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JOURNAL OF APPLIED ZOOLOGICAL RESEARCHES

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From the Desk of
Managing Editor,
JOURNAL OF APPLIED ZOOLOGICAL RESEARCHES &
General Secretary,
APPLIED ZOOLOGISTS RESEARCH ASSOCIATION (AZRA), INDIA

Dear AZRA Members,

I am very happy for your 25 years of close association with AZRA family and I congratulate you all for your deep involvement and active participation in successfully organizing AZRA Silver Jubilee International Conference on 16-18 February, 2014 at Central Rice Research Institute (CRRI), Cuttack, Odisha. I have superannuated from CRRI (ICAR) service on 31 July, 2014. Currently, I have settled at Bhubaneswar, therefore, Head Quarter of AZRA has also been shifted from CRRI, Cuttack to Bhubaneswar with the approval of Executive Council & also General Body of the Association for all future correspondence/ communication. New address of AZRA is as follows:

Dr. Anand Prakash,
General Secretary, AZRA
K-9B: 285 Bhagbanpur, Patrapada,
Bhubaneswar-751 019, Odisha, India

Term of current AZRA Executive Council will be completed by 31 March, 2015, therefore, election for new Executive Council will be held during January-February, 2015. You are requested to kindly actively participate in this election process.

An interaction meet on **"Emerging Pests in Horticultural Based Cropping Systems"** was Jointly 0rganized by Central Horticultural Experiment Station (CHES), Bhubaneswar & AZRA, India, on 17 November, 2014 at CHES, Bhubaneswar, where about 40 plant protection scientists/researchers from different institutions *viz.*, CHES, OUAT, Bhubaneswar, DRWA, Bhubaneswar, CIPMC, Bhubaneswar, CTCRI-Regional Station, Bhubaneswar, CRRI, Cuttack, Horticulture Department, Govt. of Odisha, KVKs, NRC-Litchi, Muzaffarpur, Bihar, Bihar Agricultural University, Sabour, Bhagalpur, BCKV, Mohanpur, West Bengal etc. actively participated, presented and discussed their papers. In this issue of the Journal only 32 selected research notes merged in 4 papers (from page 161-181) are published for the benefit of plant protection scientists/ researchers, and extension persons.

Further, AZRA is regularly publishing books on different topics/theme related to applied zoology and it is decided to enhance the rebate of 30% from 20% earlier to all AZRA Members including institutional members having, no postage and packaging charges. You may book your orders by email: azracuttackindia@gmail.com or prakas52@yahoo.com I am looking for your kind cooperation, suggestions and comments to improve for efficient and smooth functioning of the association, as we received in the past.

Anand Prakash
Managing Editor, *J. Appl. Zool. Res.*
General Secretary & Founder, AZRA

J. Appl. Zool. Res. (2014) **25**(2): 109-113

INCIDENCE OF AND DAMAGE BY LEPIDOPTEROUS BORERS ON IMPROVED MAIZE VARIETIES IN EKPOMA, EDO STATE, NIGERIA.

NATHANIEL OSAWE OIGIANGBE[1], MANUEL TAMO[2], IKHINE AKHABUE[1] AND BENJAMIN IGHO IGBINOSA[1]*

Received: 13 March, 2014 **Accepted:** 3 October, 2014

ABSTRACT: Maize is a valuable staple food crop in Nigeria and contributes significantly to household food security. We studied the incidence and damage caused by lepidopteran borers on the improved maize varieties at Research Farm of the Ambrose Alli University, Ekpoma, Edo State, Nigeria, during rainy season, 2013. Damage by the stem borers accounted for 90.90 % of the variability in the maize stand loss. At harvest, 100 % of the stands and cobs were found to be damaged by borers. Three stem borer species recorded were *Eldana saccharina* Walke; *Sesamia calamistis* Hampson and *Mussidia nigrivenella* Ragonot. There was no significant difference between the maize varieties in the abundance of these insects, although *E. saccharina* was relatively higher in numbers in each of the maize variety. Results indicate that lepidopterous borers are the major constraint to improved maize production in Ekpoma and need to develop the urgent control measures.

Key words: Stem borers, maize, *Sesamia calamistis*, *Eldana saccharina*, *Mussidia nigrivenella*

INTRODUCTION

Maize [*Zea mays* L. (Family Poaceae)] is a valuable staple food item in Nigeria, and indeed, most of Sub-Saharan Africa. It contributes significantly to household food security, and forms an important raw material for animal feed, agro-allied and pharmaceutical industries. Nigeria is the largest producer of maize in Africa (ANONYMOUS, 2013), yet this production is mainly from small-scale rainfed intercropping systems. Several factors including poor adoption of improved production technologies, non-existent or low-level plant health management skills, low capital and inefficient resource utilization reduce maize yield across all the agro-ecological zones in the country. Among the biotic constraints to high maize productivity, lepidopterous borers notably the noctuids (*Busseola fusca* Fuller and *Sesamia calamistis* Hampson) and pyralids (*Eldana saccharina* Walker and *Mussidia nigrivenella* Ragonot) are the most important (BOSQUE-PEREZ, 1995; BOSQUE-PEREZ and MARECK, 1991).

These insects feed on the leaves, shoots, stem, tassel and ear leading to variable yield loses depending on the location, season, sowing date, borer species composition, level of abundance, varietal susceptibility, and plant-pest interaction as influenced by climate, soil and other biotic factors (AJALA *et al.*, 2010; OKWECHE *et al.*, 2010). This study was conducted to assess the species composition, incidence of and damage by lepidopterous borers on maize in Ekpoma. Secondly, the response of five improved maize varieties to attack by these insect pests was assessed. Such information will contribute for the development of effective pest management options for these pests on maize in Ekpoma.

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[2] International Institute of Tropical Agriculture, Benin Station, Cotonou, Benin Republic.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of the Ambrose Alli University, Ekpoma, Edo State, Nigeria, during 2013 rainy season (May to August). Five improved maize varieties *viz*., SUWAN2SR, ACR94TZLCOMP5W, TZLCOMP4, TZECOMP3 and TZLCOMP3, collected from the International Institute of Tropical Agriculture (IITA), Ibadan, were used. The maize varieties were planted in 4.0 m x 5.0 m plots in a completely randomized block design with four replicates (5 x 4 = 20 plots). Planting was done at a spacing of 1.0 m between plots, 75.0 cm between rows, and 50.0 cm between stands. Three seeds were planted per hole but thinned to one plant per stand at two weeks after emergence (WAE). Stand loss, incidence of and damage by lepidopterous borers were monitored on the four inner rows of each plot beginning at 2 WAE for eight weeks. The damage to the ear by the borers was assessed after harvest from ten randomly selected stands from each plot. Data were analyzed using the analysis of variance (ANOVA) (SAS Windows 9.3) and where the means became significant, they were separated using the Student-Newman-Keul's Test. The relationship between the stem borer damage and stand loss was investigated with regression analysis.

RESULTS AND DISCUSSION

There was a steady decline in the number of stands per row during the sampling period (Fig.1). A significant difference (P<0.05) was observed between the varieties in the cumulative percentage of stands damaged by stem borers (Fig. 2).

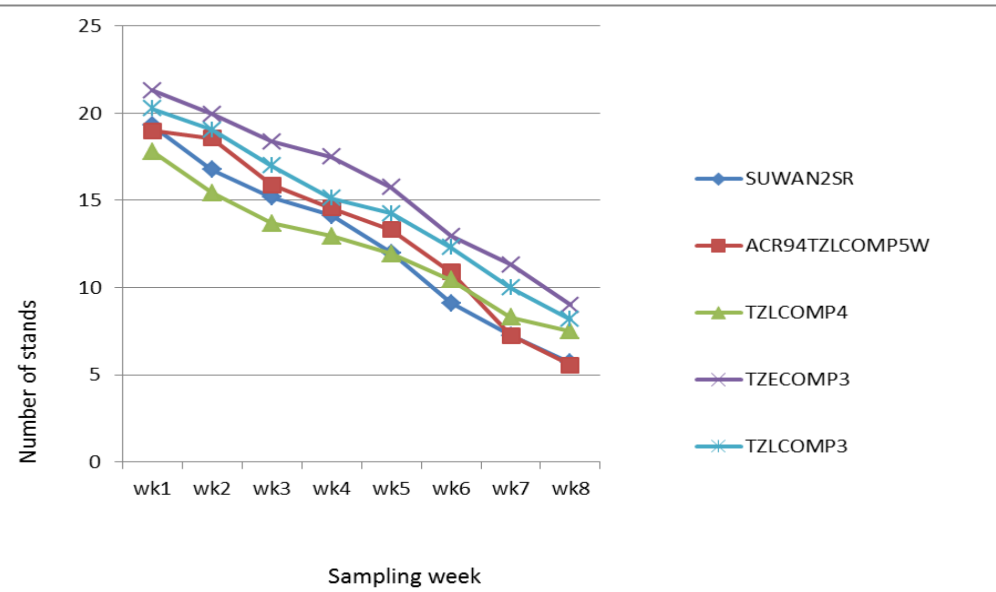

Fig. 1: Mean number of stands per row of five improved maize varieties in Ekpoma.

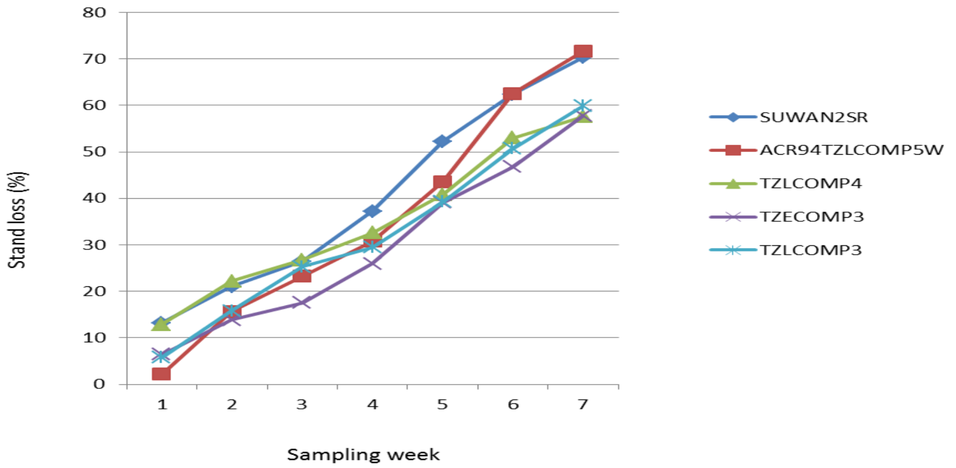

Fig. 2: Mean cumulative percentage stand loss per row of five improved maize varieties in Ekpoma.

Damage by the stem borers accounted for 90.90 % of the variability in the maize stand loss (Fig. 3). At harvest, 100 % of the stands and cobs were found to be damaged by borers. The lepidopterous stem borers found were *Eldana saccharina* Walker and *Sesamia calamistis* Hampson (Fig. 4). There was no significant difference between the maize varieties in the abundance of these insects, although *E. saccharina* was relatively higher in numbers in each of the maize variety. Three species of cob borers (earworms) recorded were *E. saccharina*, *S. calamistis* and *Mussidia nigrivenella* (Fig. 5). The number of *S. calamistis* and *M. nigrivenella* did not differ between the varieties, but *E. saccharina* was significantly less abundant in TZLCOMP4 compared with TZECOMP3 and TZLCOMP3.

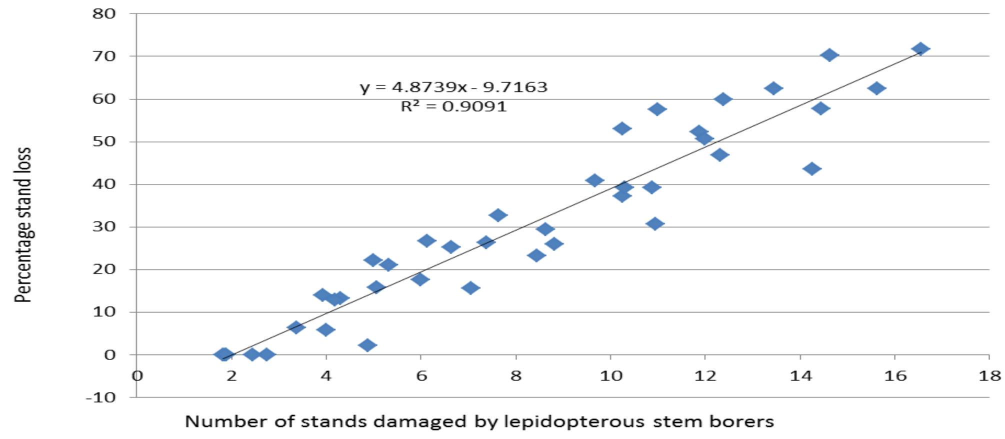

Fig. 3: Regression of percentage maize stand loss against number of stands damaged by lepidopterous stem borers in Ekpoma.

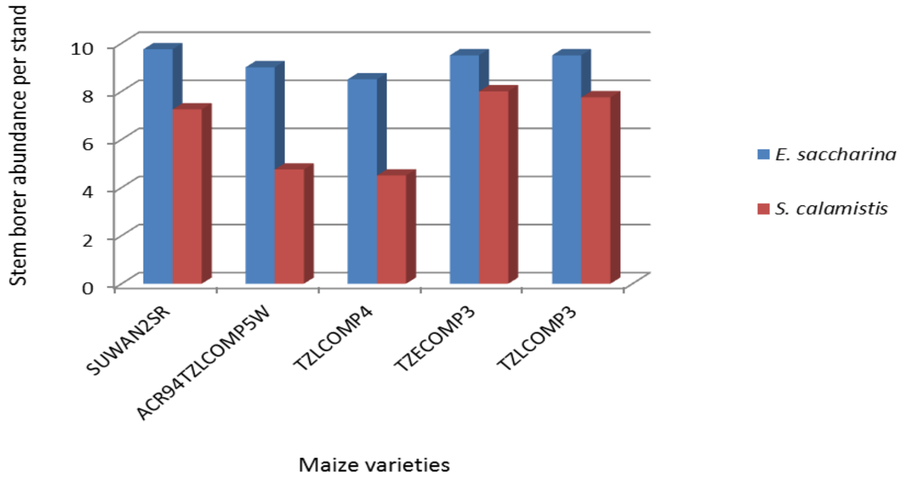

Fig. 4: Mean number of stem borers per stand of five maize varieties in Ekpoma

These results show that *E. saccharina*, *S. calamistis* and *M. nigrivenella* are serious field pests of maize in Ekpoma. Selecting appropriate maize varieties may help in reducing stand loss. The 100 % stem and cob damage found in this study calls for an urgent need to develop control measures that can effectively reduce the damage done by these borers. This study agrees with several workers who reported that *E. saccharina* and *S. calamistis* are the most important stem borers of maize in the rain forest of southern Nigeria (BOSQUE-PEREZ, 1995; BOSQUE-PEREZ and MARECK, 1991; OBHIOKHAENAN *et. al*., 2002). *Busseola fusca* Fuller and *Acigona ignifusalis* Hampson reported by some workers (USUA, 1997; POLASZEK, 1998; BALOGUN and TAMIMOLA, 2001; OKWECHE *et. al.*, 2010) were not found in this study.

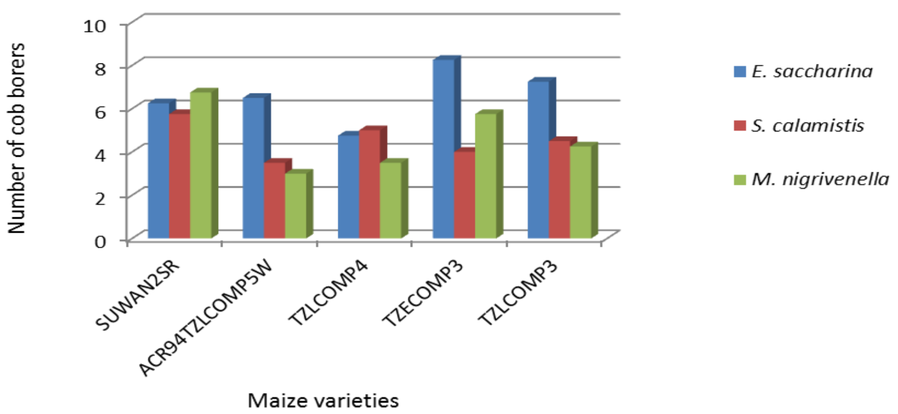

Fig. 5: Mean number of cob borers found in five improvedmaize varieties in Ekpoma

The reason for these differences in species composition may be due to the limited area and season covered in this study. It is hoped that further studies on farmers' fields across seasons and the State will give a better picture of the species composition. Based on the present results conclude that lepidopterous borers are the major constraint to improved maize production in Ekpoma and need to develop and adopt urgent control measures.

ACKNOWLEDGEMENT: We thank Dr Abebe Menkir (Maize Breeder, International Institute of Agricture, Ibadan) for providing the maize varieties.

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EFFECT OF AQUEOUS EXTRACT OF *PIPER LONGUM* LINN. (PIPERACEAE) ON REPRODUCTIVE SYSTEM OF MALE SPRAGUE DAWLEY RATS

K. SRINIVASA REDDY AND K. REVATHI*[1]

Received: 23 March, 2014 **Accepted:** 3 October, 2014

Abstract: The present study was aimed to investigate the possible effects of aqueous extract of *Piper longum* on reproductive system of male SD rat. Healthy rats were selected and three groups containing ten males each were divided G1 (vehicle control), G2 and G3 were administered with aqueous extract of *Piper longum* at 5mg/kg and 10mg/kg, respectively for 28 days. Results showed dose dependent decrease in sperm parameters. Levels of serum lactate dehydrogenase (LDH) and testosterone were significantly decreased while Follicle Stimulating Hormone (FSH) showed slight decrease. Dose dependent degeneration was also observed in the testis and epididymis of treated rats. The present study clearly indicates that aqueous extract of *Piper longum* can cause infertility through affecting the various aspects of male reproduction in male SD rat. *Piper longum* contains alkaloids piperine, piperlongumine, piperlonguminine, could be reason for such impact.

Key words: *Piper longum,* antioxidant activity, reproductive toxicity, rat

INTRODUCTION

Piper longum Linn. is commonly known as long pepper belonging to the family Piperaceae and contains alkaloids *viz*., piperine, piperlongumine and piperlonguminine. Long pepper popularly known in India as Pippali, is used as traditional medicine in Asia, especially in Indian medicine and in Pacific Islands (SHOBA *et al*., 1968). Various *Piper* species, widely distributed in the tropical and subtropical regions of the world, are reported to be used as a spice and also as the folk medicines (PARMAR *et al*., 1997; STOHR and BAUER, 2001). *P. longum* is also reported as good remedy for treating gonorrhea, menstrual pain, tuberculosis, respiratory tract infections, chronic gut related pain (SINGH, 1992). It has been found to possess antioxidant activity which neutralizes harmful effects of excessive free radicals produced in the body. Piperine is a potent inhibitor of the mixed function oxygenase system and non-specific inhibition of cytochrome P450 isoenzymes (ATAL and SINGH, 1985).

Several markers are used to assess pathophysiologic changes which would have occurred in response to toxic chemicals. Reproductive markers of potency include testicular size, serum concentrations of gonodal and pituitary steroids, semen characteristics like spermatozoal count, motility and structure. Measurement of LDH and testosterone concentrations in peripheral blood imparts information regarding hypothalamo-hypophysial function. FSH production is episodic, so the results are variable that renders the marker relatively insensitive to changes in spermatogenesis. Lactate dehydrogenase (LDH) is one of the best characterized proteins in the testis. Sialic acid secreted by peripheral cells of epididymal epithelium play important role in sperm motility and viability. Keeping this in view, the present investigation was aimed to evaluate the possible effects of aqueous extract of *P. longum* on the reproductive system of male Sprague Dawley rat, *Rattus norvegicus* especially on testicular sperm counts, epididymal sperm motility, epididymal sperm morphology and histological examination of the testes.

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MATERIALS AND METHODS

Sexually mature male Sprague Dawley rats (weighing approximately 160–180 g aged 8-9 weeks) were selected. The animals were housed in polycarbonate cages, fed with standard laboratory diet and water *ad libitum*, exposed to a 12 h light/dark cycle, and maintained at a laboratory temperature of 20±3 ^{O}C with 50±10% humidity. The animals were quarantined for 10 days before beginning the experiments. All rats were handled in accordance with guide for the care and use of laboratory animals. The rats were randomized into three groups (G1, G2 and G3) with each group consisting of 10 male SD rats. Group 1 received distilled water and served as control. Group 2 and Group 3 were administered with aqueous extract of *P. longum* at 5 and 10mg/kg respectively for 28 consecutive days. All the animals were sacrificed 1 day after receiving the last treatment. At the end of the 4th week (28 days) of treatment, the rats were euthanized and tissues were dissected and the samples were subjected for light microscope investigations such as testicular sperm counts, epididymal sperm motility, and epididymal sperm morphology. Blood samples were collected to estimate lactate dehydrogenase (LDH), follicle-stimulating hormone (FSH), testosterone and sialic acid levels in seminal vesicle, ventral prostate, vas deferens and cauda region of epididymis.

The dried powder (1 kg) of seeds of *Piper longum* was macerated with the distilled water for 48 hours. The solvent from extract was removed completely by evaporation under vacuum using rotary evaporator and dried to get fine powder. One testis of each rat was placed in 1 ml of phosphate buffer saline immediately after dissection. The tunica albuginea was cut by surgical blades and removed; the remaining seminiferous tubules were mechanically minced by using surgical blades in 1 ml of phosphate buffer saline. The testicular cell suspension was pipette in and out several times to form a homogenous cell suspension. One drop of the suspension was placed on a Neuber Chamber and the testicular sperm concentration was determined under a phase contrast microscope at 200× magnification and expressed as million sperm cells per mL of suspension (10^6 cells/mL).

