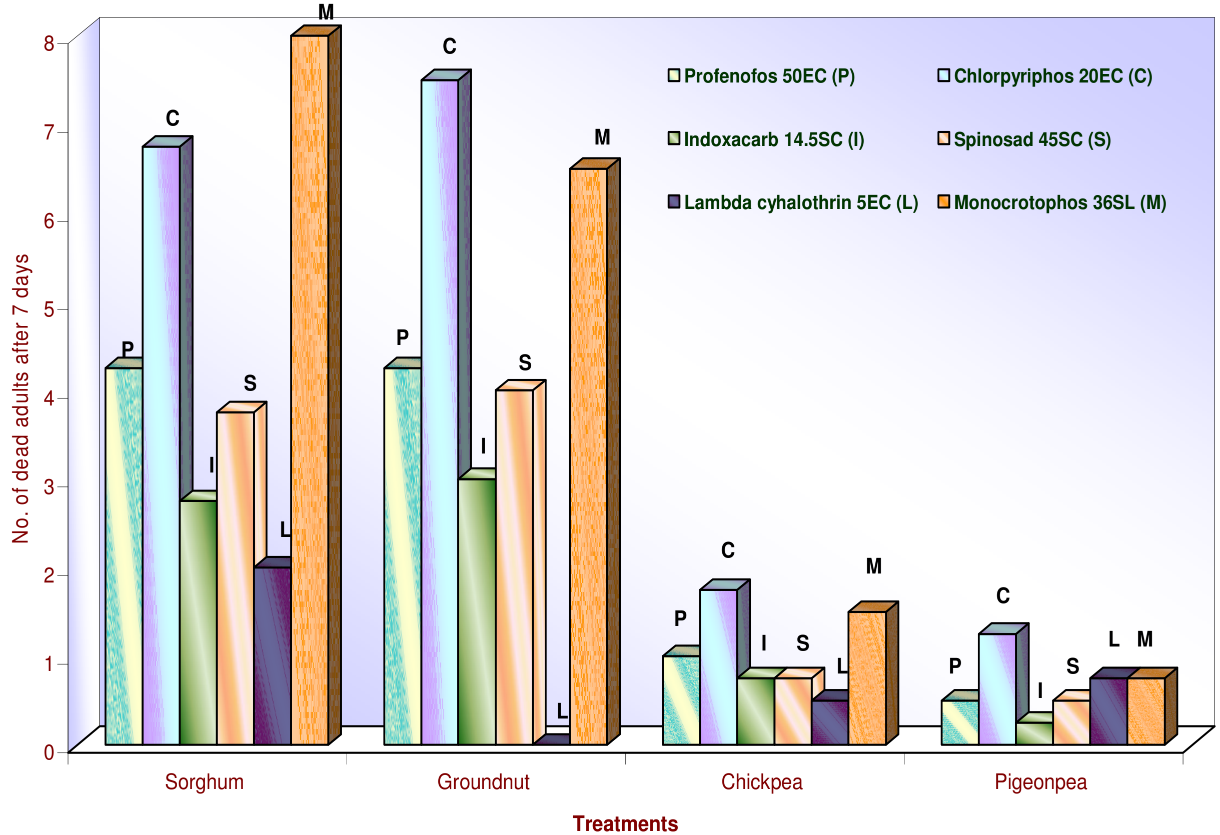

Fig. 3 : Evaluation of poison baits against adults moth in sorghum, groundnut, chickpea and pigeonpea

Fig 3: Evaluation of poison baits against adults moth in sorghum,groundnut, chichpea and pigeonpea with organophosphorous compounds but to a very less extent. In sorghum environment mortality of coccinellid beetles and ground beetles were observed only in monocrotophos treated plots. In chickpea crop mortality of ground beetles was observed in monocrotophos and chlorpyriphos bait treated fields, whereas coccinellid beetles were found dead in chlorpyriphos treated plots in pigeonpea ecosystem.

In general, organophosphorous compounds found to show mortality of non-target organisms, eventhough, it was to a less extent. The other new chemicals tried did not show mortality of any of the non target organisms. All these chemicals were found to be comparatively safe to natural enemies and other beneficial fauna in works reported earlier. McKinley *et al.* (2002) attributed the safety of indoxacarb to natural enemies to very limited ingestion due to feeding habits of these insects and lack of uptake via tarsal exposure.

