

**RELATIVE EFFICACY OF BIOPESTICIDES
AGAINST THE PEST COMPLEX OF
BITTER GOURD**

**A
THESIS SUBMITTED TO
ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS
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MASTER OF SCIENCE IN AGRICULTURE
(ENTOMOLOGY)**

By

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2012**

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*Dedicated to my beloved
Parents.....*



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CERTIFICATE-I

This is to certify that the thesis entitled “**RELATIVE EFFICACY OF BIO PESTICIDES AGAINST THE PEST COMPLEX OF BITTER GOURD**”, submitted to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfillment of the requirements for award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)** is a faithful record of the bonafide research work carried out by Ms. **SWAGATIKA MISRA** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma or published in any other form.

It is further certified that help and assistance received as well as sources of information availed during the course of this investigation have been duly acknowledged by her.

(P.K. Sarangi)
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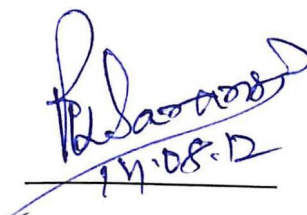
CERTIFICATE-II

This is to certify that the thesis entitled “RELATIVE EFFICACY OF BIO PESTICIDES AGAINST THE PEST COMPLEX OF BITTER GOURD”, submitted by **SWAGATIKA MISRA** to Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfillment of the requirements for award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)** has been approved by the Students Advisory Committee after an oral examination on the same in collaboration with an external examiner.

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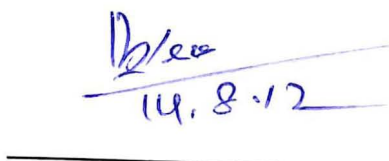
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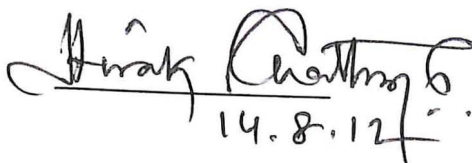

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ABSTRACT

Studies on “Relative efficacy of bio pesticides against the pest complex of bitter gourd” were carried out in the experimental field of Department of Entomology located in the upland area of Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during 2011-2012. The bio pesticides *viz.* *Bacillus thuringiensis* var *Kurstaki*, *Beauveria bassiana*, botanicals fermented in cow urine were tested against the pest complex of bitter gourd. Cartap hydrochloride was taken as standard check.

In the field evaluation, among the botanicals fermented in cow urine, cow urine + neem leaf @ 50 litres/ ha was found to be superior to cow urine + karanj and cow urine + *Hyptis* in reducing jassid, restricting leaf damage by epilachna beetle, preventing fruit damage by fruit fly and giving higher fruit yield.

Among the test bio pesticides Multineem @ 2.5 litres/ha was the best and third best among all treatments in terms of managing jassids, Epilachna beetle and fruit fly infestation and producing better yield.

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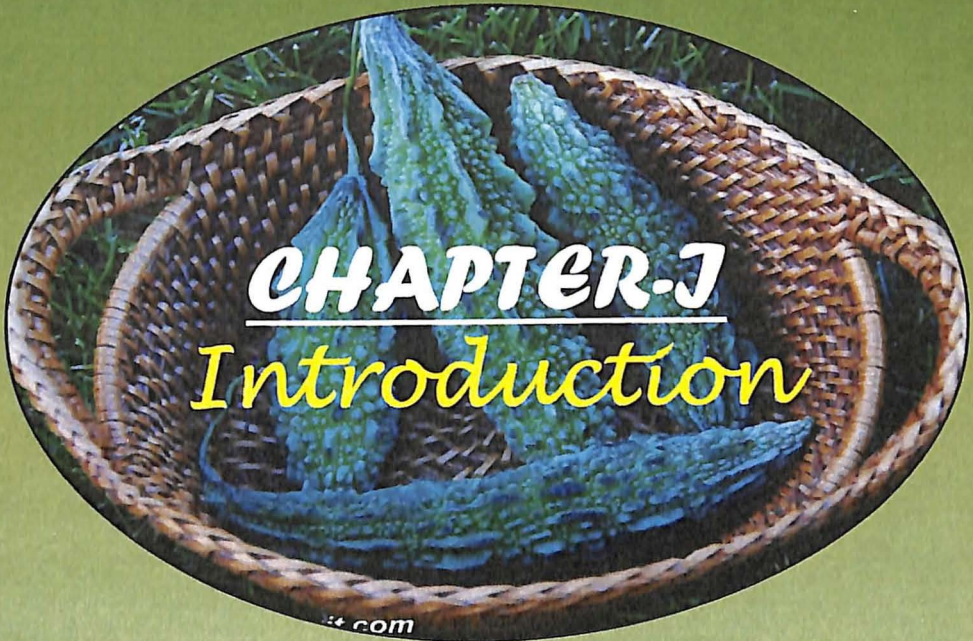
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CHAPTER-J

Introduction

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INTRODUCTION

Among the different warm season vegetable crops grown in tropics and sub tropics, bitter gourd, (*Momordica charantia* L.: Family - Cucurbitaceae) requires a long period of dry and warm weather (30-35⁰ C) and abundant sunshine. Bitter gourd is the immature pod vegetable popular in many African countries. India being the diabetic capital of world, this crop is being extensively grown for its bitter tender fruits, nutritionally rich with iron and vitamin C (Choudhury, 1967, Premnath, 1994). The pods are rich in phytonutrients like dietary fiber, minerals, vitamins and anti-oxidants. It is very low in calories provides only 17 cal per 100g. Bitter melon stimulates digestion and peristalsis which can be helpful in relieving indigestion and constipation problems. Fresh pods are an excellent source of folates; contains about 72 mcg/100g (Provides 18% of RDA). Folate helps reduce incidence of neural tube defects in pregnant mothers when taken during early pregnancy. Fresh bitter melon is an excellent source of vitamin-C (100g of raw pod provides about 140% of RDI). Vitamin-C, one of the powerful natural antioxidant, helps body scavenge deleterious free radicals one of the reasons for cancers development. The vegetable is also good source of Niacin (vitamin B-3), Pantothenic acid (vit.B-5), Pyridoxine (vit.B-6) and minerals like iron, zinc, potassium, manganese and magnesium. The vegetable is also an excellent source of health benefiting flavonoids such as b-carotene, a- carotene, lutein, zeaxanthins. It also contains good amount of vitamin A. These compounds help act as protective scavengers against oxygen-derived free radicals and reactive oxygen species (ROS) that play a role in aging, cancers and various disease processes.

Bitter gourd crop is ravaged by an array of insect pests, non-insect pests and diseases. Among the insect pests, those having economic importance are epilachna beetle *Epilachna septima*, jassids *Amrasca biguttula biguttula*, and fruit fly *Bactocera cucurbitae*. Even though reports pertaining to the extent of damage by different pests of bitter gourd are rather scanty, as high as 54 per cent damage

by the fruit fly has been documented by Rajput *et al.*, 2002). A leaf damage up to 80% by epilachna beetle in potato has been reported in potato (Rajgopal and Trivedi, 1989).

As such vegetables like bitter gourd, being directly consumable, farmers resort to indiscriminate sprayings of insecticides to have a pest free harvest and fetch a good market value. This has resulted in development of alarming resistance in pests and resurgence in minor pests. Besides problems like elimination of natural enemies, accumulation of toxic residues in fruits causing health hazards to human, environmental pollution, secondary pest outbreak, etc. have added to the woes of farming community. To overcome this problem, development of pest management strategies utilising microbial and botanical pesticides which by virtue of their insecticidal property coupled with quick biodegrading nature may prove suitable as an alternative to chemical pesticides. That apart the organic vegetables have started paying dividends to farmers opting for the same, thus highlighting the significance of bio-pesticide use.

Plant derived phytochemicals have been widely used in management of agricultural pests since the time immemorial (Choudary, 2001). The extracts of higher plants are rich sources of novel natural substances that can be used to develop environmentally safe methods for insect control. Most of the botanicals have remained largely unexploited (Kamatensil *et al.*, 2008). It has been estimated that there are about 2, 50,000-5,00,000 different plant species, but only 10% of these are examined chemically and there is a vast resources which still remained untapped (Dhaliwal *et al.* , 2004). Most of the botanicals, used as bio pesticides are locally available and cheap, biodegradable leaving no residues on plants, effective against insects, plant pathogens, nematodes and non-insect pests. Therefore these are recommended for large scale application in agriculture in general and plant protection in particular (Gahukar, 2010). In view of the potential hazards arising out of indiscriminate use of synthetic chemical pesticides, non-traditional pesticides like neem and other plant products are likely to play a major role in future. Therefore, fine-tuning of available technologies with a relook at the

utilisation of plant products, in pest management is the need of the hour. Besides, development of pest management strategies utilising bio pesticides which by virtue of their insecticides properties coupled with quick biodegrading nature may prove suitable as an alternative to chemical pesticides also needs to be considered appropriately.

Neem (*Azadirachta indica*), has a long history of use in the Indian sub-continent against house hold pests, stored grain insects and some pests of agricultural crops. It can provide a key component in integrated pest management. Compared with quick knockdown effects of persistence and vagrant synthetic pesticides, neem's subtle effects, such as repellence, feeding and oviposition deterrence, growth inhibition, mating disruption, chemo sterilisation, etc. are far more desirable in pest management as they reduce the risk of natural enemies to poisoned food or starvation. (Ramesh C. Saxena, 2011). Now neem material has been found to affect nearly 500 species of insects worldwide. Earlier attention was paid only to linkage between neem's bitterness and insect repellence and phagodeterrent properties. Now other behavioural, physiological, and cytological effects, including at molecular level, have been unravelled, providing new opportunities in insect control. However, in the recent past it has been demonstrated that botanicals fermented in cow products like cow dung and cow urine could enrich microbial cultures which helped in providing plant nutrients in addition to acting as pest repellents (Prasad and Rao, 2007).

Historically, organic wastes of animal origin were most commonly used for nutrition and plant protection. In addition the herbs processed in liquid waste of animal were used for plant protection. Surapala in his Vrikshayurveda had documented the use of cowdung around 1000AD (Sadhale, 1996). Among the naturally obtained products cow urine is one of those which is having a unique place in Ayurveda and has been described in "Sushrita Samhita" and "Ashtanga Sangraha" to be the most effective substance or secretion of animal origin with innumerable therapeutic values (Prashithn Kekuda, 2010). Cow urine contains chemicals that act as "bioenhancers" and therefore increases the efficacy of the

drug mixed with bioenhancer from cow urine distillate mixing medicines in cow urine is a very common practice in Ayurveda for improving efficacy of the medicine (Nene, 2007). Cow urine can be recommended as an insecticide by mixing it with soil and applying on plants at much diluted concentrations. A plethora of literature is available depicting role of cow urine against various insect pests (Sadwarte and Sarode, 1997; Ukey and Sarode, 2003; Boomathi *et al.*, 2006). It is thus essential to evaluate the potential of botanicals fermented in organic waste in combating pest menace as it suits well to Integrated Pest Management strategy besides being cheap, eco-friendly, cost effective and locally available with no or least cost.

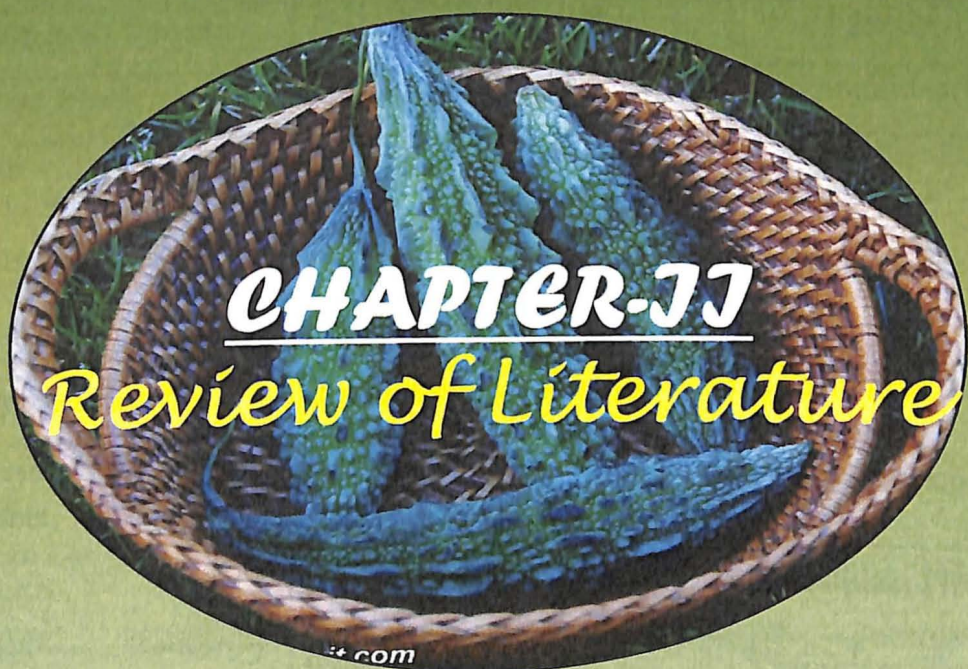
The unilateral approach of controlling insect pests by synthetic insecticides has dictated the necessity for developing cost effective, eco-friendly and safe pest management strategies which suits well in the organic farming. In this direction, scientific evaluation of biodynamic pesticides, organic wastes of animals, botanicals and biorationals including indigenous technologies are considered as very much essential. Research on these lines would benefit farmers with a commitment towards environmental safety through utilization of plant products, organic compounds for pest control. Nene (2007) also opined that utilization of organic wastes based on the methods recommended in 'Vrikshayurveda' offers tremendous opportunity to develop novel, eco-friendly methods of manuring and plant protection through research.

Studies on efficacy of bio-pesticides against pest complex of bitter gourd have not been attempted earlier in Odisha. Taking the aforesaid aspects into consideration, the present experiment entitled "Relative efficacy of bio pesticides against the pest complex of bitter gourd" was undertaken with a hope that the findings could have a rightful place in integrated management pests infesting bitter gourd. The objectives of the project are as follows:

- a) To determine the relative field efficacy of bio-pesticides against major pests infesting bitter gourd

- b) To determine the effect of bio-pesticides on fruit yield in bitter gourd
- c) To determine the avoidable loss and benefit-cost ratio

The body of scientific literature documenting bioactivity of plant derivatives to arthropod pests continues to expand, yet only a handful of botanicals are currently used in agriculture in the industrialized world, and there are few prospects for commercial development of new botanical products (Isman, 2006). Phytochemicals are known to protect the plants from attack of different insect pests (Ahmed, 2007). Active principles of different plant species like neem (Azadiractin), karanj (karanzin), calotropis (Calotropin) are widely used in insect pest control. Extensive basic and applied research conducted over the past thirty years has shown that the use of natural and enriched products derived from the neem.



