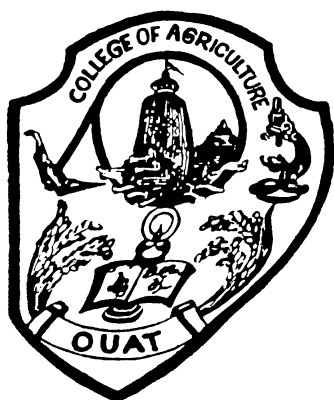


**MANAGEMENT OF ANGOUMOIS  
GRAIN MOTH (*Sitotroga cerealella* Oliv )  
IN FIELD AND STORE**

A THESIS  
SUBMITTED TO  
THE ORISSA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BHUBANESWAR  
IN PARTIAL FULFILMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF  
**MASTER OF SCIENCE IN AGRICULTURE**  
( ENTOMOLOGY )

BY

*Narottam Behera*



Department of Entomology  
**COLLEGE OF AGRICULTURE**  
**Orissa University of Agriculture and Technology**  
**BHUBANESWAR**  
**1994**

THESIS ADVISOR

Dr. B. K. MAITY

DEDICATED TO  
MY BELOVED PARENTS


Dr. B.K. Maity Ph.D.

READER,  
DEPARTMENT OF ENTOMOLOGY,  
COLLEGE OF AGRICULTURE,  
ORISSA UNIVERSITY OF AGRICULTURE  
AND TECHNOLOGY,  
BHUBANESWAR - 751003.

Bhubaneswar,  
The 20<sup>th</sup>, April 1995.

CERTIFICATE-I

This is to certify that the dissertation entitled "MANAGEMENT OF ANGOUMOIS GRAIN MOTH, Sitotroga cerealella Oliv. IN FIELD AND STORE" submitted in partial fulfilment of the requirements, for the award of the degree of MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY) to the "Orissa University of Agriculture and Technology", Bhubaneswar, is an authentic record of bona fide research work carried out by Sri NAROTTAM BEHERA under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma or published in any other form. It is further certified that such assistance and help as has been availed during the course of investigation have been duly acknowledged by him.

  
(Dr. B.K. Maity)  
Chairman

Advisory Committee

CERTIFICATE - II

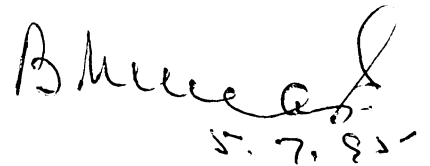
This is to certify that the thesis entitled "MANAGEMENT OF ANGOUMOIS GRAIN MOTH, Sitotroga cerealella Oliv. IN FIELD AND STORE" submitted by Sri NAROTTAM BEHERA to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY) has been approved by students advisory committee after an oral examination on the same in collaboration with an External Examiner.

ADVISORY COMMITTEE :

Chairman : Dr. B.K. Maity Ph. D.  
Reader,  
Department of Entomology.

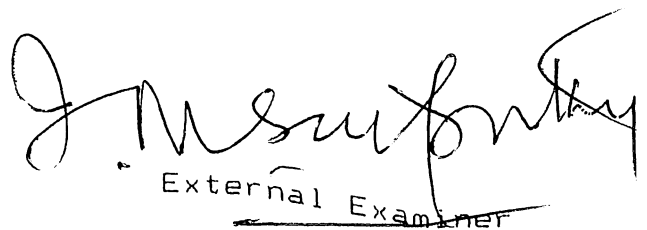


Members (i) : Dr. B. Senapati Ph. D.  
Professor and Head,  
Department of Entomology.



5.7.82

(ii) : Dr. A.K. Mohanty Ph. D.  
Reader,  
Department of Plant Pathology.



External Examiner

## ACKNOWLEDGEMENT

I overwhelmed availing the unique opportunity to study in the department of Entomology, College of Agriculture, OUAT. Bhubaneswar.

I lack words to express my deep sense of gratitude and indebtedness to Dr. B.K. Maity Ph.D. Reader, Department of Entomology, College of Agriculture for his constant encouragement, guidance, supervision and painstaking efforts carrying out this dissertation in full-fledged compliance.

My privilege to express my paramount obligation to Dr. B. Senapati Ph.D. Professor and Head, for his generous helps in carrying out the experiment in the laboratory. His timely suggestion and advice regarding the work is worth admiration.

My deep sense of gratefulness to my esteemed teachers Mr. U.K. Nanda, Dr. P. Panda Ph. D. and Mr. T.J. Jacob S.R.A. rendering helps and encouragement during the course of study. Grateful obligations are due to Mr. B.K. Sahoo Lecturer, for his help every moment in the course of investigation.

I feel it is a pleasure to express my co-ordially thanks to Jairaj and Siva for their helpful attitude to fulfil my goal.

I never forget my friends and class mates Uttam, Raghu, Harihar, Fakir, Sanjay, Manas, Nilakantha, Basant and Biswas babu for their innumerable helps during study.

I pay my sincere esteems to my parents for their blessing and constant encouragement to achieve my goal.

My best regards to my father-in-law for his blessing and encouragement during the Post Graduation study.

I am pleasure to express my hearty reverence to my brother, Anant Ku. Sahoo for his encouragement and help during the course of study.

Last but not least I, express my hearty thanks and appreciation to my wife JAYANTI for her steady inspiration, encouraging attitude and sweet cheers of my beloved niece REENA and nephew BHISHMA which enabled me to achieve my goal.

I am thankful to PC PLUS, for their costant painstaking efforts in typing this manuscript neatly.

I pray Goddess KAMACHANDI for her blessings all the moments.

Bhubaneswar,

Dated 20<sup>th</sup> April, 1995

Narottam Behera  
(Narottam Behera)

## C O N T E N T S

CHAPTERS	PARTICULARS	PAGE
I.	INTRODUCTION	1
II.	REVIEW OF LITERATURE	5
III.	MATERIALS AND METHODS	25
IV.	RESULTS	41
V.	DISCUSSION	67
VI.	SUMMARY AND CONCLUSION	83
	BIBLIOGRAPHY	I-V.

## L I S T   O F   T A B L E S

TABLE	PARTICULARS	PAGE
1	Insecticides applied on ripened grains at harvest and their doses	35
2	List of plant products and concentration used	37
3	List of rice entries with their origin and characteristics	42-43
4	Categorisation of rice varieties into relative susceptibility on the basis of successful development of <u>Sitotroga cerealella</u> and percentage grain damage	44
5	Varietal effect of resistant/susceptible categories of rice grain on the biology of <u>S. cerealella</u>	46
6	Measurement of rice grains belonging to the resistant/susceptibility groups, L/B ratios and alkali spreading values	50
7	Comparative study of physical characters in different resistant/ susceptible groups of rice	52
8	Comparative morphology of rice glumes of resistance/susceptible categories	54
9	Effect of spraying of insecticides on rice grains just before harvest	55
10	Effect of plant product admixtures on the development of <u>S. cerealella</u> and grain damage	59
11	Effect of physical barriers on the incidence and grain damage due to <u>S. cerealella</u> in the store	63
12	Use of different traps to catch Angoumois grain moth in the store	65

## LIST OF ILLUSTRATIONS

FIGURE		AFTER PAGE
1	Lay out of the field spray at harvest	34
PLATE		
1	Dial Thickness Gage (MITUTOYO)	29
2(a)	Use of traps to catch Angoumois grain moth	37
2(b)	Bio-sense trap to catch moth ( <u>S. cerealella</u> )	37
3	Site of egg laying of <u>S. cerealella</u>	46
4	Life cycle of Angoumois grain moth	47
5	Alkali spreading values	50

MANAGEMENT OF ANGOUMOIS GRAIN MOTH. Sitotroga cerealella  
Oliv. IN FIELD AND STORE

ABSTRACT

During 1994-95 a few experiments were conducted to manage the Angoumois grain moth, Sitotroga cerealella Oliv. (Gelechiidae, Lepidoptera) in various possible ways in the field and store. In the screening study twenty rice entries were evaluated for resistance to Angoumois grain moth attack. None of the test varieties proved to be immune to S. cerealella attack. Only two rice varieties namely FR 13 A and WB-1B-15B were highly resistant to S. cerealella attack which recorded upto 1.5 per cent moth emergence and 0.65 per cent grain damage. Four rice cultivars which recorded an average of 6.17 moth and 1.65 per cent grain damage. Like wise two entries belonging to moderately resistant group produce 10.00 per cent S. cerealella moth and 2.55 per cent grain damage. But five rice entries classified as susceptible and recorded 16.60 and 4.46<sup>7</sup> per cent moth and grain damage respectively. In highly susceptible group seven cultivars observed 31.14 per cent moth emergence and 9.78 per cent grain damage by S. cerealella. Varietal effect on life cycle of Angoumois grain moth at 28 ± 1°C and 75 per cent rh showed that total developmental period of the pest varied from 27.00 to 30.21 days in susceptible to highly resistant categories. Accordingly growth index of S. cerealella varied from 0.05 to 1.36 indicates the faster rate of development in susceptible rice. Grain characters like thickness of husk, weight, boldness and hardness, L/B and hulling ratios contributed towards the resistance quality of grains to S. cerealella attack. Pre-harvest spraying with insecticides like Acephate, Ethophan-prox, Azadirachtin or monocrotophus at the rate of 0.05 per cent will keep the grains in safe upto three months from S. cerealella attack. Plant product admixtures like Pongamia seed powder at the rate of 2.5 per cent, Vitex and neem leaf powder at the rate of 5 per cent will also keep the grains away from S. cerealella attack. Physical barriers like sand and rice bran, on grain surface are effective means of restricting the entry of migratory population of S. cerealella. Constant setting of bio-sense trap inside the store will keep the Angoumois grain moth population under check.

CHAPTER I

INTRODUCTION

## INTRODUCTION

Food will continue to be a weapon in all efforts towards ensuring a more orderly prosperous and peaceful country. There is tremendous increase in food grain production and India gained official recognition as an export country of food grains to abroad. Though the production of food grain has attained 180 M.T (1994) , the targetted level, still this is not sufficient to keep pace with the growing population, 2.1 per cent per annum. In spite of strenuous attempts from both Government and Research Institutions to cater every individual 542 grams food grain per day, lack of success has been ascribed to various causes. To get the best result from the two, there are three obvious ways, namely, (i) increasing the area by bringing more land under cultivation which is ceased now due to fragmentation and housing, (ii) enhancing the per acre yield of the area now being cultivated and (iii) avoiding and preventing waste from harvest to final stage of consumption and storage loss by insect pests.

About 10 per cent of food grain is lost during post harvest operations to end of its economical life which is huge enough to feed 50 million hungers. Farmers used to keep up with more than 65 per cent of their produced for consumption and seeds for more than 9 months. However, the gap between production and consumption can only be bridged by efficient handling of post-harvest operation because a grain saved is a grain produced.

Food grain harvested in the field passes through various stages to reach the ultimate consumers and are subjected to appreciable losses during storage both by abiotic factors such as temperature and humidity as well as biotic factors viz, insects, pathogens, rodents, mites and birds in various types of receptacles. Owing to the insect infestation, grains do not only suffer from quantitative loss but also there may be qualitative loss and contamination which may thus lead to physiological disorders. Out of 9.33 per cent post harvest loss of food grain insects share about 2.55 per cent which appears to be alarming.

Out of 20 species of major pests of store grains and milled cereals, Angoumois grain moth, Sitotroga cerealella (Oliv), rice weevil Sitophilus oryzae (Linn.) and lesser grain borer Rhizopertha dominica (Fab.) are injurious. Angoumois grain moth is a world wide pest and second in importance to rice weevil among the pests that attack in storage. This has also been reported to be a serious pest of paddy, cholam, maize, wheat, barley, sorghum and Oat in India (Shazali, 1987).

The larvae of Sitotroga cerealella is an internal borer and bore into the grain mostly at the germ end, viability of seed is lost. In case of severe attack the grain looks sickly and covered with scales from the bodies of the moth ; in addition it pave the way to the secondary infestations to several

bioagents (Prakash et al., 1985). During six months storage of paddy the loss was estimated to 2.4 per cent due to Sitotroga cerealella (clear, 1962). The field infestation of Angoumois grain moth can take place at any time after 25 days of flowering (Maity, 1991). So, preharvesting spraying of safest insecticides to protect grains from Angoumois grain moth attack in store is one of the focal points, Host resistance mechanism in insect control has assumed greater significance in view of toxic hazards and residue problems of grain treating chemicals which is also felt note-worthy. Plant admixtures have been in use as a preventive measure against insect infestation during storage since primitive age. Sometimes these are quite effective in keeping pest damage under control. (Singh & Rawat, 1981). Pheromone has now been exploited for monitoring the relative abundance and controlling pest population by capturing males and retarding its multiplication, thus used as an import component of integrated pest-management programme.

Considering the above facts, the present investigation will focus the following objectives to manage Sitotroga cerealella infestation for protecting rice grains in storage condition.

1. To evaluate the relative susceptibility/resistance of some popular rice varieties against Sitotroga cerealella and their interaction effecting on weight loss.

2. To evaluate the effectiveness of certain pesticides and their residual toxicity in storage condition applied just before harvest.
3. To evaluate the relative efficacy of certain plant product admixtures under natural storage condition against this pest.
4. To consider the effect of physical barriers on larval entry of S. cereallela.
5. To evaluate relative efficacy of different types of traps to monitor the Sitotroga cerealella population in store .

CHAPTER II

REVIEW OF LITERATURE

## REVIEW OF LITERATURE

Review of literature provides a guide line for every scientific investigation. It also provides methodology and helps in analysis and interpretation of results. Hence, literature available in respect to the extent of damage due to Angoumois grain moth, Sitotroga cerealella preference of rice variety for development etc. are cited and presented in this chapter.

### 2.1 Biology of Angoumois grain moth.

The Angoumois grain moth is second in importance to rice as a pest of storage. It obtained its common name from the infestation to wheat grain in the province of Angoumois, France where it was known to have been injurious since 1736 .

Sitotroga cerealella is an important pest of stored grains of paddy, cholam, maize, wheat, barely and oat. Subramaniam et al., (1950) reported that Sitotroga cerealella as a pest of standing crops of cholam and ragi at Coimbatore.

Fletcher (1914) reported that it occasionally occurs in the field of ripe ears of paddy and maize and eggs are laid on grain into which the caterpillar bores.

King (1918) reported that adult emergence chiefly in the morning, flying, pairing, and ovipositing in the dusk of

early evening and morning. Moths in confinement readily deposited their eggs in the heads of green wheat; generally under the protection of the glumes. The average number of eggs was observed to be 92. In the warm June days the egg stage lasts from 7-9 days. The larvae on hatching enter the grain by gnawing through the pericarp and as the mature, the entire content of the grain are eaten away leaving the endosperm. Larvae entering the grain in mid-June required 41-49 days before the emergence of the adults and those entering green and milky wheat required 40-44 days to complete their development.

Wenholz (1927) studied Sitotroga cerealella (Oliv.) and reported that one or several eggs are laid usually at the base of the grain on the ears while they are still immature in the field, the larvae on hatching in a few days making its way to the grain near the tip. It eats way straight through the grain to the opposite side near the crown, where it spins a cocoon and pupates. The larval stage lasts about 3 weeks and the pupal stage a few days. As many as three larvae are often found in a single maize grain.

Klein(1930) reported that a single female laid 80 to 180 eggs in Palestine and the sexes were equal in number.