Hiremath (1993) observed mortality of some beetle pests and millipedes in plots with monocrotophos poison baits. Hiremath *et al.* (1992) and Hiremath (1993) reported the safety of monocrotophos poison baits to honey bees and Peach *et al.* (1994) reported the non lethality of carbaryl bran bait to adults and immature leaf cutting bee.

However, in general insignificant detrimental effects observed in the present study could be attributed to the fact that unlike in the earlier works, reduced dosage of chemicals was tried in the present investigations.

Future line of work

1. To evaluate the effect of longer fermentation (5-7 days) of bait mixture in attracting larvae and adults of lepidopterous pests.

2. To evaluate the efficacy of newer molecules (especially insect growth regulators), as toxicant in the bait mixture.

3. To confirm the dosage requirement of pesticides in poison baits by repetition of the field trials.

6. SUMMARY AND CONCLUSIONS

Investigations to evaluate the efficacy of poison baits made out of various insecticides were conducted under laboratory and field conditions at the University of Agricultural Sciences, Dharwad during 2006. Effect of poison baits on natural enemies and soil fauna was also studied. The new chemicals tested in the poison baits were spinosad 45 SC, indoxacarb 14.5 SC, lambda cyhalothrin 5 EC, profenofos 50 EC and chlorpyriphos 20 EC along with the standard chemical monocrotophos 36 SL, in levels lower than their recommended field dosages. In the laboratory, three levels of dosages of each chemical were tested and mortality counts of larvae were recorded. 75 per cent of recommended dosage of chemicals in the poison baits was tested in the laboratory for studying attraction and preference by tracking movement patterns of larvae of *Mythimna separata* (Walker) towards baits. In the field, efficacy of these poison baits was assessed against *Spodoptera litura* (Fab.) in groundnut, *M. separata* in sorghum and *Helicoverpa armigera* (Hubner) in pigeonpea and chickpea crops. In addition, observations were made on natural enemies and soil fauna that were found attracted and dead in the treated plots. The results of these are summarized as follows.

Under laboratory conditions, chlorpyriphos at 75 per cent of recommended dosage was found to be superior to other treatments, recording 100% mortality at 48 hours after exposure of larvae to baits. Other chemicals at 75% of recommended dosages were found effective in bringing about mortality to larvae of *M. separata.* Multiple choice tests showed that larvae do not possess any preference for the chemical used in the bait. Strong aroma produced by fermentation of jaggery was found to be solely responsible for inciting oriented movements in larvae towards baits. Lambda cyhalothrin was found to be the less preferred minutes after exposure of larvae to baits, but thereafter it was found to be equally preferred as other baits

In groundnut ecosystem, chlorpyriphos bait proved to be superior in bringing about mortality to larvae of *S. litura*. But in the mortality studies of adult moths, chlorpyriphos and monocrotophos were found equally effective.In sorghum ecosystem, highest mortality of larvae was obtained by the application of chlorpyriphos poison bait. But the standard check, monocrotophos poison bait showed maximum amount of adult mortality 7 days after application. Among the test chemicals, chlorpyriphos was superior in bringing about mortality to adult moths. In chickpea ecosystem, mortality of both larvae and adult moths of *H. armigera* was highest in chlorpyriphos treated plots followed by monocrotophos treated plots. In pigeonpea ecosystem, chlorpyriphos and monocrotophos poison baits emerged superior in bringing about mortality of both larvae and adults of *H. armigera.* All the baits in general proved highly effective in groundnut and sorghum than chickpea and pigeonpea ecosystems against the target pests. In chickpea and pigeonpea ecosystem, poison baits were less effective in attracting and causing mortality to larvae and adults of *H. armigera.*

Poison baits were found to be safe to *Chrysoperla* and earthworms in various ecosystems, while organophosphorous compounds caused mortality of ground beetles, but it was negligible.