CHAPTER-11

Review of Literature

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REVIEW OF LITERATURE

Among the cucurbits, bitter gourd, *Momordica charantia* L. is grown for its nutritional as well as medicinal values (Gopalan, 1981). Apart from its nutritional values, the market for bitter gourd has grown extensively in recent times but for its role in managing sugar in diabetic patients. Among the several constraints of production of bitter melon, infestation of pests and diseases is considered to be the one of the most important factors. Bitter gourd is attacked by an array of insect pests, non-insect pests and diseases. The list of insect pests infesting bitter gourd has been presented in Table 2.

Table 2. List of insect pests infesting bitter gourd

Common name	Scientific name	Family /Order
Epilachna beetle	<i>Henosepilachna septima</i>	Coccinellidae:Hemiptera
Fruit fly	<i>Bactocerca cucurbitae</i>	Tephritidae: Diptera
Jassid or Green leaf hopper	<i>Empoasca motti</i> <i>Amrasca biguttula biguttula</i>	Cicadellidae :Hemiptera
Red pumpkin beetle	<i>Aulecophora foeviculus</i>	Galerucidae: Hemiptera
Leaf webber / Pumpkin caterpillar	<i>Diaphania indica</i>	Pyralidae: Lepidoptera
Aphids	<i>Aphis gossypi</i>	Aphididae: Hemiptera
Thrips	<i>Thrips tabaci</i> <i>Thrips palmi</i>	Thripidae :Thysanoptera
Gram pod borer	<i>Helicoverpa armigera</i> (Hubner)	Noctuidae : Lepidoptera

Even though bitter gourd in general is attacked by the aforesaid arthropod pests, in Odisha conditions the epilachna beetle (*Henospilachna septima*), jassids (*Amrasca biguttula biguttula*), and fruit fly (*Bactocera cucurbitae*) are considered

to be economically most important. The other minor insect pests associated with this crop in this State are pumpkin caterpillar (*Diaphania indica*), Aphids (*Aphis gossypi*), Thrips (*Thrips tabaci*, *T. palmi*).

In order to get a pest free harvest of bitter gourd farmers of late resorted to indiscriminate use and abuse of chemical pesticides, which in turn resulted in many counter productive events like pollution hazard, elimination and extermination of natural enemies, human health hazards and resurgence of minor pests. Thus, sole dependence on these chemicals need to be altered with equally effective but eco-friendly pest management strategies.

Thus, literature on the use of fermented botanicals and bio pesticides for suppression of insect pest incidence on vegetables in general and bitter gourd in particular have been reviewed in the following sections;

2.1 Role of botanicals in insect pest management

Plants are biochemists par excellence and during their long evolution have synthesized a diverse array of bioactive chemicals i.e., secondary metabolites like alkaloids, terpenoids, flavonoids, phenols, glycosides, sitosterols and tannins to prevent the colonization of insects and other herbivores. These phytochemical are known to protect the plants from attack of different insect pests (Ahmed, 2007). Plant derived phytochemical have been widely used in management of agricultural pests since the time immemorial (Choudary, 2001) and till date only 10% of the existent plant species could be examined chemically for their insecticidal properties (Dhaliwal and Arora, 2004). In the context of agricultural pest management, botanical insecticides not only are best suited for use in organic food production in industrialized countries but also can play a much greater role in the production and post harvest protection of food in developing countries. Despite the existence of vast scientific literature on the bioactivity of plant derivatives against arthropod pests only a handful of botanicals are currently used in agriculture and there are few prospects for commercial development of new botanical products (Isman, 2006).

The antifeedant property of plant extracts brings about retardation of growth and ultimately results in death of insects. Compounds which do not display antifeedant property are reported to have growth regulatory activity (Kraus *et al.*, 1987). Antifeedant and toxic effect of phytochemicals evoke behavioural effect of antifeedancy (Jermy, 1990). On the other hand, a few plant extracts display bimodal activity, at high concentration they act as feeding deterrent and at low concentrations as growth inhibitors (Nawrot *et al.*, 1991). Considering these facts the role of botanicals in insect pest management of bitter gourd has been reviewed in the following paragraphs.

The insecticidal properties of leaf extract of neem (*Azadirachta indica*) and karanj (*Pongamia pinnata/glabra*) have so far been well studied. Besides, published reports of recent past on the efficacy of leaf extracts of some medicinal plants and multipurpose trees against insect pests are also available for reference. As available research work on use of botanicals in pest management of bitter gourd is rather scanty, the reviews pertaining to related crops have also been included and cited below. Since the botanicals like neem, *Hyptis suaveolens* and karanj have been tested for their bio-efficacy against major pests of bitter gourd in the present study, the review of literature presented below has been classified accordingly.

2.1.1 Role of neem in insect pest management

Neem (*Azadirachta indica*) A. Juss (Family-Meliaceae) is indigenous to India from where it has spread to many Asian and African countries. For centuries the tree has been held in high esteem by Indian folk because of its medicinal and insecticidal properties. Nearly 100 proto-limonoids, limonoids, tetranor-triterpinoids, penta-triterpinoids, hexa-triterpinoids and some non-terpinoids have been isolated from various parts of the neem tree and still more are being isolated. Azadirachtin, the most important biologically active compound of neem shows phagorepellency and toxic effects to various groups of insects.

Venkataramireddy *et al.* (1993) reported that extracts of neem and *Annona squamosa* were most effective in reducing the larval population of epilachna

beetle by 94.77 and 91.44%, respectively. On the contrary, Rajendran *et al.*, (1998) could achieve partial control of this beetle by spraying with neem oil 4%.

Bajpai *et al.* (1999) tested neem formulations like Green Mark, Neem Guard and Ahook, each @ 0.4%, neem oil @ 2.0%, neem seed kernel water extract (NSKWE) @ 5.0%, Karanj [*Pongamia pinnata*] oil @ 2.0%, nicotine sulphate (40 w/v) @ 0.2% along with endosulfan @ 0.07% against *H. armigera* infesting chickpea (cv. C 235) in a field experiment in Uttar Pradesh, during 1992-93 and 1993-94. They found that the botanical insecticides were effective against the pest compared to control and resulted in significant reduction in pod damage at maturity and increased grain yield. Endosulfan gave the highest pest control in terms of decreasing pod damage and increasing chickpea yield. Among the test botanical insecticides, karanj oil application resulted in the highest grain yield of 12.9 q/ha with 44% pod damage in 1992-93; while application of neem oil produced the highest yield of 16.5 q/ha with 59% pod damage in 1993-94.

Karmarkar and Bhole, (2000) have studied the efficacy and persistent toxicity of some neem products against the epilachna beetles. According to the authors, Neemark (2%) was found to be superior and was followed by Nimbecidine (2%), Nimbitor (2%) and neem oil (2%) with respect to their efficacy against the pest. The repellent activity of Neemark (2%) and neem oil (2%) persisted according to authors for about six days.

Shanmugapriyan *et al.* (2001) studied the effect of neem (*Azadirachta indica*) oil @ 0.25, 0.5 and 1.5 per cent on grubs of *E. vigintioctopunctata*. Neem oil @ 1.5% produced the highest mortality of 95.23% in second and third instar grubs and 76.19% in fourth instars grubs. In lower concentrations i.e., @ 0.25 and 0.5%, neem oil resulted in 57.1 and 85.7% mortality in second larval instars, 47.6 and 85.7% in third instars and 57.1 and 80.9% in fourth instars, respectively.

Singh (2001) conducted bioassay studies in order to evaluate the relative efficacy of 6 neem (*Azadirachta indica*)-based biological pesticide formulations at the recommended rate, i.e. Neemgold, Nimbecidine, Ahook and Field Marshal at 1 ml/150 ml of water, and Neem Jeevan and Limonool at 0.5 ml/150 ml of water,

against *M. persicae*. At the recommended rate, the mortality of *M. persicae* after 24 h of treatment was 23.81, 19.23, 16.67, 14.75, 9.68 and 8.93% for Achook, Field Marshal, Neem Gold, Nimbecidine, Neem Jeevan and Limonool, respectively. The mortality ranged from 10.46-41.67% when the concentration was increased to 3-fold of the recommended rate. Five-fold higher concentrations than the recommended level resulted in toxicity levels of 45.28, 42.37, 24.24, 23.81, 22.86 and 14.49% for Field Marshal, Achook, Neem Jeevan, Limonool, Nimbecidine and Neemgold. Synthetic insecticides were more effective than the neem-based formulations.

Rao and Rao (2002) reported neem (*Azadirachta indica* L.), sweet flag (*Acarus calamus* L.) and karanj (*Pongamia glabra* L.) were effective against leaf hopper, *Amrasca biguttula biguttula* (Ishida) when applied at 1:1:1, 2:1:1 and 3:1:1 (v/v) ratios. Similarly, neem based insecticides like Achook and NSKE (3%) exhibited cost effective control of jassid over endosulfan (Singh, 2003).

Anam *et al.* (2006) studied the efficacy of neem oil on the biology and food consumption of epilachna beetle, *Epilachna dodecastigma* (Wied.). The feeding responses indicated that neem oil significantly reduced the food consumption by the larvae and beetles.

Jacob, *et al.* (2007) studied the allelopathic effect of leaf extract of multipurpose trees *viz.*, Ailanthus (*Ailanthus triphysa* Dennst.), cashew (*Anacardium occidentale* L.), Casuarina (*Casuarina equisetifolia* L), gliricidia (*Gliricidia sepium* Steud.), jackfruit (*Artocarpus heterophyllus* Lam.), Strychnos (*Strychnos nuxvomica* L.), mango (*Mangifera indica* L.), portia (*Thespesia populnea* (L.) Soland.), tamarind (*Tamarindus indicus* L.), teak (*Tectona grandis* L.F.). According to the above authors spraying with *Ailanthus* and cashew leaf extracts was as effective as insecticides in reducing fruit fly (*Daucus cucurbitae*) attack in bitter gourd and yield obtained was also identical to insecticides treatment. Ailanthus, cashew, tamarind and teak effectively controlled epilachna beetle (*Epilachna vigintiopunctata*). Insect control achieved by spraying tamarind and teak leaf extracts treatments was similar to insecticide spraying.

Further, the authors also observed that extracts of *Ailanthus*, cashew and *casuarina* reduced the fruit borer infestation (*Leucinodes orbonalis*) considerably in brinjal. *Ailanthus* and cashew extracts also improved the yield and was on par with that obtained with spraying of insecticides.

2.1.2 Role of *Hyptis* in insect pest management

The insecticidal and grain protectant properties of *Hyptis suaveolens* has been reported by Singh and Upadhyay as early as in 1993. Peerzada(1997) reported its pharmacological activity. The ethyl acetate extract of *H. suaveolens* was reported to exhibit antifeedant and ovicidal activity (Raja et al., 2005). No more literature on use of *Hyptis* as a plant or grain protectant was available at present.

Application of Panchagavya at 3% concentration with Cu fermented hyptis leaves 10% concentration was however, found as the best treatment in achieving the maximum marketable fruit yield of 141.70q/ha and this was found on par with Cu fermented karanj leaves (140.42q/ha), Cu fermented neem leaves (135.5q/ha) and endosulfan (140.58 q/ha). On the contrary the Cu fermented karanj leaves at 10% concentration was found to yield appreciable benefit cost ratio of 42.68:1 and this was followed by treatment with Cu fermented neem leaves (38.20:1) and Cu fermented hyptis leaves (31.29:1) B.Shailaja (2011). Thus, despite of ineffectiveness of organics against the insect pests, profitable fruit yield could be obtained with six sprayings of the above organics.

2.1.3 Role of karanj in insect pest management

B.Shailaja and Patnaik (2011) found out that the application of Panchagavya at 3% concentration with Cow urine fermented karanj leaves extract at 10% concentration was found as the best treatment in reducing the shoot damage caused by shoot and fruit borer *Leucinodes orbonalis* (Guenee) to a minimum of 16.22% followed by Cow urine fermented lantana leaves (17.35%) and Cow urine fermented hyptis leaves (17.66%) as against 20.90% in untreated control plots. However, these treatments were found to be ineffective in restricting the fruit damage caused by shoot and fruit borer *L. orbonalis*.

2.2 Role of organics of animal origin and plant origin in insect pest management

Historically, organic waste of animal origin was most commonly used for nutrition and protection of plants. Exploitation of the traditional methods practised in rural India for combating the pest problems was foreseen long back (Peries 1985 and Rankin, 1986). In the traditional and contemporary grass root innovations, the crop protection measures mostly include the use of botanicals, cow dung and cow urine. Among the cow products use of cow urine and cow dung directly or indirectly for insect control were in vogue since time immemorial. Cow urine was reported to contain chemicals that act as "bio enhancers" (Nene, 1999 and Nene, 2007).

Since no much evidence of the combined use of organics of animal origin (cow urine) and botanicals (neem, *Hyptis* and karanj) in management of insect pests infesting bitter melon is available in the literature scanned, works of various scientists in this broad field have been presented in the following paragraphs as references.

The effectiveness of cow urine along with various botanicals viz., neem, *Pongamia vitex* and *Aloe vera* have earlier been demonstrated against *S. litura* and *H. armigera* in groundnut and chickpea, respectively (Vijayalaxmi *et al.*, 1996; Barapatre and Lingappa, 2003).

Cow urine 5% with neem seed kernel extract 5% and cow dung 5% showed anti-feedant and anti-ovipositional effects against *Helicoverpa armigera* (Sadawarte and Sarode, 1997).

Usually, aqueous or solvent extracts were reported as effective against many pests. However, there is wide variation in the preparation of these extracts. It has now been indicated that plant products made by fermenting different botanicals with animal dung and urine possessed rich microbial cultures which helped not only in providing nutrients to plants, but also acted as pest repellents (Prakash and Rao, 1997; Vijayalakshmi *et al.*, 1999; Prasad and Rao, 2007).

Pawar *et al.* (2000) conducted a field trial to assess the bio efficacy of organic products against aphids and leaf hoppers. Cow urine (20%) was found to be effective both against aphids and leafhoppers.