Harukawa and Kumashiro (1938) studied that at 8 per cent moisture content, few larvae matured and none of them

gave rise to adults but at 12 per cent or moisture content, 7 per cent of the larvae reached the adult stage. There were 4 generations in a year, the first, 2nd and 3rd being completed in about 40, 30 and 30 days respectively. The egg stage varied 4 days in early August to 10 in early June, the larval stage from 15 days in July and 38 days in early June and the pupal stage from 4 days in late July to 11 days in early July. The pupal stage lasted 7 and 40 days at 35°C and 15°C . The percentage of adult emergence was highest at 20°C.

Warren (1956) showed the behaviour of Angoumois grain moth on several strains of corn of two moisture levels. It was found that increasing the moisture content of the grain from 14-17 per cent reduced the average period to initial emergence from all samples by an average of 3 days.

Mills (1965) reported that female from degermed kernels weighed less and numbers of larval instars varied from 4-7 .

Biswal (1968) reported that the average incubation period was 4.9, 4.95 and 5 days for eggs obtained from wheat, paddy and maize respectively and four larval instars. He further reported that in maize the insect was bigger and took larger period than that obtained from paddy and wheat. The average total

larval period which was 23.15 days in wheat 24.90 days in paddy and 26.30 days in maize. Pupal period was varied from 5-6 days, 6-7 days in wheat, maize and paddy respectively.

## 2.2 Extent of damage

Chatterji (1953) reported that the loss of weight was higher at 12per cent moisture content at 75per cent relative humidity than 8per cent moisture content at 75per cent relative humidity due to the attack of S. cerealella.

Gerberg and Goldheim (1957) from primary investigation of stored maize from which S. cerealella had emerged were found 10.10 per cent loss in weight than infested kernels.

Clear (1962) reported the damage and loss caused by Sitotroga cereallela was 2.4 per cent in paddy during 6 months storage period where as Khare (1972) recorded 34per cent loss in Paddy seed germination when insect infestation was only 16.61 per cent in 9 months natural storage.

Jasobanta Behera et al., (1992) studied unaccountable loss of paddy seed viability due to Angoumois grain moth at CRRRI, Cuttack, revealed that in the seeds of variety

Ratna having no visible insect damage symptoms/emergence holes, the per cent loss of germination was found to be 11.97per cent in the laboratory . This loss of seed viability was probably due to damage in its germ, caused by early instar larvae of S. cerealella . The total loss of germination was 26.54 per cent and visible grain damage of 14.57 per cent.

Prakash and Kauraw (1982), also found 3.67per cent to 41per cent germination loss in paddy seeds at 1.43 to 14.05per cent grain damage in 3-9 months under natural storage conditions. Post harvest losses were more in local varieties compared to high yielding ones. (Suriya Rao et al., 1993)

Shazali (1987) studied the weight loss caused by development of Sitophilus oryzae (L.) and Sitotroga cerealella (Oliv.) in sorghum grains of two size classes. The apparent and real weight losses caused by the development of Sitotroga cerealella (Oliver) and Sitophilus oryzae(L.) inside sorghum grains of two size classes were estimate in the laboratory . The amount of food consumed by the developing larvae of S. cerealella was similar in large and small grains, with S. oryzae the amount consumed decreased as grain weight decreased. The conversion factors for percentage weight loss estimated in S. cerealella infested grains were 0.44 (apparent or 0.51 (real) and 0.60 apparent or 0.70 (real) in large and small grain respectively.

Sudhakar and Pandey (1985) reported that milled rice is a common cereal commodity and is stored for time to time consumption. Under storage conditions the raw rice is easily infested by various stored grain pests. Many workers reported that parboiling treatment of paddy makes the grain unsuitable for stored grain insect pests. Out of 14 commonly grown varieties against Sitophilus oryzae T-9 and Rambhog were found moderately resistant both in raw rice and Parboiled rice where as , IR 8, IR 24, IET-1991 and Mahsuri, Ratna R-P 4-14 and Jaya were moderately susceptible and susceptible in raw rice. IR 8, IET-1991, Ratna, RP 4-14 and Mahsuri were moderately susceptible in parboiled rice and Jaya and IR 24 we are susceptible in parboiled rice to Sitophilus oryzae.

Prakash and Rao (1986) reported that insect infestation in stored seeds reported to directly affected the germination slender varieties showed more grain weight loss than bold grain varieties.

### 2.3.1. Varietal Resistance to Sitotraga cerealella

Varietal resistance to storage insects is a potential mean of reducing post harvest losses of rice. None of the rice varieties completely offered resistance to the attack by Angoumois grain moth so far. Varietal susceptibility of rice to

this pest during storage has been reported by many workers (Chellappa & Chelliah, 1976 and Pandey et al., 1980) well formed grains have better resistance to Angoumois grain moth. Israel and Vedamoorthy (1958) reported that fine grained scented varieties like Badsahbhog and T412 were more susceptible than coarse varieties to the attack of Sitotroga cerealella .

Pophaly and Rana (1992) on their studies on horizontal infestation of Sitotroga cerealella stated that Dubraj a scented fine rice variety was more susceptible to S. cerealella attack and Safri-17 was completely free from Sitotroga cerealella attack . Mahsuri, Pragati, Kranti and Gurmatiya were least preferred and grains were damaged between 0.5 to 1.0 per cent . Grain damage for Tripti and Ruchi was 1.7 to 1.8 per cent. For Safri local, Samridhi and Asha, the grain damaged ranged between 3.0 to 3.7 per cent. In general coarse and long duration varieties were least preferred as compared to fine to medium grain and short to medium duration varieties. There was a clear cut preference of this insect for fine and medium grains rather than coarse type.

Juliano (1981) felt that resistant was related to narrow ness of grains of aromatic varieties rather than aroma.

Nigam et al. (1977) and Uttam et al., (1984) reported that Kranti and Tripti have one of the parents as IR 8

and Saket-4 which were also reported resistant to attack of Angoumois grain moth .

Dhotmal and Dumbra (1983) studied the relative susceptibility of 10 commonly grown rice varieties to Sitotroga cerealella . The highest infestation was observed on Mahsuri while the lowest was found in Vikram. Fine grained varieties were generally more susceptible than the coarse grained ones.

Baktharatchagan (1987) in TamilNadu reported that IR 50 was most susceptible paddy variety whereas TKM-9 and CO 43 were least susceptible.

ANON (1979), Upadhyay et al. (1979) and Prakash et al. (1983) stated that certain grain characters like thickness of husk, angle of hairs on the husk surface were known to influence the insects, causing grain damage during storage.

Singh and Rizvi (1991) on their experiments on ten genetically diverse rice varieties to Sitotroga cerealella infestation for 3, 6 and 9 months under laboratory conditions found narrow angle of spinules on grain husk, thin husk and less silica content increased its infestation. One or a combination of the characters were responsible to damage the grains of varieties Kalanamak (23.5 per cent), Pankaj (21.9 per cent), Sona (21.4 per

cent) and Basmati 370 (14.4 per cent) during 9 month storage. Losses in seed weight and seed germinability increased with the increase in infestation. Variety Kalanamak with highest infestation showed maximum weight loss (27.2 per cent) and germination (33.0 per cent) whereas IR 8 showed only 7.9 per cent infestation and exhibited a lowest weight loss of 16.9 per cent during 9 month storage. Weight loss and per cent grain infestation by one pest differed significantly among the rice varieties tested as follows, Saket 10.3 per cent and 16.4 per cent, Mahsuri 15.1 per cent and 19.0 per cent, Jaya 9.8 per cent and 13.0 per cent, Cauvery 10.0 per cent and 14.2 per cent grain damage and weight loss respectively.

Anon (1979), Upadhyay et al. (1979) and Prakash et al. (1983) reported that long bold varieties Jaya and IR 8 showed less infestation. Tolerance in these varieties appeared to be due to the presence of more erect hairs (wide angle), thick husk and higher amount of silica in the husk.

Prakash et al. in CRRI, Cuttack (1983) studied varietal resistance of stored paddy grains to Sitotroga cerealella in terms of the number of adult emerged and per cent damage grains. Thickness and silica content of husk and erection of awns were negatively correlated and length breadth ratio and

relative hardness of grain kernels were positively correlated with both number of adults emerged and per cent damaged grains .

Upadhyay et al. (1979) reported that a number of factors like size, grain weight, moisture content, seed colour, thickness of husk, texture of husk, hardness of grain kernel, site for eviposition, presence of awn, physiological and nutritional value of the grains play an important role in the survival and developmental of insect pests.

Ratnasudhakar (1987) screened 47 paddy varieties against Sitotroga cerealella to know the relative susceptibility during storage found that none of the paddy varieties tested showed complete resistance to S. cerealella infestation. The test varieties were categorised into moderately resistant, moderately susceptible, susceptible and highly susceptible. Vasista (M.T.U-8089) and Gowthami (M.T.U 8002) were moderately resistant, IET-4786, Rasi (IET-1444), IET-7575, IET-7574 were highly susceptible, Swarna, Mashuri, Kanchan, Phalguna, Prakash, Nagavali were susceptible and Sona Mashuri, Vijaya Mashuri, Badava Mashuri, Lakshmi, Soubhagya etc. were moderately susceptible.

Maity (1991) screened 1207 rice entries and found 42 were highly resistance to the pest recording maximum of 2.0 per

cent moth emergence and 0.77 per cent grain damage conversely 287 entries were resistant having 6.3 per cent moth emergence and 1.8 per cent grain damage, moderately resistant having 10.48 per cent moth emergence and 2.98 per cent damage in 203 rice entries. 391 varieties were susceptible which produced 18.44 per cent of moth emergence and 4.63 per cent grain damage and 284 varieties are highly susceptible having 50.71 per cent moth emergence and 12.82 per cent grain damage.

Wu Jung Tsung (1991) in China, found that Shan-you-6 and shan-you-56 were moderately resistant to Angoumois grain moth. Further more he explained that the hybrids were more susceptible to A.G.M than pure line varieties.

In pakistan, Gillani and Irshad (1990) studied eight rice varieties in the laboratory for resistance to A.G.M, Sitotroga cerealella. They found JP-5 was most susceptible and DR-82 was found least susceptible. DR-82, KS-282 and Lateefy were seemed suitable for storage. IR 36, Basmati 370 ~~wa~~ were found susceptible to this insect.

The work of Pandey et al. (1980) showed that the larvae of S. cerealella were not able to penetrate into the harvest rice grains that had tightly closed husks, but were able to do so when there was a gap between the lemma and palea.

Acharyulu and Chaudhary (1992) screened eighty four inbred lines of maize to Sitotroga cerealella during (1989). Infestation of this pest starts from the fields as the female fly from stores and lay eggs on matured Cobs. Keeping in view the nature of damage and biology of this pest, using resistant varieties would be safe and economical method for its management during storage. Therefore, efforts have been made to screen some inbred lines of maize to find out sources of resistance against Angoumois grain moth. They have taken the parameters viz, kernel infestation, loss in grain weight and growth index to evaluate relative susceptibility to S. cerealella.

$$\text{Howe's growth index} = \frac{\text{Log}_e \text{ percentage adult emergence (No)}}{\text{Average developmental period (Days)}}$$

It was found that 21 inbred lines of maize were resistant eg. Swan 201-1-2-1-3-2 = =, 25 lines were susceptible and 38 lines were intermediate . Correlation co-efficient between Kernel infestation and loss in grain weight ( $r = 0.671$ ) and kernel infestation and per cent adult emergence ( $r = 0.958$ ) were highly significant.

### 2.3.2. Alkali speeding values:

Alkali spreading values based on grain kernels digestion in KOH solutions (Little et al., 1958) is also

considered as an index of relative hardness. Higher the spreading values (2 to 7) less in the grain hardness. Russell (1976) noted the rice varieties with alkali spreading values 3.5 to 4.0 except Delta were more resistant to S. cerealella than those with alkali spreading values of 6.2 to 7.0 (Low gelatinization).

Among three high amylose rice varieties, IR 8 (alkali spreading values of 7.0) was more susceptible than IR 5 and Peta having alkali spreading value of 4.0 (Webb, 1975; Suzuki and Juliano, 1975; Juliano and Russell, 1980). Alkali spreading values were found positively correlated with the number of adults of S. cerealella emerged and the per cent of damaged grain by this moth (Prakash et al., 1983).

#### 2.4. Pre harvesting spraying of insecticides.

Prakash and Rao (1986) stated that Angoumois grain moth infests on matured grains standing crop in paddy fields and also grains during post-harvest processings like harvesting, threshing and storage.

Field incidence of S. cerealella in rice were also well documented by Douglas (1941), Israel and Vedamoorthy (1956).

## 2.5. Plant Product Admixtures :

### 2.5.1. Neem Azadirachta indica (Juss) & Melia azadirachta.

Its various products like leaves, seeds, bark, oil, oilcake, and extracts are prepared, have been reported having fungicidal, nematocidal, insecticidal, insect repellent, antifeedant, phytoalexin properties in additives to its unique medicinal value.

Wohlgemuth and pereira (1982) studied the effectiveness of ground neem seeds and leaves (A. indica) as protectant of stored maize against the attack of Sitophilus oryzae, Sitophilus zeamais, Cryptolestes ferrugineus and Rhizopertha dominica. Neem seeds and leaves were effectively reduced the progeny production of all the pests screened and the adult emergence of Sitotroga cerealella. However, when stored for a long period under warm and humid condition, the grains were spoiled due to the growth of the neem seed borne fungus and Aspergillus sp.

Devi and Mohanandas (1982) studied the relative efficacy of 11 antifeedant or deterrents protecting stored rice from the attack by Rhizopertha dominica and S. cerealella. On the basis of efficacy, phytotoxicity and cost, 0.5 per cent neem extract was considered to be the best treatment.

Lakhani and Patel (1985) reported that neem seed powder failed to give satisfactory protection against Ephestia cautella.

Prakash et al. (1980) tested some plant products against S. cereallela and Rhizopertha domonica. The order of effectiveness was malathion > pyrethrum > garlic extract > neem oil > neem extract > onion extract in case of S. cerealella.

#### 2.5.2. Custard apple (Annona reticulata)

Lakshminarayan (1975) reported the insecticidal properties of certain indigenous plant products and revealed that, when the 2nd and 3rd instar larvae of Callosobruchus chinensis and Plutella maculipennis were made to crawl over the dust prepared from seeds of Annona, Tephrosia candida, Azadirachtin indica were effective against all insects. The toxicity principle of neem (Azadirachtin), custard apple (cyanogenic compounds) were compared with Derris roots and nicotine-sulphate for toxicity.

Laboratory test conducted by Pandey and Verma (1977) found that custard apple seed (0.5 to 2 per cent) powder was a protectant of mung against Callosobruchus maculatus.

Ali et al. (1981) experimented to elucidate the effectiveness of custard apple seed powder against the multiplication of pulse beetle basing on the Harper's report, that Annona seeds contain glycerides of hydroxylated unsaturated acids, which were toxic to the insects. The seeds of bengal gram were treated 1 g & 2 g per 100g with custard apple seed powder with little water. Seed powder paste at 2g and 1g per 100g were highly effective and inflicted only 29.33 per cent and 25 per cent survival. Egg laying was greatly suppressed.

#### 2.5.3. Begunia, Vitex negundo. (Linn)

Prakash et al. (1981), experimented with begunia leaves paddy grain protectant found that leaves of begunia 2 per cent and 1.5 per cent were effective in reducing the infestation in both paddy and rice over a period of 6 months of storage. The protective function of these leaves was suspected to be due to its volatile chemical factor which was repulsive to the storage insects.

Custard apple seed 5 per cent and 2.5 per cent neem seed powder 5 per cent more or less maintained their effectiveness upto 60 days and thereafter, a distinct fall in their efficacy . But in case of neem leaf powder, begunia leaf

powder 5per cent wt/wt efficacy was declined very fast. All the treatments have proved superior to control through out the storage period of 3 months. Mishra, (1985) .