- Laboratory studies conducted on poison baiting indicated that the chemical toxicant has no role in attracting and eliciting movements towards the source. Among the concentrations of toxicants used in poison baits 75 per cent of recommended field dosage proved to be highly effective vis-à-vis 50 per cent and 25 per cent.
- Among the new poison baits evaluated, irrespective of crops and target insects, chlorpyriphos 20 EC emerged as the most effective poison bait with efficacy being on par with the check, monocrotophos poison bait.
- Profenofos 50 EC and spinosad 45 SC were the poison baits exhibiting moderate efficacy, while lambda cyhalothrin 5 EC and indoxacarb 14.5 EC proved less effective.
- The poison baits, in general, attracted insignificant numbers of soil fauna and natural enemy compared to the pest insects.

REFERENCES

Abdulkareem, A. and Vishwanathan, T., 1980, A general account of the integrated approach for the control of bollworms on cotton. *Andhra Agri.* J., 27 : 123-124.

Anonymous, 2004, *Improved Cultivation Practices for Field Crops*, Uni. Agric. Sci., Dharwad (India).

Anonymous, 2005, Pesticides restricted for use in India http://cibrc.nic.in/list-pest-bann. htm.

Ascher, K. R. S. and Rubin, A., 1983, Laboratory and field decay experiments with insecticides poisoned wheat bran baits for the control of *Spodoptera littoralis* Fab. (Lepidoptera : Noctuidae). *Int. Pest Cont*., 24 : 156-160.

Balasubramanian, G. and Balasubramanian, M., 1984, Susceptibility of different larval instars of *Spodoptera litura* (Fabricius) to insecticides. *Indian J. Agric. Sci.,* 53 : 72-74.

Balasubramanian, G., Chelliah, S. and Balasubramanian, M., 1985, Relative susceptibility of larval instars of *Spodoptera litura* (Fab.) to insecticides. *Indian J. Plant Prot*., 12 : 143-145.

Barbara, K. A. and Pinera, J. C., 2003, Development of a toxic bait for control of eastern lubber grasshopper (Orthoptera : Acrididae). *J. Econ. Entomol*., 96 : 584-591.

Barson, G., 1982, Laboratory evaluation of boric acid plus porridge oats and iodofenphos gel in toxic baits against the German cockroach, *Blatella germinica* (L.) (Dictyoptera : Blatellidae). *Bull. Entomol. Res*., 72 : 229-237.

Bheemanna, M. and Patil, B. V., 1999, Bioefficacy of indoxacarb (Avaunt) 15% SC against cotton insect pests in irrigated conditions. *Pestology*, 28 (10) : 11-13.

Chacon, P. and Jaramillo, G. I., 2003, Effects of boric acid, Fipronil, Hydramethylnon and Diflubenzuron baits on colonies of ghost ants (Hymenoptera : Formicidae). *J. Econ. Entomol*., 96 : 856-862.

Chandla, V. K., Misra, S. S., Verma, K. D. and Bist, B. S., 1977, Insecticidal control of cutworms, *Agrotis* spp. infesting potato crop. *Pesticides*, 11 : 29-30.

Chandrasekhar, 1992, Studies on soil borne pests of potato in Karnataka with reference to biology and management of *Spodoptera litura* Fabricius (Lepidoptera : Noctuidae). *M. Sc. (Agri.) Thesis*, Uni. Agric. Sci., Bangalore (India).

Chari, M. S. and Patel, N. G., 1972, Efficacy of some newer insecticides against the tobacco leaf eating caterpillar, *Spodoptera litura*, (Fab.) *Indian J. Entomol*., 34 : 361-362.

Chougala, D. C., 1994, Biology and management of hornworm *Agrius convolvuli* L. on greengram, *Vigna radiate* (L.) Wilczek. *M. Sc. (Agri.) Thesis*, Uni. Agric. Sci., Dharwad (India).

Cook, D. R., Leonard, B. R. and Gore, J., 2004, Field and laboratory performance of novel insecticides against armyworms (Lepidoptera : Noctuidae). *Fla. Entomol*., 87 (4) : 433-439.

Creighton, C. S., Mcfadden, T. L. and Cuthbert, R. B., 1973, Tomato fruit worm : control in South Carolina with chemical and microbial insecticides. *J. Econ. Entomol.,* 66 : 473-475.