Tesfaye and Gautam (2003) while ascertaining the insecticidal property of cow urine revealed that 3 days fermented cow urine (1:6) resulted in 79.6% mortality of the banana fly, *D. melanogaster* Meigen as against 2.8% in control and was statistically at par with garlic and 3 times more effective than NSKE (5%). The bioassay of cow urine when further carried out on the cowpea aphid, *A. craccivora* Koch, the authors found that the above treatment was as effective as garlic (*Allium cepa* Linn.) and imidacloprid (0.25%) in managing the pest.

Subedi and Vaidya (2003) tested the efficacy of three concentrations of aqueous plant extracts (1kg/5 l, 1kg/10 l and 1kg/20 l of water), three concentrations of animal urine (20%, 15% and 10%) and two concentrations of Neem azal (0.1% and 0.01%) against flea beetle. The results indicated that the highest concentrations of *S. acmella*, buffalo urine and cow urine were effective in controlling the flea beetle, *Phyllotreta nemorum* L. (Coleoptera: Chrysomelidae).

Cow urine is recommended as an insecticide and can be applied by mixing it with soil and applying on plants at much diluted concentrations (Anonymous, 2005).

Gupta (2005) while evaluating Neem leaf extracts (NLE) and neem kernel extracts (NKE) in cow urine along with other treatments like neem oil, insecticides phosphamidon, Dimethoate and their combinations, against mustard aphid, *Lipaphis erysimi* Kalt. He found that the pest could be safely and successfully managed by adopting 3 or 4 foliar sprays of neem kernel extract (in cow urine) @ 3% either alone or in combination with reduced dose of Dimethoate@ 0.03%. The incremental cost benefit ratio was reported as highest in NKE 2% (15.5) and NKE 3% (15.1).

Gupta and Yadav (2006) studied the efficacy cow urine against stem borers and worked out the cost benefit in soybean production in comparison to conventional insecticide (chlorpyrifos) and bio pesticide (Dipel). The observed

that the plant infestation of Girdle beetle, *Obereopsis brevis*, was significantly reduced in lower concentrations of cow urine (15, 10 and 5 %) treated plots at 7 days after third spray. Stem fly, *Melanagromyza sozae*, infestation was significantly less at higher levels of cow urine (75 and 100 %) than control. There was reduction in percent stem tunnelling in almost all levels of cow urine, chlorpyrifos and Dipel. The yield data indicates that cow urine at 25, 50 and 75% concentration and Chlorpyrifos have significantly higher yield than control. Highest cost benefit ratio (1: 18.9) was obtained from cow urine 5%. However, highest additional yield value of Rs. 6520 per hectare was obtained with cow urine 50%.

Ahirwar *et al.* (2008) studied the efficacy of indigenous natural products like neem oil, neem leaf extract (NLE), neem seed kernel extract (NSKE), cow butter milk, cow urine and garlic buds + red pepper extracts in comparison to the effects of endosulfan against the incidence of leaf roller or capsule borer, *Antigastra catalaunalis* during *kharif*, 2003–2005. The results indicated that neem oil @ 10 ml/l, NLE (in cow urine) @ 30 ml/l, NSKE (in cow urine) @ 30 ml/l, cow butter milk @ 40 ml/l, cow urine @ 30 ml/l and garlic buds + red pepper extracts (1:1) @ 10 ml/l were highly effective and statistically on par with endosulfan 0.07% @ 2 ml/l not only in reducing the larval population, % flower and capsule damage caused by *Antigastra catalaunalis* larvae but also increasing the grain yield.

Salkinkop *et al.* (2008) informed that cow's urine as well as milk contains micro organisms which are useful in many ways. These organisms also produce substances, which have wide antibiotic activity and they kill or inhibit the growth of microbes involved in food poisoning. Urine of cow contains microorganisms, which help the growth of many plants. Similarly, the insect repellants are being produced by extracting herbs like neem with cow's urine. The panchagavya, an organic formulation used for improved composting is unique combination of five products of cow (cow dung, urine, milk, curd and ghee) and other products / byproducts of plant origin.

Rani *et al.* (2009) while studying the efficacy of plants *viz.* *Azadirachta indica* L., *Sapindus mukorossi* L., *Chrysanthemum cinerariaefolium* L., *Nerium oleander* L., *Jatropha curcas* L., *Urtica dioica* L. and *Vitex negundo* L. extracted in indigenous cow (Haryana) urine found that all the extracts @ 5 ml/litre were effective in reducing the white grub *Brahmina coriaca* (Hope) population as well as per cent tuber damage in potato. The minimum per cent tuber damage in terms of number of tubers and weight of tubers was recorded in the treatment associated with indigenous cow (Haryana) urine extract of *A. indica* and *Jatropha sp.*

The ineffectiveness of only cow urine in contending pigeon pea pod borer complex was reported by Sadwarte and Sarode (1997) and Santhosh *et al.* (2009). Similarly, Barapatre (2001) found cow urine and panchagavya to be ineffective against *H. armigera* and *S. litura*.

Gupta and Yadav (2010) studied the efficacy of cow urine against different lepidopterous pests of soybean and concluded that cow urine at higher concentrations caused significant reduction in white fly, *B. tabaci* population at 7 days after first spray and 3 and 7 days after second spray.

Neelam and Chandla (2010) from a study carried out in Shimla reported that the cow urine (Bovine spp.) and extracts of three plants (seeds) *viz.*, *Azadirachta indica* L., *Sapindus mukorossi* L. and *Jatropha curcas* L. (10%) tested against glass house white fly, *Trialeurodes vaporariorum* (Westwood) on potato crop (50 days old plants) brought about 87.97 per cent and 82.98 per cent mortality of test whitefly after 14 days of spray.

2.3 Role of microbial pesticides in insect pest management

It is now widely recognised that insects suffer from diseases which can be an effective method of suppressing their population below economic threshold level. Most frequently used microbial pesticides are entomopathogenic bacteria followed by fungi and virus.

2.3.1 Role of *Bacillus thuringiensis* in insect pest management

Entomopathogenic bacteria can be broadly divided into spore formers and non-spore formers. The latter group remains in the insect mid-gut in a relatively harmless form, but when introduced into haemocoel due to any reason becomes extremely pathogenic. Little effort has been made to utilise this group in microbial control of insects. Among the spore formers *Bacillus*, *Pseudomonas*, *Aerobacter* and *Streptococcus* bear significance in insect control. Although more than 100 bacterial species have been identified as insect pathogens only *Bacillus* spp. has enjoyed the commercial status. *Bacillus thuringiensis* is pathogenic to more than 525 species of insects of different orders (Jayaraj, 1985).

As much of the research has not been carried out on insect pest management of bitter melon by using *Bacillus thuringiensis*, the reviews on vegetable crops have been discussed below.

Yin (1993) reported that spraying of *Bt* emulsion against shoot and fruit borer in brinjal resulted in 78.8-100 per cent control over untreated check. Similar findings have also been reported by Patnaik and Singh (1997).

Puranik *et al.* (2002) evaluated different *B. thuringiensis* (*Bt*) formulations in comparison with neem and chemical insecticides against brinjal shoot and fruit borer. Among the different treatments, five sprays of Dipel 8L @ 0.2 per cent at 10 days interval resulted in minimum shoot (9.56%) as well as fruit (11.78%) infestation and maximum yield of marketable fruits (196.96 q/ha) and thus proved to be the most effective treatment.

Different microbials *B. thuringiensis* var. *Kurstaki* (Btk, Dipel 8L), *Sacharopolyspora spinosa* (spinosad 45 SC, Tracer) and *B. bassiana* were tested alone and in combinations against third instar larvae of *H. armigera*. The individual treatments of *S. spinosa* (0.0018 or 0.003%) and its combinations (0.006 or 0.0013%) with Btk (0.02 to 0.08%) resulted in significantly higher larval mortalities of 100 per cent and 64.8 to 110.00 per cent, respectively (Sridevi *et al.*, 2004).

Bhojne *et al.* (2004) have studied the effect of *Btk* against the second instar larvae of *H. armigera*. They observed that *Btk* caused 79.38% mortality of the target pest at 0.00963% concentration. The LC₅₀ value was ascertained to be 0.0055%.

2.3.2 Role of *Beauveria bassiana* in insect pest management

Over 750 fungal species (100 genera) are known to attack terrestrial and aquatic arthropods. The most commonly encountered fungi pathogenic to insects belong to three sub-divisions of Eumycotina i.e., Deuteromycotina, Mastigomycotina and Ascomycotina.

Beauveria bassiana is a naturally occurring fungus in the soil throughout the world. It has been studied for control of soil borne insects. This entomopathogenic fungus is known to produce 33 toxins (Dhaliwal and Arora, 2000) and causes diseases known as the 'White Muscardine Disease' in insects. Reviews of literature on use of this fungus in management of insect pests of vegetables have been briefly presented in the following paragraphs.

Naik and Shekharappa (2009) carried out a laboratory study on the bio-efficacy of entomopathogenic fungal formulations against sucking pests of okra at Main Agriculture Research Station, Dharwad during 2007. The results showed that *Beauveria bassiana* oil and *Metarhizium anisopliae* oil and their WP formulations and recorded 96.67% mortality of leafhoppers at 10 DAT and *Verticillium lecanii* oil and *B. bassiana* WP formulations recorded 93.33% mortality. The efficacy against aphids revealed that *V. lecanii* oil based formulation showed 100% mortality followed by *V. lecanii* WP (96.67%) and *B. bassiana* oil and WP formulations (93.33%). *V. lecanii* oil based formulation recorded the 97.00% mortality of thrips followed by *V. lecanii* WP and *B. bassiana* oil and WP and *M. anisopliae* oil (93.33%). The efficacy against mite was 96.67 and 94.67 per cent in *M. anisopliae* oil and WP followed by *B. bassiana* oil (94.00%). However, the standard check recorded cent per cent mortality of all the pests throughout the experimental period.

A field study was carried out by Gaje-Singh(2010) to evaluate bio-efficacy of the different bio-pesticides against pod borer in lentil during rabi season of 2006-07 and 2007-08. The six treatments viz., *Beauveria bassiana* at 2.0 kg/ha, *Metarrhizium* spp. at 2.0 kg/ha, 5% NSKE, neemarin at 3 liter/ha, *Bacillus thuringiensis* (Bt) at 0.5 kg/ha and endosulfan 35 EC at 1.5 liter/ha and an untreated control. The treatment with *Bacillus thuringiensis* at 0.5 kg/ha was found best with minimum pod borer infestation of 2.96 and 2.43% during rabi of 2006-07 and rabi of 2007-08 respectively and followed by *Beauveria bassiana* in which the pod infestation was 4.95 and 5.47% respectively. The maximum pod borer infestation of 10.08 and 11.29% was recorded in untreated control during both the years. The maximum average yield of 14.15 q/ha and maximum net return of Rs 15,900/ha was obtained with treatment of *Bacillus thuringiensis*. The highest cost benefit ratio of 1:9.8 was obtained with *Beauveria bassiana*, followed by *Bacillus thuringiensis* with cost benefit ratio of 1:8.8.

2.4 Role of chemical pesticides in insect pest management

Before development of bio-intensive strategy, synthetic pesticides were the main weapons to combat the notorious pests. The different insecticides which have been reported by workers as effective against bitter gourd pest complex are summarised below.

Reddy and Rao (1988) while evaluating insecticides against the insect pests of bitter gourd have reported that fenvalerate followed by monocrotophos and acephate were the most effective against jassids and epilachna beetle. Further monocrotophos (0.05%) and acephate (0.1%) were reported to degrade quickly while fenvalerate, carbaryl and malathion showed relatively long residual toxicity.

Shanmugapriyan *et al.* (2001) studied the efficacy of quinalphos (Quinalphos X @ 0.025%) and monocrotophos (Nuphos-36 @ 0.025%) on grubs of *E. vigintioctopunctata*. The results revealed that both monocrotophos and quinalphos resulted in 95.24% larval mortality.

Singh (2001) conducted bioassay studies in order to evaluate the relative efficacy of 10 synthetic insecticides (LC₅₀), i.e. lambda-

cyhalothrin (0.000533), deltamethrin (0.001975), bifenthrin (0.001983), fenvalerate (0.003023), cypermethrin (0.14890), chlorpyrifos (0.025730), betacyfluthrin (0.02670), oxydemeton-methyl (0.012950), chlorpyrifos (0.25730), endosulfan (0.132200) and malathion (0.238300), against *M. persicae*. Based on the LC₅₀ values of the insecticides and the LC₅₀ value of endosulfan as unity, the order of toxicity of the various insecticides was: lambda-cyhalothrin > deltamethrin > bifenthrin > fenvalerate > oxydemeton-methyl > cypermethrin > chlorpyrifos > betacyfluthrin > endosulfan > Malathion, with the corresponding toxicity values being 248.03, 66.94, 66.67, 43.73, 10.21, 8.88, 5.14, 5.07, 1.0 and 0.55, respectively.

Sharma and Sinha (2009) evaluated six insecticides, viz. alphamethrin, cypermethrin, endosulfan, spinosad, emamectin benzoate and Neem Baan against *Bactrocera cucurbitae* (Coquillett) on bitter gourd during kharif, 2007. He found that Alphamethrin @ 20 g a.i./ha was the most effective as its application resulted in 5.52 per cent damage as compared to 15.14 per cent in control. Emamectin benzoate @ 15 g a.i./ha and Neem Baan @ 1 ml/l were also found effective.

2.5 Epilachna beetle, *Henosepilachna septima* (Coccinellidae : Coleoptera)

The population of Epilachna beetle peaked usually during July-August and cause damage to plants upto an extend of 80 % (Rajgopal and Trivedi, 1989) and also reported that the peak period of infestation by epilachna beetle varied with region but generally noticed in July-August.