The cauda epididymis was quickly excised and placed in 1 ml of 37 ^{o}C phosphate buffer saline solution and cut into approximately 1 mm^3 pieces. The solution was pipetted in and out several times to homogenize the sperm suspension. One drop of the suspension was placed on a slide under cover-slip and evaluated under a phase contrast microscope at 200×magnification. The sperms were categorized on the basis of their motility as ‘‘motile” or ‘‘immotile”. The results were recorded as percentage (%) of sperm motility.

Thus, one drop of the suspension was smeared onto a glass slide and stained by the commercial ready-to-use nigrosin-eosin stain. 2000 sperm on each slide were evaluated and the results were recorded as the percentage of abnormal sperm. Abnormal heads and tails were evaluated by using the criteria of (NAHAS *et al*., 1989; MORI *et al*., 1991). Sialic acid was estimated using the method of Aminoff (AMINOFF, 1961). LDH and FSH levels in the plasma were measured by using automated immune fluorescent assay-based commercial kits and a Brahms Kryptor immunoassay analyzer (Brahms LH Kryptor 820.050 and Brahms FSH Kryptor 818.050, respectively). The testosterone levels were measured by using a Chemiluminescence Immunoassay- Based Commercial kit (Access testosterone 33, 560) and an Access immunoassay analyzer (Beckman Coulter). For histo-pathological examination, the testicular tissues were dissected and the tissue samples were fixed in Zenker solution for 24 h, processed by using a graded ethanol series, and embedded in paraffin. The paraffin sections were cut into 5 µm thick slices and stained with hematoxylin and eosin for microscopic examination. The sections were viewed and photographed.

RESULTS AND DISCUSSION

Statistically significant dose dependent reduction in the testicular sperm counts were observed in animals treated with *P. longum* at 5 and 10 mg/kg body weights respectively, compared to control animals. Statistically significant dose dependent reduction in the sperm motility was observed in animals treated with *Piper longum* at 5 and 10 mg/kg body weights, respectively, compared to vehicle control animals. At the end of the 4th week, rats treated with *Piper longum* had abnormal sperm morphology rates than vehicle control rats. (Table 1)

Table-1: Effect of *P. longum* on sperm count, sperm morphology and abnormal sperm morphology in rats. All the values are expressed as mean ± SD (n = 10*). **P < 0.01 and *P < 0.05 vs*. control.

Groups	Sperm Count (10^6 cells/ml)	Sperm motility (%)	Abnormal Sperm Morphology (%)
G1 (Vehicle control)	28.43 ± 0.94	71.93 ± 1.27	1.71 ± 0.05
G2 (*P. longun* 5mg/kg)	24.68 ± 0.75*	53.58 ± 1.01*	1.97 ± 0.10*
G3 (*P. longum* 10mg/kg)	22.11 ± 1.17**	45.83 ± 1.38*	2.72 ± 0.06**

Significant dose dependant reduction in the levels of LDH and testosterone was observed in rats treated with aqueous extract of *P. longum* compared to vehicle control animals. Significant reduction in FSH was observed in animals treated with aqueous extract of *P. longum* at 10 mg/kg than vehicle control rats (Table-2). Similarly significant dose dependent decrease was found in Sialic acid levels in seminal vesicle, ventral prostate, vas deferens and cauda regions in animals treated with *P. longum* at 5 and 10mg/kg than vehicle control rats (Table-3).

Table-2: Effect of *P. longum* on plasma levels of FSH, LDH and testosterone in rats. All the values are expressed as mean ± SD (n = 10). ***P < 0.01 and *P < 0.05 vs*. vehicle control.

Groups	FSH (mIU/ml)	LDH (µ/mg prot)	Testosterone (ng/ml)
G1 (Vehicle control)	3.19 ± 0.03	218.50±45.81	3.86 ± 0.07
G2 (*Piper longun* 5 mg/kg)	3.15 ± 0.03	186.34±29.01*	3.24 ± 0.05*
G3 (*Piper longum* 10 mg/kg)	2.67 ± 0.05*	123.94±24.21**	2.86 ± 0.04**

Table-3: Effect of *P. longum* on plasma levels of Sialic acid (mg/g) in rats. All the values are expressed as mean ± SD (n = 10). ***P < 0.01 and *P < 0.05 vs*. vehicle control.

Groups	Cauda epididymis	Seminal Vesicle	Ventral prostate	Vas deferens
G1 (Vehicle control)	5.12±0.12	5.31±0.3	5.21±0.21	5.32±0.33
G2 (*P. longun* 5 mg/kg)	4.21*±0.21	3.72*±0.35	4.56*±0.92	4.46*±0.30
G3 (*P. longum* 10 mg/kg)	4.11*±0.26	3.46*±0.50	3.53*±0.44	3.42*±0.54

The spermatogenic cells and sertoli cells in the seminiferous tubules of control rats were structurally normal (Fig. 1, A). Leydig cells were found in the interstitial connective tissue between the seminiferous tubules, and the tubules appeared to be uniform in size and shape. They were lined by regularly arranged rows of spermatogenic cells at different stages of maturation (Fig. 1, A). Following 4 weeks treatment with *P. longum* at 10 mg/kg, the rats were observed with fewer spermatogenic cells in some of the seminiferous tubules, necrosis in some seminiferous tubules and edema in interstitial tissue (Fig. 1, C).

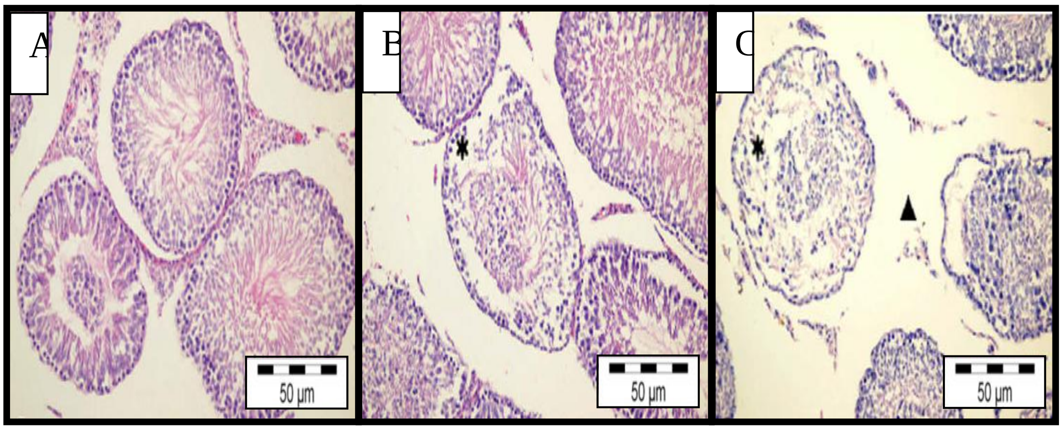

Fig. 1: Representative photomicrographs of cross section of the testes (A) vehicle control, (B) *Piper longum* 5 mg/kg treated d and (C) *Piper longum* 100 mg/kg treated sections to stained with hematoxylin and eosin (H&E).

In rats treated with *P. longum* at 5 mg/kg had fewer spermatogenic cells in some of the seminiferous tubules and mild edema in the interstitial tissues (Fig. 1, B). Many of the reproductive toxicants have primary effects on the testis, which potentially overshadow effects downstream on the efferent ducts and epididymis. The growth, development and maintenance of the mammalian testis are under the control of endocrine and paracrine mechanisms. Piperine has been reported to induce infertility in laboratory male rats (MUNSHI and RAO, 1972) and to disrupt spermatogenesis by impairing the pituitary-testicular negative feedback system. The administration of 5 and 10 mg/kg of *Piper longum* decreased the weights of various regions of the epididymis, epididymal sperm count, motility and viability. Piperine has been shown to decrease intratesticular testosterone concentrations at dose of 10 mg/kg by inhibiting cytochrome P450, which is involved in the steroidogenic pathway (MALINI *et al*., 1999).

The fertilizing potential of spermatozoa are dependent on testicular androgens, the observed decrease in testicular weight, sperm motility, count, viability and depletion of sialic acid could be due to the reduced bioavailability of testosterone. Testosterone withdrawal has been shown to cause DNA fragmentation by stimulating caspase activation in Sertoli cells *in vitro*, which indicated that decreased testosterone levels can stimulate apoptotic pathways (TESARIK *et al*., 2002). Sperm absorbs sialic acid from epididymal luminal fluid which facilitated their downward movement without friction (GUPTA *et al*., 2002) and also helps in the acquisition of motility and viability (SINGH and CHAKRAVARTY, 2001) and hence the decreased Sialic acid levels in the epididymis can also be a causative factor for impaired sperm functions.

Following piperine-treatment decrease in Sialic acid would have resulted in increase in hydrogen peroxide levels in the epididymal region resulting in significant changes in sperm viability, moility and altered morphology. Increased hydrogen peroxide levels may have brought about an imbalance in prooxidant/ antioxidant levels in the epididymis, though the mechanism is not clear. In the present study, the effect of aqueous extract of *P. longum* on male reproduction and fertility in adult albino rat clearly establishes that aqueous extract can cause infertility through affecting the following aspects of male reproduction. A 10 mg dose of piperine treatment caused a significant reduction in the weights of testis and accessory sex organs.

Histological studies revealed that piperine at 10 mg/kg dose, it caused severe damage to the seminiferous tubule, desquamation of spermatocytes and spermatids. A 10mg/kg dose of piperine also caused a marked decrease in LDH, intratesticular testosterone and sialic acid concentrations. In conclusion, piperine decreases the activity of the antioxidant enzymes and sialic acid and hampers the epididymal environment where sperm maturation takes place. Considering the above results, we propose that the inhibition of antioxidant enzyme activities along with a decrease in sialic acid levels that could generate ROS in the epididymis is the reason for the potential antifertility effects of piperine.

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POPULATION DYNAMICS OF DIFFERENT SPECIES OF FLEA BEETLE INFESTING LADYSFINGER (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH) AND THEIR SUSTAINABLE MANAGEMENT

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ABSTRACT: Ladysfinger or okra (*Abelmoschus esculentus* L. Moench) is an annual vegetable crop grown in tropical and sub-tropical areas of the globe. In the sub-Himalayan region of north east India the crop is cultivated throughout the year from the 9th to 45th Standard Meteorological Weeks (SMW) which excludes the winter months. The crop is susceptible to various pests of which flea causes heavy damage. The pest was active throughout the growing period with a peak population (5.67 flea beetles/plant) during 26th SMW (last week of June) in the pre-kharif crop. Again population reached higher (3.33/plant) on the 37th SMW (2nd week of September) in the post kharif crop. Sudden fall of population was found during July-August because of heavy rains. Flea beetle population showed significant positive correlation (p=0.05) with average temperature, relative humidity, whereas significant negative correlation with rainfall. This study evaluated the efficacy of azadirachtin, extracts from plants such as *Polygonum hydropiper* L. floral part and *Pongamia pinnata* L. fruit, tobacco leaf and garlic against flea beetle and compared with the ability of profenophos. Profenophos was found the most effective treatment for controlling flea beetle, followed by the azadirachtin and *Polygonum*. Azadirachtin and extracts of *Polygonum* plant gave moderate to higher flea beetle control, recording more than 50% mortality and produced higher yield. Azadirachtin and plant extracts having less or no hazardous effects on human health and environment. Thus these can be incorporated in IPM programs and organic farming in vegetable cultivation.

Key words: Seasonal fluctuation, bio-pesticides, vegetable IPM, organic farming

INTRODUCTION

Ladysfinger (*Abelmoschus esculentus* L.) (Malvaceae) is one of the most important vegetable crops in tropical and sub-tropical areas of the world. The tender fruits, leaves and succulent shoots are consumed, either in fresh or dried forms (ARAPITSAS, 2008). YOUDEOWEI (2002) has documented insects of primary importance in the cultivation of okra crop. Flea beetle having different species (Chrysomelidae: Coleoptera) is one of the important pests attacking crucuferous, solanaceous and malvaceous plants. It is a polyphagous pest, having wide host range. EGWUATU (1982) noted that *Podagrica uniformis*, Jacoby and *Nisotra sjostedti,* Jacoby (Col.: Chrysomelidae) are the most destructive flea beetle insect species at Nsukka, Nigeria. Okra mosaic virus (OMV), which is transmitted by insects belonging to *Podagrica* species, has been reported from Côte d′ Ivoire, Kenya, Nigeria and Sierra Leone in Africa (BRUNT *et al*., 1996; FAJINMI and FAJINMI, 2010).The flea beetles and *Syagrus calcaratus* (Fabr.) (Coleoptera: Chrysomelidae) have also been implicated in the transmission of okra mosaic virus (OMV) in okra (FAJINMI and FAJINMI, 2010). But farmers ignore such diseases because they lack information on their control (NDUNGURU and RAJABU, 2002). Okra variety Parbhani Kranti, known to be resistant to Yellow Vein Mosaic Virus, was grown in several places in Uttarkashi and found heavily infested by the flea beetle, *Podagrica bowringi* Baly, in July 1996 (LAL, 1999). The striped flea beetle, *Phyllotrata striolata* Fabricius on crucifer vegetables completed 7 generations annually with infestation peak from early april to late May and in mid

September in Shenzhen, Guangdong, China (ZHANG *et.al*., 2000). RGOWSKA (1999) reported that peak in appearance of Phyllotreta on horseradish crop were observed in June and July in Skierniewic.

. This crop is cultivated at a commercial scale in the sub-himalayan region of northeast India where insect pest damage limits its production (GHOSH *et al*., 1999). In this region flea beetles are important pest of eggplant particularly on summer crops (GHOSH, 1999). The adult beetles feed on the leaves by making large number round holes in the foliage. In case of severe infestation, the photosynthetic area markedly reduced.

Different groups of insecticides have been recommended to control this pest (SURYAWANSHI *et al*. 2000; SATPATHY *et al*., 2004). Endosulfan and carbaryl @ 0.03% and 0.05% were most effective compounds against flea beetle (Psylloides plana Maulik) on potato in Simla hills, giving 50% or greater mortality for 15-20 days (CHANDLA *et al*., 1988). However, the use of synthetic insecticides during the fruit bearing stage is problematic because the fruit is harvested at frequent intervals, creating the possibility that toxic residues could pose a health hazard. The organochlorine and organophosphorous compounds have been reported to pose a potential threat to all types of ecosystem. MISHRA and MISHRA (2002) reported that the botanical insecticides like Neemax (neem seed kernel extract) and Multineem (neem oil) regulated pest populations of okra. Direct contact toxicity of azadirachtin product has been demonstrated against termites and aphids (SRIVASTAVA, 2003). DAS *et al.* (2010) tested synthetic pesticides for the control of okra. HOU *et al.* (2000) reported that soil treatment consisting of tobacco application to a vegetable field reduced the number of stripped flea beetle (P. *striolata* Fabr.) and increased crop yield.

Polygonum is a well known weed in the terai agro-climatic region of West Bengal, India locally known as “Biskanthali” (SARKAR and MUKHERJEE, 2005). BADSHAH *et al*. (2005) reported from Pakistan that crude leaf and flower extracts of *Polygonum hydropiper* were responsible for mortality rates 10 days after feeding of 28% and 52% for *Heterotermes indicola* and 28% and 74.7% for *Coptotermes heimi,* respectively. *Beauveria bassiana* caused 100% mortality of the larvae of the mango pest *Orthaga euadrusalis* (Walk) (Noctuidae: Leoidoptera) after they crawled over the fungus for four days (SRIVASTAVA and TANDON, 1980). ACHARYA *et al*. (2002) studied the efficacy of the insecticides imidacloprid and abamectin and reported they were safer to use in the presence of coccinellid predators. In many cases, our farmers are misguided by spraying synthetic insecticides to combat this pest which are harmful to our health and environment. The objective of this study was to determine the efficacy of certain plant extracts and to formulate suitable control measure.

MATERIALS AND METHODS

Studies were conducted in UBKV Instructional Farm at Pundibari, for two years (2010-11). The experimental area is situated in the sub-Himalayan region of north-east India, which called terai zone, between $25^0$57’ and 27^0 N latitude and $88^0$25’ and $89^0$54’ E longitude. The soil of the experimental field was sandy loam with pH value 6.9. The climate of this zone is subtropical humid with a short winter spell during December to February. The ladysfinger variety ‘Nirmal-101’ was grown round the year during 2010-2011 in both years under recommended fertilizer levels (120:60:60 kg NPK/ha) in 4.8 m x 4.5m plots at the spacing of 75 cm x 35 cm. The treatments were replicated five times in a Randomized Block Design (RBD). The total flea beetle population/plant basis from 5 randomly selected plants/replication was recorded at seven days (Standard

Meteorological Week) intervals. Data obtained over two years are presented graphically with important weather parameters *viz*., temperature, relative humidity. Correlation co-efficient (r) was worked out between incidence of flea beetle and important weather parameters during the period to find out influence of weather on population fluctuation.

The ladysfinger variety 'Nirmal-101' was grown during the post kharif (early September) season in both years under recommended fertilizer levels (120: 60: 60 kg NPK/ha) and cultural practices in 4 m x 5m plots at a spacing of 75 cm. x 35 cm. The treatments were replicated three times in a Randomized Block Design. One botanical insecticide azadirachtin i.e. neem (neemactin 0.15 EC) @ 2.5 ml/L, and five botanical extracts *viz*., tobacco *(Nicotiana tabacum)* leaf extract @ 10.0 %, *Polygonum hydropiper* floral part extract @ 5.0%, *Pongamia pinnata* fruit extracts @ 5.0%, *Spilanthes paniculata* floral parts extract @ 5.0%, and garlic (*Allium sativum*) extract @ 5.0%, were evaluated and compared with the ability of profenphos (Carina 50 EC), a chemical insecticide @ 3ml/ L to control the flea beetle on ladysfinger along with no treatment (control) where no insecticide was used. This insecticide is recommended for use against this flea beetle pest.

The *Pongamia* fruits and *Polygonum* plants floral parts, *Spilanthes* floral parts and garlic edible part were extracted in methanol. After washing with water, the plant parts were powdered in a grinder. The powder (50 g) samples of each tested plant were transferred separately to a conical flask (500 ml) and dipped in 250 ml methanol. The material was allowed to stand for 72 hours at room temperature with occasional stirring. After 72 hours the extract was filtered through Whatman 42 filter paper and residues were washed twice with methanol.

Tobacco leaves were extracted in water after washing with water, dried and powdered in a grinder. The powdered sample (100 g) were transferred to a container and dipped in 1 litre water. The material was boiled for about half an hour and then allowed to stand for 72 hours at room temperature with occasional stirring. After 72 hours the extract was filtered through Whatman 42 filter paper and added 15 ml liquid soap.

Four sprays at 10 day intervals were made, starting with the initiation of infestation. Population density of flea beetle was taken before each insecticides spraying as pre-count of the pests. Flea beetle population densities were recorded 3, 6 and 9 days after each spraying by counting adults on each plant from five randomly selected plants per replication. The results were expressed as flea beetle population suppression (%) compared to densities recorded on the control treatment. Per cent reduction of flea beetle population over control was calculated by the following formula (ABBOTT, 1925):

$$Pt = \frac{Po - Pc}{100 - Pc} \times 100$$

Where, Pt = Corrected mortality, Po = Observed mortality and Pc = Control mortality.

$$\text{Per cent reduction over control} = \frac{\text{Per cent reduction in treatment} - \text{Per cent reduction in control}}{100 - \text{Per cent reduction in control}} \times 100$$

Data were analyzed by using INDO-STAT- software for analysis of variance following randomized block design (RBD) treatment means were separated by applying

CD Test (critical difference) at 5 % level of significance. The ladysfinger fruits were harvested at frequent intervals when they reached marketable size. The yield of marketable produce was calculated in different years separately on the basis of fruit yield per plot and converted to quintal per hectare.

RESULTS AND DISCUSSION

1. Seasonal incidence of flea beetle

Analysis of pooled mean data for the two years during the ladysfinger growing period (9th SMW to 45th SMW) of the year on flea beetle infestation revealed that the pest was active throughout the growing period except 9-11 SMW i.e., last week of February to mid of March (Fig 1).