Dahms, R. S. and Fenton, F. A., 1942, Experiments with poisoned bait to control armyworms in wheat. *J. Econ. Entomol*., 35 : 439-440.

Dandale, H. G., Rao, N. G. V., Tikar, S. N. and Nimbalkar, S. N., 2002, Efficacy of spinsoad against cotton bollworms in comparison with some synthetic pyrethroids. *Pestology*, 26 (11) : 6-10.

David, B. V. and Ananthakrishnan, T. N., 2004, *General and Applied Entomology*. Tata McGraw Hill Publishing Company, New Delhi.

David, B. V., 2001, *Elements of Economic Entomology*, Popular Book Depot, Chennai.

Davis, J. J. and Turner, C. F., 1918, Popular and practical entomology, Experiments with cutworm baits. *Can. Entomol*., 1 : 187-192.

Delrivero, J. M. and Planes, S., 1966, Tests on the control of *Spodpotera littoralis* in the laboratory. *Boln Patrol Veg. Entomol. Agric*., 29 : 293-306.

Deol, G. S., Sandhu, G. S. and Bhalla, J. S., 1981, Efficacy of different insecticides for the control of armyworm, *M. separata, Indian J. Entomol*. 43 : 361-363.

Devaiah, M. A., 1973, Studies on cutworm in Mysore state and their control. *M. Sc. (Agri.) Thesis*, Uni. Agric. Sci., Bangalore (India).

Dhandapani, N. and Abdulkareem, A., 1983, Poison bait for red hairy caterpillar. *TNAU News Lett*., 13 : 1.

Dhandapani, N. and Abdulkareem, A., 1986, Evaluation of poison bait for the red hairy caterpillar, *Amsacta albistriga* (Walker). *Pestology*, 11 : 8-10.

Dhandapani, N., Abdulkareem, A. and Jayaraj, S., 1987, Studies on poison baiting for the tobacco caterpillar, *Spodoptera litura* (Fab.). *Entomon*, 12 : 223-225.

Dhawan, A. K., Simwat, G. S. and Sidhu, A. S., 1991, Field evaluation of curacron for management on insect pests during reproductive phase on upland cotton. *Pestology*, 15 (11) : 7-8.

El-Nockrashy, A. S., Salama, H. S. and Taha, R., 1986, Influence of bait formulations on the effectiveness of *Bacillus thuringiensis* against *Spodpotera littoralis* (Fab.). *J. Appl. Entomol*., 101 : 381-389.

Erfurth, P., 1973, The situation regarding attack by cutworms, *Agrotis segetum* (Schiff) and methods for the prevention of attack. *Nachrichtenblatt fiit den Pflanzen Schutz dienst der DDR*, 27 : 65-68.

Fenemore, P. G. and Prakash, A., 1992, *Applied Entomology*, Wiley Eastern Limited, New Delhi.

Fernald, H. T., 1914, The armyworm *Heliophila unipuncta* (Haw.). *Massacusettes State Bd. Agric.,* 22 : 1-13.

Foster, R. N., Billingsley, C. H., Staten, R. T. and Hamilton, D. J., 1979, Field cage tests for concentrations of carbaryl in a bait and its application rates for control of Mormon cricket. *J. Econ. Entomol*., 72 : 295-297.

Gabr, W. M., Khidr, F. K. And Yousseff, A. S., 2006, Effect of spinsoad biocide as a bait and contact applications against three land snail species. *Egypt. J. Agrc. Res*., 84 : 1403.

George, T. L., Mcewen, L. C. and Fowler, A., 1992, Effects of a carbaryl bait treatment on non-target wildlife. *Env. Entomol*., 21 : 1239-1247.

Gharib, A., 1979, *Spodoptera littoralis* in Iran. Entomolo et Phytopathol Appl, 47 : 161-176.

Gholson, L. E. and Showers, W. B., 1979, Feeding behaviour of black cutworm on seedling corn and organic baits in greenhouse. *Env. Entomol*., 8 : 552-557.

Giraddi, R. S. and Kulkarni, K. A., 1987, Efficacy of insecticidal baits and granules against armyworm, *Mythimna separata* (Walker) in sorghum. *Pesticides*, 21 : 27-31.