2.6 Melon fruit fly, *Bactrocera* spp (Tephritidae : Diptera)

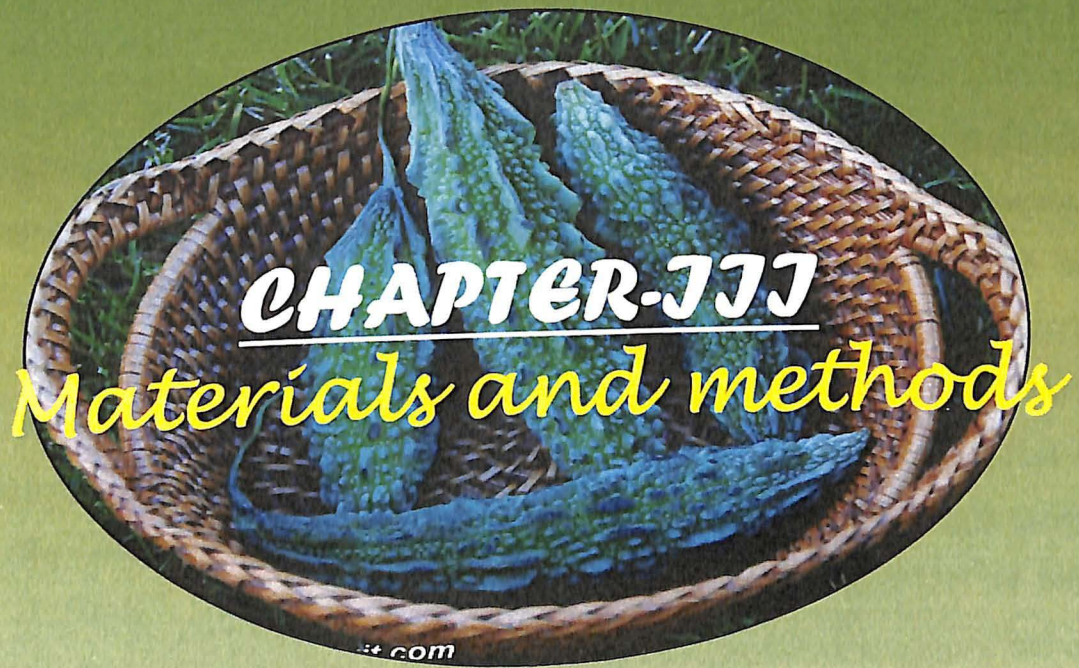
Among the pests infesting bitter gourd, the fruit fly causes several quantitative and qualitative losses. Nair (1975) reported about seven species of fruit flies belonging to two genera which attacked several cucurbitaceous crops in the field as well as after harvest. The fruit fly has been reported to occur in several countries viz., Pakistan, Burma, Malaysia, China, Taiwan, Japan, Mozambique, Australia and Hawaiian Island (Atwal, 1976).

Among the different species of fruit fly *Bactrocera cucurbitae* has been reported to infest bitter gourd (Butani and Verma, 1977).

A few scattered reports were available on the damage caused by the fruit fly. However, the damage in general is caused by the maggots which pollute and destroy the fruit by feeding on the pulp. Rotting of fruits occur due to secondary infestation by bacteria and fungi.

The fruit flies usually attack tender fruits but its attack on the vines was exceptionally reported by Mathew *et al.*, (1999).

Rajpoot *et al.*, (2002) reported that 51.2-53.5 % damage caused in bitter gourd is due to fruit fly.



CHAPTER-III

Materials and methods

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MATERIALS AND METHODS

Studies on “Relative efficacy of bio pesticides against the pest complex of bitter gourd” were made in the experimental field of Department of Entomology located in the upland area of Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar during the month of February 2012. The soil type of experimental plot is red laterite with average pH of 6.5. Botanicals and organic products used in the present experiment are documented in the following subsections.

3.1: Experiment details:

Bitter gourd seeds cv Green long were sown @ 5kg/ha on 05.02.2012 in plots of size 3.0 × 2.0 m. In each plot 5 pits were made at a spacing of 1.2 × 1.2 m and in each pit farm yard manure was thoroughly incorporated with soil at recommended levels of 5 ton/ ha. About 3-4 seeds were sown in each pit and the experiment was conducted by taking three replications and eight treatments. The crop was raised by following all the standard agronomic practices and a recommended fertilizer dose of 30:30:30 kg/ha of N₂: P₂O₅: K₂O, respectively. Full dose of P₂O₅ in the form of Single super phosphate and half the recommended dose of K₂O in the form of Muriate of potash were applied at the time of sowing. Nitrogen in the form of urea was applied in three split doses, i.e. 1/3rd at 10 days after emergence (DAE), 1/3rd at 30DAE and 1/3rd at 60DAE. Weeding in experimental field was done thrice and irrigation was provided as and when required.

All the 8 treatments as detailed below were replicated thrice in RBD.

3.1.1: Treatment details:

T ₁	<i>Bacillus thuringiensis</i> var. kurstaki @ 1kg/ha
T ₂	<i>Beauveria bassiana</i>)@ 2kg/ha
T ₃	Neem formulation (Multineem) @ 2.5 litre/ha
T ₄	Neem leaves fermented in cow urine @ 50 litre/ha
T ₅	Karanj leaves fermented in cow urine @ 50 litre/ha
T ₆	<i>Hyptis suaveolens</i> leaves fermented in cow urine @ 50 litre/ha
T ₇	Cartap hydrochloride @ 1kg/ha
T ₈	Untreated control

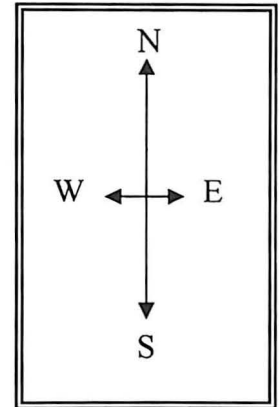
There were eight treatments including an untreated control. All the treatments were randomly allotted to the different plots as per the following layout plan of the field experiment given in Fig. 1.

Table 1. Details of bio pesticides and pesticide used in the experiment

Sl.No.	Generic name of test product	Trade Name	Manufacturing Firms
1	<i>Bacillus thuringiensis</i> subsp. Kurstaki (<i>B.t.k.</i>) (Serotype – 3a,3b,3c)	Halt	Biostadt India ltd., Mumbai.
2	<i>Beauveria bassiana</i>	Daman	International Panaceae Ltd New Delhi.
3	Neem formulation	Multineem 0.03EC (Azadirachtin 300ppm)	Multiplex Agricare Pvt. Ltd Karnataka
4	Cartap hydrochloride	Caldan	Dhanuka Agritech Limited

Fig 1. Layout plan of the Experiment

R₁	R₂	R₃
T₃	T₅	T₈
T₆	T₇	T₅
T₂	T₉	T₇
T₄	T₆	T₄
T₅	T₈	T₆
T₁	T₁	T₃
T₈	T₃	T₂
T₇	T₂	T₁



Design : RBD

Replication : 3 (R₁, R₂, R₃)

Treatments : 7

3.2: Preparation of organics for spraying:

Fresh extracts of botanicals were prepared as per the following methods.

3.2.1. Preparation of fermented botanicals:

All the required leaves of neem, karanj and hyptis were freshly collected from field. The leaves were washed and weighed. 250 g of the leaves of the corresponding plants were weighed and pulverized. The pastes prepared out of the leaves were tied to pieces of cloth and were dipped in cow urine kept in 3 different earthen pots. The botanicals were allowed to ferment in cow urine in earthen pots and their mouths covered with piece of cloth (Fig.2). The botanicals were fermented in cow urine for 7 days and were sprayed at a concentration of 10% after straining them properly. The first spraying was made on i.e., 20.02.2012 about 15 days after sowing of seeds and the subsequent sprayings as per the treatments were made at 10 days interval. In all there were three sprayings covering the crop period. Fresh preparation of botanicals was done just before each spraying. A spray volume of one litre of each botanical extract was found sufficient for spraying 3 plots.

3.3: Record of field observations on the incidence of insect pests of bitter gourd:

Periodical observations were recorded on the incidence of Epilachna beetle *Epilachna septima* (Fabricius), jassids *Amrasca biguttula biguttula* (Ishida) and fruit fly *Bactrocera cucurbitae*. Initial observations were recorded on 25.06.2010 to know the initial pest load in the field, simultaneously next observations was recorded at three days and seven days after each spraying. Different methods were followed for recording the incidence of different insect pests and they are described below:

3.3.1. Incidence of epilachna beetle:

The incidence of epilachna beetle can be observed when there is skeletonisation of leaves. The extent of leaf damage caused by epilachna beetle has been assessed by observing the top three leaves of three randomly selected

plants in each treatment. The infested leaves in ratio with the total leaves were utilized to calculate the percentage of leaf damage. The incidence of epilachna beetle was noticed by the presence of eggs, grubs, adult beetles and scraping of leaves.

3.3.2: Jassids incidence

The jassid population was recorded by examining the lower surface of three leaves (top, middle and bottom) of three randomly selected plants. Then the average count of three leaves was calculated for comparing the treatment effects.

3.3.3: Fruit fly incidence

The fruit fly incidence was assessed by sampling the infested and healthy fruits on each day of picking, during the fruiting stage of crop. The percentage of damage was calculated by the following formula:

$$\text{Per cent leaf damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

About 3 observations were recorded to indicate fruit fly incidence in response to the treatments. The data on number of fruit fly maggots per fruit was obtained by examining about 10 infested fruits at each picking date. The mean numbers of maggot population per fruit across treatments at various stages of fruit development were used to indicate periodical incidence on bitter gourd.

The fruit yield of bitter gourd with respect to various treatments was obtained from the cumulative estimate of 3 pickings. More over the benefit: cost ratio in respect of various treatments has been worked out to evaluate their cost effectiveness.

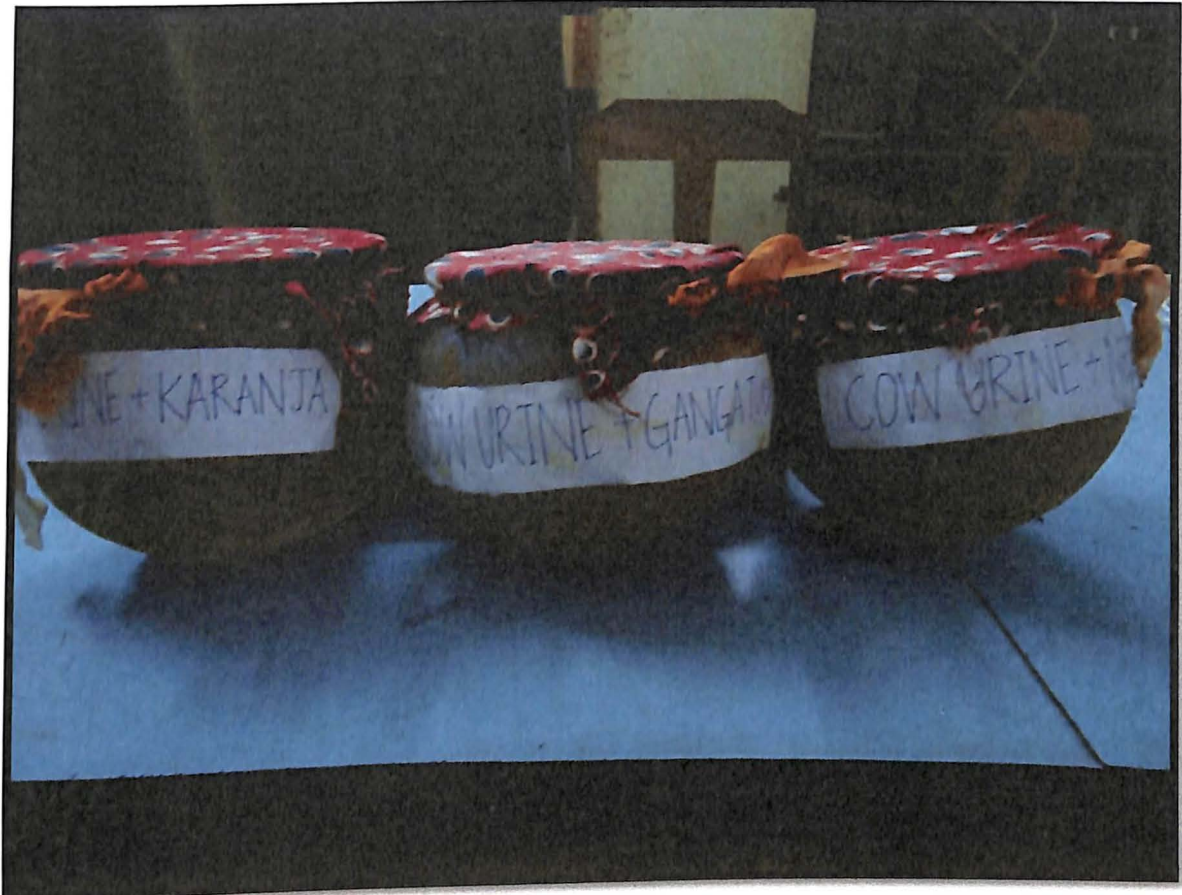


Plate 1. Botanicals fermented in cow urine



Plate 2 A view of field after planting

3.4 Calculation of avoidable loss and benefit: cost ratio

The avoidable yield loss due to fruit fly damage in bitter gourd was calculated by using the following formula as suggested by Pawar *et al.* (1984).

$$\text{Per cent of avoidable loss} = \frac{T - C}{T} \times 100$$

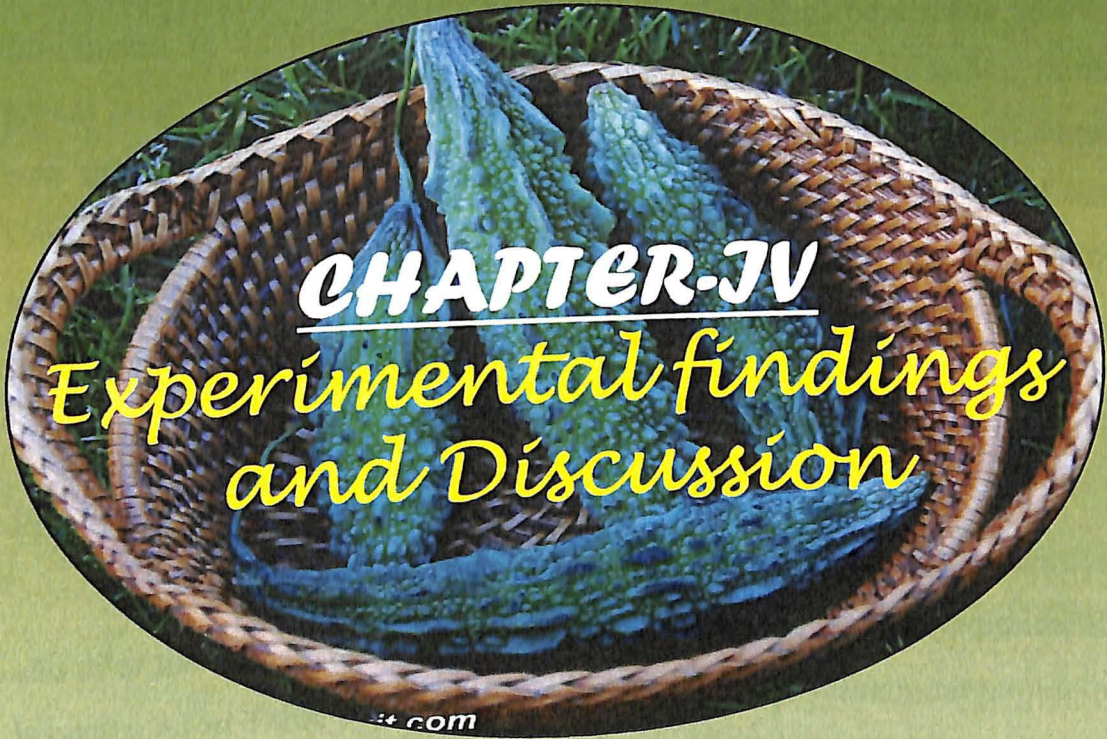
where, T = Yield in the most effective treatment

C = Yield in the respective treatment

For calculating the benefit-cost ratio, the prevailing market price of the produce, cost of pesticides and labour were taken into consideration.