Table-1: Correlation co-efficient between weather parameters and incidence of flea beetle

Environmental parameter		Correlation co-efficient (r)	Co-efficient of determination (R^2)	Regression equation
Temperature ^{0}C	Maximum	0.279	0.077	Y = 0.153X+32.30
	Minimum	0.657**	0.431	Y =0.922X+22.50
	Difference	(-)0.586**	0.342	Y=(-)0.768X+9.795
	Average	0.640**	0.410	Y= 0.537X+27.39
Relative Humidity (%)	Maximum	0.543**	0.294	Y=2.192X+77.09
	Minimum	0.516**	0.266	Y=3.14504X+67.08
	Average	0.540**	0.291	Y=2.67X+72.09
Weekly rainfall	Total	(-)0.495**	0.254	Y=(-)15.91X+23.02

*& ** Significant at 5%& 1% level of significance, respectively

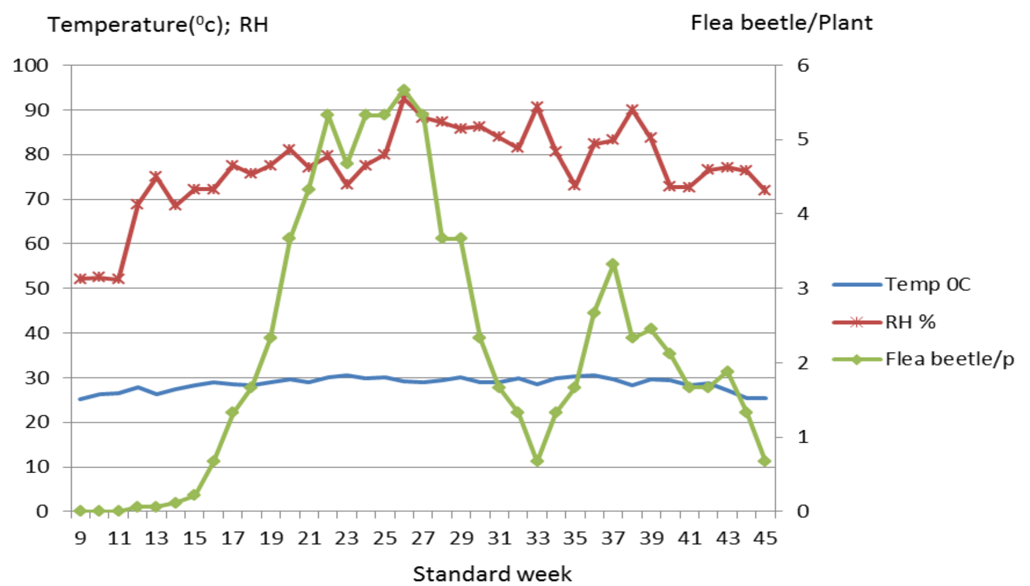

Fig. 1 Incidence of flea beetle as influence by temperature and RH

The important species of flea beetle found dominated in the ladysfinger field were *Phyllotreta striolata* Alder, *Altica ambiens* LeConte, *Agelastica alni*, *Syagrus calcaratus* F., and *Podagrica bowringi* Baly. However, population appeared during late March and remained very low up to middle of April and thereafter increased gradually with the rise of temperature. Pest population reached highest in number (5.67 flea beetles/plant) during 26^{th} SMW (last week of June) in the pre-kharif crop when the average temperature, average relative humidity and weekly total rainfall ranged 29.19^{0}c, 89.71% and 111.45 mm. respectively and thereafter started decline with the onset of monsoon and heavy rainfall, and this tendency was continued up to 33 SMW (mid of August).

After rainy season, again pest population increased and reached higher population (3.33/plant) on the 37^{th} SMW (2^{nd} week of September) in the post kharif crop when the average temperature, average relative humidity and weekly total rainfall ranged 29.67^{0}c, 85.70% and 72.50 mm. respectively. However, flea beetle was most active during May- last week June and September-mid October in this sub-Himalayan region of India. These findings are in agreement with the findings of ZHANG *et al*. (2000) and RGOWSKA (1999). There was a sudden fall of population was found in 33^{th} SMW (mid August) when weekly total rainfall 155.55 mm and very low population was found because of heavy rains during monsoon.

Correlation between flea beetle infestations with important weather parameters (Table-1) showed non-significant positive correlation (p=0.05) with maximum temperature and significant positive correlation with minimum and average temperature, relative humidity whereas significant negative correlation with temperature gradient and with weekly total rainfall. The population of flea had a tendency to increase with the increase of temperature and relative humidity and decrease of rainfall. In the present studies in multiple regression analysis, rainfall showed a negative and significant impact on the population of flea beetle.

2. Evaluation of plant extracts against flea beetle

The treatments and their persistence at different days after application varied significantly in their suppression of flea beetle populations (Tables-2 & 3).Among the seven treatments (Table-3), the chemical insecticide, profenophos provided the best suppression of flea beetle population (62.20 %), closely followed by azadirachtin i.e., neem formulation (53.71% suppression). Among the bio- pesticides, azadirachtin was the most effective followed by *Polygonum* plant floral part extract at the 5% concentration (50.79% suppression). From overall observation it was revealed that extracts of *Polygonum* plant floral part and azadirachtin gave better result, recording more than 50% flea beetle suppression. The least effective treatments were the garlic extract (30.34 % suppression) and *Pongamia pinnata* fruit extracts (32.14 % suppression). Tobacco leaf extract gave moderate suppression of flea beetle population (45.38% suppression).

Three days after spraying, profenophos was the most effective (67.37% suppression) against the flea beetle which was significantly different from all other treatments. Among the biopesticides, azadirachtin and *Polygonum* plant floral part extract provide better results against flea beetle (55.76% and 50.97% suppression, respectively). There was no significant difference in efficacy among these two treatments. Likewise, the ability of profenophos to suppress flea beetle populations extended to six and nine days after spraying. At six and nine days after spraying, among the bio-pesticides, azadirachtin was found very effective against flea beetle (55.21% suppression and 50.16% suppression, respectively) followed by the *Polygonum* plant floral part extract (52.03% suppression and 49.36% suppression, respectively).

Table-2: Overall efficacy of plant extracts against flea beetle on ladysfinger (2010 and 2011)

Yield was directly related to the efficacy of insecticides. The highest yield was obtained from plots treated with profenophos (40.21q/ha) followed by *azadirachtin* (39.32 q/ha) and *Polygonum* plant floral part extract (36.78 q/ha (Table-3). There was no significant difference in yield among these three treatments. In general, azadirachtin and the plant extract of *Polygonum* gave moderate to higher flea beetle suppression recorded more than 50% suppression and produced higher yield. Based on their moderate to high efficacy levels, as well as low toxicity to natural enemies and minimum impact on human health, and higher yield potentiality we conclude that azadirachtin and plant extracts can be incorporated in future IPM programme and organic farming in vegetable cultivation. Flea beetle incidence had a significant positive correlation with temperature and relative humidity and significant negative correlation with rainfall. Low rainfall coupled with high temperature and high RH causes outbreak of white fly population.

Table-3: Overall efficacy of plant extracts against flea beetle and fruit yield of ladysfinger (Grand mean of 2010 and 2011)

Treatments	**Dose ml / Litre (%)**	**Overall efficacy (Grand Mean of 2010 and 2011)**					**Fruit yield (q/ha)**
		Pre-Treatment flea/plant	**Days after treatment**			**Mean**	
			3	6	9		
***Polygonum* (T1)**	50.00 ml/L (5%)	3.0	50.97 (45.56)	52.03 (46.17)	49.36 (44.64)	50.79 (45.51)	36.78
***Pongamia* (T2)**	50.00 ml/L (5%)	3.03	33.85 (35.52)	32.92 (34.73)	29.97 (36.68)	32.14 (35.65)	31.12
Azadirachtin (T3)	2.5 ml/L	3.03	55.76 (48.29)	55.21 (48.02)	50.16 (45.09)	53.71 (47.13)	39.32
Garlic (T4)	50.00 ml/L (5%)	2.87	32.86 (34.92)	31.07 (33.56)	27.08 (31.22)	30.34 (33.29)	30.09
Profenophos (T5)	1 ml/ L (0.05%)	3.03	67.37 (55.21)	63.22 (52.83)	56.03 (48.49)	62.20 (52.17)	40.21
Tobacco (T6)	100.00 ml/L (10%)	3.10	47.77 (43.70)	46.78 (42.93)	41.58 (40.13)	45.38 (42.26)	32.03
***Spilanthes* (T7)**	50.00 ml/L (5%)	3.25	35.51 (36.54)	37.17 (37.53)	32.34 (34.55)	35.01 (36.21)	32.11
Untreated Control (T8)	---	2.97	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	26.15
S Em (±)	---	---	1.64	1.47	1.56	---	1.24
CD at 5%	---	NS	5.04	4.53	4.88	---	3.92

Figure in the parenthesis are angular transformed values, NS= not significant

These findings indicated that pre-kharif crop as well as post-kharif crop is most susceptible to flea beetle infestation in the sub-Himalayan region of India. Kharif crop may avoid the infestation of jassid infestation in this zone of West Bengal, India. However, flea beetle was most active during May to last week of June and September to mid October in this sub-Himalayan region of India. During these periods of the year drastic control measure should be adopted. The azadirachtin and plant extract of *Polygonum* gave moderate to higher flea beetle suppression and produced higher yield. Based on their moderate to high efficacy levels, as well as low toxicity to natural enemies and minimum impact on human health, and higher yield potential results conclude that azadirachtin and plant extracts can be incorporated in future IPM programme and organic farming in vegetable cultivation.

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BIONOMICS OF TUSSOCK CATERPILLAR, *EUPROCTIS SP.* (LEPIDOPTERA: LYMANTRIIDAE) ON SAPOTA, *ACHRAS SAPOTA* LINN.

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ABSTRACT: *Euproctis sp.* (Lepidoptera: Lymantriidae), commonly known as Tussock caterpillar, is a serious defoliator of sapota. Its bionomics was studied under laboratory condition in the department of Entomology during 2013-14 at College of Agriculture Raipur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India. The pre-oviposition, oviposition and post-oviposition period were found 4.0 to 5.0 (4.50 ± 0.14), 3.0 to 5.0 (3.80 ± 0.13) and 2.0 to 4.0 (2.90 ± 0.26) days, respectively. The incubation period was 6.0 to 8.0 (8.00 ± 0.36) days and a single female laid 197 to 220 (205.60 ± 3.72) eggs in her life span and on an average 62.49 ± 5.01 per cent egg hatchability was recorded under the laboratory conditions. The eggs were laid in batches 30 to 65 which are covered with woolly material. Freshly laid eggs were soft, dark yellow but semitransparent. Eggs were oval, 0.97 ± 0.01mm in length and 0.80 ± 0.01mm in breadth. The larvae passed through six instars. The larval stage was completed in 44.54 ± 0.25 days. Pre-pupal and pupal stages and total life cycle of the insect lasted for 1.55 ± 0.08, 7.70 ± 0.39 and 44.1 ± 1.02 days, respectively. The larvae fed on leaves and active throughout the year with the peak in October-November. The longevity of male and female was 8.20 ± 0.28 and 9.25 ± 0.17 days, respectively.

Key words: Bionomics, Tussock caterpillar, *Euproctis* sp., sapota.

INTRODUCTION

Sapota, *Achras sapota* L. is a delicious fruit crop of tropical and subtropical countries. Indian sapodillas are some of the hardiest in the world. India is considered to be the largest producer of sapota in the world with an area of about 1.60 lakh hectares and production of 1424 metric tonnes[1]. In India Sapota is grown in abundance throughout Karnataka, Maharashtra, Gujarat, Tamil Nadu, West Bengal, Andhra Pradesh and Chhattisgarh. Various factors affect the yield of Sapota, among which damage caused by insect pests is one of the important factors. More than 25 insect pest species are known to attack sapota (BUTANI, 1979) and among these, Tussock caterpillar, *Euproctis sp.* is a serious pest causing damage to the sapota. Tussock moth is polyphagous, together with its tendency to reach outbreak densities making this species a major pest of hardwood fruit trees (ANONYMOUS, 2005).

Initially, larvae were observed to scrap and skeletonize the leaves. Later instar larvae fed voraciously on young leaves of sapota. Sometimes larva completely devour the leaving only the midrib. The fifth- and sixth - instar larvae consumed more leaves than those of the first four instars (ISLAM *et al.,* 1998). The larva of this insect is notorious for its irritating hairs, which cause an allergic reaction on human skin due to a de-erythrocyte substance (BLEUMINK *et al*., 1982).This pest remained active throughout the year (SANDHU *et al*., 1974). Considering the economic importance of the pest and its

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prolonged larval duration its biology, nature of damage have been studied in detail along with morphological description of different stages of the pest.

MATERIALS AND METHODS

Studies on the biology of *Euproctis sp.* were conducted under laboratory condition in the Department of Entomology during 2013-14 at College of Agriculture Raipur, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India. The field collected larvae were transferred on to the tender leaves of sapota (cv *Kalipatti*) placed in glass jars (15 x 10cm) covered with the piece of muslin cloth. The food was changed daily till pupation. The pupae were transferred into glass jars containing 2cm moist sand at the bottom covered with a piece of blotting paper. One pair of the adults were released in glass jars lined with tissue papers and provided with terminal shoots of sapota for oviposition. Ten per cent sugar solution was provided as food for the moths. The eggs thus obtained were kept in petri-dishes (7.5 x 1.25cm) for observing the incubation period and viability. Newly emerged larvae were reared singly in petri-dishes (7.5 x 2.5cm) on tender leaves and food was changed daily till pupation. The adults emerged were sexed and after pairing released in glass jars (15 x 10cm) containing fresh shoot terminals for egg laying. Cotton swabs were kept for maintaining the humidity which was changed daily. Observations on pre-oviposition, oviposition and post-oviposition periods and fecundity of the female moths were recorded. Description of different stages of the insect was made by examining the details of the specimens and measurements of different stages were also taken.

RESULTS AND DISCUSSION

The details of the various stages recorded in the present studies are mentioned below in table 1 and 2. The pre-oviposition, oviposition and post-oviposition period were found 4.0 to 5.0 (4.50 ± 0.14), 3.0 to 5.0 (3.80 ± 0.13) and 2.0 to 4.0 (2.90 ± 0.26) days, respectively. These results are in agreement with that of SASIDHARAN *et al*., (1996). The incubation period was 6.0 to 8.0 (8.00 ± 0.36) days and a single female laid 197 to 220 (205.60 ± 3.72) eggs in her life span and on an average 62.49 ± 5.01 per cent egg hatchability was recorded under the laboratory conditions. PATIL AND KULKARNI (1990) also reported the incubation period of 6.7 days in *Euproctis sp..* The larvae passed through six instars. Similarly, ISLAM, *et al.,* (1998) also reported that larvae passed through six instars. According to ROY *et al.,* (1993) larva has several instars. The first instar larval period observed was 4.0 to 5.0 (4.60 ± 0.07) days. Average larval period for second, third, fourth, fifth and sixth instar larva was 7.94 ± 0.13, 6.68 ± 0.07, 9.90 ± 0.04, 8.58 ± 0.05 and 6.84 ± 0.07 days, respectively whereas the total larval period completed within 43.80 to 45.30 days with an average of 44.54 ± 0.25 days. The pre-pupal period varied from 1.0 to 2.0 (1.55 ± 0.08) days, whereas pupal period ranged from 7.0 to 11.0 days with an average of 7.70 ± 0.39 days. It is in agreement with that reported by SASIDHARAN *et al*., (1996), pupal period was 7.82 ± 0.27 days, whereas PATIL and KULKARNI (1990) reported that pupal period was of 11 days. The male moth lived for 7.0 to 9.0 days with an average of 8.20 ± 0.28 days while female moths for 8.0 to 10.0 days with an average 9.25 ± 0.17 days. The sex ratio was found to be 1:1.5. Under the present studies the total life cycle of *Euproctis sp.* was completed in 40.00 to 48.00 (44.1 ± 1.02) days which is in close agreement with PATIL and KULKARNI (1990) reported that total life cycle was completed in 42.77 days.

Eggs: The eggs were laid in batches of 30 to 65 which were covered with woolly material. Freshly laid eggs were soft, dark yellow but semi transparent. Eggs were oval, 0.97 ± 0.01mm in length and 0.80 ± 0.01mm in breadth.

Table-1: Bionomics of *Euproctis sp.* on sapota, *Achras sapota* L.

Stage	**Life period in days**	
	Range	**Mean**
Incubation period	6.0 - 8.0	8.00 ± 0.36
Fertility (%)	50.44 - 81.67	62.49 ± 5.01
I instar larvae	4.0 - 5.0	4.60 ± 0.07
II instar larvae	7.0 -9.0	7.94 ± 0.13
III instar larvae	6.0 - 7.0	6.68 ± 0.07
IV instar larvae	9.0 - 11.0	9.90 ± 0.04
V instar larvae	8.0 - 9.0	8.58 ± 0.05
VI instar larvae	6.0 - 8.0	6.84 ± 0.07
Total larval period	43.80 - 45.30	44.54 ± 0.25
Pre-pupal period	1.0 - 2.0	1.55 ± 0.08
Pupal period	7.0 - 11.0	7.70 ± 0.39
Pre-oviposition period	4.0 -5.0	4.50 ± 0.14
Oviposition period	3.0 -5.0	3.80 ± 0.13
Post-oviposition period	2.0 - 4.0	2.90 ± 0.26
Adult longevity (Male)	7.0 -9.0	8.20 ± 0.28
Adult longevity (Female)	8.0 - 10.0	9.25 ± 0.17
Sex ratio	1:1.5	-
Fecundity (No of eggs/female)	197 - 220	205.60 ± 3.72
Total life cycle (egg to adult stage)	40 -48	44.1 ± 1.02

Larvae: The larvae were brown to black in colour a red head. The newly hatched larvae were very active and measured 3.10 ± 0.13 mm in length and 0.48 ± 0.01mm in breadth. Initially larvae scraped to skeletonize the leaves and later fed voraciously on young leaves of sapota. Dorsal surface of larval body was covered with straight/erect hairs. There were six larval instars. The body length of second, third, fourth, fifth and six instars larvae measured on an average 7.85 ± 0.19, 11.85 ± 0.09, 15.40 ± 0.29, 19.45 ± 0.24 and 21.55 ± 0.18 mm, respectively. The body breadth of second, third, fourth, fifth and six instars larvae measured on an average 1.13 ± 0.04, 1.90± 0.02, 2.38 ± 0.11, 2.96 ± 0.01 and 3.25 ± 0.07 mm, respectively.

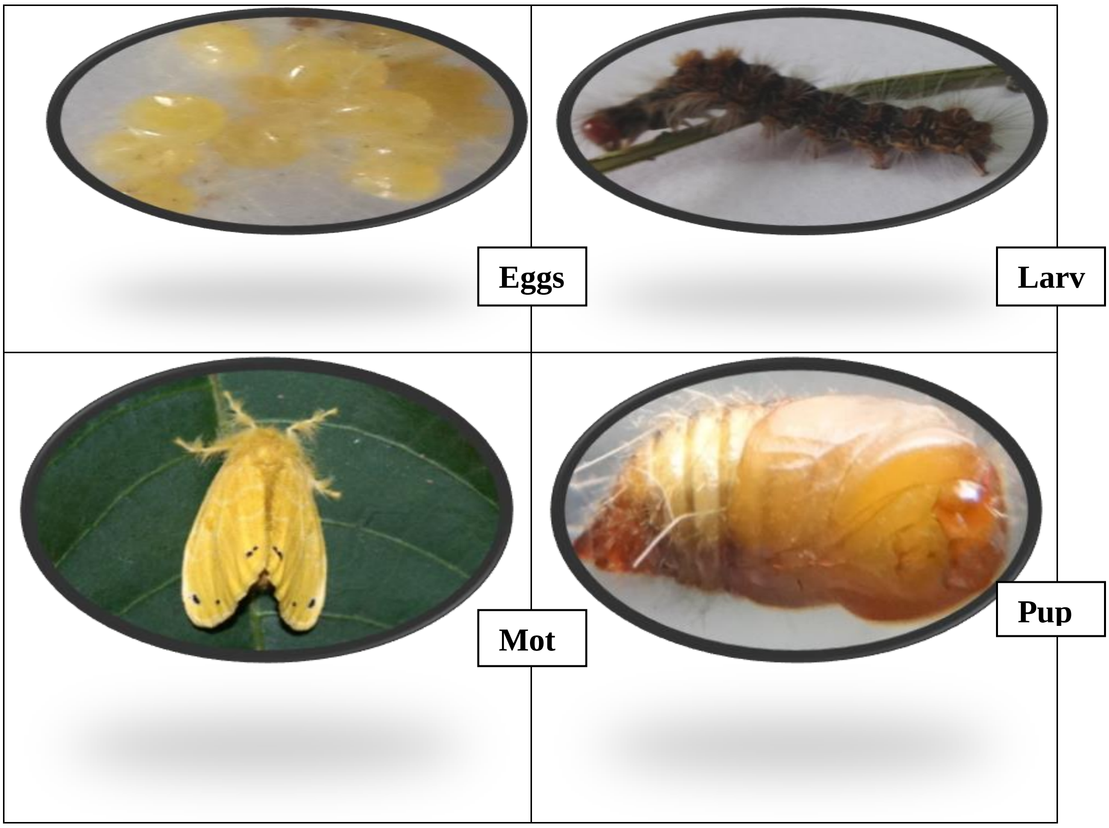
Prepupal stage: There was a pre pupal stage, which lasted from 1.0 to 2.0 days. Before the final moulting, the larvae stopped feeding and body shortened to an average of 20.5 mm length, the body hairs fall off from the body of larvae and can be seen lying near it. After this the pre-pupa prepares for pupation.

Pupa: The pre-pupa were seen to pupate under cocoon made of silk. Initially the pupae were light yellow in colour, which turned light reddish brown within 24 hrs and later became dark brown prior to the emergence of adult. It was elongated with tapering ends. It was covered in woolly material. The mean length and width of the pupa was recorded to be 9.30 ± 0.08 mm and 3.75 ± 0.07 mm, respectively. The average pupal period lasted for about 7.70 ± 0.39 days.

Adult: The adult moth was yellow with black compound eyes and pectinate antennae. The male was slightly smaller than the female with pointed abdominal tip. On an average the developmental period from egg to adult emergence took 44.1 ± 1.02 days. The male adult moth had an average body length of 12.40 ± 0.36 mm, with a wing span of 22.10 ± 0.50 mm whereas female moth had an average body length of 13.70 ± 0.18 mm, with a wing span of 24.20 ± 0.36 mm. Both wings were yellowish with two brown transverse wavy lines. Black spot present on the apical portion of the fore wing. In case of female, tip of abdomen was yellow or black with slit like genital aperture, whereas in male the tip of slender abdomen was grayish and pointed.

Table-2: Morphometrics of *Euproctis sp.*on sapota, *Achras sapota* L.