#### 2.6. Physical Barriers.

Physical barriers act as preventive measure against the entry of the larvae of Sitotroga cerealella, subsequently reducing the grain damage in store.

Singh (1967) conducted laboratory studies by keeping sand, sawdust and wheat straw layers at 2.5 cm thickness against pulse beetle and sand barrier found to be effective in protecting the grain below.

Mishra (1985), found that sand, wood ash, neem leaf powder 1 and 2 cm thickness and begunia leaf powder at 2 cm thickness completely protected the grain from the attack of S. cerealella . Begunia leaf powder at 1 cm thickness and rice bran at 1 and 2 cm thickness have allowed some larvae to enter into the grain resulting in slow population build up.

The effect of inert materials on infestation of lesser grain borer Rhizopertha dominica and their subsequent effect on germination during storage of wheat seed. Cowdung ash, wood ash, attapulгите based clay dust and Malathien dusts were

mixed with wheat seeds (H.D - 2009) at measured quantity to see the infestation of Rhizopertha dominica. The cowdung ash 40 per cent w/w was significantly better than other treatments during 15 months of storage when Malathion 5 per cent dust 0.2 per cent w/w treatment was base line for comparision (Gupta et al., 1992).

Kitchen fires and coffeewood ashes give some protection to stored grain, Rheenens et al. (1983).

#### 2.7. Trapping of moths (Sitotroga cerealella)

Loschiavo et al. (1986) concluded that the use of food and semio chemicals to bait traps has yielded encouraging results for individual.

Burkholder (1981) and Lindgren et al. (1985) in their experiment revealed the fact of capturing the multiple species of target grain beetle by the food and semiochemical bait traps.

Suzuki (1980) and Suzuki et al. (1988) recently, identified the aggregation pheromones for important pests of stored products in the families Temebrionidae and Cucujidae.

Javer, et al. (1985) Canada evaluated pheromone baited traps for monitoring of Cucujid and Tenebrionid beetles in

stored grain. Plastic probe traps, corrugated card board traps and weighing boat traps either pheromone baited or unbaited, pheromone baits showed efficient in capturing Cucujids but not so efficient in Tenebrionids. Out of these three traps plastic probe trap was superior to other two types of traps.

## 2.8. Chemical control

### 2.8.1. Malathion:

Senapati and Satpathy (1972) reported that Malathion and pyrethrin had persistent toxicity against S. cerealella. But Malathion at 16 ppm was most persistent insecticide which protected grains up to 4 months.

Lahue and Kodoum, (1979) reported that encapsulated formulations of Malathion were more effective than emulsion concentration.

Three species of moth infesting store products were susceptible to pyrethrin 0.007 per cent concentrations, Lloyd & Hewlett (1960).

Relative toxicity of Lindane, Malathion, Nicotine-Sulphate, Sevin, Pyrethrin and diazinon to the eggs of Sitotroga

cerealella were studied and LD<sub>50</sub> values were found out as 0.036, 0.0283, 0.027, 0.013, 0.0048 and 0.00348 respectively. Considering low mammalian toxicity pyrethrin appeared safer for use against Angoumois grain moth, (Biswal, 1968).

CHAPTER III

**MATERIALS AND METHODS**

## MATERIALS AND METHODS

As a component of integrated pest management in the field, breeding of rice varieties for resistance to different pests affecting the crop has been successful to some extent. Attempts had been made by different workers against susceptibility to insect pests. So, attempts were made to screen commonly grown high yielding rice varieties resistant in the field as well as in the store.

Preliminary survey revealed some differential reactions of rice varieties to the pest attack. Therefore, series of experiments were conducted to study various factors responsible for offering resistance to the pest infesting husked rice in storage.

### 3.1. Collection of Angoumois grain moth :-

Freshly emerged male and female of Angoumois grain moths were collected with the help of an aspirator from the Central farm and store of students experimental plot, Orissa University of Agriculture and Technology, Bhubaneswar. Rearing and multiplication of the insect was carried out in glass jars of size 20 X 10 cm. in the grain storage laboratory of the Department of Entomology, College of Agriculture, Bhubaneswar.

### 3.2. Food materials for larvae :

Husked paddy grains of variety IR 36 were supplied as food of the larvae. There was natural breeding of the insects in the jars and hence continuous production of adults was maintained to carry out the experiments. Prior to start the culture of the insects the grains were disinfected with E.D.B. (Ethylene Di Bromide) for seven days. A weekly intervals a fresh culture was set so as to get a steady supply of freshly emerged moths which were used to procure eggs, to be used in different experiments.

### 3.3. Collection of eggs of Angoumois grain moth :

Freshly hatched larvae of Sitotroga cerealella bore into the grain soon after hatching, it was not possible to collect the larvae for the experiments. Under natural condition eggs of Angoumois grain moth could not be collected as female lays eggs on the grain surface, cracks, crevices of the grain container as well as on the boat shaped empty glumes. Several methods like Cigarette tin method, paper strip method and indegenous method was adopted in this piece of experiment to obtain more number of eggs within short time.

The open end of round bottom flasks of ten litre capacity containing infested paddy grains and adult moths were closed with cotton plugs and the flasks were kept in dark place to facilitate gravid females to lay eggs. Generally the moths congregated on the inner surface and female were found to lay gelatinous eggs on the cotton plug. Each morning a thin outer layer of cotton from the plug containing eggs were separated and kept in petridishes for hatching. The temperature  $28 \pm 1^{\circ}\text{C}$  and relative humidity 75 per cent were maintained during this period. The relative humidity was maintained by means of KOH (Potassium hydroxide) in desiccators (Solomon, 1957). The incubation period was about 3 to 4 days and hatching took place between six to nine A.M. . Soon after hatching the larvae wandered in search of food and were collected and released on the test grains by fine camel hair brush.

#### 3.4. Use of first instar larvae for studies

Angoumois grain moths sometimes oviposit infertile eggs which do not hatch (Avertay, 1979). Under normal condition, all the eggs do not get chance to hatch owing to desiccation, predation, parasitisation etc. With a view to maintain equal number of population in each treatment, artificial infestation of grains by first instar larvae were utilised for detail studies needed in the present investigation.

### 3.5. Materials used for the experiment:

#### 3.5.1. Test insect :

Larvae of Angoumois grain moth, Sitotroga cerealella, Gelechiidae, Lepidoptera .

#### 3.5.2. Specimen Tubes :

Glass specimen tubes of (10 X 1.8 cm) size were used in carrying out the experiments. Such specimen tubes were selected for easy handling in incubator. The specimen tubes were labelled by glass marking pencil indicating the treatment, replication number date of treatment and release of larvae into the tube.

#### 3.5.3. Muslin cloth:

Muslin cloth was used for covering the rearing jars, specimen tubes and jars containing plant product admixtures etc., were secured with rubber band during the period of studies for safe aeration to the grains and respiration of the larvae.

#### 3.5.4. Food grains for treatment with admixtures :

Husked paddy grains having 16 per cent moisture content were selected for experimental purpose which were fumigated with E.D.B. to destroy the eggs and adults of other

insects and mites. In each treatment 100 grams of paddy grains were taken for conducting the experiment.

#### 3.5.5. Glass jars:

Fifty four glass jars of 250 g capacity were selected to store paddy grains treated with various plant product admixtures. The jars were labelled properly indicating the date of treatment, replication number, concentration of the plant products, etc.

#### 3.5.6. Desiccator :

Desiccators were used inside the incubator for controlling relative humidity with KOH at a constant temperature of  $28 \pm 1^{\circ}\text{C}$ . The relative humidity maintained during the experiment was 75 per cent.

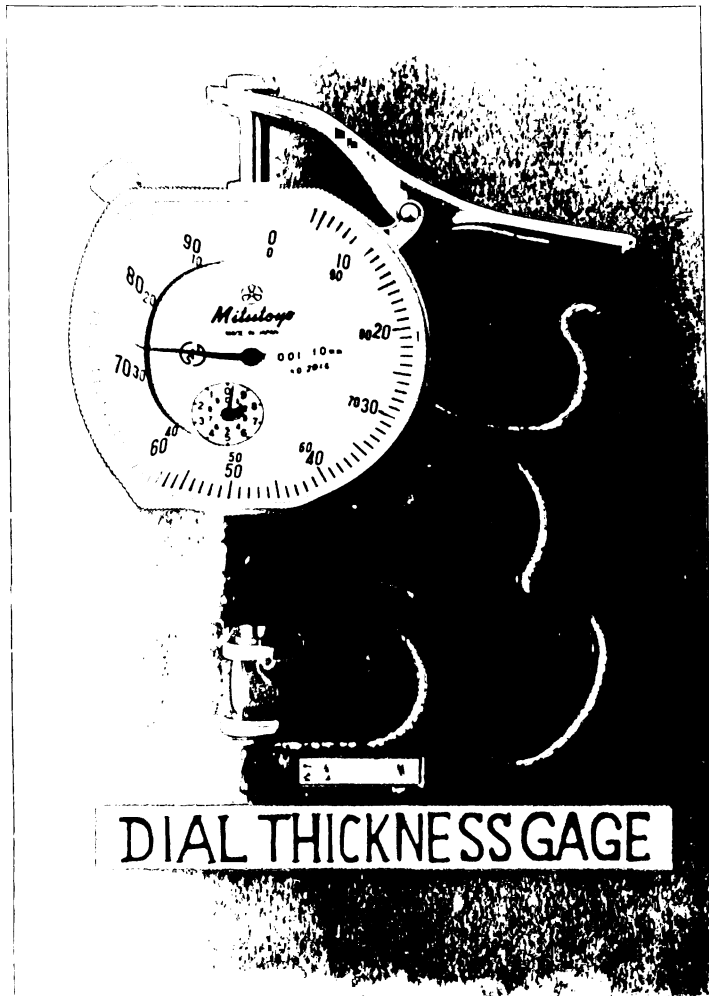
#### 3.5.7. Measuring cylinder :

The measuring cylinders of 5 ml, 10ml, 50ml capacity were chosen for measuring the water in the desiccator and measuring the water in the desiccator, measuring insecticides, kerosene etc.

### 3.6. Growth Index

The growth index was calculated by dividing the average percentage of adult emergence (n) by total developmental period.

PLATE - 1



(Grain measuring Instrument)

$$\text{Growth Index} = \frac{n}{\text{A.V.}} \quad (\text{Vijay Singh, 1987})$$

### 3.7. Measurement of grains

Measurement in respect of length and breadth of husked and dehusked grains, glumes and thickness of husk was done by Dial Thickness Gage (MITUTOYO) (Plate 1).

### 3.8. Number of grains per unit volume

Healthy grains of each entry were filled up to 100 ml mark of a measuring cylinder and closely tapped ten times prior to final counting.

### 3.9. Interspace (porosity) of grains in storage

One hundred ml. of grains of test varieties was measured after uniform tapping in a measuring cylinder. In another cylinder 100 ml of kerosene was measured and poured slowly into the cylinder containing grains until the grains was obtained by the volume of kerosene used to fill up the space upto 100 ml mark and expressed in ml .

### 3.10. Categorisation of rice varieties for resistance/susceptible.

Immune	-	0.0 percent
Highly resistant	-	0.1 to 3.0 percent
Resistent	-	3.1 to 8.0 percent
Moderately resistant	-	8.1 to 12.0 percent
Susceptible	-	12.1 to 24.0 percent
Highly susceptible	-	24.1 and above

Twenty rice entries were selected and subjected to artificial infestation with 25 larvae to 100 grains to study their relative resistance/susceptibility to AGM. The test rice entries were as follows. IR 36 Kalashree, Lalat, Jaya, Andharchaki, Badami, Keshari, Annapurna, FR-13-A, TNAU 6464, Jagannath, Rambha, Parijat, Sakti, WB-1B-15B, CR 1014, CR 1028-14-4, CR 1022-27 and Pankaj categorised as per the infestation range followed by Maity (1991).

#### 3.10.1. Grain type :

Rice grains were classified basing on its length and length breadth ratio and considered as short-bold, long-bold, medium-slender and long-slender (Chatterjee et al., 1977 and Bhattacharya and Sowbhagya 1980).

### 3.10.2. Colour of grains :

Colour of husked grains was judged according to the colour of lemma and palea and for dehusked rice and as per the aleurone layer of endosperm of the grain.

### 3.10.3. Hulling ratio :

Weighed amount of grains were dehusked carefully. Dehusked grains and husks were separately weighed. The percentage of dehusked grain and husk to grain were calculated as follows.

$$\text{Hulling ratio} = \frac{\text{Weight of dehusked grain}}{\text{Weight of grain}} \times 100$$

$$\text{Percentage of husk} = \frac{\text{Weight of husk}}{\text{Weight of grain}} \times 100 .$$

### 3.10.4. Alkali values of grain kernels

Alkali value of rice kernels is considered as one parameter to record the relative hardness/softness of rice grains. Rice kernel after abressing were kept in dilute alkali (1.7 per cent KOH) solution for 23 hours in petridishes and then scoring the grades/values (1-7) was done basing upon the visual observation and measurements was made in general procedure to record alkali values. Relative alakali values of rice entries

were determined as per the method developed by Bhattacharya and Sowbhagya (1972) and Bhattacharya (1979). Six polished rice kernels of each test rice entry were soaked in 1.7 per cent KOH solution at 30°C for 23 hours in petridish of 7 cm diameter and the degradation of rice kernel was noted. Each rice kernel was placed in equal distance of 2.0 to 2.5 cm and sufficient potassium hydroxide solution was maintained above the kernel to give chance for degradation.

Scoring pattern of rice kernels for alkali values in KOH (potassium hydroxide solution).:

<u>Score(s)</u>	<u>Observation</u>
1-2	No disintegration of kernel but swollen
3-4	Collar disintegration.
5	Half kernel disintegration.
6	More than half kernel disintegration
7	Completely opaque.

#### 3.10.5. Recovery of head rice:

Breaking of dehusked rice is also a relative parameter to know the hardness or softness of the paddy grain. To know the percentage of recovery of head rice, 100 dehusked grains were kept and a pressure of 40 lb/square cm was rolled over it by

a roller and the head rice were counted. Consequently per cent recovery of head rice was calculated.

3.10.6. Percentage of successful development of adult in various rice entries :

Twenty five first instar larvae of S. cerealella were released in each specimen tube containing 100 grains. The number of moths emerged and number of grain damaged were counted and converted into percentage of emergence.

3.11. EXPERIMENTAL DESIGN AND LAYOUT

The experiment was laid out in a randomised complete block design with ten treatments including an untreated check, each of which was replicated thrice. (Fig. 1)

	RI	RII	RIII	
	3M			N
2M	ACEPHATE	MONOCROTOPHOS	ENDOSULFAN	
	TRIAZOPHOS	METHOMYL	AZADIRACHTIN	
	MONOCROTOPHOS	ACEPHATE	CARBOSULFAN	
	ENDOSULFAN	TRIAZOPHOS	MALATHION	
	ETHOPHAN-PROX	CARBOSULFAN	CONTROL	
	AZADIRACHTIN	MALATHION	ETHOPHAN-PROX	
	CARBOSULFAN	CONTROL	METHOMYL	
	METHOMYL	AZADIRACHTIN	MONOCROTOPHOS	
	CONTROL	ETHOPHAN-PROX	TRIAZOPHOS	
	MALATHION	CARBOSULFAN	ACEPHATE	

Fig. 1 LAYOUT OF THE FIELD SPRAY AT HARVEST

3.12. Efficacy of insecticides sprayed at harvest to study their residual effect on Angoumois grain moth infestation under natural condition.

To study the effect of insecticides in storage condition rice variety IR-36 was transplanted on 02.07.94 in 6 square meter sub plots. All agronomical practices were followed during crop growth stages. The fertiliser dose was given to the crop at the rate of 80:40:40 kg N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O per hectare. The layout was made as per the randomised block design with nine treatments including control which were replicated thrice (Table-1).