3.5 Statistical analysis

The data on jassid population and per cent leaf damage obtained from field experiment were subjected to statistical analysis after suitable transformation (Gomez and Gomez, 1984). The significance of the difference among the treatment combination means was tested by DMRT (Duncan's Multiple Range Test) at 5% level of probability.



CHAPTER-IV

*Experimental findings
and Discussion*

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EXPERIMENTAL FINDINGS AND DISCUSSION

During the month of February 2012, a field experiment was conducted in the Central Research Station, OUAT, Bhubaneswar to study the relative efficacy of bio pesticides viz. *Bacillus thuringiensis* var. Kurstaki, *Beauveria bassiana*, a neem based pesticide, Multineem, botanicals along with cow urine against the pest of bitter gourd. The results of these experiments have been presented in this chapter, with appropriate figures and tables.

4.0 Field evaluation of bio pesticides

In this set of experiment bio pesticide viz., *Bacillus thuringiensis* subsp. Kurstaki (Halt 5 WP) @ 1kg/ha, *Beauveria bassiana* (Daman) @ 2kg/ha, Multineem @ 2.5 litre/ ha, neem leaves fermented in cow urine @ 50 litre/ha, karanj leaves fermented in cow urine @ 50 litre/ha, *Hyptis* leaves fermented in cow urine @ 50 litre/ha were tested against the pest complex of bitter gourd. Cartap hydrochloride (caldan) @ 1kg/ha was taken as an insecticidal check. The sprayings were given when leaf damage by epilachna beetle was found in the field. Three sprayings were given during the experimental period.

4.1.1 Population dynamics of jassids after first spraying

Pre- treatment population:

The variation in population of jassid, *Amrasca biguttula biguttula* before and after the first spraying in bitter gourd recorded within the experimental period is presented in Table 3. The data revealed that the pre-treatment population varied from 10 to 12.50/ 3 leaves in different sub plots and the difference between the plots was statistically significant.

3 days after first spraying (3DAS):

At 3 days after first spraying, a general decline in jassid population was observed in all the treatment including untreated control which resisted about less than 1% decrease, the highest jassid population of 12.44 per 3 leaves was recorded in the untreated control plot while the lowest population (5.23 per 3

leaves) was recorded in the plot treated with cartap hydrochloride @ 1kg/ ha (T₇), closely followed by T₄ (6.98), i.e. cow urine + neem leaf @ 50 litre/ha. However, these two treatments (T₇ and T₄) are not statistically at par with each other. The treatment with Multineem @ 2.5litre/ ha, (T₃) recorded the next lowest jassid population of 7.13/ 3 leaves followed by T₅, cow urine + karanj leaves @50 litre/ ha with a jassid population of 8.38/3 leaves. These two treatments were also statistically different from each other. However T₂ (*Beauveria bassiana* @2 kg/ha) and T₆ (cow urine + Hyptis @ 50 litre/ ha) were statistically at par with each other with a jassid population of 9.55 and 6.78 / 3 leaves, respectively. T₁ (*Bacillus thuringiensis* var. kurstaki@ 1 kg/ha) though not statistically at par with untreated control recorded the second highest jassid population (10.88 / 3 leaves) among the treatments. A high degree of variation was observed among the treatment with respect to jassid population 3 days after spraying.

The efficacy of these treatments in the descending order of their performance was as follows:

$$T_7 > T_4 > T_3 > T_5 > T_2 > T_6 > T_1 > T_8$$

7 days after first spraying (7DAS):

After 7 days of first spraying, a further decline in jassid population was once again observed in all treated plots barring untreated control which recorded the highest population of 12.77/3 leaves. The least jassid population (1.90/ 3 leaves) was recorded in the plot which was treated with cartap hydrochloride @ 1 kg/ha proving its supremacy over rest of the treatments. This was followed by the treatment T₄ (Cow urine + neem leaf) and T₃ (Multineem) with a population of 6.38 and 7.58 / 3 leaves, respectively. The treatment with cow urine + karanj registered superiority over control with a population of 8.88 jassids / 3 leaves. In the rest of the treatment, population varied between 9.75 to 10.78. All the treatments exhibited their superiority over the untreated control and their relative efficacy in managing the jassid population in descending order was as follows:

$$T_7 > T_4 > T_3 > T_5 > T_6 > T_1 > T_2 > T_8$$

Post-treatment population reduction of jassids after first spraying:

The reduction in the jassid population, following the first spraying is presented in Table 3. The data obtained indicated that there was a mean rise of 2.32% jassid population in the untreated control plot, as compared to the pre-treatment population. Since a consistent decline in jassid population was recorded in all the treated plots it may be envisaged that the treatments were effective in causing mortality of jassids.

4.1.2 Population dynamics of jassids after second spraying

3 Days after second spraying (3DAS):

The second spraying was given at 10 days after the first spraying. The population of jassids observed on third day after second spraying is presented in Table 4. The data in table revealed that all the treated plots registered a general decline of jassid population while the untreated plots continued to harbour the maximum jassid population i.e., 13.47/3 leaves. The plots treated with cartap hydrochloride (T₇) @ 1kg/ha were almost free from jassid infestation (1.18/ 3 leaves) followed by T₄ (cow urine + neem leaf @ 50 litres/ha), T₅ (cow urine + karanj leaf@ 50 litres/ha) and T₃ (Multineem @ 2.5 litre/ha) with a population of 5.52, 7.45, 7.72/ 3 leaves respectively. The treatments, T₃ and T₅ were at par with each other. The treatment with cow urine + *Hyptis* @ 50 litres/ha was superior to untreated control with a population of 9.31/3 leaves. In the rest of treatments, the population varied from 9.5 to 10.98/3 leaves. All the treatments exhibited their superiority over untreated control and their relative efficacy in declining order of performance in managing jassid was as follows

$$T_7 > T_4 > T_5 > T_3 > T_6 > T_2 > T_1 > T_8$$

7 Days after second spraying (7DAS):

The data revealed that the untreated plot had maximum jassid population i.e., 13.62/ 3 leaves. The plots treated with cartap hydrochloride (T₇) @ 1 kg / ha were free from jassid infestation (0.58/ 3 leaves) followed by T₄ (Cow urine + neem leaf @ 50 litre/ ha), T₃ (Multineem @ 2.5 litre/ha),

Table 3. Effects of treatments on population of jassid after first spraying

Tr No.	Treatments	Mean population of jassids/ 3 leaves			Population reduction 7 DAS (%)
		Before spraying	First spraying		
			3DAS	7DAS	
T ₁	<i>Bacillus thuringiensis</i> var kurstaki @ 1 kg/ha	10.98(3.39) ^g	10.88(3.29) ^g	10.78(3.35) ^g	1.82
T ₂	<i>Beauveria bassiana</i> @ 2kg/ha	9.85(3.22) ^{cd}	9.55(3.09) ^e	9.75(3.20) ^e	1.01
T ₃	Multineem @ 1 litre/ha	8.68(3.03) ^{ab}	7.18(2.77) ^{bc}	7.58(2.84) ^c	12.67
T ₄	Cow urine + neem leaf @ 50 litres/ha	8.48(3.00) ^a	6.98(2.74) ^b	6.38(2.62) ^b	24.76
T ₅	Cow urine + karanj leaf @ 50 litres/ha	9.68(3.19) ^c	8.38(2.98) ^d	8.88(3.06) ^d	8.26
T ₆	Cow urine + <i>Hyptis</i> leaf @ 50 litres/ha	10.51(3.24) ^e	9.78(3.21) ^{ef}	10.28(3.28) ^f	2.18
T ₇	Cartap hydrochloride @ 1kg/ha	10.61(3.33) ^{ef}	2.23(1.65) ^a	1.90(1.54) ^a	82.09
T ₈	Control (Untreated)	12.48(3.60) ^h	12.44(3.52) ^h	12.77(3.57) ^h	-2.32

Similar superscripts in a column indicate that the differences among the treatments are not statistically significant (DMRT P=0.05)

Figures in parentheses are transformed values ($\sqrt{x+0.5}$)

Mean of three replications DAS: Days after spraying

Table 4. Effects of treatments on population of jassid after second spraying

Tr No.	Treatments	Mean population of jassids/ 3 leaves			Population reduction 7 DAS (%)
		Before spraying	Second spraying		
			3DAS	7DAS	
T ₁	<i>Bacillus thuringiensis</i> var kurstaki @ 1 kg/ha	10.78(3.28) ^g	10.98(3.39) ^g	10.91(3.38) ^g	-1.20
T ₂	<i>Beauveria bassiana</i> @ 2kg/ha	9.75(3.20) ^e	9.75(3.20) ^f	9.65(3.10) ^{ef}	1.02
T ₃	Multineem @ 2.5 litre/ha	7.58(2.84) ^c	7.72(2.78) ^{cd}	7.18(2.77) ^c	5.27
T ₄	Cow urine + neem leaf @ 50 litres/ha	6.38(2.62) ^b	5.52(2.34) ^b	5.32(2.41) ^b	16.61
T ₅	Cow urine + karanj leaf @ 50 litres/ha	8.88(3.06) ^d	7.45(2.82) ^c	7.85(2.88) ^d	11.59
T ₆	Cow urine + <i>Hyptis</i> leaf @ 50 litres/ha	10.28(3.28) ^f	9.31(3.10) ^e	9.53(3.17) ^e	7.29
T ₇	Cartap hydrochloride @ 1kg/ha	2.00(1.58) ^a	1.18(1.29) ^a	0.58(1.03) ^a	71.00
T ₈	Control (Untreated)	12.77(3.57) ^h	13.47(3.67) ^h	13.62(3.69) ^h	-6.65

Similar superscripts in a column indicate that the differences among the treatments are not statistically significant (DMRT P=0.05)

Figures in parentheses are transformed values ($\sqrt{x+0.5}$)