Stage parameter	**Morphometric measurements (mm)**	
	Range	**Mean**
Egg length	0.95 - 0.99	0.97 ± 0.01
Egg breadth	0.75 - 0.85	0.80 ± 0.01
Length of I instar larva	2.50 - 3.50	3.10 ± 0.13
Breadth of I instar larva	0.45-0.50	0.48 ± 0.01
Length of II instar larva	7.00 - 9.50	7.85 ± 0.19
Breadth of II instar larva	1.00 - 1.25	1.13 ± 0.04
Length of III instar larva	11.50 - 12.00	11.85 ± 0.09
Breadth of III instar larva	1.75 - 2.00	1.90± 0.02
Length of IV instar larva	14.00 - 16.00	15.40 ± 0.29
Breadth of IV instar larva	2.00 - 2.75	2.38 ± 0.11
Length of V instar larva	17.00 - 20.00	19.45 ± 0.24
Breadth of V instar larva	2.90 - 3.00	2.96 ± 0.01
Length of VI instar larva	20.00 -22.00	21.55 ± 0.18
Breadth of VI instar larva	3.00 -3.25	3.25 ± 0.07
Pupal length	9.00 - 9.50	9.30 ± 0.08
Pupal breadth	3.50 - 4.00	3.75 ± 0.07
Adult male length at resting	11.00 - 13.00	12.40 ± 0.36
Adult male length with wing span	20.00 - 23.00	22.10 ± 0.50
Adult female length at resting	13.00 – 14.00	13.70 ± 0.18
Adult female length with wing span	23.00 – 25.00	24.20 ± 0.36



Nature of damage: The caterpillars of *Euproctis sp.* feed on chlorophyll of young leaves. Initially larvae damaged the leaves by scrapping while later instar larvae damaged both by scraping and biting the leaves some times completely devoured the leaves and only midrib remained. The fifth- and sixth - instar larvae consumed more leaves than those of the first four instars. ISLAM *et al.* (1998) also reported that fifth- and sixth-instar larvae were voracious feeders as compared to other instars. NIKDEL *et al.* (2010) also reported that the larval stage of this insect feeds on the foliage of many fruit trees. Larval feeding causes reduction of growth and occasional mortality of valued trees.

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BIOLOGY OF THE COMMON BANDED AWL, *HASORA CHROMUS* CRAMER (LEPIDOPTERA: HESPERIIDAE) ON KARANJ, *PONGAMIA PINNATA* AT RAIPUR, CHHATTISGARH

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ABSTRACT: Studies on the biology of the common banded awl, *Hasora chromus* on karanja, *Pongamia pinnata* conducted under laboratory conditions at Raipur Chhattisgarh, revealed that the eggs are laid singly or in small groups of 2-3 on young shoots and staple of the leaves or on the margin of the upper surface of young leaves. The eggs are bun shaped with ridges running from top to base measuring 58.25µm in diameter. Base of the eggs are flattened providing surface for attaching to the substratum. The neonate larvae measured about 1.5 to 2 mm in length and 0.5 to 1 mm in width and after completing five instars, grew to an maximum average size of 32 to 35 mm long and 3 to 4 mm wide. Pre-pupal stage noticed prior to pupation in which the full grown caterpillar stopped feeding and their body shortened, shrinked and decolorized and attached itself to the rolled leaf by a silken thread to seal the pupation shelter. It is pale greenish with yellowish brown coloured head having a number of short setae. Pre-pupal period lasted for 1-2 days. Chrysalis type pupation took place inside the folded leaves. Pupa is naked and attached itself to the leaf surface by silk threads and remained inside the rolled leaf. The average pupal period observed to be of 9-11 days. The adult butterfly was brownish black in colour with an average body length of 14 mm breadth of 3 mm and wing span of 45 mm. The wings of male butterfly are unmarked and female butterfly had two spots on both side of the fore wings and horizontal white band present in both sexes on a lower side of hind wings.

Key words: Common banded awl, *Hasora chromus, Pongamia pinnata*, Karanja

INTRODUCTION

Pongamia pinnata, commonly known as karanja is leguminous oil yielding multipurpose tree. It grows well in tropical and sub-tropical conditions in India, and in many parts of Asia. The tree is known for its pesticidal property (PRAKASH and RAO, 1997) but attacked by a number of insect pests which deteriorates the overall vigor and oil yielding capacity of the tree. Among the important insect pests, the common banded awl, *Hasora chromus* is one of the major defoliator pests causing heavy losses to the leaves leading to total defoliation in extreme cases. The larva of *H. chromus* is a defoliator and feeds on leaves, particularly on young and tender leaves and its severe infestation causes total defoliation. An attempt was made to study the biology of *Hasora chromus* under laboratory conditions on karanja, *Pongamia pinnata* leaves during December to January, 2013 at the Department of Entomology, College of Agriculture, IGKV, Raipur, Chhattisgarh.

MATERIALS AND METHODS

Eggs of the test insect were collected from the fields and brought to the laboratory and kept in petriplates along with leaves. After emergence of larvae, fresh leaves were provided daily and checked regularly for the head capsule to ensure moulting. A cotton dipped in sugar solution was kept in the petriplate to maintain humidity. Development of different stages of the pest was studied.

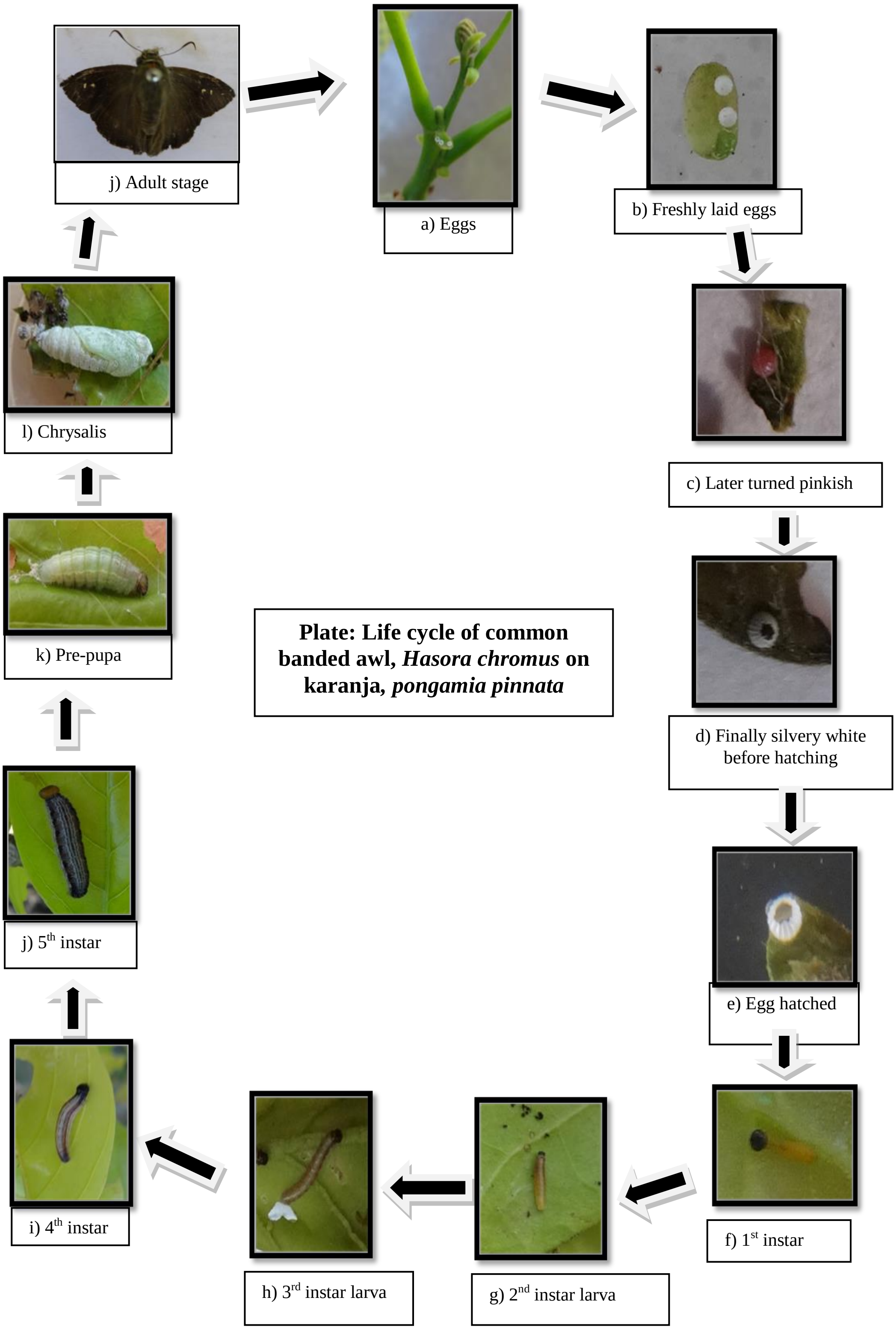

Plate: Life cycle of common banded awl, *Hasora chromus* on karanja, *pongamia pinnata*

Eggs: Eggs were laid singly or in small groups of 2-3 on young shoots like staple of the leaves or on the margin of upper surface of young leaves. Eggs were bun shaped with ridges running from top to base and base eggs and measured about 58.25µm in diameter. The eggs were flattened at the base which helped to be attached on to the substratum. The freshly laid eggs were whitish in colour but later turned pinkish and finally turned into silvery white colour before hatching. Black coloured head of the larvae could be easily seen on the upper part of the eggs from where they fed on the upper portion of the chorion and cut a hole to emerge out of the egg shell. After emergence larvae did not feed on the entire shell but fed only partly. The incubation period was about 2 to 3 days.

Table-1: Duration of various stages of the common banded awl, *Hasora chromus* on Karanj *Pongamia pinnata* at Raipur, Chhattisgarh

S.No.	Stage		Date	Mean Size (mm)	Total duration (Days)
1	Eggs Stage		06-12-2013	58.25µm diameter	2 ±1
2	Larvae Stage	1st instar	08-12-2013	01.5 -03.2	2 ±1
		2nd instar	11-12-2013	03.5 - 06.0	4 ±1
		3rd instar	15-12-2013	06.0 – 11.0	4 ±1
		4th instar	19-12-2013	11.0 – 20.0	2 ±1
		5th instar	21-12-2013	20.0 - 35.0	4 ±1
3	Pre-pupation		25-12-2013	22.0 - 25.0	1 ±1
4	Pupa Stage		26-12-2013	20.0 - 22.0	9 ±1
5	Adult Stage		04-01-2013	13.0 - 15.0	4 ±1
	Total life cycle		**06-12-2013 to 13-01-2013**	**1.50 – 35.00**	**34 – 36**

Larvae: The neonate larvae measured about 1.5 to 2 mm. in length and 0.5 to 1.0 mm in width and after completing five instars, grew to an average size of 32 to 35 mm. in length and 3 to 4 mm. in width. The first instar larva was typically cylindrical in shape with yellowish brown body which later became pinkish brown having a number of short setae with three pairs of thoracic legs (true legs) and five pairs of abdominal legs (prolegs). The head was large, black, hairy with four white stripes on the dorsal side toward the pro thorax up to last abdominal segment of the body. Moulting was confirmed by seeing the head capsule. The feeding propensity increased with their age. The larva folded leaves of young plants and fed within. In grown up plants, leaf was folded longitudinally bringing together the margins with the help of silken threads, and living inside the tubes thus formed fed on leaves from tip to base. The total duration of larval stage ranged from 16- 18 days.

Pre-pupa: Toward the end of the 5th instar, the larvae stopped feeding and their body shortened, shrinked and decolorized prior to pupation. The pre-pupa attached itself to the rolled leaf by silk threads to seal the pupation shelter. It was pale greenish with yellowish brown head having a number of short setae. Pre-pupal period lasted for 1-2 days.

Pupa: Chrysalis type pupation took place inside the folded leaves. It was naked and attached itself to the leaf surface by a silk thread and remained inside the rolled leaf. Pupa became greenish in colour with white powder over the body surface being blunt at the posterior end and broad interiorly. The average pupal period was observed to be 9-11 days.

Adult: Adult butterfly was brownish black in colour with an average body length of 14 mm, breadth of 3 mm. and wing span of 45 mm. The wings were completely covered with scales. The wings of male butterfly are unmarked whereas the female butterfly had two spots on both side of the fore wings and horizontal white band present in both sexes on a lower side of hind wings. HARINATH *et al*. (2012) reported *Hasora chromus* as dimorphic and the wings of male being unmarked whereas female having two pale yellow cresentic spots on the hind wing. The adult butterfly was very active. Antenna was about 10 mm in length which enlarged gradually towards the tip with hook like projection on the terminal segment. The total life cycle was completed in about 34-36 days.

Table- 2: Details of the adults of *Hasora chromus*

S.NO.		Male	Female
01	Body colour	Dark brownish black	Light brownish black
02	Body length	1.2 cm	1.3 cm
03	Thorax width	4 mm	4 mm
04	Abdomen width	2 mm	3 mm
05	Wing span	4.2 mm	4.5 mm
06	Antennae length	About 1 cm (hooked)	1 cm (hooked)
07	Adult (Dorsal view)		
08	Adult (Ventral view)		

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RELATIVE EFFICACY OF NOVEL INSECTICIDES AGAINST STEM BORERS IN RICE AND THEIR EFFECTS ON NATURAL ENEMIES

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ABSTRACT: Field trials on the study of relative efficacy of novel insecticides against the incidence of stem borers in rice were conducted during *kharif* , 2010 and 2011 in the Central Research Station, OUAT, Bhubaneswar, Odisha. The study revealed the superiority of Cartap hydrochloride 75SG @ 500g/ha followed by Cartap hydrochloride 75SG @ 425g/ha and Cartap hydrochloride 50SP @ 1000g/ha in controlling the stem borer in rice. Stem borer incidence (Dead heart) was less in Cartap hydrochloride 75SG @ 500g/ha(2.0-12.0/m^2), Cartap hydrochloride 75SG @ 425g/ha(2.6-12.8/m^2) and Cartap hydrochloride 50SP @ 1000g/ha(2.8-14.6/m^2) treated plots at different growth stages as compared to other treated and untreated plots(13.5-36.5/m^2). With respect to WEH incidence the said treatments were found promising. The effective control of stem borers was manifested with the marked increase in yields over untreated check which were 34.54,31.19 and 21.17% in Cartap hydrochloride 75SG @ 500g/ha, Cartap hydrochloride 75SG @ 425g/ha and Cartap hydrochloride 50SP @ 1000g/ha treatments, respectively. Natural enemies *viz*., mirid bugs and coccinellid beetles were not affected by the novel insecticides.

Key words: Novel insecticides, rice stem borer, *Scirpophaga incertulas,* mired bug, Cartap hydrochloride

INTRODUCTION

The attack of an array of insect pests at various growth stages of rice crop is considered to be one of the major constraints of rice production in India (PRAKASH *et al*., 2007). Among the pest complex, the stem borers are the most destructive one. Four species of stem borers, *viz.*, yellow stem borer (*Scirpophaga incertulas* Walker), white stem borer (*Scirpophaga innotata* Walker), pink stem borer (*Sesamia inferens* Walker) and dark headed stem borer (*Chilo polychrysa* Meyrick) constitute the borer complex. The yellow stem borer (YSB) (*Scirpophaga incertulas* Walker) has been reported to be the predominant species in rice growing tracts of South East Asian countries including India, inflicting severe damage to the crop (Islam, 1996). It attacks the plants from seedling to maturity in almost all rice ecosystems and in *boro* rice also (MISHRA *et al.*, 2005). The economic injury threshold as dead heart and white ear head was reported to be 5.7-12.0% and 9.4-14.7%, respectively (RAO *et al*., 1990). In India, more than 30% yield loss is caused by this pest (TRIPATHY and SENAPATI, 1999; SUBUDHI *et al.*, 2007).

In order to mitigate the pest menace, farmers usually apply a number of synthetic insecticides without proper knowledge on time, dose and suitability of their application. Such use and abuse of highly toxic chemicals have brought in many detrimental effects *viz*., insecticide resistance, secondary pest outbreak and pollution in the rice eco-system, ultimately leading to economic loss. In view of these facts, the present investigation was carried out to evaluate the relative efficacy of three different insecticide molecules against stem borer for ascertaining the possibilities of their inclusion in IPM of rice in coastal Odisha conditions.

MATERIALS AND METHODS

Field trials were carried out in randomized block design (RBD) in the Central Research Station of the Orissa University of Agriculture and Technology (OUAT), Bhubaneswar during *kharif*, 2010 and 2011 in order to study the efficacy of novel insecticides against stem borer of rice. Rice seedlings (30 days old) of variety Swarna (MTU 7029) were transplanted in lines at 20 x 15 cm spacing in 40 m^2 experimental plots. The standard agronomic practices excluding insect control measures were followed for raising the crop. The insecticidal treatments *i.e*., Mortar 75 SG (Cartap hydrochloride) at three doses *i.e*, @ 375, 425 and 500 g/ha, Cartap hydrochloride 50 SP @ 1000 g/ha, Lambda cyhalothrin 2.5 EC @ 500 g/ha, Fipronil 5 SC @ 500 g/ha were applied thrice as foliar sprays at 30, 45 and 60 days after transplanting (DAT).

The incidences of stem borer were recorded in terms of dead hearts (DH) from from randomly selected hills from each treatment at one day before and 7, 15 and 30 days after each spraying. The observation on white ear head (WEH) was also taken from randomly selected hills before 15 days of harvest of the crop. Grain yield from each plot was recorded separately at harvest and converted to kg/ha. In order to have a comparative study of the treatments, an untreated check plot was maintained in each replication. The data thus obtained for the two seasons were then transformed and analyzed following appropriate statistical methods (GOMEZ AND GOMEZ, 1984).

RESULTS AND DISCUSSION

Effects on Stem Borers: The stem borer incidence in tillering and heading stage (15days before harvest) of rice was low in *Kharif* 2010 which affirms the findings of RATH (2011) and might be due to climatic factor. The mean pooled Dh/m^2 in the treated plots after 7, 15, and 30 days of spraying was found to be low to the tune of 2.9 to 6.1, 3.6 to 6.8 and 2.0 to 5.1, respectively as compared to untreated check. Among the insecticide treatments, Cartap hydrochloride 75SG @ 500g/ha, Cartap hydrochloride 75SG @ 425g/ha and Cartap hydrochloride 50SP @ 1000g/ha recorded minimum number of dead hearts with higher reductions of 86.58, 82.55 and 81.2% over untreated check, respectively (Table1). On the other hand, the stem borer incidence before harvest varied from 4.3 to 7.8 number of WEH/m^2in different treatments in the same season. All the chemical treatments were found to be significantly superior to untreated check. Among the test insecticides, Cartap hydrochloride 75SG @ 500g/ha, Cartap hydrochloride 75SG @ 425g/ha and Cartap hydrochloride 50SP @ 1000g/ha also recorded minimum WEH (4.3 to 5.0/m^2) with 68.55 to 72.96 percent reduction over untreated check.

The stem borer incidences were quite high during *Kharif,* 2011 both at tillering and heading stage (15days before harvest) of the crop (36.5 DH and 37.3 WEH per m^2) as was evident from the untreated check plots. All the test chemicals were found to be significantly superior to the untreated check. Low stem borer incidence was observed in Cartap hydrochloride 75SG @ 500g/ha, Cartap hydrochloride 75SG @ 425g/ha and Cartap hydrochloride 50SP @ 1000g/ha recording 72.33 to 78.08% and 77.75 to 80.70% reduction over untreated check with respect to DH and WEH, respectively. The mean reduction of DH from 76.77 to78.94% and WEH from 73.15 to 76.70% were observed in Cartap hydrochloride 75SG @ 500g/ha, Cartap hydrochloride 75SG @ 425g/ha and Cartap hydrochloride 50SP @ 1000g/ha followed by Cartap hydrochloride 75SG @ 375g/ha (73.53% DH and 71.3% WEH), Lambda cyhalothrin 2.5 EC @ 500 ml/ha (69.72%DH and 66.82% WEH) and fipronil 5SC (65.77% DH and 59.38% WEH).

Grain Yield: The maximum grain yield of 4275.0 and 4806.3 kg/ha were obtained in Cartap hydrochloride 75SG @ 500g/ha with the highest yield increase of 31.03 and 38.06

Table -1: Effect of insecticides on occurrence of dead heart due to infestation of stem borer in rice

Table- 2: Effect of insecticides on occurrence of white ear head (WEH) and grain yield due to infestation of stem borer in rice

Table- 3: Mirid bug and *Coccenellid* population/m^2 in different treatments percent during *Kharif,* 2010 and 2011, respectively with mean increase being 34.54 per cent. Besides, other treatments like Cartap hydrochloride 75SG @ 425g/ha, Cartap hydrochloride 50SP @ 1000g/ha, Cartap hydrochloride 75SG @ 375g/ha and Lambda cyhalothrin 2.5 EC @ 500 ml/ha showed 15.96 to 31.19 per cent increase in yield over untreated check. Cartap hydrochloride 50SP and Lambda cyhalothrin 2.5 EC were also reported as effective insecticides against major pests of rice (SATAPATHY and MUKHERJEE, 2012) which corroborate with the present findings.

Effects on Natural Enemies: Among the natural enemies, presence of mirid bugs and coccinellid beetles were found along with the insect pests of rice. The populations of both the predators remained at par in all the doses of insecticides including control (Table-3).Thus the application of Cartap hydrochloride75 SG indicates safer to these natural enemies.

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OCCURRENCE OF INSECT PESTS ON CABBAGE AND THEIR NATURAL ENEMIES IN THE PERIPHERY OF RAIPUR

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ABSTRACT: Studies on occurrence of insect pests and their natural enemies of cabbage were conducted through periodical surveys during 2007-08 and 2008-09 at the periphery Raipur. The major insect pest recorded were diamond-back moth, *Plutella xylostella* Linn. and two species of aphids (Cabbage aphid, *Brevicoryne brassicae* L. and Mustard aphid *Lipaphis erysimi* Kalt.). Among natural enemies, four species of predators *i.e.* lady bird beetles (*Coccinella repanda* Thunb., *Cheilomenes sexmaculata* Fab., *Micraspis discolar* Fabr., *Coccinella septempunctata* Linn.), one species of chrysopid predator, *Chrysoperla carnea* Stephens, and one species of Syrphid predator, *Syrphus* sp. were observed preying upon aphids, while *Aphidius sp.* was found to parasitize upon aphids.