Table. 1

Insecticides applied on ripened grains at harvest and their doses.

Sl. No.	Insecticides	Formulation	Trade name	dose/concentration(%)
1.	Monocrotophes	36 SL	Monovol	0.05
2.	Endosulfan	35 EC	Hildan	0.05
3.	Triazophes	40 EC	Hostathion	0.05
4.	Ethophan prox	10 EC	Tieban	0.05
5.	Acephate	75% EC	Asataf	0.05
6.	Carbosulfan	25 EC	Marshal	0.05
7.	Methomyl	12.5 L	Dunel	0.05
8.	Azadirachitin	0.15 EC	Rakshak	0.05
9.	Malathion	50 EC	Malathion	0.05

The crop was sprayed with the above insecticide in different treatments two days before harvest. Grains were collected treatmentwise and dried properly, so that the moisture content of grain samples were 15-16 per cent. To study the residual toxicity of the insecticides 250 grams of grains from different treatments were taken in cotton bags and kept under natural storage condition. Three such replications were taken for each treatment. The observations on percentage of moth emergence, grain damage and weight loss were recorded at 30 days intervals upto three months.

### 3.13. Treatment of paddy grains with plant product admixtures

The leaves of neem (Azadiracttin indica), Vitex negundo, Pongamia, custard apple, Ageratum, Chorchorous capsularis, Lantana and Ipomoea, were collected and dried under shade and ground to powder of 60 mesh. Likewise the seeds of neem, Pongamia, custard apple and bark of neem, Pongamia, Moringa were dried under shade and ground to form by grinder. Banana and other dried leaves were collected and burnt to get ash of 60 mesh sieve size separately for carrying out the experiment. To obtained 2.5 and 5 per cent leaf and seed powder 100 g of paddy were mixed with 2.5 g and 5 g ash, seed and leaf powder respectively and kept for three months under natural storage condition. (Table - 2).

Table 2.

## List of plant products and concentrations used.

Sl. No.	Common Name	Scientific/Botanical name	Family	Preparation used	Concentration (%) w/wt.
1.	Neem	<u>Azadirachta indica</u> (Juss)	Meliaceae	Seed powder	2.5
2.	-do-	-do-	-do-	Leaf powder	5
3.	-do-	-do-	-do-	Bark powder	2.5
4.	Karanj	<u>Pongamia glabra</u>	Leguminosae	Seed powder	2.5
5.	-do-	-do-	-do-	Leaf powder	5
6.	-do-	-do-	-do-	Bark powder	2.5
7.	Custard apple	<u>Annona reticulata</u> (Linn)	Annonaceae	Seed powder	2.5
8.	-do-	-do-	-do-	Leaf powder	5
9.	Begunia	<u>Vitex negundo</u> (Linn)	Verbanaceae	Leaf powder	5
10.	Pokasungha	<u>Ageratum conyzoides</u>	Compositae	Leaf powder	5
11.	Sojana	<u>Moringa pterygosperma</u>	Moringaceae	Bark powder	2.5
12.	Amari	<u>Ipomoea carnea</u>	Convolvulaceae	Leaf powder	5
13.	Nagairi	<u>Lantana camara</u>	Verbanaceae	Leaf powder	5
14.	Banana	<u>Musa paradisiaca</u>	Musaceae	Leaf ash	2.5
15.	Mixed leaf ash			Leaf ash	2.5
16.	Nalita	<u>Chorchorus capsularis</u>	Tiliaceae	Leaf powder	5
17.	Malathion		----	Dust	0.02



TRAPS USED IN TRAPPING ANGOUMOIS GRAIN MOTH.

**.14. Penetration ability of Sitotroga cerealella larvae through physical barriers.**

To study the penetrating ability of Angoumois rain moth larvae through surface layers of sand, rice bran, rice husk and chaffy grain were put on the surface of test grains of one cm thickness and ten freshly hatched larvae were transferred. In separate set of specimen tubes containing test grains and one cm layer of above physical barriers were taken and five pairs of freshly emerged Angoumois grain moth S. cerealella were released to confirm the penetration ability of the larvae. All specimen-tubes were secured by muslin cloth and rubber bands and kept under  $28 \pm 1^{\circ}\text{C}$  and 75 per cent relative humidity. Successful development of larvae were noted after three months by counting the number of adults from each specimen tube.

**.15. Use of Traps to catch Angoumois grain moth :**

Pheromone trapping is the most promising means of capturing moths in pest management programme. To study the effect of sex-lures on Angoumois grain moth biosense lure 02, specific for Angoumois grain moth was used. The biosense trap and lure were supplied by M/S ECOMAX AGRO SYSTEM, Bombay (Plate 2).

The trap was set in the paddy godown of central arm QUAT continuous for twenty days. To kill the attracted moths

in the trap, D.D.V.P was used after soaking in a piece of cotton and kept in the bottom of the trap. The number of moths caught in every 24 hours were counted sex-wise. To compare the effectiveness of sex-lure, four different types of locally used traps were also used. These traps were consisting as following materials.

1. Water
2. Water + Kerosene 10 ml.
3. Water + Kerosene 10 ml + Turmeric powder 5 g.
4. Water + Kerosene 10 ml + candle.

The above materials were kept in equal size of four galvanised iron (G.I) trays measuring 12" x 9" separately and set in the same godown. Number of moths caught in every 24 hours were counted sex wise. The efficiency of these traps were observed and compared one another.

## STATISTICAL ANALYSIS

Data obtained on the life cycle of Angoumous grain moth, grain damage and weight loss percentage of different plant product admixtures, as well as physical barrier, moth emergence in pre-harvest spraying with insecticides and moth emergence in different rice entries, morphology of husk number of adult moth captured in different traps were subjected to statistical

analysis. (Snedecor and Cochran, 1959). Observations pertaining to grain damage and moth emergence percentage which were ranged from 30 to 90 the values were converted to angular transformation. The all observations related to insect population and percentage range between 0 to 30 per cent were converted to  $\sqrt{n}$  transformation. When most of the values were small and especially many zeroes were present  $\sqrt{n + 0.5}$  in .stead of  $\sqrt{n}$  was used (Gomez and Gomez, 1970).

Complete Randomised Block Design was followed for statistical analysis. Fishers method of analysis of variance was applied to test the significance of data at 5.0 and 1.0 percent probability level. After testing the significance of results, critical difference was calculated to compare the mean differences among the treatments.

## CHAPTER IV

# RESULTS

## RESULTS

During 1994-95 a series of experiments were conducted to determine the extent of damage, loss in weight, successful development of Angoumois grain moth on different popular rice varieties in the laboratory of Department of Entomology, College of Agriculture, OUAT, Bhubaneswar. The study was also pertaining to the field infestation of Angoumois grain moth and effect of chemicals sprayed at harvest to evaluate the effectiveness of those chemicals upto the storage period of three months. Observations were recorded on the relative efficacy of certain plant product admixtures under natural storage condition against this pest and to determine the comparative efficacy of different traps to monitor the pest population in store house. The results thus, obtained are critically analysed and ascribed in the following paragraphs.

### 4.1 Screening of rice entries to Angoumois grain moth :

A test was conducted to screened out 20 popular rice entries to determine their relative resistance/susceptibility to Sitotroga cerealella in the laboratory at  $28 \pm 1^{\circ}\text{C}$  and 75 per cent relative humidity observed that the percentage of successful development from larva to adult stage widely varied from 1.50 to 31.14 which clearly demonstrated a difference in the varietal characters of the cultivar to Sitotroga cerealella (Table 3).

Table - 3.

List of rice entries with their origin and characteristics.

Sl. No.	Rice entries	Cross	Percentage of moth emergence	Grain colour	Colour of the endosperm	Grain type
1.	FR 13A	Pure line selection from Dhulla pakhia	1.33 (6.54)*	Straw	Red	S.B.
2.	WB-1B-15B		1.67 (7.33)	Brown	White	M.S.
3.	TNAU 6464	Bala/Co - 13	4.67 (12.46)	Straw	White	S.B.
4.	Sakti	Ptb 21/Ptb 18//IR 8	5.00 (12.88)	Straw	White	S.B.
5.	Jagannath	Mutant of T 141	7.00 (15.32)	Straw	White	S.B.
6.	Andharchaki	Local	8.00 (16.08)	Brown	Opaque -white	S.B.
7.	Badami	Suphala/Annapurna	9.33 (17.71)	Light brown	Red	S.B.
8.	Parijat	T(N) 1/TKM-6	10.67 (19.01)	Straw	White	S.B.
9.	Rambha	Pankaj/W 1263	14.67 (22.37)	Straw	White	S.B.
10.	Jaya	T(N) 1/T 141	14.67 (22.19)	Straw	Red	L.B.

(Contd. )

11. Pankaj	Peta/Tangkairatan	16.33 (23.82)	Straw	White	S.B.
12. Annapurna	T(N) 1/Ptb 10	17.33 (24.57)	Brown	Red	L.B.
13. Lalat	Obs 677/IR 2071// Vikram/W 1263	20.00 (26.57)	Straw	White	M.S.
14. CR 1014	T 90/Urangurangan	81.00 (64.27)	Straw	White	M.S.
15. Keshari	Kumar/Jagannath	44.67 (41.92)	Light red	White	L.S.
16. IR 36	IR 8/Tadukan/TKM 62/ T(N)1/IR 243/Dryzani- vera 4/IR 8/Ptb 18/ Ptb 21.	30.67 (33.17)	Straw	White	L.S.
17. CR 1030 (Utkal Prava)	Waikoku/CR 1014	28.00 (31.91)	Straw	White	M.S.
18. CR 1028-14-4	-----	26.67 (31.08)	Straw	White	S.B.
19. Kalashree	CR 151-70/CR 1014	32.00 (34.42)	Straw	White	L.S.
20. CR 1022-27	-----	24.00 (27.28)	Straw	White	M.S.
-----					
S.E. (m) <sub>±</sub>	-----	4.055			
C.D. at 0.05	-----	8.170			

\* Figures in parentheses are angular transformed value.

#### 4.2 Categorisation of rice entries to Angoumois grain moth :

Rice entries which exhibited significant difference in the degree of successful development of the insect were grouped into six categories, viz. immune, highly resistant, resistant, moderately resistant, susceptible and highly susceptible.

Table-4.

Categorisation of rice varieties into relative susceptibility on the basis of successful development of Sitotroga cerealella and percentage grain damage.

Category	No. of entries under the group	Name of the rice cultivars	Average moth emergence (%)	Average grain damage (%)
Immune	--	-----	---	---
Highly resistant	2	FR 13A and WB-1B-15B	1.50	0.65
Resistant	4	TNAU 6464, Sakti, Jagannath and Andharchaki.	6.17	1.65
Moderately resistant	2	Badami and Parijat	10.00	2.55
Susceptible	5	Rambha, Jaya, Pankaj, Annapurna and Lalat	16.60	4.67
Highly susceptible	7	Kalashree, Keshari, IR 36 CR 1014, CR 1030, CR 1028-14-4 and CR 1022-27.	31.14	9.78
S.E. (m) $\pm$		-----	4.05	0.141
C.D. at 0.05		-----	8.17	0.284

It is revealed from the Table 4 that none of the rice entries proved to be immune to the attack of S. cerealella larvae. Only two rice entries were highly resistant to the pest upto 1.5 per cent moth emergence and 0.65 per cent grain damage. In the resistant category four cultivars recorded average infestation of 6.17 per cent moth emergence and 1.65 per cent grain damage. The moderately resistant group recorded 10.00 per cent moth emergence and 2.55 per cent grain damage in two rice entries. On the other hand the susceptible category recorded 16.60 per cent moth emergence and 4.67 per cent grain damage and five rice entries come under this category. In the highly susceptible group seven entries showed a mean percentage of 31.14 moth emergence and 9.78 per cent of grain damage (Table 4).

Statistical analysis of data on degree of successful development of the insect and damage grains due to the larval feeding indicated a highly significant difference between a resistant and susceptible groups of grains. But there was a non-significant effect between highly resistant and resistant, resistant - moderately resistant and moderately resistant - susceptible groups of rice cultivars where as susceptible and highly susceptible groups in respect of moth emergence and moderately resistant, susceptible and highly-susceptible in respect of grain damage differed significantly.

4.3 Varietal effect of resistant/susceptible categories of rice on the biology of S. cerealella.

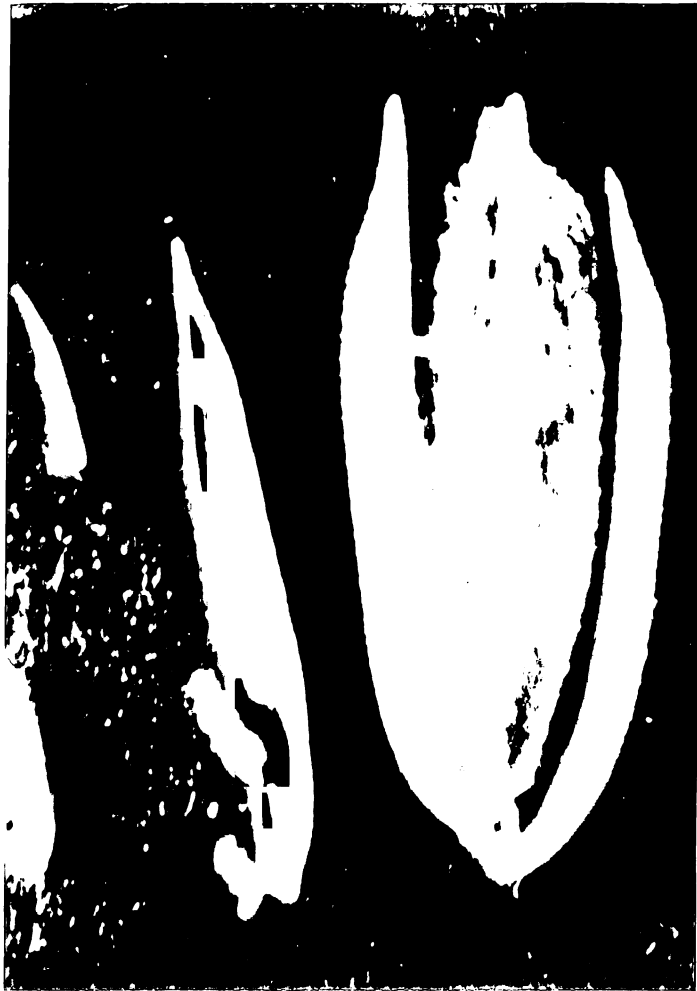
Studies on the duration of life stages of Sitotroga cerealella were carried out in the laboratory on twenty rice entries. The insect was reared at a temperature of  $28 \pm 1^{\circ}\text{C}$  and 75 per cent relative humidity. The developmental period of different stages of life cycle of the pest were recorded and described in the following paragraphs.

Table-5.

Varietal effect of resistant/susceptible categories of rice grain on the biology of S. cerealella.

	Moth emergence (%)	Incubation period	Larval-pupal period	Total developmental period	Growth Index N/AV
Immune	--	--	--	--	--
Highly resistant	1.50	5.00	25.21	30.21	0.05
Resistant	6.17	4.67	24.33	29.00	0.21
Moderately resistant	10.00	4.67	23.67	28.34	0.35
Susceptible	16.60	4.67	22.86	27.53	0.57
Highly susceptible	31.14	4.43	22.57	27.00	1.36
S.E.(m) $\pm$	4.045	NS	NS	--	0.126
CD at 0.05	8.170	--	--	--	0.260

PLATE - 3



SITE OF EGG LAYING OF ANGOUMOIS GRAIN MOTH  
( Bigger empty glumes facilitate space for more number  
of egg deposition)

#### 4.3.1 Engg :

Freshly laid eggs are gelatinous white turn pinkish after a day and these are deposited on the surface of flowering glumes and cavity of empty glumes of rice grain (Plate 3). The incubation period varied from 4.43 to 5.00 days on different groups of rice grains (Table 5). Statistical analysis revealed that the period from egg laying to hatching was non-significant among the categories of rice entries.