Mean of three replications DAS: Days after spraying

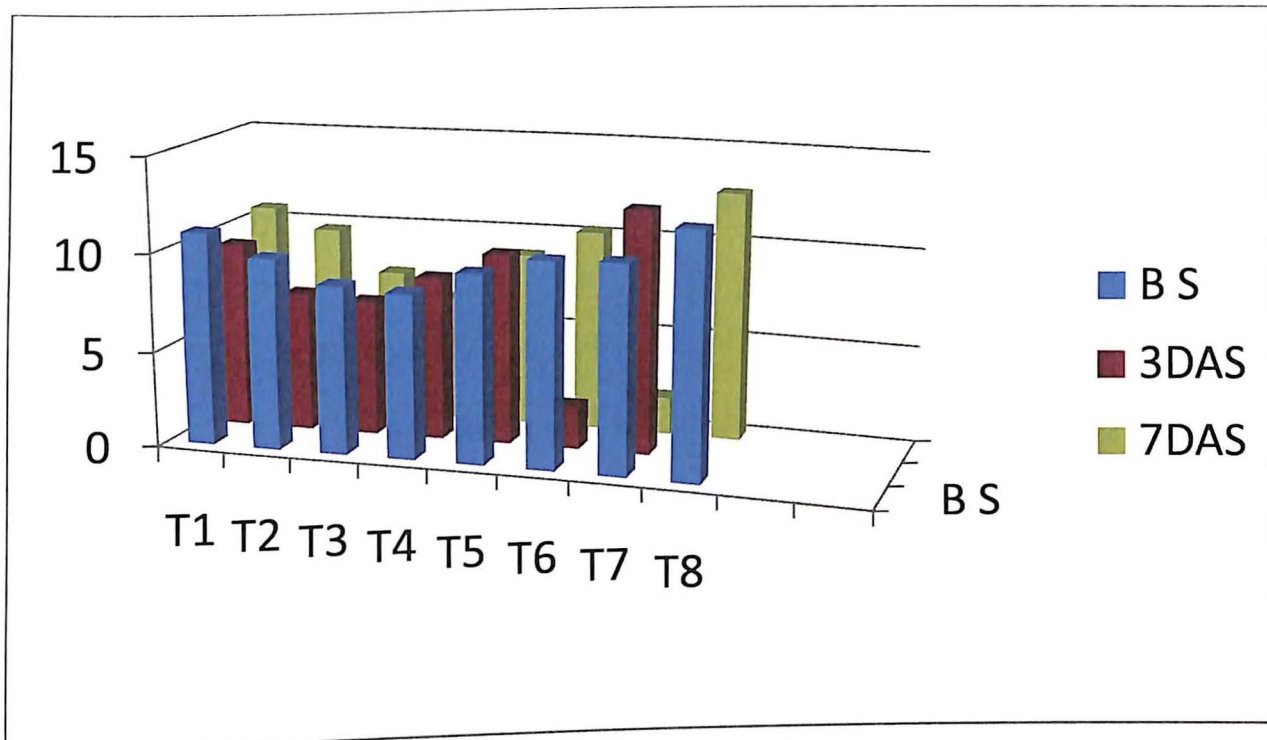


Fig 2. Population of jassid after first spraying

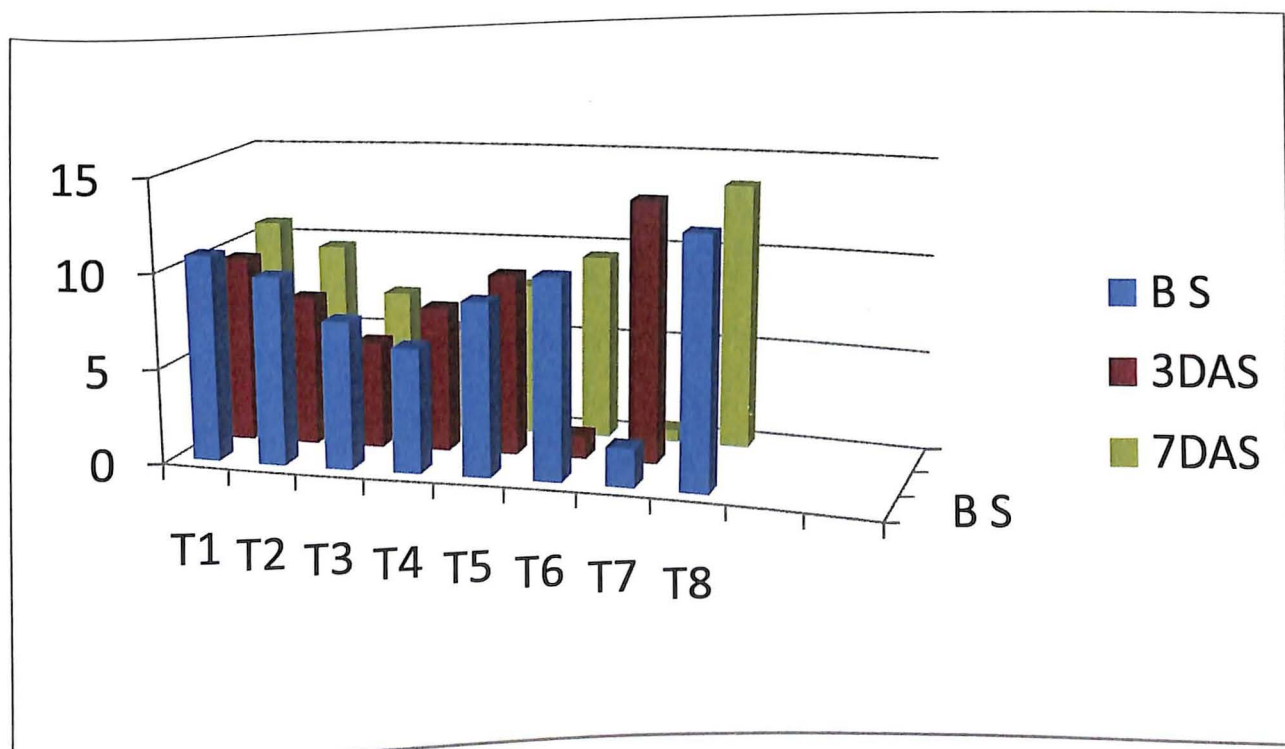


Fig 3. Population of jassid after second spraying

T₅ (cow urine + karanj leaf @ 50 litres/ha), T₆ (cow urine + *Hyptis* @ 50 litres/ha) with a population of 5.32, 7.18, 7.85, 9.53/ 3 leaves respectively. However a population increase of 1.2% was noticed in T₁ (*Bacillus thuringiensis* var. Kurstaki @ 1 kg/ha) while there was 6.65 % population increase in the untreated control plot.

The efficacy of these treatments in the descending order of their performance was as follows:

$$T_7 > T_4 > T_3 > T_5 > T_6 > T_2 > T_1 > T_8$$

Post-treatment population reduction of jassids after second spraying:

The data presented in Table 4 indicated that there was a general decline of jassid population in all the experimental plots as compared to the initial population, following second spraying. The data obtained indicated that there was a mean rise of 6.65% population in the untreated plot and 1.20% rise in the plot treated with *Bt* var kurstaki (T₁). Since a decline in jassid population was recorded in all the treated plots it may be envisaged that the treatments were effective in causing mortality of jassids.

4.1.3 Population dynamics of jassids after third spraying

3 Days after third spraying (3DAS):

The third spraying was given at 10 days after the second spraying. The population of jassids observed on third day after third spraying is presented in Table 5. The data revealed that the untreated plot had maximum jassid population i.e., 14.27 / 3 leaves. The plots treated with cartap hydrochloride (T₇) @ 1 kg / ha were free from jassid infestation followed by T₄ (Cow urine + neem leaf @ 50 litre/ ha), T₃ (Multineem @ 2.5 litre/ha), and T₅ (cow urine + karanj leaf @ 50 litres/ha). The treatments T₃(Multineem) and T₅ (cow urine + karanj leaf) were statistically at par. The treatments T₆ (cow urine + *Hyptis* @ 50 litre/ha) and T₂ (*Beauveria bassiana* @ 2 kg/ha) recorded a population of 9.52 and 9.89/ 3 leaves and were statistically at par. The plot treated with *Bt* var kurstaki was least effective in population reduction of jassids with a record of 11.10/ 3 leaves.

The efficacy of these treatments in the descending order of their performance was as follows:

$$T_7 > T_4 > T_3 = T_5 > T_6 = T_2 > T_1 > T_8$$

7 Days after third spraying (7DAS):

Observations recorded at 7 DAS showed that there had been a sharp decline in jassid population in plot treated with cartap hydrochloride, T_7 i.e., 0.02/ 3 leaves and maximum population of jassid in untreated plot i.e., 14.56/ 3 leaves. The treatments T_4 (cu + neem) and T_3 (Multineem) were the next best treatments. The treatments T_5 (cu + karanj), T_6 (cu + Hyptis) and T_2 (*Beauveria bassiana*) recorded a population of 7.58, 9.42 and 9.93/3 leaves. In the rest of the treatments the population was 11.28/3 leaves. All the treatments exhibited their superiority over the untreated control and their relative efficacy in managing the jassid population in descending order was as follows:

$$T_7 > T_4 > T_3 > T_5 > T_6 > T_2 > T_1 > T_8$$

Post-treatment population reduction of jassids after third spraying:

The data presented in Table 5 indicated that there was a general decline of jassid population in all the experimental plots as compared to the initial population, following second spraying. The data obtained indicated that there was a mean rise of 6.90% population in the untreated plot, 3.39 % rise in the plot treated with *Bt* var kurstaki (T_1) and 2.90 % rise in T_2 (*Beauveria bassiana*). The highest population decline of 80 % was observed in the plot treated with cartap hydrochloride @ 1 kg/ha. The treatments, T_4 (cu + neem) and T_3 (multineem) continued to maintain their supremacy over rest of the treatments by registering 6.01% and 4.17 % reduction in population of jassids respectively. In the rest of the treatments, 1.15 to 3.43 % decline in jassid population was recorded. It was established that the pesticidal application (Cartap hydrochloride @ 1 kg/ha) was found superior to that of bio pesticide application in the context of population reduction of jassids.

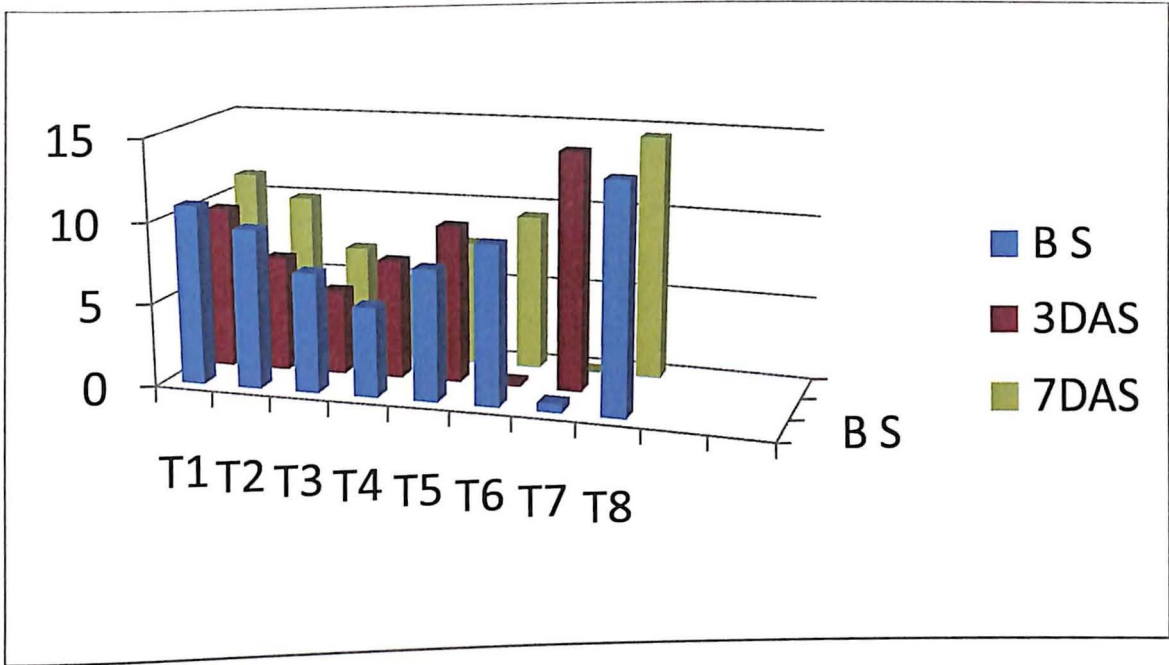


Fig 4. Population of jassid after third spraying



Plate No. 3 Jassid, *Amrasca biguttula biguttula*

During the experimental period (2011-2012) the jassids started appearing with the early flowering stage.

In the present study, the *Bacillus thuringiensis* subsp. *Kurstaki* (Halt 5 WP) @ 1kg/ha, *Beauveria bassiana* (Daman) @ 2kg/ha, Multineem @ 2.5 litre/ ha , neem, *Hyptis* and karanja leaves fermented in cow urine, each @ 50 litre/ha , were tested against the jassids infesting bitter gourd. Cartap hydrochloride (Caldan) @ 1kg/ha was taken as an insecticidal check. It was concluded from the experimental data that cartap hydrochloride consistently proved its superiority over the two bio pesticides and three botanicals used, registering the highest population reduction of 80% in jassids population over untreated check. The present finding is in similar lines as that of Reddy (1997), who found fenvalerate to be quite effective against jassids infesting bitter gourd. Similarly, Reddy and Rao (1998) reported that fenvalerate followed by monocrotophos and acephate were most effective against jassids in bitter gourd. Mohapatra (2002) also found acetamiprid 20% SP (0.002% conc) as the most effective of all insecticides tested against jassids in bitter gourd by limiting its population (2.8/10 leaves). This treatment was followed by neem leaves fermented in cow urine @ 50 litre/ha with a population reduction of 6.01% followed by Multineem @ 2.5 litre/ha (4.17%), karanja leaves fermented in cow urine @ 50 litre/ha (3.43%) and *Hyptis* leaves fermented in cow urine @ 50 litre/ha (1.15%). Pawar *et al.* (2000) from a field study found Cow urine (20%) to be effective both against aphids and leafhoppers. It may be observed here the cow urine extracts almost failed to contend the jassids in bitter gourd. Usually, aqueous or solvent extracts were reported as effective against many pests. However, there is wide variation in the preparation of these extracts. Since literature in this regard are unavailable for proper comparison and justification, the reduction of their efficacy against jassids in the present study may be attributed to lower concentration and other abiotic stresses inclusive of higher temperature.....The other treatments with microbial insecticides viz., *Btk* @ 1 Kg/ha and *Beauveria bassiana* @ 2.0 Kg/ha were rather ineffective against jassids as they recorded a rise in the test insect population by 3.39 and 2.90 per cent, respectively over untreated check. The foremost reason being *Btk* is rather ineffective against non-lepidopteran pests, irrespective of crop species. Even though Sosa-Gomez and

Table 5. Effects of treatments on population of jassid after third spraying

Tr No.	Treatments	Mean population of jassids/ 3 leaves			Population reduction 7 DAS (%)
		Before spraying	Third spraying		
			3DAS	7DAS	
T ₁	<i>Bacillus thuringiensis</i> var kurstaki @ 1 kg/ha	10.91(3.38) ^g	11.10(3.33) ^g	11.28(3.35) ^g	-3.39
T ₂	<i>Beauveria bassiana</i> @ 2kg/ha	9.65(3.10) ^{ef}	9.89(3.14) ^f	9.93(3.15) ^f	-2.90
T ₃	Multineem @ 2.5litre/ha	7.18(2.77) ^c	6.99(2.74) ^c	6.88(2.71) ^c	4.17
T ₄	Cow urine + neem leaf @ 50 litres/ha	5.32(2.41) ^b	5.09(2.25) ^b	5.00(2.24) ^b	6.01
T ₅	Cow urine + karanj leaf @ 50 litres/ha	7.85(2.88) ^d	7.19(2.77) ^{cd}	7.58(2.84) ^d	3.43
T ₆	Cow urine + <i>Hyptis</i> leaf @ 50 litres/ha	9.53(3.17) ^e	9.52(3.16) ^{ef}	9.42(3.14) ^e	1.15
T ₇	Cartap hydrochloride @ 1kg/ha	0.5(1.00) ^a	0.25(0.86) ^a	0.02(0.72) ^a	80.00
T ₈	Control (Untreated)	13.62(3.69) ^h	14.27(3.77) ^h	14.56(3.81) ^h	-6.90

Similar superscripts in a column indicate that the differences among the treatments are not statistically significant (DMRT P=0.05)

Figures in parentheses are transformed values ($\sqrt{x+0.5}$)

Mean of three replications DAS: Days after spraying

Moschardi (1998) reported that *Metarrhizium anisopliae* and *Beauveria bassiana* are effective against sucking pests like, Green vegetable bug (*Nezara viridula*) and, Green and Brown mirids (*Creontiades sp*) infesting vegetable crops, the white muscardine fungus failed to combat jassids infesting bitter gourd in the present study. The higher temperature and lower Relative Humidity during the experimental period might not have favoured the growth of this fungus thus adding to its deterred efficacy.

4.2.1 Percentage leaf damage by epilachna beetle after first spraying

Pre- treatment leaf damage:

The variation in population of epilachna beetle, *Henosepilachna septima* before and after the first spraying in bitter gourd recorded within the experimental period is presented in Table 6. The data revealed that the percentage leaf damage before spraying varied from 20.73 to 29.3 % in different sub plots and the difference between the plots was statistically significant.

3 Days after first spraying (3DAS):

At 3 days after first spraying, a general decline in epilachna beetle leaf damage was observed in all the treatment including untreated control (T₈) which resisted about more than 1% increase in leaf damage by epilachna. The lowest leaf damage was observed in T₇ (Cartap hydrochloride @ 1 kg/ha) with 13.20% leaf damage, followed by T₄ (Cow urine + neem @ 50 litres/ha) and T₃ (Multineem @ 2.5 litres/ha) with 17.65% and 20.78% leaf damage. The treatments T₅ (cu + karanj @ 50 litres) and T₆ (cu + *Hyptis*) were statistically at par with each other with 21.80 and 21.34 %. T₁ (*Btk*) and T₂ (*Beauveria bassiana*) resulted in 20.52 and 25.55% leaf damage.