Key words: Survey, insect pest, natural enemies, cabbage

INTRODUCTION

Among the vegetables, cabbage is a most important vegetable crop being grown throughout the world including India. The chief constraint in production of cabbage, is damage caused by pest complex right from germination to harvesting stage (SINGH *et al*., 2013). In India, this crop is attacked by a number of insect pests *viz*., tobacco caterpillar, diamondback moth, painted bug, cabbage semi-looper, aphids, flea beetle etc. have been reported to feed on cabbage **(**ZAZ and KUSHWAHA, 1983; MAKHMOOR and VERMA, 1989; DEVJANI and SINGH, 2002; MANDAL and PATNAIK, 2006; SINGH et al., 2013**)**. The extent of damage due to these pests in India is ranging from 7 to 90 per cent with consequent reduction in yield from 20 to 80% (PRASAD, 1963). Similarly, there is also a long array of natural enemies, which associated with these insect pests of cabbage **(**ZAZ and KUSHWAHA, 1983; MAKHMOOR and VERMA, 1989; MANDAL and PATNAIK, 2006**)**. However, no systematic study has been conducted so far to record the array of various insect pests and their natural enemies associated on cabbage crop at Raipur in the Chhattisgarh state, which is useful in deciding the appropriate strategies for ecofriendly pest management. Keeping these points in view the present investigation was carried out during 2007-08 and 2008-09 at Raipur.

MATERIALS AND METHODS

In order to study the insect pest of cabbage crop, field survey was conduced in small vegetable growers farm yard of different locations at Patan, Raipura, Chherikhedi and Horticulture Research farm of IGKV, Raipur for two consecutive crop seasons during 2007-08 and 2008-09. The selected vegetable growers were mostly organic farmers; they mostly avoid use of chemical pesticides. The observations on population of different insect pests and their natural enemies were recorded at weekly interval in the selected sites.

RESULTS AND DISCUSSION

Survey of insect pest and their natural enemies on cabbage was conduced at vegetable field of small farmer’s farm yard at different locations in Patan, Raipura and Chherikhedi and Horticulture farm, College of Agriculture, IGKV, Raipur, for two consecutive *rabi* seasons during 2007-08 and 2008-09. The infestation of different insect pests and natural enemies were recorded from the farmer's field are presented in Table-1 & 2, respectively.

Table-1: Survey of insect pests in cabbage to find the dominant species of the pests around Raipur, during *Rabi* season 2007-08 and 2008-09

S.No.	Common Name	Scientific Name	Stage of Crop	Nature of Damage	Peak Population	Pest status
(A) Order- Hemiptera: (a) Aphididae						
1	Cabbage aphid	*Brevicoryne brassicae* Linn.	Trans-planting to harvest	Nymph & adult suck sap from leaves.	109.25 Nymph & Adult /3 Leaves	Regular
2	Mustard aphid	*Lipaphis erysimi* Kalt.	Transplanting to harvest	Nymph & adult suck sap from leaves	94.15 Nymph & Adult / 3 leaves	Regular
(b) Pentatomidae						
1	Painted bug	*Bagrada cruciferarum* Kirk.	Transplanting to harvest	Nymph & adult suck sap from leaves	0.35 Nymph & Adult / 3 leaves	Sporadic
2	Green sting bug	*Nezara virudula* Linn.	Transplanting to harvest	Nymph & adult suck sap from leaves.	0.65 Nymph & Adult / 3 leaves	Sporadic
(c) Aleyrodidae						
1	Cotton whitefly	*Bemesia tabaci* Genn.	Trans planting to harvest	Nymph & adult suck sap from leaves.	0.25 Nymph & Adult / 3 leaves	Sporadic
(B) Lepidoptera: (a) Plutellidae						
1	Diamond back moth	*Plutella xylostella* Lin.	Nursery to harvest	Larvae damage the foliage	36.65 Larvae/5 Plants	Regular
(b) Noctuidae						
1	Cabbage semi-looper	*Plusia orichalcea* Fab.	Transplanting to harvest	Larvae damage the foliage	2.55 Larvae/ 5 Plants	Sporadic
2	Tobacco caterpillar	*Spodoptera litura* Fab.	Transplanting to harvest	Larvae damage the foliage	3.15 Larvae/ 5 Plants	Sporadic
(c) Pieridae						
1	Cabbage butterfly	*Pieris brassicae* L.	Transplanting to harvest	Larvae damage the foliage	1.85 Larvae/5 Plants	Occasion al
(d) Arctiidae						
1	Bihar hairy caterpillar	*Spilosoma obliqua* Walker	Transplanting to harvest	Larvae damage the foliage	2.20 Larvae/ 5Plants	Occasion al
(C) Orthoptera: (a) Acrididae						
1	Short-horned grashopper	*Atractomorpha crenulata* Fab.	Trans-planting to harvest	Adult & nymphs damage to leaves	1.25 Nymph & Adults/ 5 Plants	Sporadic
(D) Coleoptera: (a) Chrysomellidae						
1	Flea beetle	*Phyllotreta cruciferae* Goeze	Seedling to harvest	Make irregular holes on vegetative parts	1.60 Larvae/ 5 Plants	Sporadic
(D) Hymenoptera: (a) Tenthredinidae						
1	Mustard sawfly	*Athalia lugens proxima* Klug.	Transplanting to harvest	Skeletonize the leaves completely	0.35 Larvae/ 5 Plants	Occasion al

Cabbage crop was found attacked by thirteen species of insect pest belongings ten families and five orders, in which two species are aphids (Cabbage aphid, *Brevicoryne brassicae* L. and Mustard aphid *Lipaphis erysimi* Kalt.), painted bug, *Bagrada cruciferarum* Kirk., green Stink bug, *Nezara virudula* L., cotton whitefly, *Bemesia tabaci* Genn., diamond-back moth, *Plutella xylostella* Linn., cabbage semi-looper, *Plusia orichalcea* Fab., tobacco caterpillar, *Spodoptera litura* Fab., cabbage butterfly, *Pieris brassicae* L., Bihar hairy caterpillar, *Spilosoma obliqua* Walker, short-horned grasshopper, *Atractomorpha crenulata* Fab., flea beetle, *Phyllotreta cruciferae* Goeze and mustard sawfly, *Athalia lugens proxima* Klug. *etc.* Population of insect pest other than aphids, diamondback moth and tobacco caterpillar appeared in trace in number.

The present findings are in accordance with MANDAL and PATNAIK (2006) who reported twenty species of insect pests belonging to six orders and fourteen families on the cabbage crop in coastal Orissa. Similarly, BADJENA and MANDAL (2005) did noticed *Plutella xylostella, Spodoptera litura* and three species of aphids on cauliflower. DEVJANI and SINGH (2002) also reported the occurrence of twenty four insect species belonging to five orders and twelve families with varying intensity of attack, period of activity and species composition on cauliflower.

Table- 2: Survey of natural enemies of insect pest of cabbage around Raipur, during *Rabi* season 2007-08 and 2008-09

S.No.	Common name	Scientific name	Nature of damage	Peak population	Status
(A) Coeoptera: (a) Coccinellidae					
1	Lady bird beetle	*Coccinella repanda* Thunb.	Grubs and Adults feed on aphids	4.80 Grubs and Adults/ Five Plants	Major
2	Lady bird beetle	*Cheilomenes sexmaculata* Fab.	Grubs and Adults feed on aphids	2.95 Grubs and Adults/ Five Plants	Major
3	Lady bird beetle	*Micraspis discolar* Fab.	Grubs and Adults feed on aphids	1.20 Grubs and Adults/ Five Plants	Minor
4	Lady bird beetle	*Coccinella septempunctata* L.	Grubs and Adults feed on aphids	0.45 Grubs and Adults/ Five Plants	Minor
(B) Neuroptera: (a) Chrysopidae					
1	Chrysopid predator	*Chrysoperla carnea* Stephens	Grubs and Adults feed on aphids	0.85 Grubs and Adults/ Five Plants	Minor
(C) Diptera: (a) Syrphidae					
1	Syrphid fly predator	*Syrphus sp.*	Maggots feed on aphids	1.65 Maggots/ Five Plants	Minor
(D) Hymenoptera: Braconidae					
1	Aphidius parasitoids	*Aphidius sp.*	It mummified to the aphids and single parasite comes out from each parasitized aphid	22.67% Mummified Aphids	Major

Similarly, different kinds of natural enemies were also recorded from the cabbage crop ecosystem, which were found preying and parasitizing the insect pest feeding on cabbage. Seven species of natural enemies belonging to four families and four orders were found attacks different insect pest species of cabbage. Among them four species of predatory lady bird beetle (*Coccinella repanda* Thunb., *Cheilomenes sexmaculata* Fabr., *Micraspis discolar* Fabr., *Coccinella septempunctata* Linn.), one species of chrysopid predator, *Chrysoperla carnea* Stephens, one species of syrphid fly predator, *Syrphus sp.* were observed preying upon aphids, while *Aphidius sp.* was found parasitize upon aphid species. Population of natural enemies' other than ladybird beetle and syrphid fly appeared in trace in number.

Present findings are in agreement with MANDAL and PATNAIK (2006) who also found four species of coccinellids, two species of syrphid fly and single species of chrysopid, feeding on all the three species of aphids that attack cabbage crop in the coastal Orissa. Similarly BADJENA and MANDAL (2005) observed four species of ladybird beetle and two species of syrphid fly on cauliflower. DEVJANI and SINGH (2002) also recorded the presence of nineteen insect species of natural enemies belonging to four orders and six families on cauliflower.

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FIELD EFFICACY OF NEWER INSECTICIDES ON POD BORER (*LAMPIDES BOETICUS* LINN.) IN GREEN GRAM (*VIGNA RADIATA*) (L.) WILZECK

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ABSTRACT: A field experiment was conducted to study the effect of different newer insecticides on pod borer (*Lampides boeticus*) of green gram variety 'Nayagarh Local' during summer, 2012. Pod borer (*Lampides boeticus*), Lycaenidae, Lepidoptera was found damaging the crop from 52 DAS to 72 DAS with peak population of 2 larvae/plant on 64 DAS. Amongst six insecticides tested spinosad and emmamectin benzoate were the most promising insecticides against the pest species(2.66 and 3.33 insects per 10 plants, respectively) as against 18.33 nos/ 10 plant in untreated control. Cartap hydrochloride, cyazypyr were the other promising insecticides against the pod borers and kept the pest population less than 6.5/10plants. Thiomethoxam and chlorpyriphos did not produce any significant effect against the pod borer. All the test products except chlorpyriphos yielded more than 5.0q/ha as against 4.42q/ha in control.

Key words: *Lampides boeticus,* newer insecticides

INTRODUCTION

Green gram *Vigna radiata* (L.) Wilzeck is considered as the third most popular pulse crop cultivated throughout India. About 70 per cent of the world's production of greengram is in India wherein it is cultivated annually in an area of 2.99 million hectares with total production and average productivity of 1.02 million tonnes and 343 kgs per hectare, respectively (ANON., 2004). Insect pests cause around 10-15 per cent reduction in yield and are one of the potential constraints that limit pulse production in India (PAI and DHURI, 1991; AKHILESH KUMAR and PARASNATH, 2003). Especially pod borers influence the productivity to a greater extent (SAHOO and SENAPATI, 2000). Among the pod borers, the blue butterfly, *Lampides boeticus* Linnaeus (Lycaenidae: Lepidoptera) is considered as one of the major borers of pulses (GANAPATHY and DURAIRAJ, 2000). It caused loss to the crop by boring into the flower buds and pods and consuming and contaminating the seed wholly or partly. The pod borer was known to cause considerable damage to different pulse crops by reducing seed yield and can be effectively controlled by cypermethrin, deltamethrin, triazophos and endosulfan (YADAV and CHAUHAN, 2000). Therefore, the main aim of the study was to evaluate efficacy of different newer insecticides to develop an integrated approach for the management of the pod borer to reduce seed yield losses in green gram without less bad effects on environment.

MATERIALS AND METHODS

The study on pest complex of green gram was conducted in a replicated trial in the experimental field of Department of Entomology, Bhubaneswar during summer 2012. Green Gram variety "Nayagarh local" was line sown at 15cm apart from plant to plant and 20 cm. between the rows. Five insecticides of different groups with novel mode of action viz., cartap hydrochloride, cyazypyr, emmamectin benzoate, spinosad, thiomethoxam, along with one standard check chlorpyriphos were tested randomly along with one untreated control. Regular monitoring of the insect pest was done and the insecticidal treatments was imposed i.e. 40 days after sowing of the crop. Observation on the pod borer incidence was recorded at the time of maturity of the crop from each treatment plots . Ten plants were selected randomly and the total no. of pods and the infested pods were counted and was expressed as percentage infested pods by pod borer as follows:

$$\% \text{ infested pods} = \frac{\text{Total no. of infested pods}}{\text{Total no. pods}} \times 100$$

After examination of the each individual pod collected from each plant was examined thoroughly for the presence of holes by pod borer and also by splitting the pods, the pod borer species present was also noted. Statistical analysis of the data was done following GOMEZ and GOMEZ (1984).

RESULTS AND DISCUSSION

The pod borer was found damaging the crop from 52 DAS to 72 DAS with peak population of 2 larvae/plant on 64 DAS. Amongst six insecticides tested spinosad and emmamectin benzoate were the most promising insecticides against the pest species (2.66 and 3.33 insects/10 plants, respectively) as against 18.33 nos/ 10 plant in untreated control. Cartap hydrochloride, cyazypyr were the other promising insecticides against the pod borers and kept the pest population less than 6.5/10 plants (Table-1).

Table-1: Effect of newer insecticides on pod borer, *L. boeticus* of greengram in Odisha (Summer 2012)

Treatment	**Dose (Kg a.i./ha)**	**Pod borer (Population/10 plant)***		**Yield (q/ha.)**	**Benefit over control (%)**
		L. boeticus	Pod damage		
T1 (Cartap hydrochloride)	0.50	5.00(2.34)	11.90%	5.08	14.93
T2 (Emmamectin benzoate)	0.007	3.33(1.93)	9.52%	5.16	16.74
T3 (Spinosad)	0.067	2.66(1.76)	6.66%	5.23	18.32
T4 (Thiomethoxam)	0.031	10.00(3.23)	18.42%	5.02	13.57
T5 (Cyazypyr)	0.08	6.33(2.60)	14.28%	5.10	15.38
T6 (Chlorpyriphos)	0.50	12.33(3.57)	20.51%	4.96	12.21
T7 (Untreated control)	_	18.33(4.33)	27.02%	4.42	
S.E.(m)(+_)	0.158			0.01	
C.D.	0.48			0.03	

* Mean of three replications, Figures in parenthesis are square root transformation values.

Fig. 1: Pod damage by *Lampides boeticus*

Fig. 2: Larva of *Lampides boeticus*

Thiomethoxam and chlorpyriphos did not produce any perceptible effect against the pod borer. Among the insecticides significantly highest yield was obtained from spinosad (5.25q/ha.) closely followed by emmamectin benzoate (5.16 q/ha) and both the treatments were at par. However, more than 5.0 q/ha seed yield was obtained from cartap hydrochloride, emmamectin benzoate, spinosad, thiamethoxam and cyazypyr. On the contrary chlorpyriphos treatment yielded 4.96 q/ha as against 4.42 q/ha in the untreated control plots.

The present findings are in close confirmity with reports of UDIKERI *et al.* (2004) who reported similar impact of emamectin benzoate on cotton with a fairly high level of efficacy against boll worms. Highest cotton yield was however, reported from spinosad treated crops (DANDALE *et al*., 2000 and VADODARIA *et al.,* 2002). Similarly, higher yield reported in chick pea due to spinosad treatment against pod borers.Thus considering the overall impact of the test insecticides and a novel group of insecticides spinosad and emamectin benzoate may be recommended for integrating into the IPM system in greengram in Odisha.

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POPULATION DYNAMICS OF BROWN PLANT HOPPER, *NILAPARVATA LUGENS* (STAL.) AND MIRID BUG, *CYRTORHINUS LIVIDIPENNIS* (REUTER) IN UPLAND TRANSPLANTED RICE AGRO-ECOSYSTEM

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ABSTRACT: Brown plant hoppers have been an important menace to rice in Asian countries not only because of their severe damage but also of their ability to transmit virus diseases. Field experiment was conducted at research farm of Indira Gandhi Krishi Vishwa Vidyalaya, Raipur during *kharif* season 2013-14. The maximum population of brown plant hopper, *Nilaparvata lugens* (Stal.) was recorded in last week (44 SMW) of October with 5.25 nymph/adult/25 sweeps showed significant negative correlation with minimum temperature (r = - 0.627*), evening relative humidity(r = - 0.619*), average relative humidity (r = - 0.554*) while non-significant positive correlation with morning relative humidity and sunshine hours in upland transplanted rice agro-ecosystem (UTP). The maximum population of mirid bug was recorded during 3rd week (42 SMW) of October with 2.75 adult/25 sweeps and showed non-significant correlation with weather parameters and brown plant hopper at 1% and 5% level of significance in UTP.

Key words: Brown plant hopper, Mirid bug, Rice, Transplanted, Upland, Weather parameters

INTRODUCTION

Chhattisgarh state is known as the rice (*Oryza sativa* L.) bowl of India because nearly 74-76 per cent area during rainy season is under rice cultivation. In Chhattisgarh there are 5 agro-ecosystems in which rice is cultivated with different practices. These ecosystems are: upland ecosystem, midland ecosystem, lowland ecosystem: drought prone and lowland favourable, submergence prone and controlled irrigation and flood irrigated ecosystem (ANNONYMOUS, 2009). Raipur is situated in central-eastern part of Chhattisgarh and lies between 21^{o} 6' North latitude and 18^{o} 36' East longitude with an altitude of 289.56 meters above the mean sea level. Rice plant hoppers are major pests across the country especially in irrigated rice. Two species *viz.,* Brown plant hopper (BPH), *Nilaparvata lugens* (Stal.), white backed plant hopper (WBPH), *Sogatella furcifera* (Horvath) (Hemiptera: Delphacidae) are of economic importance. Besides direct damage to crop by nymphs and adults sucking phloem sap and leading to hopper burn, BPH also transmits viral disease like rice ragged stunt virus and rice grassy stunt virus (WATANABE and KITAGAWA, 2000).

Mirid bug, *Cyrtorhinus lividipennis* Reuter (Hemiptera: Miridae) is an important egg and nymph predator of plant and leaf hoppers in both tropical and temperate rice fields. Predators are distributed in about 167 families belonging is 14 order of class insecta. In Chhattisgarh, BPH has assumed greater importance due to its severe outbreak in 1975 and consequent yield losses reported to the extent of 34.3% (GANGRADE *et al*., 1978). In 1960s and 1970s, with the beginning of green revolution, the cropping systems and cultural practices were mostly focused to achieve higher yield using huge amount of chemical fertilizers in rice varieties, while the excessive use of

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nitrogen fertilizer was considered to be one of the key factors in shifting of BPH from minor to major insect pest (DYCK and THOMAS, 1979). The present study was undertaken to find out the influence of meteorological parameters like temperature (maximum and minimum), rainfall, sun shine (hours) and relative humidity on light trap catches of aforesaid insect pests so that active period may be ascertained for controlling them in the field condition to avoid the loss to the rice crop caused by them.

Upland rice is usually grown in unfavourable soil and weather conditions and needs regular attention for obtaining good productivity. The diversity of upland rice environments gives rise to a more heterogeneous insect fauna compared with the more homogeneous lowlands. A wide array of soil-inhabiting pests -ants, termites etc. common in upland rice cannot tolerate flooding. The less stable upland environment more restricted growing season, smaller area planted, greater drought stress-poses greater problems of survival to insects, which have overcome them by polyphagy, greater longevity, off-season dormancy and dispersal. In upland rice a rich fauna of natural enemies exists, but they face even greater problems of survival than the pests (LITSINGER *et al.,* 1987). Aerobic rice is direct seeded in non-puddled field requires less water and labour than flooded rice established via transplanting, thus aerobic rice system can reduce water application relative to conventionally transplanted system. Populations of leaf hopper and spiders in upland transplanted rice agro-ecosystem are influenced by ecological and biological factors, crop physiology, climate changed and farmer's control practices. The aim of this study was to determine the changes in "population dynamics of brown plant hopper, *Nilaparvata lugens* (Stal.) and mirid bug, *Cyrtorhinus lividipennis* in upland transplanted rice agro-ecosystem between different stages of rice and it's relation with the biotic and abiotic factors. It is hoped that the findings from the study can contribute to the more ecological precise ways in dealing with outbreaks and control of insect pests of rice.

MATERIALS AND METHODS

The population of rice brown plant hopper and mirid bug was recorded through sweeping net. Sampling was done randomly in four places by 25 sweep of rice field in morning, at weekly interval. The observations on occurrence of brown plant hopper and mirid bug were recorded by taking total 4 samples from 4 locations in rice ecosystem. All samples were collected near the center of the ecosystem, at least 5 m from the edge in order to reduce edge effects. Weekly collection were calculated for determining the population dynamics of rice brown plant hopper and mirid bug according to standard meteorological weeks prescribed by the Agro-meteorological Department, Raipur IGKV (C.G.) were used. Correlation analysis was carried out between field population of brown plant hopper, mirid bug and weather parameters during *kharif* season 2013-14. Regression analysis was worked out as per method given by GOMEZ and GOMEZ (1985).