Giraddi, R. S., 1992, Ecobiology and management of cutworms, *Agrotis* spp. (Lepidoptera : Noctuidae) on cotton. *Ph. D. Thesis*, Uni. Agric. Sci., Dharwad (India).

Hill, M. G., Atkins, A. W. and Allon, D. I., 1983, Baits for control of greasy cutworm larvae : Field trials. *Proceedings of New Zealand Weed and Pest Control Conference*, 36 : 171-175.

Hiremath, I. G., Bhuti, S. G. and Lingappa, S., 1992, Ecobiology and management of *Mythimna separata* (Walker). *Karnataka J. Agric. Sci.,* 5 : 38-44.

Hiremath, I. G., Bhuti, S. G., Kachapur, M. D., Viraktamath, S. and Lingappa, S., 1990, Mass killing of moths – A new approach in the management of armyworm, *Mythimna separata* (Walker). *Karnataka J. Agric. Sci*., 3 : 128-130.

Hiremath, K. G., 1993, Evaluation of poison baits against lepidopterous pests of economic importance in Karnataka. *M. Sc. (Agri.) Thesis*, Uni. Agric. Sci., Dharwad (India).

Hislop, R. C., Reidl, H. and Joos, J. Z., 1981, Control of walnut huskfly with pyrethroids and bait. *Calif. Agric.,* 35 : 23-25.

Hough, W. S. and Mason, A. F., 1951, Spraying, Dusting and Fumigating of Plants, The MacMillan Company, New York.

Hsu, M., Chang, G. and Chu, H., 1958, A study on the cotton bollworm, *Heliothis armigera* (Hubner) (Lepidoptera : Noctuidae). *Acta Oecon-ent . Sin. Ino*, 1 : . 18-30.

Jayaraj, S., 1983, Ecology based integrated control of *Spodoptera litura* on cotton. Paper Presented. In : *ICAR Summer Institute on Microbial Control of Insects and Pest Management*, Tamil Nadu Agricultural University, Coimbatore, June 1-25.

Jech, L. E., Foster, R. N., Colletto, D., Walgenbach, D. D., Roland, T. J., Rodriguez, G. D., Bohls, R., Houston, R. D., Meeks, W. K., Queener, R. L., Jackson, C. L., Dines, J. L., Puclik, M. J. and Scott, A. K., 1993, Field evaluation of diflubenzuron and carbaryl bran baits against graashopper (Orthoptera : Acrididae) populations in South Dakota. *J. Econ. Entomol*., 86 : 557-565.

Johnson, D. L. and Henry, J. E., 1987, Low rates of insecticides and *Nosema locustae* (Microsporidia : Nosamatidae) on baits applied to roadsides for grasshopper (Orthoptera : Acrididae) control. *J. Econ. Entomol*., 80 : 685-689.

Kadapatti, S. M., 1993, Bioecology and control of black headed hairy caterpillar, *Spilosoma obliqua* Walker (Lepidoptera : Arctiidae) on sunflower. *M. Sc. (Agri.) Thesis*, Uni. Agric. Sci., Dharwad (India).

Kalode, M. B., Rao, P. S. P. and Varma, A., 1972, Toxicity of some modern insecticides to paddy cutworm, *Pseudaletia separata* Walker. *Indian J. Entomol.,* 34 : 84-85.

Kamel, A. A. M. and Shoeb, A., 1958, The chemical control of the greasy cutworm. Agric. *Res. Rev*., 36 : 24-39.

Kepner, R. L. and Yu, S. J., 1987, Development of a toxic bait for control of molecrickets (Orthoptera : Gryllotalpidae). *J. Econ. Entomol*., 80 : 659-665.

Kulkarni, K. A., 1989, Bioecology and management of *Spodoptera litura* (Fabricius) (Lepidoptera : Noctuidae) on groundnut. *Ph. D. Thesis*, Uni. Agric. Sci., Dharwad (India).

Lampert, E. P. and Southern, P. S., 1987, Evaluation of pesticide application methods for control of tobacco bud worms (Lepidoptera : Noctuidae) on Flue-cured tobacco. *J. Econ. Entomol*., 80 : 961-967.