#### 4.3.2 Larval-pupal stage :

The pest is an internal feeder and both larval and pupal stages are completed inside the grain, so both the stages recorded as developmental stage of the pest. The newly hatched larvae crawled on the surface of grain in search of food. After confinement, the larvae usually started spinning a loose case around themselves and attempted to bore a hole on the grain surface. After entering into the grain it started feeding on the germ and endosperm leaving the aleurone layer till it become fully grown. Before pupation, the full grown larva made an exit tunnel leaving a very thin layer of untouched husk for emergence of the adult (Plate 4). The duration of larval-pupal period varied from 22.57 to 25.22 days in different categories of rice entries at  $28 \pm 1^{\circ}\text{C}$  and 75 per cent rh (Table 5). Statistical analysis showed that larval-pupal period did not vary significantly among the groups of rice entries.

PLATE - 4

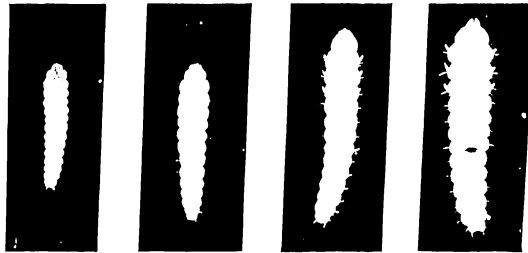
LIFECYCLE OF ANGOUMOIS GRAIN MOTH



ADULT MALE

ADULT FEMALE

Eggs



1st INSTAR LARVA    2nd INSTAR LARVA    3rd INSTAR LARVA    4th INSTAR LARVA



MALE PUPA



FEMALE PUPA

DIFFERENT STAGES OF LIFE CYCLE OF A.G.M.

#### 4.3.3 Growth index :

Growth index of the insect developed from the rice entries varied widely from 0.05 to 1.36 which showed a greater range of infestation by the pest was exist among twenty rice entries studied (Table 5). Critical study showed that there is non-significant effect on growth index in between highly resistant - resistant, resistant - moderately resistant and moderately resistant - susceptible group of entries, but growth index of highly susceptible group differed significantly among all the groups under study. So it is evident that larvae of S. cerealella negate faster rate of development in resistant rice grains than the susceptible ones resulting in less number of moth emergence.

#### 4.4 Physical characters of Grains on the Resistance/susceptibility of Rice Entries to Sitotroga cerealella

##### 4.4.1 Grain colour :

Colour of rice grain is determined by the colour of the husk. In twenty rice varieties mainly two husk colour observed namely straw and brown. The colour of the endosperms were observed as whitish or reddish. Among the test entries straw coloured rice husk was observed in 15 per cent rice and such grains were recorded in highly resistant, resistant and

susceptible categories of rice. Colour of the endosperm (aleurone layer) was observed as red and white in rice categories. No specific colour in respect of husk or endosperm was found to be associated with grain resistance/susceptibility to S. cerealella attack.

#### 4.4.2 Grain type (Grade)

Rice grains are classified into different grades based on their length and length and breadth (L/B) ratio. Though rice varieties have been classified into five categories viz., long-slender, long-bold, medium-slender, short-slender and short-bold but in present study only four categories viz., short-bold, medium-slender, long-bold and long-slender were observed to study of resistance/susceptibility to S. cerealella.

It was observed from the Table 3 that rice entries of highly resistant, resistant and moderately resistant were mostly short bold, whereas in susceptible group grains were of short bold, medium slender and long bold. But grains of highly susceptible group were mostly medium and long-slender. Thus it is indicated that, fineness of rice grains has some affinity to the attack by Angoumois grain moth.

## 4.4.3 Length and Breadth of Rice grains

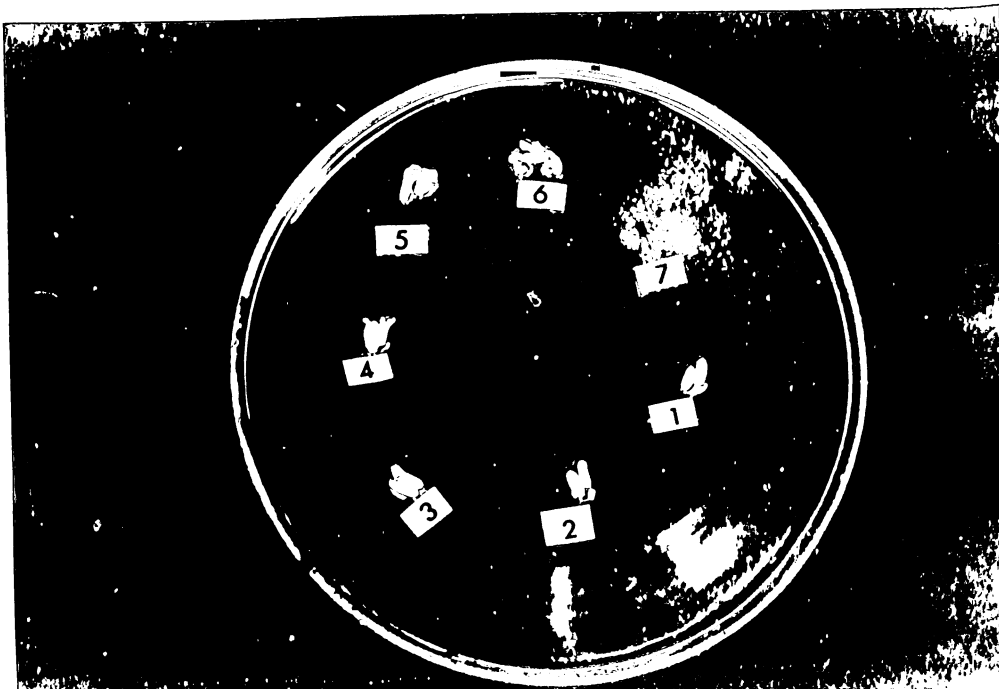
An attempt was made to study the effect of length and breadth of different categories of rice grains on the degree of susceptibility to S. cerealella attack. The average length of husked and dehusked grains in various groups varied from 7.84 to 8.55 mm and 5.48 to 6.29 mm respectively (Table 6). Similarly breadth of husked and dehusked rice groups varied from 2.05 to 3.36 mm and 1.81 to 2.77 mm respectively. L/B ratio of husked and dehusked grains ranged from 2.49 to 4.07 and 2.23 to 3.33 mm respectively.

Table-6.

Measurement of rice grains belonging to the resistant/susceptibility groups, L/B ratios and Alkali spreading values.

Categories of rice entries	Husked grain			De-husked grain			Alkali spreading values
	length (mm)	breadth (mm)	L/B ratio	length (mm)	breadth (mm)	L/B ratio	
Immune	--	--	--	--	--	--	--
Highly resistant	8.55	3.36	2.49	6.14	2.77	2.23	3.50
Resistant	7.84	2.54	3.14	5.48	2.19	2.54	4.75
Moderately resistant	8.08	2.43	3.32	5.69	2.14	2.66	5.35
Susceptible	8.46	2.23	3.79	6.29	1.97	3.19	5.60
Highly susceptible	8.21	2.05	4.07	5.94	1.81	3.33	6.03
S.E. (m) $\pm$ 1	0.130	0.058	0.124	0.165	0.052	0.153	0.537
C.D. at 0.05	0.263	0.117	0.250	0.334	0.105	0.310	1.085

PLATE - 5



ALKALI SPREADING VALUES OF RICE KERNELS.

Alkali spreading values which indirectly indicates the hardness of the grains was studied for all entries of rice grain of different categories. Average alkali spreading value ranged from 3.50 to 6.03 (plate 5).

Statistical analysis of data revealed that there were significant differences among the rice entries in respect of length, breadth, L/B ratio and alkali spreading value. It is seen from Table 6 that the length of the grains did not increase or decrease with the percentage of moth emergence in different categories. But it is interesting to note that the percentage of moth emergence decreased with the increase in breadth, L/B ratio and alkali spreading values of the rice entries.

#### 4.4.4 Grain weight and hulling ratio

The weight of the grain depends on the material contained in the endosperm and in the husk. So the weight of the endosperm and the husk may contribute some factors towards susceptibility or resistance of grains to S. cerealella. Therefore, in the laboratory weight of grains, endosperm and husk were recorded and hulling ratio of individual rice entries were calculated to correlate the data with relative susceptibility/resistance to the pest attack.

Table-7.

Comparative study of the physical characters in different Resistant/Susceptible groups of rice.

Sl. No.	Rice varieties categories	1000 grain weight		Hulling ratio	Recovery of head rice	Interspace in volume (cc)	No. of grains/ 100 cc
		husked grain (gm)	dehusked grain (gm)				
1.	Immune	--	--	--	--	--	--
2.	Highly resistant	34.52	20.90	1.67	82.70	55.20	1987.00
3.	Resistant	21.93	18.10	1.22	81.40	49.30	2757.80
4.	Moderately resistant	21.21	16.90	1.25	78.60	47.30	2939.50
5.	Susceptible	24.43	20.30	1.18	79.10	50.90	2680.60
6.	Highly susceptible	20.63	16.86	1.23	78.10	49.80	3217.40
	S.E. (m) $\pm$	0.115	0.100	0.23	1.24	0.32	22.00
	C.D. at 0.05	0.232	0.202	0.465	2.50	0.65	44.90

On critical observation it was seen that weight of 1000 husked and dehusked rice grains belonging to different categories varied from 20.63 to 34.52g and 16.86 to 20.90g (Table 7) respectively. Hulling ratio of different categories varied from 1.23 to 1.67 whereas recovery of head rice was recorded 78.1 to 82.7 per cent in rice categories. Volume and interspace of rice grains were examined in the laboratory showed that interspace of the grains of different categories varied from 47.3 to 55.2cc and number of grains contained in 100 cc varied from 1987.0 to 3217.4.

The above table showed significant effects in respect of weight of husked and dehusked grains, hulling ratio, recovery of head rice, interspace and number of grain/100 cc. Though the data significantly differed among the rice categories but these were not in sequence with the respective resistant/susceptible groups .

#### 4.5 Morphology of rice husk :

Husk of rice grain consists of two empty and two flowering glumes (Lemma and Palea) and as an important protective structure against the pest attack. Some characteristics of husk such as thickness, texture and bristles present on the husk surface were found to influence the degree of infestation by S. cerealella. Length, breadth and thickness of flowering glumes of selected rice varieties of different categories have been evaluated as follows.

Measurement of glumes showed that length of lemma and palea ranged from 6.96 to 7.89 mm and 7.12 to 7.71 mm and breadth from 1.89 to 2.43 mm and 1.09 to 1.36 mm respectively (Table 8). Thickness of glumes (husk) varied from 0.15 to 0.27 mm.

Statistical analysis indicated that length of glumes of rice grain belonging to different categories differed significantly but there was no systematic increase or decrease in length of grains from highly resistant to highly susceptible groups. But breadth and thickness of glumes gradually increased from susceptible to resistant entries significantly.

Table-8.

Comparative Morphology of Rice glumes of the Resistance/susceptible categories.

Sl. No.	Categories	Lemma		Palea		thickness (mm)
		Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	
1.	Immune	--	--	--	--	--
2.	Highly Resistant	7.83	2.43	7.65	1.36	0.27
3.	Resistant	6.96	2.17	7.12	1.28	0.23
4.	Moderately resistant	8.07	2.14	7.51	1.26	0.21
5.	Susceptible	7.81	2.07	7.71	1.24	0.18
6.	Highly susceptible	7.89	1.89	7.60	1.09	0.15
7.	S.E. (m)	$\pm 0.18$	0.11	0.28	0.097	0.06
8.	C.D. at 0.05	0.37	0.23	0.57	0.200	0.12

Table-9.

Effect of spraying of insecticides on rice grains just before harvest.

Sl. No.	Treatments	Dose (%)	After one month (30 days)			Two months after (60 days)			Three months after (90 days)		
			No. of moth emerged	grain damage (%)	weight loss (%)	No. of moth emerged	grain damage (%)	weight loss (%)	No. of moth emerged	grain damage (%)	weight loss (%)
1.	Acephate	0.05	3	0.024 (0.155)*	2.62 (1.62)	30	0.35 (0.59)	2.96 (1.72)	175	1.7 (1.3)	4.32 (2.08)
2.	Monocrotophos	0.05	4	0.032 (0.179)	2.70 (1.64)	67	0.72 (0.85)	3.34 (1.83)	198	2.02 (1.41)	4.66 (2.16)
3.	Endosulfan	0.05	5	0.040 (0.200)	2.72 (1.65)	82	0.86 (0.93)	3.48 (1.87)	283	2.86 (1.69)	5.49 (2.34)
4.	Methomyl	0.05	11	0.088 (0.297)	2.85 (1.69)	198	2.04 (1.43)	4.52 (2.13)	349	3.57 (1.89)	6.19 (2.48)
5.	Triazophos	0.05	7	0.056 (0.237)	2.73 (1.65)	118	1.23 (1.11)	3.77 (1.94)	268	2.86 (1.69)	5.49 (2.34)
6.	Azadirachtin	0.05	5	0.04 (0.200)	2.62 (1.62)	52	0.57 (0.75)	3.19 (1.79)	128	1.29 (1.13)	3.91 (1.98)
7.	Carbosulfan	0.05	9	0.072 (0.268)	2.85 (1.69)	210	2.08 (1.44)	4.63 (2.15)	413	4.3 (2.07)	6.9 (2.63)
8.	Malathion	0.05	7	0.056 (0.237)	2.74 (1.66)	105	1.09 (1.04)	3.61 (1.90)	223	2.24 (1.5)	4.86 (2.20)
9.	Ethophan-prox	0.05	2	0.016 (0.126)	2.60 (1.61)	10	0.17 (0.41)	2.85 (1.69)	186	2.0 (1.41)	4.61 (2.15)
10.	Control		19	0.152 (0.390)	3.20 (1.79)	351	3.44 (1.86)	6.00 (2.45)	556	5.48 (2.34)	8.10 (2.85)
S.E. (m) $\pm$			1.210	0.0035	0.035	3.116	0.067	0.0245	3.580	0.0852	0.042
C.D. at 0.05			2.542	0.0074	0.074	6.547	0.141	0.052	7.522	0.1786	0.088

\* Figures in parentheses are square root transformed value ( $\sqrt{x}$ ).

#### 4.6 Field Infestation of Angoumois grain moth and effect of insecticides in the stored rice sprayed at harvest

Angoumois grain moths lay eggs on the grains of standing crops during its dough to matured stage. Eggs are hatched, larvae bore into the grain and complete its larval-pupal stage inside which generally require 25 to 30 days. In the mean time, the crop is harvested and in some cases threshed and stored. Thereby, infested grains carried to the store is one of the sources of infestation by S. cerealella.

With view to the above fact, for academic interest a field trial was conducted during Kharif-1994 adjacent to the field store to investigate the effect of spraying at harvest and to study the residual toxicity of different insecticides.