RESULTS AND DISCUSSION

Population dynamics of brown plant hopper, *Nilaparvata lugens* (Stal.):

Brown plant hopper, *Nilaparvata lugens* nymph/adult populations initiated in the upland transplanted rice ecosystem (UTP) during 3rd week (38 SMW) of September with 2.00 nymph/adult/25 sweeps and remain up to crop harvesting. The maximum population of *Nilaparvata lugens* was recorded in last week (44 SMW) of October with 5.25 nymph/adult/25 sweeps. The average population varied from 0.00 to 5.25 nymph/adult/25 sweeps during *kharif* season. The seasonal mean population of *Nilaparvata lugens* was 1.55 nymph/adult/25 sweeps during cropping season. The present findings corroborate with the peak incidence of brown plant hopper and are in agreement with the reports of

GARG (2012) who reported that the highest population BPH found during 2nd fortnight of October. RAJENDRA (2009) reported that BPH only during reproductive stage *i.e.*, second fortnight of October and increased steadily reaching a peak population in upghat transplanted paddy ecosystem. NAGANAGOUD *et al.* (1999) reported, the pest occurrence definitely after 60 days of transplanting during the *kharif* season, coinciding with the peak occurrence during October – November in Tungabhadra Project Area of Karnataka. KHAIRE and DUMBER (1984) observed the adults BPH were first to appear in mid–September and reached peak numbers in October- November in Maharashtra.

Correlation co-efficient between population of BPH :

It was evident from the data (Table 2) that the population of brown plant hopper, showed significant negative correlation with minimum temperature (r = - 0.627*), evening relative humidity(r = - 0.619*), average relative humidity (r = - 0.554*) and non-significant negative correlation with maximum temperature (r = - 0.020), average temperature (r = - 0.513), and average rainfall (r = - 0.491) while non-significant positive correlation with morning relative humidity (r = + 0.071) and sun shine hours (r= + 0.346). The regression equation for weather parameter like maximum temperature are [y = -0.013x + 30.23, R^2 = 0.000], minimum temperature [y = -0.664x + 24.54, R^2 = 0.393], average temperature [y = -0.339x + 27.38,R^2 = 0.263], Rainfall(mm) [y = -18.67x + 98.68, R^2 = 0.240], morning relative humidity [y = 0.109x + 92.60, R^2 = 0.005] evening relative humidity [y = -3.798x + 77.99, R^2 = 0.383], average relative humidity[y = -1.844x + 85.29,R^2 = 0.307] and bright sunshine hours[y = 0.432x + 3.542, R^2 = 0.119]. The present findings are corroborate with NAIR *et al.,* (1980) who reported that the plant hopper population was significantly influenced by climatic factors especially rainfall in association with high relative humidity and high temperatures. REDDY *et al.* (1983) reported that, relative humidity had a significant and negative effect on populations of *Nilaparvata lugens* (Stal.). RAJENDRA (2009) reported that the BPH showed non-significant negative correlation with maximum temperature (r = -0.279) and minimum temperature (r = - 0.684). Similarly, a non significant positive relationship was noticed with average rainfall (r = + 0.342), morning relative humidity (r = + 0.536) and evening relative humidity (r = + 0.241). BARWAL and RAO (1986) reported negative relationship between brown plant hopper and temperature. NARAYANSAMY *et al.* (1979) reported positive correlation between BPH population and relative humidity. MANCHARAN and JAYARAJ (1979) reported non-significant relationship between *Nilaparvata lugens* population and maximum temperature, relative humidity and rainfall.

Population dynamics of mirid bug, *Cyrtorhinus lividipennis*

Mirid bug *Cyrtorhinus lividipennis* Reuter was recorded in upland transplanted rice ecosystem. The peak populations of mirid bug were found during 3rd week (42 SMW) of October with 2.75 adult/25 sweeps. The seasonal mean populations of mirid bug were observed 1.55 nymph/adult/25 sweeps during cropping season in upland transplanted rice (Table 1 and Fig.1.). The present findings are in agreement with the report of CHIU (1979) and RAJENDRA (2009) who reported that the population of *Cyrtorhinus lividipennis* was highest during November in upland transplanted paddy ecosystem.

Table-1: Population of brown plant hopper, Nilaparvata lugens (Stal.) and mirid bug in upland transplanted rice ecosystem

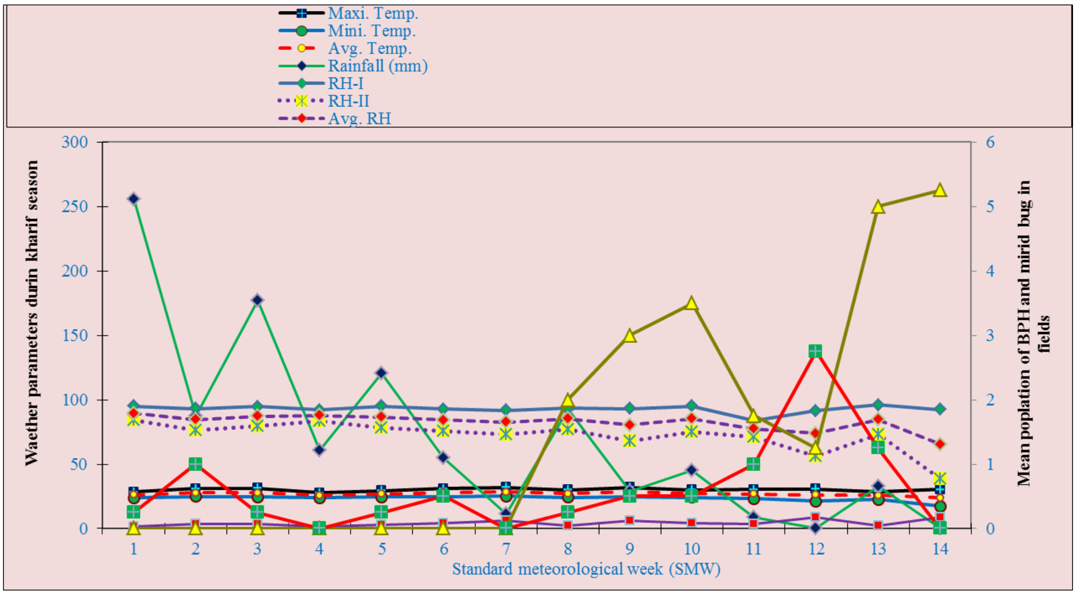

Fig.-1: Field population of brown plant hopper, *Nilaparvata lugens* and mirid bug and weather parameters

Table-2: Correlation coefficient (r) between mean population of *Nilaparvata lugens* (Stal.) in upland transplanted rice ecosystem and abiotic factors

Correlation with			Correlation coefficient (r)	Coefficient of determination (r^2)	Coefficient of variation	Regression equation value
Rice insect	**Weather parameter**					
Mean population of BPH in upland transplanted rice ecosystem	Temperature (°C)	Maxi. Temp.	-0.020	0.000	0.042	y = -0.013x + 30.23, R^2 = 0.000
		Mini. Temp.	-0.627*	0.394	39.360	y = -0.664x + 24.54, R^2 = 0.393
		Average Temp.	-0.513	0.264	26.364	y = -0.339x + 27.38, R^2 = 0.263
	Rainfall (mm)		-0.491	0.241	24.090	y = -18.67x + 98.68, R^2 = 0.240
	Relative humidity (%)	Morning	0.071	0.005	0.506	y = 0.109x + 92.60, R^2 = 0.005
		Evening	-0.619*	0.383	38.333	y = -3.798x + 77.99, R^2 = 0.383
		Average	-0.554*	0.307	30.727	y = -1.844x + 85.29, R^2 = 0.307
	Sun shine (hours)		0.346	0.119	11.945	y = 0.432x + 3.542, R^2 = 0.119

*Significant at 5 % level (2.179), **Significant at 1 % level (3.055)

Perusal of data presented (Table-3) mean population of mirid bug showed non-significant positive correlation with maximum temperature (r = + 0.098) and sun shine hours (r= + 0.311) while non-significant negative correlation with minimum temperature (r = - 0.181), average temperature (r = - 0.270), average rainfall (r = - 0.328) morning relative humidity (r = - 0.202), evening relative humidity (r = - 0.269), average relative humidity (r = - 0.294) at 5 and 1 per cent level of significance. The regression equation for weather parameter like maximum temperature are [y = 0.172x + 30.10, R^2 = 0.009], minimum temperature [y = -0.507x + 23.81, R^2 = 0.032], Average temperature [y = -0.167x + 26.96, R^2 = 0.009], Rainfall (mm) [y = -32.97x + 89.70, R^2 = 0.107], morning relative humidity [y = -0.819x + 93.26, R^2 = 0.040] evening relative humidity [y = -4.36x + 74.74, R^2 = 0.072], average relative humidity[y = -2.589x + 84.00, R^2 = 0.086] and bright sunshine hours[y = 1.027x + 3.590, R^2 = 0.096]. On the contrary RAJENDRA (2009) reported that the mirid bug showed non-significant negative correlation between with maximum temperature while positive significant correlation with minimum temperature and morning relative humidity and Positive and non significant relationship with evening relative humidity (r = + 0.568) and average rainfall (r = + 0.634). These findings are in close agreement with VIJAYKUMAR (2002) who reported positive correlation with average rainfall, morning and evening relative humidity.

Table-3: Correlation coefficient (r) between mean population of mirid bug in lowland rice ecosystem and abiotic factors

Correlation with			**Correlation coefficient (r)**	**Coefficient of determination (r^2)**	**Coefficient of variation**	**Regression equation value**
Rice insect	**Weather parameter**					
Mean population of mirid bug in upland transplanted rice ecosystem	Temperature (^{0}C)	Maxi. Temp.	0.098	0.010	0.966	y = 0.172x + 30.10, R^2 = 0.009
		Mini. Temp.	-0.181	0.033	3.288	y = -0.507x + 23.81, R^2 = 0.032
		Average Temp.	-0.096	0.009	0.920	y = -0.167x + 26.96, R^2 = 0.009
	Rainfall (mm)		-0.328	0.108	10.760	y = -32.97x + 89.70, R^2 = 0.107
	Relative humidity (%)	Morning	-0.202	0.041	4.062	y = -0.819x + 93.26, R^2 = 0.040
		Evening	-0.269	0.072	7.231	y = -4.36x + 74.74, R^2 = 0.072
		Average	-0.294	0.087	8.673	y = -2.589x + 84.00, R^2 = 0.086
	Sun shine (hours)		0.311	0.096	9.646	y = 1.027x + 3.590, R^2 = 0.096

*Significant at 5 % level (2.179), **Significant at 1 % level (3.055)

Correlation co-efficient between brown plant hopper and mirid bug

It was evident from the data (Table 4) that the mirid bug showed non-significant positive correlation with brown plant hopper (r = + 0.108) at 5 and 1 per cent level of significance. These findings are in agreement with RAJENDRA (2009) reported that the BPH showed significant positive correlation with natural enemy fauna such as spider per hill, mirid per hill, staphylinidae and odonata. These findings are in conformity with OOI (1980) and LUA (1985) in Gung XI, analysed the correlation of population fluctuations of rice plant hoppers with their natural enemies in China. The density of mirid in the field was positively correlated with that of the delphacids. GAVARRA and RAROS (1982) reported low pest densities were caused by high predator densities. Commonly the outbreak of BPH was followed by increase in mirid population. RAI and CHANDRASEKAR (1979) observed increased mirid bugs to increase with the increasing population of the BPH and decreased with the declined population of the pest in Karnataka. Thus present study concludes that the October month is a crucial periods for pest and natural enemies protections. It is clear that the maximum population of the brown plant hopper and mirid bug were observed during 44 SMW and 42 SMW of October, respectively. In bio-meteorological interaction study mirid bug showed positive significant correlation with BPH (r = + 0.108) at 5 % 1% levels of significance.

Table-4: Correlation coefficient (r) between mean population of brown plant hopper, *Nilaparvata lugens* (Stal.) and mirid bug in upland transplanted rice ecosystem

Correlation with		Correlation coefficient (r)	Coefficient of determination (r^2)	Coefficient of variation	Regression equation value
Mean population of BPH in upland transplanted rice ecosystem	Mean population of mired bug in upland transplanted rice ecosystem	0.108	0.012	1.160	y = 0.040x + 0.543, R^2 = 0.011

*Significant at 5 % level (2.179), **Significant at 1 % level (3.055)

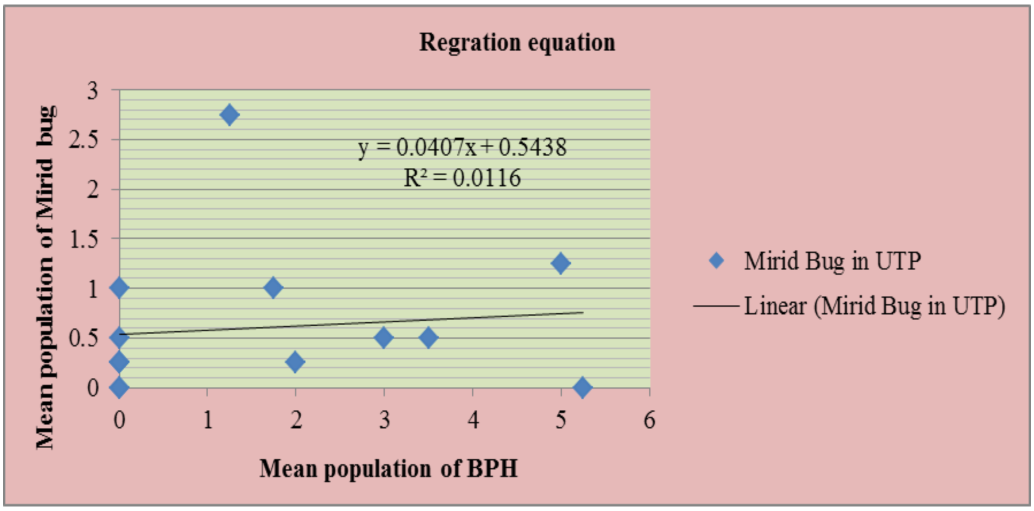

Fig-2: Regression equation between mean populations of brown plant hopper, *Nilaparvata lugens* and mirid bug in upland transplanted rice ecosystem (UTP)

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EMERGING PESTS OF FRUIT CROPS, LIKE MANGO, LITCHI, BAEL, TAMARIND, SWEET ORANGE, BANANA, PAPAYA AND GUAVA IN EASTERN INDIA

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MANGO

Mango shoot gall psylla, *Apsylla cistellata* Buckton (Hemiptera: Psyllidae) has been observed as an emerging pest of mango orchards in Mayurbhanj district of Odisha. This is a monophagous pest of mango, often seen causing serious damage in north Bihar, Uttar Pradesh, Uttrakhand and West Bengal (SUSHIL KUMAR *et al*., 2006). But in the year 2012 and 2013, this pest became a serious problem in Mayurbhanj district of Odisha and about 70 ha mango orchard in 2013 and 250 ha mango orchard in 2014 were affected by this pest, causing 100% crop loss. Gall formation initiated only after the tree starts flowering and fruiting, which directly interferes with the formation of inflorescence and thus adversely affects the yield of mango crop.

Conical green galls on central axis of mango twig

Adult females lay eggs at the sides of midribs during first week to end of March. Incubation lasts from first week of March to middle of August. Eggs hatch in the middle of August and gall formation start from first week of September. Nymphal period lasts from mid of August to end of February. Nymphs burst open the tissues and crawl to the adjacent buds to suck the cell sap and such feeding makes the buds develop scaly leaves that imbricate the central axis and forms hard conical green galls (Photo-plate) in the growing buds. Adult emergence starts from fourth week of February and continued up to third week of March.

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The mango leaf-cutting weevil, *Deporaus marginatus* Pascoe (=*Eugnamptus marginatus* Pascoe, Coleoptera: Attelabidae) has become a serious pest of mango in eastern India and difficult to control this pest. Adult weevils after emergence feed on the epidermis of young leaves, turning the affected leaves brown, curly and crumple. Stripped shoots can be easily seen on the infested plant. Adult feeding produces 'windowpanes' on young leaves. The gravid females excavate small cavities on either side of the midribs on upper surfaces of leaves for egg laying, one in each cavity varying from 2-14/leaf. Then it cut this leaf near the base from one edge through the midrib to the other edge and thus damage leaves containing eggs drop to the ground. Infested shoots become almost leafless. When pest density is high, adults can cause serious damage by their feeding alone. When young leaves are heavily bitten, they easily become dry and die. The larvae mine in the tissue of the fallen leaves and full grown larvae pupate in moist soil, within earthen cells. On emergence, the adults start new cycle.

Weevil congregation below the leaf

D. marginatus attacks delay growth of the root stock and grafting process. Its damage to the autumn shoots in orchard has a great impact on fruit setting and yield. Collection and destruction of fallen and egg loaded leaves and ploughing the soil under the crowns of plants to kill the pupae and also 2-3 applications of pesticides at weekly intervals when young leaves are 3 cm wide are suggested to control this pest. Leaf bagging with mosquito net/polythene bags is also recommended. However, these control measures are not practically feasible due to heavy rainfall in rainy season. This insect is a good flier and leaves the plant once sprayed and comes back shortly after rains wash away the sprayed pesticide. Development of pest alert model based on phenology i.e. synchronization between the development of young shoots and its larvae inhabiting the soil may provide clues for initiation of pest control is needed.

Early stage leaf damage by weevil

Red banded mango caterpillar, *Deanolis sublimbalis* Snellen (Lepidoptera: Pyralidae) previously considered as minor pest of mango, in recent two decades has assumed as a serious pest and now it is a threat to India's mango industry. *D. albizonalis* has been described as a major pest in Andhra Pradesh (ZAHERUDDEEN AND SUJATHA, 1993), West Bengal (SAHOO and DAS, 2004), Karnataka (VERGHESE, 1998). Presently it is causing serious damage in Odisha for last few years. The larva is quite distinctive, red in colour with white inter-segmental streaks and is about 22 mm long when fully grown.

Caterpillar damaging mango fruit

The pest infests mango fruits in all stages of fruit development, feeding on both the flesh and the immature kernel. During March the caterpillar bores into marble size fruit and after damaging one fruit migrates to another fruit. In grown up fruits, first instar larvae bore into the fruit in the lower third, usually near the beak region. First and second instars feed on the fruit pulp approaching towards the soft kernel. Later instars feed on the immature seed making several tunnels and complete its larval stages within the same fruit. If seed is already hard, they remain and feed on flesh to complete their larval stages. Rotting of fruits may occur due to secondary infection by microorganisms. Damaged fruits fall off the tree prematurely. Cracking of fruits may also be found at the point of entry hole.

Mango leaf webbers, *Orthaga* spp. is reported from various parts of the country having its sporadic occurrence and damage restricted to a few orchard/ tree in isolated areas (SUSHIL KUMAR *et al.,* 2006). Three species of *Orthaga* genus i.e. *O. euadrusalis, O. exvinacea and O. mangiferae* have been reported infesting mango in India and first reported on mango in Uttar Pradesh (TANDON and SRIVATAVA, 1982). Presently this pest is attaining serious proportions in eastern region especially Odisha. After cessation of rains, hardly any orchard is free from this pest. Its infestation starts from the month of April and goes up to December.

Eggs are laid singly or in clusters within silken webbings on leaves. Upon hatching, the caterpillars feed on leaf surface by scrapping. The larvae web the leaves and the terminal shoots into clusters. A webbed cluster of leaves harbours several larvae in the initial stage. Affected trees, present sickly appearance and can be observed from a distance due to brown dry clustered leaves. Later, they make web of tender shoots and leaves together and feed within. Generally, 1-9 larvae are found in a single web. Pupation takes place inside the webs in silken cocoons. However, the last generation (December-January) pupates in the soil. About 90% of the defoliated shoots observed to get dry and fail to fruit in the forthcoming season. The infestation is severe in shady conditions. Old orchards with lesser space between tree canopies have more infestation than open orchards.

The mango gall midge/ mango blister midge, *Erosomyia (indica) mangiferae* Felt. (Cecidomyidae: Diptera), is a major pest elsewhere in India, destroying flowers and up to 70% of set fruit (VERGHESE *et al*., 1988; SUSHIL KUMAR *et al*., 2006). The pest was not seen in the state of Odisha, however recent studies have revealed the presence of this pest, *Erosomyia* sp. in the region.

The midge infests and damages the crop in three different stages. The first attack is at the floral bud burst stage. The larvae tunnel the axis which prevents flower opening and thus destroy the inflorescence completely. Infested panicles have a characteristic right-angled bend, with a soiled exit hole, from which last instar maggots emerge. The mature larvae make small exit holes in the axis of the inflorescence and slip down into the soil for pupation. The second attack of the midge takes place at fruit set. The eggs are laid on the newly set fruits and the young maggots bore into these tender fruits, which slowly turn yellow which eventually drop before the marble stage. The third attack is on tender new leaves encircling the inflorescence. The most damaging one is the first attack in which the entire inflorescence is destroyed even before flowering and fruiting. The inflorescence shows stunted growth and its axis bends at the entrance point of the larvae. It finally dries up before flowering and fruit setting. Of 41 mango varieties & hybrids screened for inflorescence infestation at CHES, Bhubaneswar, damage ranged from 10-%. Highest damage was recorded in Mallika (90%), followed by Lat Sundari (80%). The average damage was recorded to be 45.21%, an alarming situation. The pest may get spread to other mango growing belts hence needs attention.

Fruit fly has also become a major problem in mango orchards in Bihar whereas **Anthracnose** (Die Back) has been found to be the most serious disease in mango in Bihar followed by powdery mildew, and blossom blight for last few years.

Litchi

Litchi, *Litchi chinensis* Sonnerat (Sapindaceae) is a delicious fruit indigenous to China but introduced to India via Japan in 7^{th} Century and today India is the second largest producer of litchi in the world after China (SUSHIL KUMAR *et al*., 2006). Eastern India comprising of Bihar, Jharkhand and West Bengal accounts for 85% of the total litchi production in India.