Learmount, J., Chapman, P. A., Morris, A. W. and Pinniger, D. B., 1996, Response of strains of housefly, *Musca domestica* (Diptera : Muscidae) to commercial bait formulations in the laboratory. *Bull. Entomol. Res*., 86 : 541-546.

Lofgren, C. S., Bartlett, F. J. and Stringer, C. E., 1963, Imported fire ants toxic studies : Evaluation of carriers for oil baits. *J. Econ. Entomol*., 56 : 62-63.

Mathirajan, V. G., Natarajan, K., Kuttalam, S., Chandrasekhar, S. and Regupathy, A., 2000, Evaluation of lambda cyhalothrin for control of pod borer on redgram. *Ann. Pl. Protec. Sci.*, 8 (2) : 246-247.

Mathur, Y. K. and Upadhyay, K. D., 1982, Field evaluation of some modern insecticides against armyworm attacking paddy crop. *Indian J. Plant Prot.*, 9 : 74-77.

Mallapur, C. P., 1993, Studies on ecobiology and management of armyworm, *Mythimna separata* Walker (Lepidoptera : Noctuidae) on sorghum. *Ph. D. Thesis*, Uni. Agric. Sci., Dharwad (India).

McKinley, N., Kijima, Coock, G. and Sherrod, D., 2002, Avaunt (indoxacarb) : A new mode of action insecticide for control of several key orchard pests. *76th Annu West Orch Pest Disease Mana. Conf.*, Washington, 9-11 Jan. 2002.

McQuate, G. T., Peck, S. L., Barr, P. G. and Sylva, C. D., 2005, Comparative evaluation of spinosad and phloxine B as toxicants on protein baits for suppression of three fruit flies (Diptera : Tephritidae) species. J. *Econ. Entomol.*, 98 (4) : 1170-1178.

Meister, R. T., 1992, *Farm Chemicals Handbook - 92*, Meister publishing Co., Willoughby.

Metaweh, H. H., Gomma, E. A. A., Sherif, R. M. and Abdel-Fattah, T. A., 2002, Toxicity and persistence of some poison baits against the fourth nymphal instar of two species of grasshopper. *Egypt. J. Agric. Res.*, 80 : 73-78

Metcalf, C. L. and Flint, W. P., 1979, Destructive and useful insects : their hosts and control, Tata McGraw Hill Publishing Company, New Delhi (India).

Metcalf, C. L. and Flint, W. P., 1990, *Fundamentals of Insect Life*, Low Price Publications, New Delhi (India).

Metcalf, R. L., 1985, Plant kairomones and insect pest control. *Bull. Ill. Nat. Hist. Sur.*, 33 : 175-198.

Metcalf, R. L., Ferguson, J. F., Lampman, R. and Rinderson, J. F., 1987, Dry cucrbitacin containing baits for controlling diabroticite beetles. *J. Econ. Entomol.*, 80 : 870-875.

Misra, S. S., Nagia, D. K., Ram, G. And Bist, B. S., 1984, Evaluation of contact insecticides against potato cutworm, *Agrotis* spp, *Indian J. Ent.*, 46 : 460-466.

Mittal, V. P., Kadam, J. R. and Desai, K. B., 1980, Efficacy of some insecticides in controlling the armyworm, *Pseudatetia separata* on CSH-5 sorghum, *Sorghum News Lett.*, 23 : 79-80.

Mohan, S., Varadharajan, N. and Balasubramanian, M., 1989, Development and testing of pesticide bait pellets for tobacco cutworm, *Spodoptera litura*, Fab. *Pestology*, 13 : 22-23.

Montiel, A. B. and Jones, O., 2002, Alternative methods for controlling the olive fly, *Bactrocera oleae,* involving semiochemicals. *International Organization for Biological and Integrated Control of Noxious Animals and Plants Bulletin*, 25 : 7-11.

Morgan, L. W. and French, J. C., 1971, Granulate cutworm control in peanuts in Georgia. *J. Econ. Entomol.*, 64 : 937-939.

Moustafa, O. K., 1983, Effects of carrier and soil moisture on the performance of baits used for the control of greasy cutworm, *Agrotis ipsilon. Bull. Entomol. Soc. Egypt.*, 11 : 271-274.