One day before the harvest nine insecticides were sprayed at the rate of 0.05 concentration. Among these insecticides Malathion was kept as standard and one treatment was kept unsprayed to see the natural infestation of grains by Sitotroga cerealella. After threshing, the grains were kept in bags and replicated thrice and which finally stored in the godown. In each month the grains were observed and number of moth emerged, percentage of grain damage and weight loss were recorded. After one month average number of moth emerged varied from 2 to 19. Grains collected from the plots received with

Ethophan-prox recorded only two moths followed by three in Acephate in comparison to 19 moths in untreated plots. Grain damage after one month storage was very negligible as pest population in first generation was very low. In different treatments weight loss was varied from 2.60 to 3.20 per cent which is mainly due to drying of moisture from the grains (Table 9).

Observations on moth emergence after 60 days of storage showed that grains from Ethophan-prox, only 15 moths followed by 30 in Acephate, 52 in Azadiractin and 67 in Monocrotophos in comparison to 351 moths in control. Likewise grain damage was ranged from 0.17 to 3.44 per cent and varied significantly among the insecticides used. Weight loss after 60 days varied from 2.85 to 6.00 per cent significantly.

Observations after 90 days showed a significant variation in moth emergence among the treatments and maximum of 556 moths was recorded from grains collected from control plots as against 128 in Azadirachtin, 175 on Acephate and 186 in Ethophan-prox etc. Grain damage ranging from 1.29 to 5.48 per cent which was significant among the treatments. Similarly weight loss also recorded from 3.91 to 8.10 per cent damage and there was significant variation among the treatments. In respect of grain damage and weight loss best residual protection to Angoumois grain moth was offered by Azadirachtin followed

Acephate followed by Ethopran-prox. Though other insecticides afforded protection superior to untreated check and their residual toxicity was not satisfactory in comparison to above three insecticides.

The best protection to Angoumois grain moth due to Ethopran-prox was found upto 60 days but in the long run Azadirachtin was found to be the best in keeping grain safer even after 90 days of treatment among the insecticides tested.

#### 4.7 Effect of plant admixtures on the occurrence of Angoumois grain moth

Plant products are the richest source of organic chemicals which provide protection to the insect pests because of the presence of unpalatable substance in them. Application of insecticides or fumigants to the grains lead to pollution, health hazards and high cost involvement. On the contrary, locally available known plant products are harmless, low cost, eco-friendly may also provide comparable results in respect of chemical use.

To find out the relative efficacy of the plant product admixtures to protect rice grains against Sitotroga cerealella was evaluated in the laboratory by releasing 5 pairs of adults. Products of ten plant species including leaf, bark, seed and ash were mixed at the rate of 5 per cent in case of leaf

Table - 10.

Effect of plant product Admixtures on the development of *S. cerealella* and grain damage.

Sl.	Plant admixtures	Dose (%)	After one month (30 days)			After two months (60 days)			After three months (90 days)		
			No. of month emerged	Grain damage (%)	Loss in weight (%)	No. of month emerged	Grain damage (%)	Loss in weight (%)	No. of month emerged	Grain damage (%)	Loss in weight (%)
1.	<i>Vitex negundo</i>	Leaf 5	12	0.28(0.53)*	2.71(1.65)	15	0.29(0.54)	2.80(1.66)	12	0.72(0.84)	3.86(1.96)
2.	<i>Pongamia glabra</i>	bark 2.5	10	0.23(0.46)	4.19(2.05)	173	2.10(1.45)	5.80(2.40)	73	4.75(2.12)	6.34(2.52)
3.	<i>Pongamia glabra</i>	Leaf 5	85	1.80(1.34)	6.07(2.46)	78	2.30(1.51)	6.40(2.56)	50	6.20(2.49)	7.14(2.67)
4.	<i>Pongamia glabra</i>	seed 2.5	4	0.01(0.10)	2.39(1.55)	14	0.28(0.53)	3.45(1.86)	65	0.35(0.59)	5.49(2.34)
5.	<i>Azadirachta indica</i>	bark 2.5	70	1.50(1.22)	5.66(2.38)	77	1.80(1.34)	3.70(1.92)	103	4.65(2.16)	7.61(2.76)
6.	<i>Azadirachta indica</i>	Leaf 5	44	0.50(0.70)	3.33(1.81)	13	0.40(0.63)	3.75(1.93)	41	4.30(2.07)	4.76(2.18)
7.	<i>Azadirachta indica</i>	seed 2.5	35	0.40(0.63)	3.63(1.90)	35	1.40(1.18)	7.40(2.72)	127	6.90(2.63)	10.73(3.28)
8.	<i>Annona reticulata</i>	Leaf 5	64	1.20(1.08)	3.80(1.95)	132	2.70(1.64)	3.90(1.97)	117	3.90(1.98)	5.00(2.24)
9.	<i>Annona reticulata</i>	seed 2.5	19	0.30(0.54)	2.86(1.69)	10	0.35(0.59)	3.50(1.87)	15	1.40(1.18)	4.16(2.40)
10.	<i>Ageratum conyzoides</i>	Leaf 5	5	0.01(0.10)	2.46(1.57)	52	0.80(0.89)	3.00(1.71)	100	2.12(1.45)	5.33(2.31)
11.	<i>Ipomoea carnea</i>	Leaf 5	145	2.10(1.44)	6.71(2.59)	138	3.50(1.87)	8.50(2.91)	107	5.95(2.44)	9.52(3.09)
12.	<i>Chorchorous capsularis</i>	Leaf 5	122	1.95(1.39)	4.40(2.09)	64	2.65(1.63)	6.40(2.53)	95	6.65(2.58)	9.24(3.04)
13.	<i>Musa paradisiaca</i>	Leaf 2.5	45	0.45(0.67)	4.59(2.14)	132	2.01(1.42)	4.65(2.15)	45	3.20(1.79)	4.80(2.19)
14.	Mixed ash	ash 2.5	157	2.15(1.47)	6.37(2.52)	92	4.43(2.10)	6.50(2.55)	85	6.20(2.49)	8.39(2.90)
15.	<i>Norinqa pterygosperma</i>	bark 2.5	12	0.26(0.51)	3.24(1.80)	67	1.35(1.16)	3.65(1.91)	157	2.32(1.52)	4.44(2.11)
16.	<i>Lantana camara</i>	Leaf 5	48	0.45(0.67)	5.24(2.28)	80	2.32(1.53)	5.78(2.40)	137	5.60(2.37)	6.67(2.58)
17.	Malathion	0.02	6	0.02(0.14)	2.62(1.62)	15	0.80(0.89)	2.96(1.72)	87	1.80(1.34)	4.30(2.07)
18.	Control	--	144	2.15(1.47)	8.97(3.00)	243	4.25(2.06)	9.53(3.08)	289	7.00(2.65)	12.60(3.55)
S.E. (m) ±			3.204	0.071	0.1210	4.050	0.067	0.161	6.240	0.073	0.056
(C.D. at 0.05)			6.504	0.144	0.2460	8.220	0.136	0.327	12.670	0.148	0.114

\* The figures in the parentheses are transformed value ( $\sqrt{n}$ ).

and 2.5 per cent in case of bark, seed and ash. Malathion 5 per cent dust @ 0.02 per cent was mixed with the grains to compare the efficacy of plant admixtures upto 3 months and observations were recorded at one month interval.

After 30 days of natural storage, the observations were seemed that moth emergence was least in case of seed powder of Pongamia but corresponding grain damage and weight loss were 0.01 and 2.39 per cent respectively followed by Ageratum leaf powder resulting only 5 moths and corresponding grain damage and weight loss were 0.01 and 2.46 per cent respectively in comparision to standard i.e. Malathion dust where the moth emergence was 6 resulting grain damage and weight loss were 0.02 and 2.62 per cent respectively. Maximum number of moth emergence 157 and 145 from the grains where mixed ash and Ipomoea leaf powder were mixed respectively as compared to 144 moths in control. All aspects of studies after 30 days showed there were significant differences amongst the plant admixtures used. There was very negligible percentage of grain damage and weight loss in first month study. The major weight loss in treatments was due to drying of grains rather than the grain damaged by the insect alone (Table 10).

Observations after 60 days revealed that number of moth emerged varied from 10 to 243 and significantly differed in the treatments. The best protection was afforded by custard apple seed powder followed by neem leaf powder and begunia leaf powder. Number of moth emergence from these treatments were 10,13 and 15 respectively as compared to 15 in Malathion and 243 in control. Unsatisfactory protection recorded after two months observed in custard apple and Ipomoea leaves, banana leaf ash and Pongamia bark where maximum number of moths were emerged. Corresponding percentage of grain damage and weight loss were 0.35 and 3.5, 0.40 and 3.75 and 0.29 and 2.80 respectively as compared to Malathion 0.80 and 2.96 and in control 4.25 and 9.53 respectively. Though the lowest number of moths emerged in custard apple seed powder but least grain damage was observed in Pongamia seed and lowest loss was recorded from grains mixed with Vitex leaf powder (Table 10).

Observations after 3 months revealed that the best residual effect on moth emergence was observed in Vitex leaf powder (12) followed by 15 in custard apple seed powder in comparison to 289 moths in control. Though Malathion used as standard which could not keep its residual efficacy till 3 months, where 87 moths were emerged and it revealed that mixing of Vitex, Pongamia leaf seed and bark, neem leaf, custard apple seed, banana leaf ash, mixed ash were superior to Malathion.

Grain damage and weight loss at 3rd months observation revealed that grain damage was less than one per cent recorded in Pongamia seed powder followed by begunia (Vitex) leaf powder. Mixing of Pongamia leaf, neem seed, Chorchorous, and mixed ash which recorded more than 6 per cent grain damage did not keep much residual toxicity as compared to 7 per cent in control. Weight loss due to grain damage after three month was lowest in Vitex leaf powder (3.68 per cent) followed by custard apple seed (4.16 per cent) compared to 12.6 per cent in control. The weight loss in different plant product admixtures differed significantly.

#### 4.8 Effect of physical barrier on the incidence of Sitotroga cerealella.

The penetrating capacity of Angoumois grain moth larvae through layers of dust were tested by using four commonly available materials viz. sand, rice bran, rice husk and chaffy grains revealed that there were significant difference in emergence of moth and grain damage.

Table-11.

Effect of physical barriers on the incidence and grain damage due to Sitotroga cerealella in the store.

Sl. No.	Physical barriers	Infection due to release of adults		Infection due to release of 1st. instar larvae	
		No. of moth emerged	Grain damage (%)	No. of moth emerged	Grain damage (%)
1.	Sand	9.25	2.16 (1.47)*	7.75	1.95 (1.03)
2.	Rice bran	13.50	3.42 (1.82)	9.75	2.25 (1.50)
3.	Rice husk	28.50	5.30 (2.30)	15.00	3.36 (1.83)
4.	Chaffy grain	23.25	4.60 (2.14)	12.25	2.52 (1.59)
5.	Control	64.50	12.60 (3.55)	37.50	8.98 (3.00)
	S.E. (m) ±	3.101	0.040	1.202	0.033
	(C.D. at 0.05)	6.757	0.087	2.619	0.072

\* Figures in parantheses are square root transformed value( $\sqrt{n}$ ).

Use of sand on the top of grains resulted less survival of larvae resulted only 9.25 moths and 2.16 per cent grain damage compared to 64.5 moths and 12.6 per cent grain damage respectively in control (Table 11). However, satisfactory results were obtained by using rice bran where 13.5 moths were observed and the grain damage was 3.42 per cent . In other barriers like rice husk and chaffy grains number of moths were 28.5 and 23.25 and grain damage were 5.3 and 4.6 per cent respectively.

Statistical analysis among the barriers used to protect the grain from S. cerealella attack were significantly differed among the treatments in respect of moth emergence and percentage of grain damage.

Study the penetration effect of just hatched larvae through the above barriers showed that there was significant effect of both on moth emergence and grain damage and maintained the similar trend in respect of moth emergence and grain damage by S.cerealella.

#### 4.9 Trapping of Moths (Sitotroga cerealella)

A set of traps were used to monitor the Angoumois grain moth population from 20/9/94 to 9/1/94 in the store of central farm. Types of traps consisting of bio-sense trap and

Use of sand on the top of grains resulted less survival of larvae resulted only 9.25 moths and 2.16 per cent grain damage compared to 64.5 moths and 12.6 per cent grain damage respectively in control (Table 11). However, satisfactory results were obtained by using rice bran where 13.5 moths were observed and the grain damage was 3.42 per cent . In other barriers like rice husk and chaffy grains number of moths were 28.5 and 23.25 and grain damage were 5.3 and 4.6 per cent respectively.

Statistical analysis among the barriers used to protect the grain from S. cerealella attack were significantly differed among the treatments in respect of moth emergence and percentage of grain damage.

Study the penetration effect of just hatched larvae through the above barriers showed that there was significant effect of both on moth emergence and grain damage and maintained the similar trend in respect of moth emergence and grain damage by S.cerealella.

#### 4.9 Trapping of Moths (Sitotroga cerealella)

A set of traps were used to monitor the Angoumois grain moth population from 20/9/94 to 9/1/94 in the store of central farm. Types of traps consisting of bio-sense trap and

Table-12.

Use of different traps to catch Angoumois grain moth  
Sitotroga cerealella in the store.

Types of Traps	20/9/94	21/9/94	22/9/94	23/9/94	26/9/94	28/9/94	29/9/94	30/9/94	1/10/94	2/10/94	5/10/94	6/10/94	7/10/94	8/10/94	9/10/94	Average
Biosense Trap	340 (18.45)*	615 (24.81)	295 (17.19)	430 (20.75)	730 (27.03)	450 (21.22)	170 (13.06)	115 (10.75)	190 (13.80)	175 (13.25)	175 (13.25)	320 (17.90)	315 (17.76)	322 (17.96)	215 (14.70)	323.8 (17.46)a
Water-Kerosene- terracic powder	30 (5.52)	70 (8.40)	100 (1.02)	55 (7.45)	90 (9.51)	25 (5.05)	90 (9.51)	95 (9.77)	55 (7.45)	10 (3.24)	30 (5.52)	35 (5.95)	45 (6.75)	95 (9.77)	62 (9.08)	60.47 (7.53)b
Water-kerosene	25 (5.05)	30 (5.52)	30 (5.52)	50 (7.11)	80 (8.97)	20 (4.53)	25 (5.05)	30 (5.52)	5 (2.35)	10 (3.24)	40 (6.36)	15 (3.94)	20 (4.53)	72 (8.51)	60 (7.78)	34.13 (5.60)c
Candle-Water- Kerosene	60 (7.78)	50 (7.11)	70 (8.40)	90 (9.51)	110 (10.51)	50 (7.11)	110 (10.51)	100 (10.02)	65 (8.09)	45 (6.75)	80 (8.97)	65 (8.09)	70 (8.40)	100 (10.02)	95 (9.77)	77.33 (8.74)b
Water	0 (0.71)	0 (0.71)	10 (3.24)	5 (2.35)	0 (0.71)	0 (0.71)	10 (3.24)	0 (0.71)	0 (0.71)	0 (0.71)	15 (3.94)	0 (0.71)	0 (0.71)	10 (3.24)	0 (0.71)	3.33 (1.54)d
S.E. (m) $\pm$																0.248
(C.D. at 0.05)																1.697

\* Figures in the parentheses are  $\sqrt{n+0.5}$  square root transformed values.

some ready made traps like water-kerosene-termeric powder, water-kerosene and candle-water-kerosene which were set in the store. Number of Angoumois grain moths irrespective of sex were counted separately after 24 hours (Plate 2).

The data in table 12 showed that there was wide difference in collection of moths. Average catch in 24 hours varied from 3.33 to 323.8 which were highly significant. Efficacy of bio-sense trap recorded 323.8 moths followed by 77.33 moths in candle-water-kerosene. It was evident from the table 12 that the efficiency of bio-sense trap was much better than other traps used. Besides the use of pheromone trap, other traps were also effective in comparision to use of only water in capturing adult moths of S. cerealella.