Incidence of **Bag worm, *Eumeta crameri*** larvae has been noticed throughout the year on litchi in Bihar with maximum population during the month of September-October. Bag worm larvae are known to infest the older leaves and bark of litchi trees. Young caterpillars construct silken bags covering with bark and dry twigs and by living inside scrap the leaf surface (AGRAWAL, 2002). Coffee, tea, maize, pomegranate, tamarind, castor, sandal, casuarina, cinnamon, *Shorea robusta*, are the alternate hosts of the bagworm (AGRAWAL and PATI, 2003). After mating, female laid eggs on pupal case. Newly emerged larva initially feed on dead mother, then constructs its own cage. Life cycle of the pest is completed in about 3 months and bug has usually 4 generations in a year. Silken bags can be removed as easily seen on the surface of leaf.

Litchi looper, *Perixera illepidaria* (Lepidoptera: Geometridae) is now becoming new threat to litchi production acquiring the status of major pest from minor importance in Bihar. Looper attacks tender leaves in mass and defoliate the new shoots. In severe attack, it completely defoliates the newly emerged flush. Besides litchi so many host plants *viz.* longan, rambutan, mango, and castor have been reported for this pest (KUMAR *et al.*, 2014). Incidence of this pest has been observed from July to December however, highest population in September- October. The total life cycle of looper is completed in around 25 days. Female lay eggs on the under surface of the leaves and egg hatches within 4-5 days. Larval and pupal periods are completed in 8-9 and 5-7 days, respectively (KUMAR *et al.*, 2014). This pest has 5-6 overlapping generations in a year.

Litchi stink bug, *Tessaratoma javanica* Thunberg (Hemiptera: Tessaratomidae) is found to be an emerging pest on litchi in Jharkhand and Bihar.

Earlier this pest was considered as a minor pest of litchi in India and low incidence of pest has been reported from different regions of India (KUMAR *et al*., 2008). An outbreak of this pest has been observed in litchi orchards in Jharkhand and Bihar drawing attention to the researchers for its effective management strategies (CHOUDHARY *et al*., 2013). In India, this pest is also noticed in all litchi growing areas in U.P., Punjab, H.P. and J. & K. Besides litchi, it also found to attack kusum, karanj, longan, rambutan, pummelo, castor, pomegranate, eucalyptus, loquat and rose are host plants of this bug ((SINGH *et al*., 2009).

Bug nymphs on litchi twigs

Incidences of this bug was found low to medium in Gumla, Khunti and Lohardaga litchi orchards at Ranchi and also in some of the orchards at Mujaffarpur during 2011-14. The hibernated adults observed active in the last week of January and started dispersing to litchi plants which coinciding with emergence of panicles on litchi variety Shahi. The population of nymphs of stink bug found to increase drastically from the second week of March and the highest population (up to 159 nymphs/ 30 cm shoot length in research farm orchard at Ranchi was recorded during the first week of April.

Damaged litchi fruits

Incidences of the **fruit borer, *Dichocrocis* sp.** (Pyralide: Lepidoptera) have been observed for the first time during March and April in the years 2012, 2013 & 2014 in the Deogarh district, Odisha and 20-25% fruits were infested by the borer during fruit developmental stage (side-photo-plate) and also caused fruit drop. Pest species identification is under process. Litchi (varieties: Bombai and Muzaffarpur) is also being cultivated in Barkote, Tileibani and Reamal block of Deogarh district in Odisha. Flowering comes during the month of January and the fruits mature in May.

Fruit borer inside litchi fruit

Affected shoots may be removed and all agronomic efforts such as ploughing and nutrient management should be done so that flushing takes place before the month of September. Moths can be excluded by enclosing the fruit panicles in nylon mesh bags, but is uneconomic in areas with high labour costs. National Research Centre, Litchi for Muzaffarpur suggests application of imidachlorpid 0.05% to control this pest having 1st spraying at pea stage and second spray at 15-20 days after first spray. Neem based products may be applied at the time of new shoot emergence to avoid heavy population of the pest.

Red weevil, *Apoderus blandus* Faust (Coleoptera: Curculionidae) has also been observed as an emerging pest of litchi in Bihar. This pest is already been reported from Saharanpur in U.P. (SINGH, 1974)). It attacks leaves, shoot and flower. Adult weevils congregate on the tender leaves and nibble irregular holes on the leaves and sometimes consume the entire leaf leaving the midrib only. The damage of red weevil is more severe at the time of shoot emergence as it prefers newly leaves therefore; newly established orchard/ nurseries are more vulnerable for pest attack (KUMAR *et al.,* 2011).

Powdery mildew has also been recorded as the most serious disease on litchi in Bihar.

Papaya

The papaya mealybug, *Paracoccus marginatus* (Hemiptera: Pseudococcidae) is a small polyphagous sucking insect with pest status that attacks several genera of host plants, including economically important tropical fruits, vegetables and ornamentals. This is a native of Mexico but the end of 20^{th} century it spreaded to the rest of Central America, the Caribbean Islands, Florida, and tropical South America. In Asia, it was reported from Indonesia, India and Sri Lanka in 2008. In India it was recorded in July 2007 at Tamil Nadu Agricultural University, Coimbatore (REGUPATHY, 2008) and subsequently spread to neighbouring districts. Now it is found in almost all the states of India (PRAKASH *et al*., 2014). Papaya mealybug now has become an important pest of papaya in Odisha and West Bengal.

Sweet Orange

The fruit sucking moth, *Ophideres* sp. (Noctuidae: Lepidoptera) recorded to be regular pest and infested the fruits of sweet orange (Variety- Nagpur Santra) during September-October, 2013 and damage caused by the pest resulted 15-20% fruit drop in about 500 ha in Reamal block of Deogarh district, which is known for sweet orange cultivation in the state of Odisha. Flowering came during the last week of January and the fruits matured in October-November.

Damaged fruit due to pest infestation

Fruit fall due to pest attack

In India, two species of fruit sucking moth, *Ophideres materna* and *O. fullonica* have been reported infesting sweet orange (SHIVANKAR *et al*., 2006). Pest species found infesting sweet orange in Odisha is under process of its identification. Poison baiting for fruit sucking moths with 20g malathion w.p. + 200 g jaggery with some vinegar or fruit juice in 2 litres of water per 25-30 trees and foliar application of dichlorovos @ 0.05% (National Research Centre for Citrus, Nagpur, 2010) and also to minimize the moth infestation bagging of fruit with paper bag may be done.

Banana

An emerging leaf and fruit spotting disease of banana cv. Grand Naine in protected cultivation in Odisha recorded to occur in severe form as a new kind of spotting disease on immature as well as matured bananas during 2014. The disease also occurs on leaves, pseudostem, peduncle, fruit stalk and most importantly on fruits. On immature and matured fruits, spots starts as reddish brown zone, which is surrounded by greenish water soaked halo. At maturity, the centre of spots splits, the damage doesn't extend to pulp, however in severe case fruit splitting occurs on matured fruits. Further, at maturity the fruit drops occur on severely infected bunches and makes them difficult to handle at harvest.

As per previous similar reports, pitting disease or Johnson fruit spot caused by *Pyricularia grisea* and the diamond spot caused by *Fusarium roseum* are the most common blemishes on the Cavendish banana group reported from Philippines (SAN JUAN, 1982). Further, STOVER *et al.* (1972) reported that diamond spot is caused by *Fusarium solani*, *F. paliidoroseaum* and possibly by other invading lesions initiated by *Cercospora hayi*.

Spots on pseudostem **Matured spots on fruits** **Fruit splitting in severe case**

However, identity of this disease is not yet confirmed, based on symptom it is it difficult to distinguish them either as diamond spot or pitting disease and further investigation is going on in proving the Koch's postulates of the isolated pathogen. Similar disease reports are also coming farmers growing banana in open field from some places of Odisha. However, similar such disease has not reported on banana from India so far. Since this disease, cause unsightly blemish, which affect the market value of fruit drastically, it needs attention and study to check further spread of this disease in Odisha.

In banana, **Panama wilt, Sigatoka disease** and **root knot nematode** were found to be the key pest of the crop in Bihar. Sigatoka disease was recorded to be the most distributed disease whereas Panama wilt was found to be the most economic loss causing disease.

Bael & Tamarind

The fruit borer, *Cryptophlebia ombrodelta* (Lower) (Tortricidae: Lepitoptera) earlier reported as a pest of legumes, macadamia, litchi, and longan fruit from other regions of India has been observed damaging bael (*Aegle marmelos*) and tamarind (*Tamarindus indica*) at CHES, Bhubaneswar, Odisha as first record on these crops from the eastern region of India.

Puparium partially in bore hole of tamarind

Fruit damage by the fruit borer in bael recorded to be 80% & 25% with an average of 45.51 and 9.91% during 2013 & 2014, respectively, causing premature fruit fall. In tamarind crop fruit damage was 10% during 2013 & 3.50% in 2014.

Another **fruit borer, *Cryptophlebia (Argyroploca) illepide*** (Lepidoptera: Tortricidae) is considered as a major pest of tamarind (MORTON, 1987) from different regions of India (ANONYMOUS, 2014). *C. illepide* is recorded to infest bael fruit and growing newly twigs and found to be prevalent during the entire fruiting season from July to April in Jharkhand region during 2012-2014.

Infested fruit of bael by fruit borer

The adult female lays eggs on young fruits or even found on growing tip of twigs. On hatching, the caterpillar bores into fruit and feed on the pulp leaving behind frass (LINGAPPA, and SIDDAPPAJI, 1981). Pupal cases were found to attach on infested fruits. The infested fruits rot and even drop off. The keeping quality of infested fruit also reduces down.

Larva feeding inside the fruit

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EMERGING PESTS OF VEGETABLES, GINGER AND TUBER CROPS IN EASTERN INDIA

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Chilli crop

Occurrence of **chilli gall midge, *Asphondylia capparis* Rubsaaman** in chilli crops is being recorded in eastern India especially in Odisha for last few years. Chilli gall midge incidence commences from October and continues till January end with peak incidence during November and December. The infestation declines in summer months.

Earlier infestation by this gall midge resulted in severe flower drop, reduction in yield, fruit size, seed number, production of malformed fruits and 42.10 % damage to floral parts in Tamil Nadu (RANGARAJAN and MAHADEVAN, 1974). *A. capparis* is considered as major pest that causes paprika floral galls (NAGARAJU, 2000). MARYANA *et al.* (2006) observed flower buds or very young pods of chilli transformed into galls and opined that when young pods were attacked, they did not grow normally and remained smaller than normal pods.

Infested chilli fruits

Whitefly*, Bemisia tabaci* has emerged as an important pest in vegetables and caused extensive economic damage. Earlier this pest was considered as a minor pest of vegetables. For last 4-5 years (2008-2013) this pest is occurring regularly and attained the major pest status and currently observed infesting vegetable crops like chilli, tomato and okra in Bhadrakh district, Odisha, causing considerable yield losses. This pest damages the crops by direct feeding through sucking the cell sap and excretion of honeydew that promotes the growth of sooty mold on leaves and different plant parts. Both nymphs and adults feed on lower surface of the leaves causing deformation of young leaves. However, they cause maximum damage through transmission of important viral diseases like little leaf in brinjal, leaf curl in tomato and chilli, YVMV in okra, apical leaf curl virus in potato and many viral diseases in cucurbits, beans and cowpea.

Thrips and **mite** complex were noticed throughout with 10.0% infestation in Bihar during 2012-14.

In chilli, **Leaf Curl & Mosaic complex** disease with 19% incidence, followed by Anthracnose (12.1%), Mosaic (18.8%) and Bacterial Wilt (9.0%) were found to be the most serious diseases in Bihar during 2012-14.

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Brinjal/egg plant

Mealybug, *Phenacoccus solenopsis* Tinsley (Pseudococcidae: Hemiptera) has become is a major threat to agriculture and horticulture in many tropical and subtropical countries including India. In India, this pest considered as minor pest earlier, has acquired the status of major pest of cotton in Punjab, Haryana and Rajasthan. Incidences of *Phenacoccus solenopsis* on vegetables like brinjal, okra and ornamental like *Hibiscuss rosasinensis* in a serious proportion for last 4-5 years in West Bengal. Brinjal is an important vegetable crop in West Bengal.

Brinjal shoot & leaves infested by the mealy bug

Mealybugs are small soft-bodied sucking insects covered with white mealy wax, which often extends laterally to form a series of wax tassels. *P. solenopsis* causes crinkling, twist and condense flower, bud, and bolls growth. In brinjal, shoot and fruit borer infestation was most serious throughout the survey, varying 6-65% in Bhagalpur area in Bihar during 2012-14.

Phomopsis blight (9.0%) and **Bacterial wilt** with 18.7% incidence were found to be the most distributed disease in brinjal in Bihar during 2012-14.

Tomato

Tomato Spotted Wilt Virus (TSWV): An emerging threat to tomato and chilli cultivation in eastern India. TSWV incidences on tomato and chilli have been recorded in recent years in Bhubaneswar region. Currently this virus started spreading in the region and its incidence has been recorded in tomato fields near Rourkela in 2013. Thrips (*Frankliniella occidentalis*) is the vector of this virus.

Before 1990, TSWV was considered a monotypic group of plant viruses. Currently at least 12 distinct viruses (species) are on record in the *Tospovirus* genus. TSWV has a host range spanning several hundred species in both monocotyledonous and dicotyledenous plants.

During the 1980's TSWV caused significant losses on peanuts, tobacco and tomatoes in the Southeastern United States. Groundnut bud necrosis virus of this genre causes significant disease losses to groundnut production in India. TSWV is the key disease of tomato in northern Florida and southern Georgia (MOMOL *et al*., 2002).

Tomato plant infected by TSWV

Tomato and chilli plants infected with TSWV are usually stunted and tip of the leaves show a purplish discoloration. TSWV causes distinctive yellow ring-spots on mature tomato fruits. Cultural practices and varietal selection have proven effective in minimizing losses due to TSWV in some field crops. A series of risk factors including prior history, planting date, cultivar selection and plant and row spacing have been identified as critical factors. Many challenges remain as investigations of Tospoviruses continue.

TSWV infected tomato

In tomato, **fruit borer** infestation was noticed irrespective of cultivated varieties especially more severe in late transplanted crop & its infestation varied from 8-55% in Bihar during 2012-14.

Early Blight complex disease with 48.5% severity and **Late Blight disease** with 44.5% severity in Tomato have been reported from Bihar during the survey in 2012-14.

Potato, bean, okra & onion etc,

Late Blight of potato with 55.7% severity was recorded to be the most serious and key diseases in Bihar during 2012-14. In bean, Mosaic disease was found to be the serious most disease and distributed throughout with high incidence of 76.3% in Bihar.

In okra, **Yellow Vein Mosaic** disease with 30.5% incidence was found to be the most distributed disease. In onion**, Purple Blotch** with 11.6% severity followed by Onion Smudge (11.5% severity) were the two main diseases.

During pest and disease survey in Bihar (2012-14) **root-knot nematode** was the most serious causing economic loss in tomato, brinjal and chilli. In okra, **leaf hopper and whitefly** were seriously observed irrespective of cultivated varieties. In cabbage and cauliflower, infestation of **diamond back moth (DBM)** with 35% was seriously found at most of the places in Bihar.

Ginger

Bacterial wilt of ginger has also been found to be an emerging disease in odisha. Bacterial wilt of Ginger is reported to be caused by *Ralstonia solanacearum* race 4 (Scot Nelson, *Plant Disease* October, 2013) one of the soil- and water-borne bacteria. Ginger has been found to be affected by bacterial wilt disease at DRWA, Experimental Farm, Bhubaneswar during 2008 and also in the farmers fields in Kandhamal district, Odisha.

Leaves of infected plants turned yellow followed by browning. Progress of the wilting was slow. Wilt progressed upward, affected the younger leaves first, and followed by yellowing and browning of entire shoot. Infested plants were stunted and yellow. Young succulent part of the plant completely rotted. Plant dried rapidly and total foliage became yellow brown within a week. Underground rhizome was also soft and rotten. Water-soaked appearance on infected rhizomes and **vascular tissues** was noticed. Diseased plants died before harvest.

ERYTHRINA: an ornamental plant and living fences for black pepper & betelvine

Erythrina gall wasp, *Quadrastichus erythrinae* Kim **(**Hymenoptera: Eulophidae) is considered as one of the most swiftly invasive and destructive arthropod pests to sweep across the world, posing imminent threat to native *Erythrina* species across the world. In India, this pest was noted in Maharashtra and Karnataka during 2004 (KORE, 2006) and reported during 2005 in a serious proportion in Kerala (FAIZAL *et al*., 2006). This pest infestation led to Erythrina mortality, resulting in the collapse of the entire canopy of black pepper vines (JACOB and DEVASAHAYAM, 2010).

Deformed leaves of erythrina

DAS and TALUKDAR (2010) reported infestation from West Bengal in 2008 attacking *ythrina variegate* L. in various proportion and bsequently it was found that the insect was ogressing its way northwardly. Galls are induced developing shoot, petiole, rachis, leaflet and wers. Adult females lay eggs inside young plant sue. The larvae develop and pupate within the ll tissue. After pupation within the gall, adult sps escape through the holes cut by them. vious swelling and deformation can be seen on ected tissue parts. Severe infestations may lead death of the tree. Only bio- control agents from its tive range could be useful to control this pest.

Galls formed due to wasp infestation

Tuber crops

Corm borer, *Aplosonyx chalybaeus* (Hope) is a serious, univoltine pest of colocasia (taro) in north eastern hill states and hilly regions of West Bengal. Infestations of *A. chalybaeus* were recorded in Darjeeling, Kalimpong in West Bengal. Soon after hatching, the white tiny grubs (5-7mmL) bored into the shoot and consumed the developing corm resulting in the death of the plant. The grubs overwinter in the corms as the temperatures during winter in the region ranges between 0^0C to 3^0C. The damaged plants wither, wilt and became yellow. The dead plants (photo-plate) emit foul smell. The adults consume the leaves by damaging up to 20-30%. The adults make circular holes (trenches) of different sizes ranging between 2-3 cm on the leaf (Fig. 1) and the damaged leaf exuded milky and waxy latex. Number of holes was recorded more on the edges of the leaf than inside.

Beetles emerged with the start of the first summer showers in the region during middle of May. However, peak adult activity has been noticed from the month of June till August with peak populations during July first week (5-6/plant). Damaged plants withered, wilted and became yellow. The local cultivars with purple or pink colouration on the leaves were less preferred by *A. chalybaeus*. A maximum of 70-80 grubs were found per plant. One generation per year was recorded. Several wild species of taro *viz*., *Colocasia esculenta* var. *antiquorum, C. esculenta* var. *esculenta*, *C. esculenta* var. *sylvestris*, *C. affinis*, *C. fallax* in Sikkim, up to 3000 meters altitude, were infested by *A. chalybaeus.*

Cassava mosaic disease (CMD) is the most serious viral disease of Cassava in India and presently being also observed in Odisha. The first symptom appears on young leaves as chlorotic speck. Gradually, they enlarge and intermix with green tissue to provide a mosaic pattern. The pale discoloration may be intensified to yellow colour depending on the varieties. The leaf area is reduced and in extreme cases leaf distortion and shoe string appearance are observed. Intensity of symptoms varies with season, genotypes and virus load present. There may be symptom variation in the same plant. Some plants show symptoms on the younger leaves and recover at the later stages. In serve case of infection, the growth of the plant is affected which ultimately leads to crop loss.

Tuber yield of diseased plants vary with different varieties as well as time of infection. Up to 80% crop losses have been recorded in highly susceptible varieties as against 18% in field tolerant varieties. Crop loss is maximum when the disease appears at the time of planting. However, no reduction in yield is recorded when the disease occurred after 5 months of planting.

Taro leaf blight caused by *Phytophthora colocasiae* is the most destructive disease of taro (*Colocasia esculenta* var. *esculenta* and *C. esculenta* var. *antiquorum*). Affected leaves initially show small dark spots which enlarge rapidly and turn purplish brown with yellowish margins. The lesions frequently from concentric zones and exude drops of yellowish liquid. Periphery of the diseased tissues may be covered with whitish fuzz consisting of sporangia. As the disease progresses, the lesions (mostly along the leaf margin) continue to expand and frequently coalesce. Diseased tissues disintegrate forming holes of irregular size and shape on the affected leaves. Occasionally the pathogen may cause water-soaked lesion on the petioles. Infected leaves collapse within 20 days of unfurling, compared to 40 days for healthy leaves. The normal 6-7 leaves/plant are reduced to 3-4 leaves/plant in severe disease incidence.

After harvest, grey-brown to dark-blue lesions occur on undamaged corms. These lesions enlarge rapidly and coalesce. The boundary between the healthy and diseased tissues is distinct and soft. Affected corms are almost completely decayed within 8 days after harvest in wet conditions. Deciduous sporangia with apical papilla are produced on slender sporangiophores which branch irregularly or sympodially with a swelling at the point of branching Sporangia are ovoid to ellipsoid mostly 45-50 X 23 µm with a length-to width ratio of 1:1.6. Chlamydospores are thick walled, usually 26-30 µm diameter. Oospores averaging 29µm diameter are produced in oogonia with amphigynous antheridia attached

The **collar rot disease** of elephant foot yam (*Amorphophallus poeniifolius*) caused by *Sclerotium rolfsii* is a major constraint affecting this crop. This disease is generally observed in later part of crop growth but it can infect the crop at any stage of crop growth. The symptoms include water soaked patch on the collar region of the pseudostem and finally the entire plant falls due to rotting of the collar region. The white mycelial mat and lot of sclerotia could be seen on the collar region of the affected plant. Application of

Trichoderma in soil and treatment of planting material in cow-dung slurry mixed with *Trichoderma* have been found very effective against collar rot.