Mukerji, M. K., Ewen, A. B., Craig, C. H. and Ford, R. J., 1981, Evolution of insecticide treated bran baits for grasshopper control in Saskatchewan (Orthoptera : Acrididae). *Can. Entomol.,* 113 : 705-710.

Nagaraja, H. V., 1993, Bioecology and management of horn caterpillar *Agrius convolvuli* (L.) (Lepidoptera : Sphingidae) on greengram. *M. Sc. (Agri.) Thesis*, Uni. Agric. Sci., Dharwad (India).

Nikolov, N., 1981, *Nauka Gradina Lozarska*, 18 : 55-60. (Cited in Giraddi R. S., 1992).

Onsager, J. O., Henry, J. E., Nelson, R. and Staten, R. T., 1980, Acceptance of wheat bran bait by the species of rangeland grasshoppers. *J. Econ. Entomol*., 73 : 548-551.

Parasuraman, S., Jayaraj, S., Gopalan, M. and Kumaraswamy, T., 1985, Attraction of *Spodoptera litura* Fabr. larvae to baits. *Indian J. Agric. Sci*., 55 : 773-774.

Patel, A. R. and Chari, M. S., 1983, Evaluation and economics of some insecticides in the control of *Spodoptera litura* (Fab.) in tobacco nursery. *Pesticides*, 17 : 11-14.

Paul, L. C., 1942, A dry bait for grasshopper control. *Can. Entomol*., 74 : 77-78.

Peach, M. L., Alston, D. G. and Tepedino, V. J., 1994, Bees and bran bait : Is carbaryl bran bait lethal to alfalfa leaf cutting bee (Hymenoptera : Megachilidae) adults or larvae. *J. Econ. Entomol*., 87 : 311-317.

Peters, B. C. and Fitzgerald, C. J., 2003, Field evaluation of the bait toxicant chlorfluazuron in eliminating *Coptotermes acinaciformis* (Froggatt) (Isoptera : Rhinotermitidae). *J. Econ. Entomol.,* 96 : 1828-1831.

Petrik, N. P., 1981, How to determine the dates of release of *Trichogramma. Zashchita Rastenii*, 6 : 62.

Phillips, F. T., Etheridge, P. E. and Martin, A. P., 1979, Further laboratory and field evaluations of experimental baits to control leaf cutting ants (Hymenoptera : Formicidae) in *Brazil. Bull. Entomol*. Res., 69 : 309-316.

Ramana, V. V., Reddy, G. P. V. and Krishna Murthy, M. M., 1988, Synthetic pyrethroids and other bait formulations in the control of *Spodoptera litura* Fab. attacking *rabi* groundnut. *Pesticides*, 22 : 13-16.

Ramaprasad, G., Joshi, B. G., Sitaramaiah, S. and Chari, M. S., 1989, Efficacy of insecticides in bait formulations for control of fourth instar larvae of *Spodoptera litura* Fab. in tobacco nurseries. *Indian J. Plant Prot*., 17 : 53-57.

Rao, M. D. and Ahmed, K., 1995, Evaluation of certain insecticides for the control of the pest complex on chilli (*Capsicum annuum* L.) in Andhra Pradesh. *Pesticides*, 19 (2) : 41-44.

Ray, D. E., 1991, Pesticides derived from plants and other organisms. In *Handbook of Pesticide Toxicology*, Ed. Wayland, H. J. and Laws, E. R., Academic Press, Inc. New York, p. 131.

Reddy, U. K., Ramsubbaiah, K., Reddy, G. P. V. and Subramanyam, K., 1985, Studies on persistence and efficacy of nuclear polyhedrosis virus against field populations of *Spodoptera litura* (Fab.) on groundnut. *Andhra Agri. J.,* 32 : 165-169.

Scott, L. B., 1945, Arsenical residues in straw and grain from wheat dusted by airplane or treated with poisoned bait. *J. Econ. Entomol*., 38 : 464-466.

Sechriest, R. E. and Moore, S. N., 1968, A field experiment with insecticides impregnated baits to control the armyworm. *J. Econ. Entomol*., 61 : 879-880.