The treatment T₂ (*Beauveria bassiana*) and T₁ (*Bacillus thuringiensis* var *kurstaki*) resulted in 24.06 and 26.55% leaf damage, respectively.

All the treatments exhibited their superiority over the untreated control and the percentage leaf damage in descending order was as follows:

$$T_7 > T_4 > T_3 > T_6 = T_5 > T_2 > T_1 > T_8$$

7 Days after first spraying:

Observations recorded at 7 DAS showed that there was significant decrease in leaf damage percentage by epilachna in cartap hydrochloride (T₇) which is 10.66 % followed by 16.36% in T₄ (cow urine +neem) and 19.68% in T₃ (Multineem). The percentage of leaf damage in other plots varied from 19.79 to 26.35 % exclusive of untreated control (T₈), which gave 29.10 % leaf damage. The efficacy of these treatments in the descending order of their performance was as follows:

$$T_7 > T_4 > T_3 > T_6 > T_5 > T_2 > T_1 > T_8$$

Post-treatment percentage leaf damage by epilachna after first spraying:

The data presented in Table 6 indicate the leaf damage by epilachna. The highest population decline was observed from the plot treated with cartap hydrochloride (T₇) with 10.07 % reduction in leaf damage. The treatments T₄ (Neem leaves + cow urine @ 50 litre/ha) and T₃ (Multineem) followed the trend with 8.94 and 7.98 % reduction in leaf damage followed by 6.61% in T₆ (cu + *Hyptis* @ 50 litres/ha). The rest of the treatments varied from 5.75 to 0.22 %. There was a considerable decrease in leaf damage per cent in untreated plot by 0.22%.

4.2.2 Percentage leaf damage by epilachna beetle after second spraying

3 Days after second spraying:

The second spraying was given at 10 days after the first spraying. At 3 days after first spraying, there was a general reduction in leaf damage in all the treatment including untreated control (T₈) which registered about 28.72% leaf damage. The highest per cent leaf damage in the untreated control plot while the lowest leaf damage (7.15%) was recorded in the plot treated with cartap hydrochloride @ 1kg/ ha (T₇), closely followed by T₄ (14.21%), i.e. cow urine + neem leaf @ 50 litre/ha. The treatment with multineem @ 2.5litre/ ha, (T₃) recorded 17.64% leaf damage and was statistically at par with T₅ (cu + karanj @ 50 litres/ha), which is 19.29 %. However T₁ (Btk @ 1 kg/ha) and T₂ (*Beauveria bassiana* @2 kg/ha) recorded a leaf damage of 25.55 and 21.58%, respectively.



Plate 4. Egg mass of Epilachna beetle, *Henosepilachna septima*



Plate 5. Grubs of Epilachna beetle, *Henosepilachna septima*



Plate 6. Pupae of Epilachna beetle, *Henosepilachna septima*



Plate 7. Adults of Epilachna beetle, *Henosepilachna septima*

The efficacy of these treatments in the descending order of their performance was as follows:

$$T_7 > T_4 > T_6 > T_3 > T_5 > T_2 > T_1 > T_8$$

7 Days after second spraying:

The data recorded 7 DAS are shown in the Table 7. The treatment T_7 (Cartap hydrochloride) showed the lowest leaf damage i.e. 5.18% and the highest per cent of leaf damage was seen in the untreated control plot, (T_8) with 30.10%. The next lowest leaf damage was recorded from T_4 (cu + neem) with 12.13%, followed by T_3 (Multineem) and T_6 (cu + *Hyptis*) with 14.32 and 15.22% respectively. These two treatments were found to be statistically at par with each other. The per cent leaf damage varied from 18.99 to 26.12 % in rest of the treatments. All the treatments exhibited their superiority over the untreated control and the percentage leaf damage in descending order was as follows:

$$T_7 > T_4 > T_3 > T_6 > T_5 > T_2 > T_1 > T_8$$

Post-treatment percentage leaf damage by epilachna after second spraying:

Table 7 indicates the data of epilachna damage percentage after second spraying. There was a general reduction in leaf damage in all the treatment excluding untreated control which registered about 1.00% increase in leaf damage. The highest per cent reduction in leaf damage was recorded in plot treated with cartap hydrochloride (T_7), with 5.48% followed by T_3 (multineem) and T_4 (cu + neem) at 5.22 and 4.20 % reduction in leaf damage. The percent reduction in leaf damage in all the other plots varied from 4.32 to 0.42%. The least reduction in leaf damage was seen in T_1 (*Btk*) which is 0.42%.

4.2.3 Percentage leaf damage by epilachna beetle after third spraying

3 Days after third spraying:

The third spraying was given at 10 days after the second spraying. The population of jassids observed on third day after third spraying is presented in Table 8. The data revealed that all the treated plots registered a general decline in leaf damage while the untreated plots continued to have the maximum leaf damage i.e., 30.11%.

The plots treated with cartap hydrochloride (T₇) @ 1kg/ha almost recorded the leaf damage of 0.38% followed by T₄ (cow urine + neem leaf @ 50 litres/ha,) and T₃ (Multineem @ 2.5 litre/ha) and T₅ (cow urine + karanj leaf@ 50 litres/ha) with 9.16, 11.69 and 13.26%, respectively. The treatment T₃ and T₆ are statistically at par with each other. The treatment T₁ (*Btk*) and T₂ (*Beauveria bassiana*) resulted in 26.01 and 19.92% leaf damage, respectively. The efficacy of treatments in descending order is as follows:

$$T_7 > T_4 > T_3 > T_6 > T_5 > T_2 > T_1 > T_8$$

7 Days after third spraying:

The data recorded 7 DAS are shown in the Table 8. The treatment T₇ (Cartap hydrochloride showed the lowest leaf damage i.e. 0.12% followed by T₄ (cow urine + neem leaf @ 50 litres/ha), T₅ (cow urine + karanj leaf@ 50 litres/ha) and T₃ (Multineem @ 2.5 litre/ha) with 5.24, 12.31 and 12.34% leaf damage. The treatments T₃ (Multineem @ 2.5 litre/ha) and T₅ (cow urine + karanj leaf@ 50 litres/ha) are statistically at par with each other. The treatment T₁ (*Btk*) and T₂ (*Beauveria bassiana*) resulted in 25.98 and 18.99% leaf damage, respectively. The efficacy of treatments in descending order is as follows:

$$T_7 > T_4 > T_6 > T_3 = T_5 > T_2 > T_1 > T_8$$

Post-treatment percentage leaf damage by epilachna beetle after third spraying:

The reduction in leaf damage by epilachna beetle after third spraying was recorded as shown in Table 8. There was least reduction of leaf damage by epilachna beetle in T₈ (untreated control) i.e. 1% increase in leaf damage, followed by T₁ (*Bacillus thuringiensis* var *kurstaki*) and T₂ (*Beauveria bassiana*) with 0.14% and 1.57% reduction in leaf damage, respectively. The plot treated with cartap hydrochloride, T₇ gave 5.06% reduction in leaf damage. Cow urine + neem (T₄) reduced the leaf damage by 4.94% followed by multineem (T₃) and Cow urine + *Hyptis* (T₆) with 3.96% and 3.43%.

Table 7. Extents of leaf damage by *Henosepilachna septima* after second spraying

Tr No.	Treatments	% leaf damage by epilachna beetle / 3 leaves			Leaf damage 7 DAS (%)
		Before spraying	Second spray		
			3DAS	7DAS	
T ₁	<i>Bacillus thuringiensis</i> var kurstaki @ 1 kg/ha	26.54(5.20) ^{efg}	25.55(5.09) ^{efg}	26.12(5.15) ^{efg}	0.42
T ₂	<i>Beauveria bassiana</i> @ 2kg/ha	23.98(4.94) ^{cdef}	21.58(4.69) ^{cdef}	20.56(4.58) ^{cdef}	3.42
T ₃	Multineem @ 2.5 litre/ha	19.54(4.47) ^{bcd}	17.64(4.25) ^{bcd}	14.32(3.84) ^{bc}	5.22
T ₄	Cow urine + neem leaf @ 50 litres/ha	16.33(4.10) ^b	14.21(3.83) ^b	12.13(3.55) ^b	4.20
T ₅	Cow urine + karanj leaf @ 50 litres/ha	20.03(4.53) ^{bcde}	19.29(4.44) ^{bcde}	18.99(4.41) ^{cde}	1.04
T ₆	Cow urine + <i>Hyptis</i> leaf @ 50 litres/ha	19.54(4.47) ^{bcd}	16.29(4.09) ^{bc}	15.22(3.96) ^{bcd}	4.32
T ₇	Cartap hydrochloride @ 1kg/ha	10.66(3.34) ^a	7.15(2.76) ^a	5.18(2.38) ^a	5.48
T ₈	Control (Untreated)	29.10(5.44) ^{fgh}	28.72(5.40) ^{fgh}	30.10(5.53) ^{gh}	-1.00

Similar superscripts in a column indicate that the differences among the treatments are not statistically significant (DMRT P=0.05)

Figures in parentheses are transformed values ($\sqrt{x+0.5}$)

Mean of three replications

DAS: Days after spraying



Table 8. Extents of leaf damage by *Henosepilachna septima* after third spraying

Tr No.	Treatments	Leaf damage by epilachna beetle / 3 leaves			Leaf damage 7 DAS (%)
		Before spraying	Third spray		
			3DAS	7DAS	
T ₁	<i>Bacillus thuringiensis</i> var kurstaki @ 1 kg/ha	26.12(5.15) ^{gh}	26.01(5.14) ^{efg}	25.98(5.14) ^g	0.14
T ₂	<i>Beauveria bassiana</i> @ 2kg/ha	20.56(4.58) ^{cdef}	19.92(4.51) ^{def}	18.99(4.41) ^{ef}	1.57
T ₃	Multineem @ 2.5 litre/ha	14.32(3.84) ^{bc}	11.69(3.49) ^{bc}	12.34(3.58) ^{cd}	3.96
T ₄	Cow urine + neem leaf @ 50 litres/ha	10.18(3.26) ^{ab}	9.16(3.10) ^b	5.24(2.39) ^b	4.94
T ₅	Cow urine + karanj leaf @ 50 litres/ha	18.99(4.41) ^{cde}	17.28(4.21) ^{cde}	15.58(4.00) ^{cde}	3.41
T ₆	Cow urine + <i>Hyptis</i> leaf @ 50 litres/ha	15.56(4.00) ^{bcd}	13.26(3.70) ^{bcd}	12.13(3.55) ^c	3.43
T ₇	Cartap hydrochloride @ 1kg/ha	5.18(2.38) ^a	0.38(0.93) ^a	0.12(0.78) ^a	5.06
T ₈	Control (Untreated)	30.10(5.53) ^{gh}	30.11(5.53) ^{gh}	31.10(5.62) ^{gh}	-1.00

Similar superscripts in a column indicate that the differences among the treatments are not statistically significant (DMRT P=0.05)

Figures in parentheses are transformed values ($\sqrt{x+0.5}$)

Mean of three replications

DAS: Days after spraying

4.3 Effect of bio pesticides on fruit fly population

At harvest the observations on the number of maggots per fruit of bitter gourd was recorded. The results thus obtained have been presented in Table 9. No maggot to as high as 5.4 maggots / fruit are recorded in the entire experimental plot. The untreated check (T₈) was the worst affected with 5.4 maggots / fruit at par with T₂ (*Beauveria bassiana*) (5.2 maggots / fruit). T₇ (Cartap hydrochloride) was the most effective treatment of all, where no maggots could be found in the fruits harvested from sub plots, closely followed by T₄ (cu + neem) and T₆ (cu + *Hyptis*) with 0.50 and 0.70 maggots/fruit, respectively. These treatments were statistically at par with each other. Multineem (T₃) with 1.7 maggots / fruit was the next best treatment. In rest of the treatments i.e. T₅ (cu + karanj) and T₁ (BtK) the maggots / fruit were 2.7 and 3.2, respectively. The descending order of their efficacy is as follows:

$$T_7 > T_4 > T_6 > T_3 > T_5 > T_1 > T_2 > T_8$$

4.3.1 Effect of bio pesticides on fruit fly damage

At harvest fruit fly damage in bitter gourd fruits were assessed both on number and weight basis in order to find out the effect of bio pesticides tested. The results thus obtained have been presented in Table 9.

On number basis

The results obtained (Table) reflected similar trends as that of the population of fruit fly. The untreated control plot (T₈) received the highest fruit fly damage of 9.9 % on number basis closely followed by T₂ () with 7.9% fruit fly damage, being statistically at par with each other. Once again superiority of the synthetic insecticide over bio pesticides was observed in this experiment as T₇ () recorded the lowest fruit damage (2.9%) on number basis even though it was closely followed by T₄(), T₆(), T₃(), T₅() with 3.2, 4.0, 4.4 and 5.2 per cent damage, respectively. All these treatments were statistically at par with each other. The treatment with Btk (T₁) received a damage of 5.70 % by the fruitfly while considering on number basis.

The ascending order of their efficacy is as follows:

$$T_8 > T_2 > T_1 > T_5 > T_3 > T_6 > T_4 > T_7$$

On weight basis

A perusal of the results presented in Table 9 revealed similar trends as that of the fruit fly damage to bitter gourd fruits on number basis were also observed while assessing the damage on weight basis. The untreated control (T8) suffered the highest significant damage in weight of fruits by 8.9%, while the least fruit damage of 2.1 % was yet again associated with T7() once again proving the superiority of test chemical insecticide which was statistically at par with T4 () with 3.10% fruit damage on weight basis. The third lowest fruit damage of 3.70% was recorded in T6() which was at par with T1() and T3 ()(3.90%). In rest of the treatments more than 5% weight loss was observed in terms of damage on weight basis, proving their inefficiency in combating the target pest.

The ascending order of their efficacy is as follows:

$$T8 > T2 > T1 > T5 > T3 > T6 > T4 > T7$$

There is paucity of information in the available literature for making any comparison with the present findings.

Among the treatments cartap hydrochloride proved superior over others as maximum fruit yield with least leaf damage by epilachna beetle (0.72%) and fruit damage by fruit fly (2.8%) was obtained. As the fruit fly usually infests tender fruits, its infestation is obviously related with fruit yield. Therefore, its control using chemical pesticides instead of bio pesticides and botanicals as evidenced in the present finding was considered imperative as no reference is available for confirming the findings.