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EMERGING PESTS OF PULSE AND OILSEED CROPS IN EASTERN INDIA

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Pulse crops

Severity of web forming **pod borer, *Grapholitha critica*** Meyr. has been recoded in early pigeonpea grown in coastal Odisha during rabi 2012-13. The larval population of *G. critica* recorded at OUAT Farm, Bhubaneswar was highest of 100% (1.13/plant), 100% (3.66/plant), 100% (3.62/plant), 56.42% (5.49/plant), 37.19% (5.66/plant), 32.39% (5.15/plant) at vegetative, budding, flowering, pod development, grain filling and grain maturity stage, respectively. Only *G. critica* occurred during vegetative, budding and flowering stage, recording no occurrence of other pod borer species. Incidences of *G. critica* were recorded earlier in Odisha (SENAPATI *et al*., 2000). The average larval population of *G. critica* was higher with 71.00% (4.12/plant) relative abundance followed by *Maruca testulalis*, *Callosobruchus chinensis* and *H. armigera* having 23.27% (3.77/plant), 19.36% (2.47/plant) and 11.84% (1.73/plant), respectively over different stages of pigeonpea.

Intensive surveys (2012-14) carried out by a team of Bihar Agricultural University scientists of Plant Pathology and Entomology in all the agro-ecological zones of Bihar come under jurisdiction of the University at block level. During three years (2012-2014) of survey for pest and disease incidences, **dry root rot and stunt disease in chickpea** has been recorded to be an emerging one.

Oilseed crops

In groundnut, the incidence of **leaf miner, *Aproaerema modicella*** & tobacco caterpillar, *Spodoptera litura* are on increase in *rabi* seasons in Odisha. The peanut bud necrosis and stem necrosis are static in their status. Incidence of color rot and root rot are also increasing in some districts of western and southern Odisha. Earliar incidences of *A. modicella* on groundnut leaves were found to be 5-30% in coastal Odisha (JENA and KULIA, 1997).

In castor crop, among the leaf eating caterpillars, the population of castor semi**-looper, *Achaea janata*** has remained static or at times found decreasing. However, the populations of tobacco caterpillar, *Spodoptera litura* and hairy caterpillar, *Spilosoma (Diacrisia) obliqua* are on increase. The shoot and capsule borer, *Conogethes (Dichocrocis) punctiferalis* incidence is also on increase in the recent years. Earlier shoot and fruit borer was pest of minor and sporadic in Odisha (SINGH and SINGH, 2000).

In rapeseed & mustard, incidences of **mustard sawfly, *Athalia lugens proxima*** and **mustard aphid, *Lipaphis erisymi*** are also increasing in rabi season for last 4 years, especially in western part of Odisha. Earlier RAUT and PANI (1967) reported *L. erisymi*

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incidences on mustard to cause 12-30% yield losses in Odisha. White blister disease is seen now in some parts of north-western Odisha in sporadic form.

In sunflower, **head borer, *Helicoverpa armigera*** and **tobacco caterpillar, *Spodoptera litura*** are occurring in sporadic form in some parts of Kalahandi and Bolangir districts of Odisha. Information on incidences of both these pests on sunflower in Odisha is not available.

In sesame, occurrence of **sesame gall midge, *Asphondylia sesame*** Felt (Cecidomyiidae) is also reported from Odisha but level of incidences and extent of damage have not been studied (AHUJA *et al*., 2000).

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EMERGING PEST SCENARIO IN RICE IN INDIA

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Rice is the most important food crop in India and on research, and production priority for national food security. Since the onset of green revolution in the country, there has a constant increase in the number of insect and non-insect pests like mites and nematodes, and also a concomitant shift in their pest status/intensity, diversity, and spread in rice. The major factors that have contributed towards changes in the pest scenario are extensive cultivation of high yielding varieties, growing of varieties lacking resistance to major pests, intensified rice cultivation throughout the year providing constant niches for pest multiplication, imbalanced use of fertilizers, particularly application of high levels of nitrogen, non-judicious use of insecticides resulting in pest resistance to insecticides, and resurgence of pests and out breaks of minor pests (SAIN and PRAKASH, 2008; PRAKASH *et al*., 2014)

Insect pests

Among the major insect pests, stem borers [yellow stemborer-YSB (*Scirpophaga incertulas*), white stemborer-WSB (*Scirpophaga innotata*), pink stemborer-PSB (*Sesamia inference*), stripped stemborer-SSB (*Chilo polychrysus*), dark-headed stemborer-DHSB (*Chilo suppressalis*)] have shown geographical variation in their species composition and occurrence across the country. Though, YSB is the dominant species, WSB and PSB have made inroads in hill regions, parts of Punjab and Haryana in northern India and Kerala in southern region (PRAKASH *et al*., 2005). At Ludhiana (Punjab), WSB, PSB & YSB occurred at equal proportion during maximum tillering phase; during flowering stage the YSB was the dominant and almost 90% attack was due to PSB during dough stage. Similarly at Kaul during kharif 2005, the YSB was dominant in maximum tillering; but PSB & YSB were equal in heading stage. At Titabar (Assam), WSB was dominant during tillering stage and maximum tillering stage. In Odisha, YSB is the dominant during both vegetative & heading stages during dry season. At Wangbal, YSB remained dominant throughout the season, though at heading stage WSB was about 30% of the composition (SAIN and PRAKASH, 2008). YSB reported to be serious pest in about 15000 ha in Chinsura, Hoogly district (West Bengal) causing white-ear heads from 15-90% during *boro* (Janaury-May) *rabi*-12.

Rice gall midge, *Orseolia oryzae* remained a key pest with wide spread up to 1990s and emergence of six biotypes, causing serious losses in new areas like Bihar and North Eastern state of Manipur in addition to traditional areas of Odisha, Andhra Pradesh, Madhya Pradesh and Kerala. Currently this pest is a minor & sporadic restricted only in few rice growing pockets in Manipur & Andhra Pradesh (PRAKASH, 2013).

The delphacid planthoppers *viz*., brown planthopper, *Nilaparvata lugens* and white-backed planthopper, *Sogatella furcifera* have emerged as serious pests in many rice growing states round the year. During the *Kharif* -2008. There was a severe

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infestation of these hoppers in Punjab and Haryana in about 120, 000 ha. These have been a regular pest in the East & West Godavari districts in Andhra Pradesh and Bellary and Sindanur areas in Karnataka and in Burdwan district of West Bengal during *kharif*-2009-12 (PRAKASH *et al*., 2014).

Leaf folder, is another pest of minor significance earlier, has assumed major pest status in the entire country particularly in areas of high fertiliser use. This pest has three species *viz., Cnaphalocrocis medinalis, Marasmia patnalis* and *M. exigua*, of which *C. medinalis* is dominant and wide spread. There are also other pests of regional significance such as hispa, gundhi bug, mealy bug, termite, white grub and caseworm (BEHERA *et al*., 2013).

The cutworms are becoming serious in many rice growing areas in the eastern part of the country. For last few seasons, the climbing cutworm, *Mythimna separata*, has been regularly occurring in coastal Andhra Pradesh and in the Eastern States. Similarly, the swarming caterpillar, *Spodoptera mauritia* has acquired a status of major pest in Odisha, Bihar and Jharkhand during kharif-2007-09, 2012, 2013 and devastated paddy crop in early stage in considerable areas (PRAKASH *et al*., 2014).

Rice hispa, *Dicladispa armigera*, a coleopteran pest is problem in specific rice ecologies viz., irrigated paddy fields as well as lowland boro rice cultivation in West Bengal, Assam and North-East Indian states. Termites (white ants) and gundhi bug are major insect pests in upland rice ecology. White grubs are problem in specific upland hill rice, whereas in deep water ecology, only the stem borers and in semi-deepwater ecology stem borers, caseworms and hispa are the key insect pests (PRAKASH, 2013).

Mite pests

Rice panicle mite, *Steneotarsonemus spinki* Smiley found to be an emerging pest infesting paddy fields in India especially at flowering stage when temperature ranged 26-30 ^{o}C and relative humidity above 80%, Its incidences in India have been reported from Andhra Pradesh and West Bengal, more severe during September and October where congenial conditions of temperature and humidity prevailed, resulting considerable yield losses in term of sterility (20-50%) in rice (RAO *et al.,* 1999; RAO and PRAKASH, 2003). Recently out-break of the panicle mites is reported in about 30,000 Ha farmers paddy fields in districts Balasore, Bhadrak, Puri, Ganjam, Gajapati and Kedrapada districts of Odisha (DHARITRI, 2 November, 2014). Rice leaf mite, *Oligonychus oryzae* is also emerging as important mite pest in irrigated and upland rice especially in the roadside fields for last few years.

Nematode pests

Rice root-knot nematode, *Meloidogynae graminicola* has become a major pest in aerobic rice cultivation in the recent years (2009-2013), though this was earlier a pest of upland rice in eastern India (MISRA, 2008). Ufra disease caused by nematode, *Ditylechus angustus* has been found increasing in its spread in Assam and West Bengal.

Rice diseases

In rice, several diseases *viz*., rice blast (*Pyricularia grisea)*, brown spot (*Helminthosporium oryzae*), sheath blight (*Rhizoctonia solani),* false smut (*Ustilaginoidea virens)*, sheath rot (*Sarocladium oryzae*), seedling blight (*Sclerotium oryzae)*, bakanae (*Fusarium moniliformae)*, bacterial blight (*Xanthomonas oryzae* pv. *oryzae*), bacterial grain and seedling rot (*Burkholderia glumae*), and tungro (rice tungro bacilliform virus and rice tungro spherical virus), do occur, resulting in significant damage to the grain and straw yield in India.

Among the rice diseases, blast and bacterial blight still considered as major diseases. False smut has emerged as an important diseases for about last one decade and its' out-break has been reported in Chhatisgarh during *kharif*-2007 in about 6000 ha. This disease is now widespread in Odisha and infects panicles in field rice especially dominant variety like Pooja. Sheath blight and sheath rot have also emerged again as major diseases for last 6-8 years in eastern India.

Rice tungro, a vector (GLH) born disease, was a major viral disease in eastern India during 1980s, 1990s but now restricted to only Assam and in few pockets in West Bengal. In Punjab & Haryana, Bakane disease of rice has emerged as major problem in export scented rice (Pusa Basmati 1121) and reported to infect about 20,000 ha during *kharif*-2011. Sheath rot disease is again emerging important disease in rainfed lowland ecology and generally associated with incidences of rice mites. Another seed borne disease, seedling blight caused by *Sclerotium oryzae* is severely damaging rice production especially scented rice varieties and during *kharif* 2014 severe damage of seedlings has been recorded in Haryana (PRAKASH *et al.,* 2014).

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Table-2: Overall efficacy of plant extracts against flea beetle on ladysfinger (2010 and 2011)

Treatments	Dose ml / Litre (%)	Overall efficacy (% reduction) 2010					Overall efficacy (% reduction) 2011				
		Pre-Treatment Obs. flea/plant	Days after treatment			Mean	Pre-Treatment Obs. flea/plant	Days after treatment			Mean
			3	6	9			3	6	9	
Polygonum (T1)	50.00 ml/L (5%)	3.33	49.38 (44.64)	52.83 (46.63)	48.39 (44.07)	50.20 (45.11)	2.67	52.56 (46.47)	51.23 (45.71)	50.33 (45.20)	51.37 (45.79)
Pongamia (T2)	50.00 ml/L (5%)	3.47	32.05 (34.41)	30.17 (33.23)	27.33 (38.58)	29.85 (35.41)	2.59	35.66 (36.62)	34.98 (36.23)	32.62 (34.79)	34.42 (35.88)
Azadirachtin (T3)	2.5 ml/L	2.96	54.78 (47.68)	58.31 (49.82)	51.80 (46.03)	54.96 (47.84)	3.11	56.74 (48.90)	52.10 (46.21)	48.52 (44.14)	52.45 (46.42)
Garlic (T4)	50.00 ml/L (5%)	2.98	35.09 (36.28)	28.43 (31.70)	25.45 (30.25)	29.66 (32.74)	2.77	30.62 (33.55)	33.71 (35.42)	28.71 (32.20)	31.01 (33.72)
Profenophos (T5)	1 ml/ L (0.05%)	3.11	69.13 (56.29)	62.18 (52.35)	54.34 (47.49)	61.88 (52.04)	2.96	65.60 (54.12)	64.26 (53.30)	57.72 (49.49)	62.52 (52.30)
Tobacco (T6)	50.00 ml/L (5%)	2.87	46.79 (43.13)	48.39 (44.07)	43.97 (41.52)	46.38 (42.91)	3.33	48.74 (44.27)	45.17 (41.79)	39.20 (38.74)	44.37 (41.60)
Spilanthes (T7)	50.00 ml/L (5%)	3.17	36.22 (36.96)	39.20 (38.74)	34.04 (35.59)	36.49 (37.10)	3.33	34.79 (36.11)	35.13 (36.32)	30.64 (33.51)	33.52 (35.31)
Untreated Control (T8)	---	3.27	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	2.67	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)
S Em (±)	---	---	1.60	1.79	1.52	---	---	1.50	1.45	1.66	---
CD at 5%	---	NS	5.05	5.47	4.66	---	NS	4.64	4.47	5.18	---

Figure in the parenthesis are angular transformed values, NS= not significant

Table -1: Effect of insecticides on occurrence of dead heart due to infestation of stem borer in rice

Tr. No.	Insecticides	Dead Hearts/m²*										Mean reduction over UC (%)
		Kharif, 2010					*Kharif*, 2011					
		One day before spray	7 DAS	15 DAS	30 DAS	Reduction over UC (%)	One day before spray	7 DAS	15 DAS	30 DAS	Reduction over UC (%)	
T_1	Cartap hydrochloride 75 SG@ 375 g/ha	10.60 (3.33)	4.70* (2.28)	5.50 (2.45)	3.60 (2.01)	75.84	29.40 (5.47)	13.50 (3.73)	14.90 (3.92)	10.50 (3.32)	71.23	73.53
T_2	Cartap hydrochloride 75 SG@ 425 g/ha	11.10 (3.40)	3.60 (2.03)	4.00 (2.13)	2.60 (1.74)	82.55	29.20 (5.44)	11.40 (3.45)	12.80 (3.64)	9.00 (3.0)	75.34	78.94
T_3	Cartap hydrochloride 75 SG@ 500 g/ ha	10.70 (3.34)	2.90 (1.84)	3.60 (2.01)	2.00 (1.58)	86.58	28.30 (5.36)	10.00 (3.24)	12.00 (3.53)	8.00 (2.91)	78.08	82.33
T_4	Cartap hydrochloride 50 SP@ 1000 g/ ha	11.20 (3.41)	4.40 (2.21)	4.70 (2.28)	2.80 (1.81)	81.21	29.20 (5.44)	13.00 (3.67)	14.60 (3.88)	10.10 (3.26)	72.33	76.77
T_5	Lambda cyhaloin 2.5 EC @ 500ml/ ha	11.00 (3.39)	5.60 (2.46)	6.00 (2.54)	4.00 (2.13)	73.15	27.80 (5.32)	14.70 (3.90)	16.10 (4.07)	12.30 (3.58)	66.30	69.72
T_6	Fipronil 5 SC @ 500 ml/ ha	11.00 (3.39)	6.10 (2.57)	6.80 (2.71)	5.10 (2.36)	65.77	28.20 (5.35)	15.00 (3.93)	16.60 (4.13)	12.80 (3.65)	64.93	65.35
T_7	Untreated Check	10.70 (3.34)	13.50 (3.74)	14.10 (3.82)	14.90 (3.92)	-	28.20 (5.35)	34.70 (5.93)	33.10 (5.78)	36.50 (6.08)	-	-
SE(m) ±		0.05	0.04	0.04	0.06	-	0.10	0.05	0.09	0.03	-	-
CD (P=0.05)		NS	(0.11)	(0.12)	(0.18)	-	NS	0.15	0.26	0.09	-	-

Figures in parenthesis are transformed values {√(x+0.5)}   * Mean data of 3 sprays   DAS = Days After Spraying, UC = Untreated Check

Table- 2: Effect of insecticides on occurrence of white ear head (WEH) and grain yield due to infestation of stem borer in rice

Tr. No	Treatments	White Ear Head / m2					Yield (Kg / ha)				
		Kharif, 2010		*Kharif,* 2011		Mean Reduction over UC (%)					
		Before harvest	Reduction over UC (%)	Before harvest	Reduction over UC (%)		*Kharif,* 2010	Increase over UC (%)	*Kharif,* 2011	Increase over UC (%)	Mean Increase over UC (%)
T_1	Cartap hydrochloride 75 SG@ 375 g/ha	5.80 (2.50)	63.52	7.80 (2.87)	79.09	71.30	3881.25	18.96	3943.80	13.28	16.12
T_2	Cartap hydrochloride 75 SG@ 425 g/ha	4.90 (2.33)	69.18	7.20 (2.77)	80.70	74.94	4143.75	27.01	4712.50	35.37	31.19
T_3	Cartap hydrochloride 75 SG@ 500 g/ ha	4.30 (2.20)	72.96	7.30 (2.78)	80.43	76.70	4275.00	31.03	4806.30	38.06	34.54
T_4	Cartap hydrochloride 50 SP@ 1000 g/ ha	5.00 (2.35)	68.55	8.30 (2.96)	77.75	73.15	4087.50	25.29	4075.00	17.05	21.17
T_5	Lambda cyhalothrin 2.5 EC@ 500ml/ ha	6.80 (2.71)	57.23	8.80 (3.04)	76.41	66.82	3900.00	19.54	3912.50	12.39	15.96
T_6	Fipronil 5 SC @ 500 ml/ ha	7.80 (2.88)	50.94	12.0 (3.53)	67.83	59.38	3600.00	10.34	3843.80	10.41	10.37
T_7	Untreated Check	15.90 (4.04)	-	37.30 (6.16)	-	-	3262.50	-	3481.30	-	
SE(m) $\pm$		(0.05)	-	0.06	-	-	80.15	-	98.74	-	
CD (P=0.05)		(0.15)	-	0.19	-	-	232.56	-	286.57	-	

Figures in parentheses are square root {$\sqrt{(x+0.5)}$} transformed values. UC = Untreated Check

Table- 3: Mirid bug and *Coccenellid* population/m^2 in different treatments

Tr. No	Treatments	Mirid bug/m^2		*Coccenellid* sp./m^2	
		Kharif-2010	*Kharif*- 2011	*Kharif*-2010	*Kharif*-2011
T_1	Cartap hydrochloride 75 SG@ 375 g/ha	3.2 (1.92)	2.5 (1.73)	0.9 (1.18)	1.9 (1.54)
T_2	Cartap hydrochloride 75 SG@ 425 g/ha	4.8 (2.30)	2.2 (1.64)	1.0 (1.22)	1.2 (1.30)
T_3	Cartap hydrochloride 75 SG@ 500 g/ ha	3.9 (2.09)	2.4 (1.70)	1.2 (1.30)	1.6 (1.44)
T_4	Cartap hydrochloride 50 SP@ 1000 g/ ha	4.1 (2.14)	2.1 (1.61)	0.8 (1.14)	1.8 (1.51)
T_5	Lambda cyhalothrin 2.5 EC @ 500ml/ ha	3.6 (2.02)	1.9 (1.54)	1.8 (1.51)	1.3 (1.34)
T_6	Fipronil 5 SC @ 500 ml/ ha	3.8 (2.07)	2.8 (1.81)	0.7 (1.09)	1.6 (1.44)
T_7	Untreated Check	3.0 (1.87)	2.2 (1.64)	0.9 (1.18)	1.6 (1.44)
SE(m) $\pm$		(0.29)	(0.25)	(0.19)	(0.24)
CD (P=0.05)		(NS)	(NS)	(NS)	(NS)

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

Table-1: Population of brown plant hopper, *Nilaparvata lugens* (Stal.) and mirid bug in upland transplanted rice ecosystem

S. No	SMW	Date of observation	Mean population of BPH in upland transplanted rice ecosystem	Mean population of mired bug in upland transplanted rice ecosystem	Temperature (^{0}C)			Rainfall (mm)	Relative humidity (%)			Sun shine (hours)
					Maxi. Temp.	Mini. Temp.	Avg. Temp.		Morn.	Even.	Avg.	
1	31	01/08/2013	0	0.25	28.30	23.90	26.10	255.80	95.10	83.90	89.50	1.30
2	32	08/08/2013	0	1	31.10	24.70	27.90	87.40	93.10	76.00	84.55	3.30
3	33	15/08/2013	0	0.25	31.30	24.40	27.85	177.00	94.70	79.60	87.15	3.30
4	34	22/08/2013	0	0	27.80	23.80	25.80	60.50	92.00	83.60	87.80	1.50
5	35	29/08/2013	0	0.25	29.30	24.50	26.90	120.80	94.90	78.10	86.50	3.10
6	36	05/09/2013	0	0.5	31.10	24.80	27.95	54.80	92.60	75.70	84.15	4.20
7	37	12/09/2013	0	0	31.90	25.20	28.55	11.60	91.70	73.30	82.50	6.20
8	38	19/09/2013	2	0.25	29.90	24.10	27.00	92.60	93.40	76.90	85.15	2.50
9	39	26/09/2013	3	0.5	32.00	24.90	28.45	28.60	93.00	68.00	80.50	6.30
10	40	03/10/2013	3.5	0.5	30.10	24.20	27.15	45.20	95.00	75.30	85.15	4.20
11	41	10/10/2013	1.75	1	30.20	23.30	26.75	8.60	83.70	71.10	77.40	3.50
12	42	17/10/2013	1.25	2.75	30.70	21.40	26.05	0.00	91.40	56.30	73.85	8.60
13	43	24/10/2013	5	1.25	28.80	22.60	25.70	32.60	95.90	73.10	84.50	2.10
14	44	31/10/2013	5.25	0	30.50	17.30	23.90	0.00	92.30	38.40	65.35	8.90
Seasonal mean/25 sweeps			1.55	0.61								

CONTENTS

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