## CHAPTER V

### THE HISTORY OF THE CITY OF BOSTON

## DISCUSSION

Studies on the "Management of Angoumois grain moth, Sitotroga cerealella Oliv. in field and store" was carried out in the Department of Entomology, College of Agriculture, Hubaneswar. In course of investigation to determine the relative resistance to the attack by S. cerealella, percentage of successful development from egg to adult stage of the pest in different rice entries and physical characters of rice grains were studied. The study was also aimed to control the pest by various plant admixtures, spraying of chemicals at harvest, use of some barriers on grain surface and trapping of moths by different traps. The results of these experiments have been presented under the experimental findings which clearly indicated that some of the characters of the rice grain are closely associated with the relative resistance/susceptibility of the pest. Mixing of admixtures in protecting grains, physical barriers, catching of moth and spraying at harvest stage proved some important informations to control the pest. The important findings of the experiments are discussed in the following paragraphs.

### 1.1 Screening and categorisation of rice entries to Angoumois grain moth

To determine the relative resistance of twenty rice entries, grains were subjected to infestation by freshly emerged S. cerealella larvae at  $28 \pm 1^{\circ}$  C and 75 per cent rh. The percentage of successful development from larvae to adult emergence, per centage of grain damage and the growth index were taken as parameters in determining the relative resistance of the rice entries and placing them in different categories. The percentage of moth emergence varied from 1.33 to 81.00 per cent and the average percentage of grain damage ranged from 0.65 to 78 in test entries. Based on the percentage of moth emergence, the rice entries were put into six categories of relative resistance/susceptibility. The entries in which there was no moth emergence, considered as immune and entries with 0.10 to 3.00 per cent moth emergence, were put in highly resistant category. Accordingly, rice entries resulting with 3.10 to 8.00, 8.10 to 12.00, 12.10 to 24.00 and 24.10 per cent and above moth emergence were taken as resistant, moderately resistant, susceptible and highly susceptible categories respectively. Artificial pest infestation in the laboratory showed that none of the rice entries proved to be immune to the attack by S. cerealella. Among twenty rice entries tested, two were highly resistant to the pest, resulting minimum per cent moth emergence

1.33 and 0.50 grain damage. In the resistant category four entries in an average produced 6.17 per cent moth and 1.65 per cent grain damage. The moderately resistant grain recorded 10.00 moth and 2.55 per cent damaged grain in two rice entries. In susceptible group 16.60 per cent moth and 4.67 per cent of damaged grains were recorded in five rice entries. Maximum number of seven rice entries were classified as highly susceptible which produced 31.14 and 9.78 per cent moth emergence and grain damage respectively. Statistical analysis of percentage of moth emergence and damaged grain differed significantly among the various categories of rice entries.

None of the rice entries completely offered resistance to Angoumois grain moth and resulted in 0.00 per cent moth emergence. Kittur and Patel (1972) ; Pandey and Singh (1982) and Maity (1991) conducted similar tests and found that none of the entries tested were free from S. cerealella attack. The present findings fully support of these statements. But Popholly and Rana (1992) recorded rice entry Safri 17 was completely free form S. cerealella attack. But other varieties tested were infested by this pest. In the present study selected rice entries FR13A and WB-1B-15 B recorded less than two per cent moth emergence and thus were placed under highly resistant category. Rice entries like TNAU 6464, Sakti, Jagannath and Andharchaki

recorded upto eight per cent moth emergence of S. cerealella adults and were put in the resistant category. But Badami and Parijat upto ten per cent moth emergence and kept in moderately resistant group (Table 4).

Nigam et al. (1977), Dhotmol and Dumbra (1983), Baktharatchagan (1991), Prakash et al. (1981), Maity (1991) Popholly and Rana (1992) have reported varietal preference of rice entries like IR 8, Saket 4, Vikram, TKM-9, CO 43, Jaya, Sakti, TNAU 6464, Hema, Bala and Parijat etc., have been categorised as resistant to S. cerealella. Though some <sup>u</sup>^<sub>^</sub> hours categorised rice variety Jagannath as susceptible one, basing on the present study, this variety has come under resistant group resulting seven per cent moth emergence. But TNAU 6464, Sakti, Parijat at present study come under resistant and moderately resistant group which are in support of findings of Maity (1991). Many of the rice entries studied in the present investigation have not been put under test by other investigators, therefore, it is difficult to provide comparative discussion in all such entries.

Rice entries Rambha, Jaya, Pankaj, Annapurna and Lalat recorded average moth emergence of 16.60 per cent infestation by Angoumois grain moth and therefore, are placed under susceptible category. Chellappa and Chelliah (1976) and

Maity (1991) stated that rice entries Pankaj, Ratna, Cauvery, IR 8, T 141, IR 36, BM-6, Jaya, Supriya, Sakti, Mahsuri, Annapurna etc. have come under susceptible group which confirmed the results of the above <sup>u</sup>athours but Sakti recorded five per cent moth emergence and IR 36 which recorded 30.67 per cent moth emergence come under resistant and highly susceptible categories respectively.

Rice entries Kalashree, Keshari, IR 36, CR 1014, CR 1030, CR 1028-14-4 and CR 1022-27 showed 24-81 per cent moth emergence and have come under highly susceptible group. During the study it is seen that these cultures are severely effected due to the attack of the pest. Kittur and Patel (1977), Prakash et al. (1979), Ratna Sudhakar (1987) and Chatterjee et al. (1991) found that rice entries Jajati, Keshari, CR 1014, Kumar, Hamsa, IET - 7574, IET-7575, Rasi, Baspati, Sabarmati etc., were highly susceptible to S. cerealella. In the present study Keshari & CR 1014 recorded more than 31.40 per cent moth emergence and come under highly susceptible group which confirmed the results of the above <sup>u</sup>athours. In contrary, rice variety IR 36 which recorded 30.67 per cent moth emergence in the present study but above <sup>u</sup>athours recorded this entry in susceptible group.

As regard the damage due to this pest was found during the investigation, which were almost corresponding to the

positively higher percentage of moth emergence. In the present study grain damage due to the pest was varied from 0.50 to 20.43 per cent in different groups of rice cultivars. But Khare (1972), Josobanta Behera (1992) and Prakash and Kauraw (1982) reported that weight loss due to damage of the pest was 34.00, 14.57 and 14.05 per cent respectively. But Maity (1991) reported that maximum grain damage due to larvae of S. cerealella to highly susceptible rice cultivar CR 1014 was 24.85 per cent and minimum damage of 1.00 per cent recorded in rice entry FR 13A. But present study revealed that rice entry FR 13A which is in highly resistant group recorded only 0.50 per cent at against 20.43 per cent grain damage in CR 1014. The results of the present investigation confirmed the opinions of above <sup>U</sup>hours in respect of percentage of grain damage to these varieties by S. cerealella.

#### 5.1.2 Varietal effect on Biology of *Sitotroga cerealella*:

Varietal effect on life cycle of Angoumois grain moth was studied in the laboratory at  $28 \pm 1^{\circ}$  C and 75 per cent rh on twenty rice entries of different categories. Incubation period varied from 4.43 to 5.00 days which are not differed significantly among the rice entries tested.

King (1918) observed egg period of this pest was 7- days in summer but Harukawa & Kumashiro (1938) observed 4-10 days

and Biswal (1968) reported that it was varied from 4.9-5 days on paddy. The present investigation agreed with the findings of Biswal and Harukawa and Kumshiro.

On hatching the larvae made their way into the grain through the central vascular bundle and fed on the germ and endosperm in apical direction. Larval-pupal period varied from 22.57 to 25.21 days in different categories of rice grain. But these developmental stages was minimum 21 days in rice entry Parijat and maximum 28 days in WB-1B-15B which were not significantly differed among the varieties tested (Table 5). King (1918) found larval stage was varied from 15-38 days and pupal stages 4-40 days as per variation in temperature whereas Biswal (1968) observed that larval stage was 24.9 days and pupal stage 6 to 7 days. But in present investigation the larval-pupal stage varied from 22.57 to 25.21 days at  $28 \pm 1^{\circ}$  C and 75 per cent rh on different rice entries. The growth index of S. cerealella varied from 0.05 to 1.36 in susceptible/ resistant group of rice cultures. Minimum growth index (0.05) of the insect was recorded in the rice entries FR 13 A and WB- 1B- 15B and maximum growth index of 1.89 was found in rice culture CR 1014. But maity (1991) observed the growth index of the pest on FR 13A was 0.078 and maximum was 2.67 on OR 101-5-1. The present study showed that the minimum growth index 0.05 on FR 13A

which was almost same as the observation of Maity (1991). But it is contradictory with his result regarding the highly susceptible group of paddy.

### 3.1.3 Physical characteristics of rice grains influencing S. cerealella attack:

Colour of rough rice is determined by the colour of the husk. Mainly two husk colours and their intermediate colour were observed on the test entries namely straw, brown and straw-brown and endosperm colour was observed in rice entries as red and white (Table 3).

No specific husk endosperm colour was observed to be determining the resistance/susceptibility of rice grain to S. cerealella infestation.

Grade and size of the grain showed different developmental response to S. cerealella. Prakash *et al.* (1979) and (1983), Juliano (1981) and Dholmol and Dumbra (1983). In present study the test grains came under four categories, viz. long-slender, long-bold, medium-slender and short-bold. Short-bold grains were mostly found in the resistant groups. Long-slender grains were available in susceptible group. In general, it was observed that fine and superfine rice entries where L/B ratio more were preferred to attack by S. cerealella.

Grain weight was considered as one of the important factors in determining the grain resistance/susceptibility to S. cerealella. In the present study 1000 grain weight of husked and dehusked rice grains varied from 20.63 to 34.42 g and 16.86 to 20.90 g respectively (Table-7). 1000 grain weight of rice grains differed significantly among the different categories of rice and both husked and dehusked rice grains of resistant groups were heavier than susceptible ones. Hulling ratio and recovery of head rice varied from 1.18 to 1.67 and 78.10 to 82.70 respectively and found significantly differed among the test entries. Inter space of rice entries varied from 47.30 to 55.20 cc and number varied from 1987.00 to 3217.40. Chellappa and chelliah (1976), Upadhyay (1979) and Maity (1991) stated that the plumpy and well-formed grains, more hulling ratio, more recovery of head rice, more inter space and less number of grains in 100 cc offered better resistance against S. cerealella attack. In the present study rice varieties FR 13A and WB-1B-15B had more 1000 grain weight, more hulling ratio, recovery rice and inter-space, had only 1.5 per cent moth emergence. Therefore, it is confirmed that S. cerealella resistant rice grains are heavier, more hulling ratio, and less number of grains in 100 cc in comparison to susceptible ones.

Alkali reaction to endosperm is indirectly indicate the relative hardness of the grain. Alkali values of

test entries were varied from 3.50 to 6.03 and significantly varied in different groups of rice entries. Prakash *et al.* (1983), Maity (1991), Russell (1979) and Little (1958) found that harder grains of resistant category had less number of adult emergence which was also observed in the present study.

#### 5.1.4 Morphology of rice grains:

Rice husk is an important protective structure against S.Cerealella attack to the endosperm on which the larva of the insect feeds and develops. In the present investigation the length, breadth and thickness of husk (glumes) were measured to find the degree of successful development of S. cerealella in different categories of rice varieties. The length of flowering glumes i.e. lemma and palea varied from 6.96 to 8.07 mm and 7.10 to 7.71 mm and breadth 1.89 to 2.43 mm and 1.09 to 1.36 mm respectively (Table-8). Though the length and breadth of lemma and palea varied significantly among the categories of rice entries the length of both the glumes were not proportionate to the order of preference but average breadth of both glumes was proportionate in order of preference by S. cerealella larva. Breadth of rice glumes were always more in case of highly resistant entries than susceptible ones. Compactness of husk had a relevance with the successful development of S. cerealella in different categories of rice grain. Pandey *et al.* (1980)

concluded that the larvae S. cerealella were not able to penetrate into the rice grain that had tightly closed husk which is confirming the results of present investigation.

The thickness of the husk of various categories of rice varied from 0.15 to 0.27 mm and significantly differed among the test rice grain (Table -8). Highly resistant grains FR 13A and WB -1B-15B had thicker husk which prevented the larval entry into the endosperm resulted less percentage of grain damage. Chatterjee et al. (1977), Prakash et al. (1982), Upadhyay et al. (1979) and Maity (1991) observed that rice grain with thicker husk afforded resistance to Angoumois grain moth attack. The results of present investigation are in full agreement that husk thickness plays an important role in determining the relative resistance of the rice entries to the attack of S. cerealella.

## 5.2 EFFECT OF INSECTICIDES ON FIELD INFESTATION OF ANGOUMOIS GRAIN MOTH :-

A field trial was conducted to determine the residual efficacy of nine insecticides applied at harvest on the occurrence of field infested S. cerealella in the store. The residual effects of insecticides were judged on the emergence of S. cerealella moth upto three months. The present investigation showed that a significant variation on moth emergence among the treatments varied from 128 to 556. The best residual effect was

observed in Azadirachtin followed by Acephate, Ethopan-prox (Table 9). Grain damage and weight loss among the treatments were ranging from 1.29 to 5.48 and 3.91 to 8.10 per cent respectively which were significant among the chemicals used. In respect of grain damage Acephate (1.70 per cent) found the best whereas minimum weight loss was recorded the grains collected from Azadirachtin (3.91 per cent) treated plots. Biswal (1968) and Senapati and Satpathy (1972) reported that Malathion dust can protect the grains against S. cerealella attack upto four months. In present study showed that application of Acephate, Azadirachtin, Monocrotophos were found best grain protectants than Malathion in respect of grain damage and weight loss due to S. cerealella. Farmers can use those chemicals as grain protectants specifically those grains will be consumed minimum three months after harvest.

### 5.3 EFFECT OF PLANT ADMIXTURES ON THE OCCURANCE OF ANGOUMOIS GRAIN MOTH :

In India various indigenous medicinal plants are being used in different forms in grain storage against insect pests of store grains. In view of this some of the indigenous plant products have been evaluated to study the efficacy as grain protectant against Sitotroga cerealella. The study was undertaken by mixing products of ten plant species including leaf, seed,

bark and ash at the rate of 5 per cent in case of leaf and 2.5 per cent in case of bark, seed and ash. Malathion dust at the rate of 0.02 per cent was mixed with the grains to compare the efficacy of plant admixtures upto three months.

Observations recorded at 30, 60 and 90 days on the emergence of moth, percentage of grain damage and weight loss. After one month least number of moth emerged was noted in case of Pongamia seed powder. Observations after 60 days revealed that the number of moth varied from 10-243 and was significantly differed among the treatments. The best protection was afforded by custard apple seed powder followed by neem leaf and Vitex leaf powder. Vitex leaf powder and Malathion which were at per and ranked as 3rd in respect of residual toxicity to S. cerealella corresponding grain damage and weight loss were 0.35 and 3.5, 0.40 and 3.75 respectively as compared to Malathion 0.80 and 2.96. Observations after three months revealed that the best residual effect on moth emergence was in Vitex leaf powder followed by custard apple seed powder. Though Malathion was used as standard which could not keep its satisfactory residual efficacy upto three months and found inferior to Vitex leaf powder, Pongamia seed and bark, neem leaf, custard apple seed and banana leaf ash. Grain damage and weight loss after three months revealed that less than one per cent damage of grain was recorded in Pongamia seed powder followed by Vitex leaf powder whereas

weight loss due to insect damage was lowest in Vitex leaf powder (3.68 per cent) followed by custard apple seed (4.16 per cent) compared to 12.60 per cent in control.

Wohlgemuth and Pereira (1982), Devi and Mahanandas (1982) and Mishra (1985) the effectiveness of ground seeds and leaves of neem as protectant against store product insects and reported that the products were effectively reduce the progeny production of Sitotroga cerealella.