Table 9. Fruit damage by fruit fly, *B.cucurbitae* in bitter gourd

Sl.no	Treatments	Maggot/fruit	Fruit damage by fruit fly		Fruit yield(q/ha)
			Number basis	Weight basis	
T1	<i>Bacillus thuringiensis</i> var kurstaki @ 1kg/ha	3.2(1.92) ^{def}	5.7(2.48) ^{bcdef}	5.0(2.34) ^{def}	38.00
T2	<i>Beauveria bassiana</i> @ 2kg/ha	5.2(2.38) ^{efg}	7.9(2.89) ^{efg}	5.4(2.42) ^{efg}	39.09
T3	Multineem @2.5 litre/ha	1.7(1.48) ^{bcd}	4.4(2.21) ^{abcd}	3.9(2.09) ^{bcd}	41.50
T4	Cow urine + neem leaf @ 50 litres/ha	0.5(1.00) ^{ab}	3.2(1.92) ^{ab}	3.1(1.89) ^{ab}	43.50
T5	Cow urine + karanj leaf @ 50 litres/ha	2.7(1.78) ^{de}	5.2(2.38) ^{abcde}	4.5(2.23) ^{cde}	40.6
T6	Cow urine + <i>Hyptis</i> leaf @ 50 litres/ha	0.7(1.09) ^{abc}	4.0(2.12) ^{abc}	3.7(2.04) ^{bc}	40.9
T7	Cartap hydrochloride @ 1kg/ha	0.0(0.83) ^a	2.9(1.84) ^a	2.1(1.61) ^a	62.7
T8	Control (Untreated)	5.4(2.42) ^{fgh}	9.9(3.22) ^g	8.9(3.06) ^h	37.5

Similar superscripts in a column indicate that the differences among the treatments are not statistically significant (DMRT P=0.05)

Figures in parentheses are transformed values ($\sqrt{x+0.5}$)

The fruit yield varied of bitter gourd cv Green long varied significantly with respect to the treatments. Significantly the maximum yield obtained was 62.7 q/ha with T₇ (Cartap hydrochloride) and this was followed by T₄ (Cu + neem @ 50 litres/ha) with a yield of 43.50 q/ha. (Table 9)

4.4 Calculation of avoidable loss and benefit: cost ratio

The avoidable loss due to infestation of insect pests in bitter gourd was calculated by the formulae suggested by Pawar et al., 1984. The cost effectiveness of different treatments have been worked out and presented below.

Avoidable loss and benefit: cost analysis

The avoidable loss and benefit: cost analysis due to the application of bio pesticides against the pest complex of bitter gourd were calculated on the basis of fruit yield data recorded from the experiment has been presented in Table 10. On the basis of the data in the table, cartap hydrochloride was considered as the best treatment so far as fruit yield was concerned and the avoidable loss in bitter gourd was upto 40.19 %.

Analysis of data revealed that maximum profit (Rs.95250/ha) was derived in T₇(Cartap hydrochloride @ 1kg/ha) followed by T₄ (cu + neem @ 50 litres /ha) (Rs. 20974.50/ha), T₆(cu + *Hyptis* @ 50 litres/ha) and T₃(Multi neem @ 2.5 litres/ha) with a profit of Rs.10547.50 and Rs. 11155 per hectare. There was loss in treatments with *BtK* might be because of its higher cost.

Table 10. Avoidable loss and benefit-cost analysis due to application of bio pesticides and botanicals in bitter gourd

Tr.no	Treatments	Mean yield (q/ha)	Increased yield over control (q/ha)	Avoidable loss (%)	Cost of increased yield over control (Rs./ha)	Cost of pesticides + labour (Rs./ha)	Net profit (Rs./ha)	Benefit: cost
T ₁	<i>Bacillus thuringiensis</i> var kurstaki @ 1kg/ha	38.0	0.50	39.39	2000	5820	-3820	0.66:1
T ₂	<i>Beauveria bassiana</i> @ 2kg/ha	39.09	1.59	37.65	6360	4380	-1980	0.45:1
T ₃	Multineem @ 2.5 litre/ha	41.5	4.00	33.81	6000	4845	11155	2.30:1
T ₄	Cow urine + neem leaf @ 50 litres/ha	43.5	6.00	30.62	24000	3052.50	20974.50	4.33:1
T ₅	Cow urine + karanj leaf @ 50 litres/ha	40.6	3.10	35.24	12400	3052.50	9347.50	3.02:1
T ₆	Cow urine + <i>Hyptis</i> leaf @ 50 litres/ha	40.9	3.40	34.76	13600	3052.50	10547.50	3.5:1
T ₇	Cartap hydrochloride @ 1kg/ha	62.7	25.20	-	100800	5550	95250	17.16:1
T ₈	Control (Untreated)	37.5	-	40.19	-			

Cost of biopesticides

BtK = Rs.1200/kg

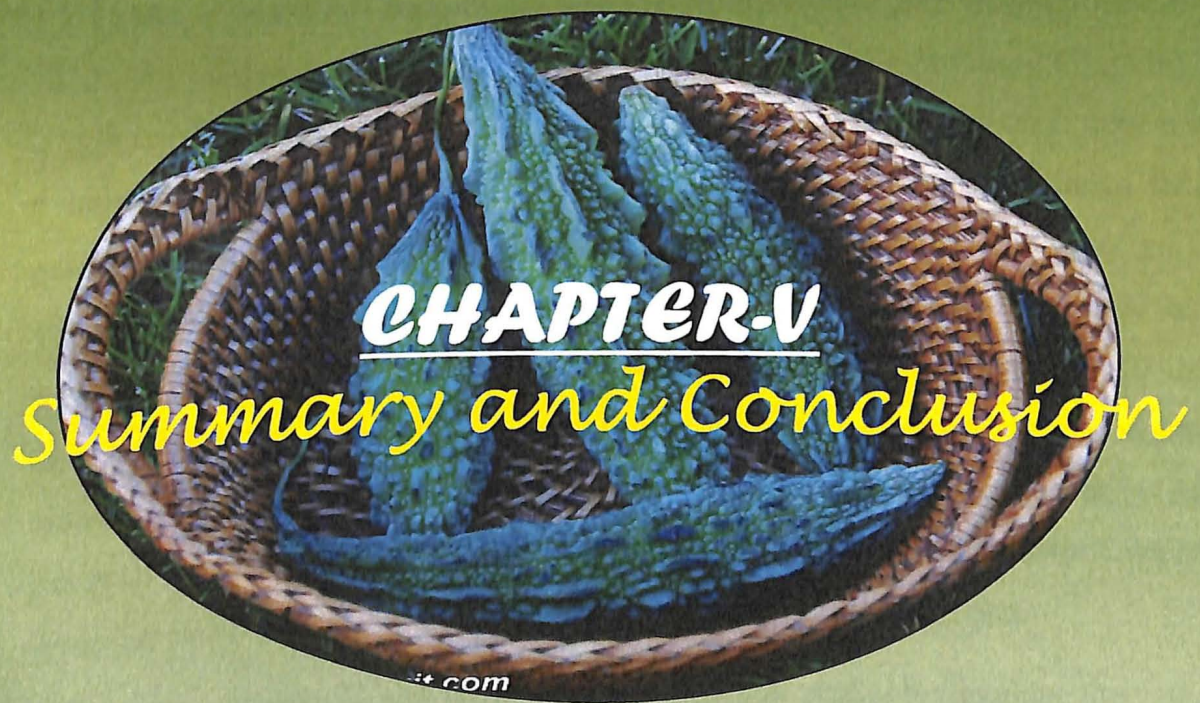
Beauveria bassiana = Rs. 360/ kg

Multineem = Rs. 350/kg

Cartap hydrochloride = Rs.1100/kg

Cost of labour = Rs. 92.50/ labour (8 man hour)

Cost of bitter gourd = Rs. 4000/q



CHAPTER-V

Summary and Conclusion

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SUMMARY AND CONCLUSION

In order to find out the “Relative efficacy of bio pesticides against the pest complex of bitter gourd” field studies were carried out in the experimental field of Department of Entomology located in the upland conditions of Central Research Station of Orissa University of Agriculture and Technology, Bhubaneswar during *summer* 2011-12. For the purpose two bio pesticides, viz., *Bacillus thuringiensis* var *kurstaki* (*Btk*) and *Beauveria bassiana*, three cow urine fermented botanicals, viz., cow urine + neem, karanj and *Hyptis* leaves, a neem based pesticide (Multineem) and a synthetic insecticide (Cartap hydrochloride) were field evaluated to find out their relative efficacy against the pest complex of bitter gourd.

Bitter gourd cv. Green long was grown during the first week of February, 2012. The biopesticides, *Btk* (Halt) @ 1 kg/ha, *Beauveria bassiana* (Daman) @ 2 kg/ha, botanicals fermented in cow urine i.e., cow urine+ neem leaf, cow urine + karanj leaf and cow urine + *Hyptis* leaf, each @ 50 kg/ha, a neem based pesticide (Multineem) @ 2.5kg/ha were tested against the pests of bitter gourd. The insecticides Cartap hydrochloride (Caldan) @ 1 kg / ha was used as a standard check. The treatments were applied thrice as foliar sprays at 10 days interval. The first spraying was applied with the first appearance of skeletonised leaves by epilachna beetle followed by the second and third sprayings at 10 days intervals, each. The results of the investigations made and conclusions derived from the studies have been summarised in the following paragraphs.

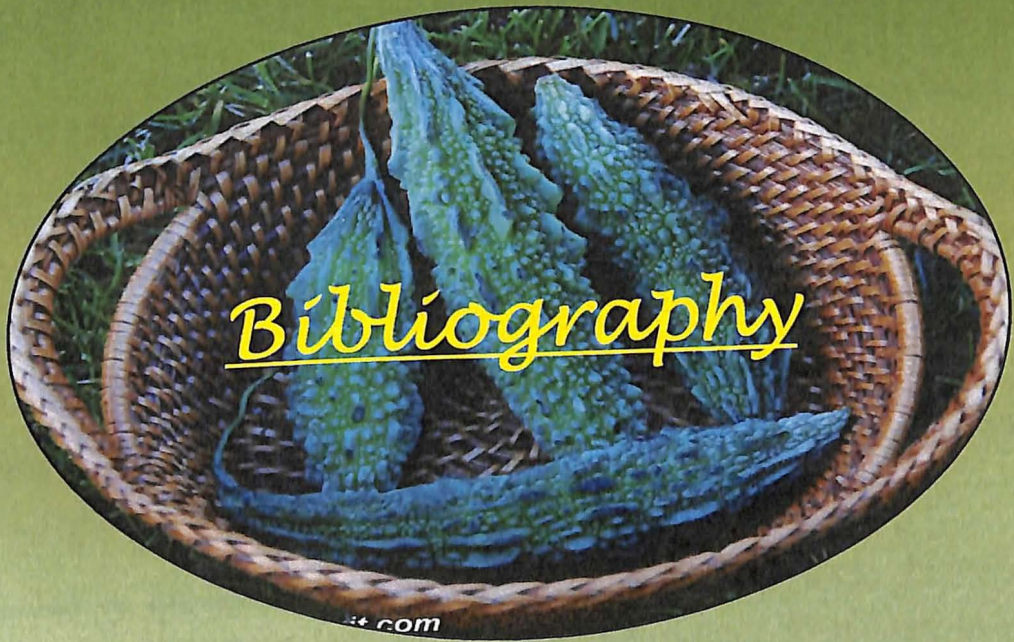
The results of the field evaluation of bio pesticides against the jassids infesting bitter gourd revealed that, following three sprayings, the maximum reduction of 80% in population in case of jassids (*Amrasca biguttula biguttula*) was obtained from Cartap hydrochloride (1 Kg/ha). Among the test botanicals fermented in cow urine, cow urine + neem @ 50 litres/ha was the best treatment (next to Caldán) against the jassids infesting bitter gourd, followed by cow urine + karanj and cow urine + *Hyptis* each @ 50 litres/ha, with a population reduction of 6.01, 3.43 and 1.15 percent, respectively. Among the bio pesticides tested

Multineem @ 2.5 litres /ha with 4.17% population reduction ranked as the third best treatment. The other two bio pesticides, *Btk* and *Beauveria bassiana* failed to contend jassids population in bitter gourd.

From the results of field evaluation of bio pesticides against epilachna beetle (*Henusepilachna septima*) infesting bitter gourd it was observed that Cartap hydrochloride (1 Kg/ha) was once again the best treatment bringing about 5.06% reduction of leaf damage. Among the test botanicals fermented in cow urine, cow urine + neem @ 50 litres/ha was the best treatment (next to Caldan) against *H. septima* infesting bitter gourd, followed by cow urine + *Hyptis* and cow urine + karanj each @ 50 litres/ha, with a reduction of 4.94, 3.43 and 3.41 percent leaf damage, respectively. Among the test bio pesticides, Multineem @ 2.5 litres /ha with 4.94% reduction in leaf damage, ranked as the third best treatment. The other two bio pesticides, *Beauveria bassiana* and *Btk* almost failed to contend the leaf damage by epilachna in bitter gourd with very negligible reduction in percent leaf damage (1.57 and 0.14).

The investigations revealed that the synthetic pesticide gave the highest yield among all the treatments (62.7 q/ha) with a benefit: cost ratio of 17.16:1

Hence it is concluded that synthetic insecticide was the best treatment among all the treatments used in the experiment.



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Meteorological data during crop growth period, Summer 2012

Standard Week	Temperature			Relative humidity			Rainy Days(mm)	Bright Sunshine Hours(hrs/day)	Wind Velocity (km/hr)
	Max.	Min.	Mean	Max.	Min.	Mean			
1.	20.2	30.8	25.5	57.0	91.7	74.2	0.65	5.9	5.0
2.	15.2	25.5	20.4	58.2	89.2	73.8	5.68	5.1	5.7
3.	14.1	29.4	21.8	43.1	94.1	68.5	-	8.4	4.2
4.	15.3	28.9	21.7	49.2	93.2	71.4	-	5.1	3.3
5.	14.5	28.0	21.2	36.0	84.5	60.2	-	6.9	4.0
6.	15.3	31.9	23.6	36.0	85.1	60.5	-	7.6	3.8
7.	19.6	31.4	25.5	51.4	92.1	71.7	-	6.5	5.2
8.	17.3	36.1	26.7	22.4	91.5	57.0	-	9.0	3.6
9.	20.5	37.1	28.8	34.4	90.2	62.4	-	6.5	5.6