Sechriest, R. E. and Sherrod, D. W., 1977, Pelletted bait for control of the black cutworm in corn. *J. Econ. Entomol*., 70 : 699-700.

Sechriest, R. E., 1968, Greenhouse experiments with baits for control of the black cutworm. *J. Econ. Entomol*., 61 : 591-593.

Shotwell, R. L., 1942, Evaluation of baits and bait ingredients used in grasshopper control. *Tech. Bull.,* No. 12 United States Department of Agriculture.

Singh, D. and Deol, G. S., 1988, Efficacy of different insecticides for the control of the armyworm, *M. separata* under field and laboratory conditions. *Pesticides*, 22 : 19-21.

Su, N. and Scheffrahn, R. H., 1993, Laboratory evaluation of two chitin synthesis inhibitors hexaflumuron and diflubenzuron, as bait toxicants against Formosan and eastern subterranean termites (Isoptera : Rhinotermitidae). *J. Econ. Entomol.*, 86 : 1453-1457.

Sunandita and Gupta D., 2001, Testing of boric acid and protein hydrolysate bait mixture against fruit fly, *Bactrocera tau* Walker. *Indian J. Entomol.*, 63 : 125-129.

Tunblad, B., 1947, Poison bran against cutworms in a nursery. *Vaxtskyddsnotiser*, 4 : 53-55.

Usman, S., 1953, Outbreak of cutworm in ragi and cotton fields can be effectively controlled by poison baits. *Mysore Agric. Cal*, 1 : 98-99.

Viswanadham, J. K., Punnaiah, K. C. and Rao, C. R. S., 1986, Studies on certain bait compositions against tobacco caterpillar, *Spodoptera litura* Fabricus (Noctuidae : Lepidoptera). *Andhra Agri. J.,* 33 : 16-19.

William, B. and Showers, 1982, Tracking the black cutworm. *Agric. Res.*, 31 : 8-10.

Yelshetty, S., Siddegowda, D. K. and Patil, B. V., 1999, Efficacy of indoxacarb against pigeonpea pod borer, *Helicoverpa armigera* (Hub.). *Pestology*, 23 (7) : 60-64.

Yokoi, S., Omino, T. and Tsuji, H., 1975, Experiment studies on behavioural differences among three Noctuid species larvae, *Agrotis ipsilon, Momestra brassicae* and *Spodoptera litura* in relation to the efficacy of commercial bait. *Japanese J. App. Entomol. Zool.*, 19 : 11-16.

Yonce, C. E. and Gentry, C. R., 1970, Bait for oriental fruit moth attracts lesser peach tree borer moths. *J. Econ. Entomol.*, 63 : 6-9.

EVALUATION OF NEWER INSECTICIDAL POISON BAITS AGAINST LEPIDOPTEROUS CROP PESTS

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ABSTRACT

Laboratory and field studies were conducted at the University of Agricultural Sciences, Dharwad during 2006, to find out an alternate insecticidal toxicants to monocrotophos in poison baits against lepidopterous crop pests. The new chemicals tested in poison baits were spinosad 45 SC, indoxacarb 14.5 SC, lambda cyhalothrin 5 EC, profenofos 50 EC and chlorpyriphos 20 EC along with the standard chemical monocrotophos 36SL, in levels lower than their recommended field dosages.

Under laboratory conditions, chlorpyriphos at 75 per cent of recommended dosage was found to be superior to other treatments in brining about mortality to larvae of *Mythimna separata* (Walker). Among the concentrations of toxicants used in poison baits, 75 per cent of recommended dosages proved to be effective vis-à-vis 50 and 25 per cent. Multiple choice tests showed that larvae do not possess any preference for the chemical used in the bait. In all crop ecosystem, chlorpyriphos bait proved to be superior in bringing about mortality to larvae and adults of target insects (*S. litura*, *M. separata* and *H. armigera*) which was comparable to monocrotophos.

All the baits in general proved highly effective in groundnut and sorghum crops than chickpea and pigeonpea ecosystems against the target pests. Among the new poison baits evaluated, irrespective of crops and target insects, chlorpyriphos 20 EC emerged as the most effective poison bait. The poison baits, in general, attracted insignificant numbers of beneficial soil fauna and natural enemies compared to the pest insects.