In the present investigation neem leaf powder restricted moth emergence to only 41 against 289 in control and grain damage was also statistically less in comparison to few other admixtures which is agreed with the opinion of above workers. Laxminarayan (1957), Pandey and Verma (1977) and Ali and Singh (1981) have reported that custard apple seed powder was effective against all insects occurring in store. In the present study residual toxicity of custard apple seed powder was most effective against moth emergence and grain damage upto three months which is proved to be effective against S. cerealella. Prakash et al. (1981) reported that Vitex leaves can be used as grain protectant in reducing infestation in both paddy and rice over a period of six months. The present investigation supported this statement as Vitex leaves provided minimum moth emergence (12) and less grain damage (0.72 per cent) upto the period of three months.

#### 5.4 EFFECT OF PHYSICAL BARRIERS :

Physical barriers act as preventive measure against the entry of the larvae of S. cerealella. Singh (1967) and Mishra (1985) used different physical barriers like saw dust, wood ash, neem leaf powder etc. upto 2.5 cm thickness which completely protect the grain from the attack of S. cerealella. Vitex leaf powder and rice bran could not keep the grain free from entry of larvae. In the present investigation use of sand, rice bran, rice husk and chaffy grains of one cm layer could not keep the grains free from insect damage but sand layer was found to provide satisfactory protection over other barriers used. Therefore, definite conclusion could not be drawn with contradictory opinions of above workers and needs further investigations to confirm the result.

#### 5.5 EFFICACY OF TRAPS :

A set of traps like bio-sense trap and traps of kerosene-water-termeric powder and their combinations were used to study the efficacy in capturing adults of S. cerealella. It is revealed from the table 12 that setting of bio-sense trap which was much superior to other traps where 323.8 moths were caught per day followed by candle-water-kerosene (77.33), water-kerosene-termeric powder (60.47), water-kerosene (34.13) as against 3.33 in only water. The superiority of trapping moths due

to sex-lure O2 which attracting moths. Suzuki (1980) identified the aggregation of pheromone for Tenebrionids and Cucujids but Javer et al. (1985) proved the efficiency of pheromones in capturing cucujids. But the present investigation proved that sex-lure O2 is quite efficient in capturing Sitotroga cerealella adults.

## CHAPTER VI

# SUMMARY AND CONCLUSION

## SUMMARY AND CONCLUSION

Studies on the management of Angoumois grain moth, Sitotroga cerealella in field and store, were carried out in the Department of Entomology, College of Agriculture, OUAT, Bhubaneswar, (i) to find out relative resistance/susceptibility of twenty rice entries to S. cerealella, (ii) to evaluate the effectiveness of certain insecticides and their residual toxicity in storage condition applied at harvest, (iii) to evaluate the efficacy of certain plant product admixtures under natural storage condition against the pest, (iv) to consider the effect of physical barriers on the entry of S. cerealella and (v) to evaluate the relative efficiency of different traps to monitor S. cerealella moth population in the store.

In the screening studies, out of twenty rice entries none of them proved to be immune to S. cerealella attack. Only two rice entries were highly resistant to S. cerealella attack which favoured upto 1.50 per cent moth emergence and 0.65 per cent grain damage. In the resistant category four rice entries recorded an average of 6.17 per cent moth and 1.65 per cent grain damage. Only two entries belonging to moderately resistant group produced 10.00 S. cerealella moth and 2.55 per cent grain damage. Five rice entries classified as susceptible category recorded 16.60 per cent successful development of S. cerealella larvae and 4.67 per cent grain damage. Maximum rice entries i.e., seven showing a mean percentage of 31.14 moth

emergence and 9.78 grain damage were taken as highly susceptible to S. cerealella attack.

Varietal effect on the biology of S. cerealella at  $28 \pm 1^{\circ}$  C and 75 per cent rh showed that egg period varied from 4.33 to 5.00 days in different groups of rice grains, larval-pupal stage from 22.57 to 25.22 days which significantly differed in different categories of rice entries. Growth index showed that larvae of S. cerealella varied from 0.05 to 1.36 which restricts faster rate of development in resistance rice grains than the susceptible ones resulting less number of moth emergence.

Physical characters like colour, grade, L/B ratio, weight, volume, number and hardness of grains included in resistance study. The results revealed that no specific colour in respect of rice husk or endosperm was found to be associated with grain resistance/susceptible to S. cerealella attack. Long - slender grains (IR 36, Kalashree and Keshari) were highly susceptible to S. cerealella attack but short bold grain (FR 13A, TNAU 6464, Sakti, Jagannath, Andharchaki, Badami and Parijat) found resistant. Length-breadth (L/B) ratio of husked and dehusked grain ranged from 2.49 to 4.07 and 2.23 to 3.33 respectively. Resistant rice grains had always lower L/B ratios. As the L/B ratios of grain increase, damage and moth emergence in susceptible groups increase indicating a relationship between L/B

ratio and degree of susceptibility to S. cerealella attack. Weight of 1000 grains of husked and dehusked rice varied from 20.63 to 34.52 g and 16.86 to 20.90 g respectively and differed significantly among the test categories. It is concluded that more grain weight offered more resistance to S. cerealella infestation. Hulling ratios of rice belonging to different groups varied from 1.23 to 1.67 which was observed to be associated with grain resistance to the pest attack.

Alkali values indicate indirect hardness of rice grain which ranged from 3.50 to 6.03 and varied significantly lower alkali value i.e. more hardness of grains provided positive effect on grain resistance to the S. cerealella attack. More number of grains were recorded in highly susceptible group than resistant grains within the same volume. Length and breadth of flowering glumes (Lemma and Palea) ranged from 6.96 to 7.89 and 1.89 to 2.43 mm and 7.12 to 7.71 and 1.09 to 1.36 mm respectively. There was significant difference in dimension of rice glumes among the categories. Length of Lemma and Palea did not influence resistance but there was significant relation between the breadth of Lemma and Palea with S. cerealella infestation. Thickness of rice husk played a major role in restricting the entry of S. cerealella larvae into the grain. Husk thickness of twenty rice entries ranged from 0.15 to 0.27 mm and differed significantly. Resistant rice entries had thicker

husk and thickness increased from highly susceptible to highly resistant grains.

To avoid the field infestation of Angoumois grain moth to the grains which is one of the sources of initial infestation in store nine insecticides, viz. Monocrotophos, Ethophan-prox, Endosulfan, Carbosulfan, Acephate, Methomyl, Triazophos, Malathion and Azadirachtin were applied at 0.05 per cent on ripened grains one day before harvest. Grains observed after 30, 60 and 90 days showed that the best residual protection to S. cerealella was found in Ethophan-prox upto 60 days, but in the long run Azadirachtin was found to be the best in keeping grain safer even upto 90 days.

The relative efficacy of plant product admixtures of ten plant species to protect rice grain against S. cerealella showed that grain damage was less than 1 per cent recorded in 2.5 per cent Pongamia seed powder followed 5 per cent Vitex leaf powder, weight loss due to grain damage was lowest i.e. 3.60 per cent, in 2.5 per cent Vitex leaf powder followed by 2.5 per cent custard apple seed powder.

Effect of physical barriers like sand, rice bran, rice husk and chaffy grains of one cm thickness above the grains on penetration of S. cerealella revealed that sand and rice bran

were restricted the entry of both larvae and adult satisfactorily.

Different traps used to monitor the Angoumois grain moth population showed that sex-lure 02 used in bio-sense trap was the best amongst the traps in which 323.8 moths were captured per day as compared to only 34.13 moths in the trap containing water and kerosene.

#### CONCLUSION :

Today, when Entomologist world wide are under pressure to evolve safer plant protection devices due to growing impetus on toxic hazards of chemical insecticide specifically in storage of food grain, the present findings will provide some vital recommendation on management of Angoumois grain moth to reduce loss of grain damage at reasonably low cost.

1. Growing of high yielding rice resistant varieties to Angoumois grain moth should be extensively cultivated to minimise the grain damage in store due to S. cerealella infestation.

2. The results indicate that thickness of husk, hardness and boldness of grains contribute towards grain resistance to S. cerealella and therefore, these factors be possibly included in a long term breeding programme.

3. Pre-harvest spraying of pesticides like Ethophan-prox, Azadirachtin, monocrotophos may be included to manage the pest those grains will be kept in the store for a minimum period of three months to avoid the residual toxicity.

4. Use of plant product admixtures like Pongamia seed powder, Vitex leaf and neem leaf can proved effective against S. cerealella attack. Therefore, exploiting of plant products to protect store grains from insect menance is note-worthy.

5. Constant setting of bio-sense traps, which can easily be handled by the farmers in store to keep the Angoumois grain moth population under check.

# BIBLIOGRAPHY

## BIBLIOGRAPHY

- Acharyulu, B.S. and Chaudhary, R.N., 1992. Screening of some maize inbred lines to Sitotroga cerealella Oliver. Indian J of Ento. 54(3):248-254.
- Ali, S.J. Rawat, R.R. and Singh, O.P., 1981. Effectiveness of various forms of custard apple seed powder as seed protectant against pulse beetle Callosobruchus chinensis. Bull. grainTech. 19(1):53-55.
- Baktharatchagan, R., 1991 comparative tolerance of certain paddy varieties to Angoumois grain moth, Sitotroga cerealella Oliv. and its incidence in five districts in Tamil Nadu. J. Appl. zool. Res. 2(1):33-36.
- Bareth, S.S. and Gupta, H.C. and Sharma, S.K., 1993. Effect of inert materials on infestation of lesser grain borer Rhizopertha dominica Fab. and their subsequent effect on germination during storage of wheat seed. Agri. Biol. Res. 9(1):15-19.
- Behera, J., Rao, Jagadiswari. and Prakash, A., 1992. Unaccountable loss of paddy seed viability due to Angoumois grain moth, Sitotroga cerealella J. Appl. Zool. Res. 2(1):30-32.
- Biswal, L., 1968. Biology of Angoumois grain moth Sitotroga cerealella on different food stuffs and its control by various contact insecticides and fumigants. A part of P.G. thesis submitted to QUAT.
- Borden, J.H., A, Javer., Pierce, H.D., and Pierce, A.M., 1990. Evaluation of pheromone-baited traps for monitoring of Cucujid and Tenebrionid beetles in stored grain. J. Eco. Ent. 83(1):268-272.
- Chatterji, S., 1953. Effect of humidity on some pests of stored cereals at IARI. Ind. J. Ent. 15:327.
- Chellappa, K. and Chelliah, S., 1976. Varietal susceptibility of rice to infestation of Sitotroga cerealella Oliv. and Rhizopertha dominica Fab. Madras Agric. J. 63(3) 190-192.
- Clear, L.D., 1962. Damage and loss caused by insects to stored rice and paddy in British Guinea. Rice storage invest. Publ. 4:18.

- Dhotmal, G.S. and Dumbra, R.B., 1983. Relative susceptibility of some rice varieties to Angoumois grain moth; Maharashtra Agric. Univ. 8(3):220-223.
- Devi, D.A. and Mahanandas, N., 1982 Relative efficacy of some antifeedants and deterrants against insect pests of stored paddy. Entomon. 7(3):261-264.
- Fletcher, T.B., 1914. Some south Indian insects and other animals of economic importance. J. Eco. Ent. 44(2):454.
- Gerberg, E.J. and Goldheim, S.L., 1957. Weight loss in stored corn and beans caused by insect feeding J. Eco. Ent. 50(4):391-393.
- Gillani, W.A. and Irshad, M., 1990. Reaction of rice varieties to rice moth, Sitotroga cerealella. IRRINL. 15(6):16.
- Harukawa, C. and Kumashiro, 1938. On Sitotroga cerealella. Nogakukunya, 29:1-44.
- Israel, P. and Vedamoorthy, G., 1956. Origin of infestation to stored paddy. Rice News letter, 4:75-82.
- Juliano, B.O., 1981. Rice grain properties and resistance to store insect. A Review IRRI pap. ser. 56:9.
- Khare, B.P. and Johari, R., 1979. Relative susceptibility of paddy varieties to Sitotroga cerealella Olive. Oryza 16(2):131-134.
- Khare, B. P., 1972. Insect pests of stored grain and their control in Uttar Pradesh. G.B. Pant. Agric. Tech. Univ. Pantnagar Res. Bull. 5:152.
- King, J.L., 1918. Notes on the biology of the Angoumois grain moth, S. cerealella. J. Eco. Ent. XI(1):87-93.
- Kittur, S.V. and Patel, R.K., 1972. Preference of Sitotroga cerealella Oliv. to rice varieties during storage. Ind. J. Agric. Science. 42(7):621-622.
- Klein, H.Z., 1930. Life history and epidemiology of grain moth S. cerealella. Anz. Schadlingsk, Berlin. VI(9):97-101.
- Lahue and Kodoum, 1979. Residual effectiveness of emulsion and encapsulated formulation of malathion against Tribolium castaneum. J. of Eco. Ent. 72(2):234-237.

### III

- Lakhani, G.K. and Patel, N. G., 1985. Nonpesticidal control of Ephestia cautella. Pesticides. 19(1):46-48.
- Lakshmi Narayan, K., 1957. A preliminary note on studies of mysore plants as a source of insecticides. Indian J. of Ent. 17:165-170.
- Lloyd, C.J. and Hawlett, P.S., 1960. The susceptibility of pyrethrin of 3 species of moth infesting stored products. Pyrethrum Post. 5(3):12-13.
- Little et al., 1958. Differential effect of dilute alkali on 25 varieties of milled white rice. Cereal. Chem. 35:111-126.
- Maity, B.K., 1991. Evaluation of rice varieties for resistance to Angoumois grain moth Sitotroga cerealella Oliv. A part of Ph. D. thesis submitted to OUAT.
- Mills, R.B., 1965. Early germ feeding and larval development of the Angoumois grain moth. J. Eco. Ent. 58(2):220-223.
- Mishra, H., 1985. Effect of some plant product admixtures on the control of Sitotroga cerealella (Olive.). Part of P.G. thesis submitted to OUAT.
- Popholy, D. J. and Rana, D. K., 1992. Horizontal infestation of Sitotroga cerealella Oliv. on rice. Oryza, 29:79-80.
- Prakash, A. Pasalu, I.C. and Mathur, K.C., 1981. Evaluation of plant products as grain protectants against insect pests of stored paddy. Bull. grain. Tect. 18(1):25-28.
- Prakash, A. and Kauraw, L.O., 1982. Studies on insects, mites and fungal infestations in rural and farm stored rice. J. Res. Assam Agric. Univ. 3(2) : 190-196.
- Prakash, A., Pasalu, I.C. and Mathur, K.C., 1983. Varietal resistant of stored paddy grains to Sitotroga cerealella Oliv. Oryza 20 2/3:133-137.
- Prakash, A. and Rao, Jagadiswari., 1986. Angoumois grain moth a serious pest of stored paddy. Bull. Grain Technology. 23(3):240-247.
- Prakash, A., Rao, Jagadiswari., Pasalu, I.C. and Mathur, K.C., 1987. Rice storage and insect pest management. B. R. Publishing Corporation, New-Delhi, pp 337.

IV

- masudhakar, T., 1987. Relative susceptibility of paddy varieties against Sitotroga cerealella Oliv. infestation during storage. Indian J. Ent. 49(4):471-474.
- men, H.A., Pere, W. M. and Magoya, J.K., 1983. Protection of stored bean seeds against the bean bruchid. F.A.O., Plant protection bulletin. 31(3):121-125.
- el, M.P., 1976. Resistance of commercial rice varieties to S. cerealella. (Oliv.). J. stored product Res. 12(2):105-109.
- apati, B. and Satapathy, J.M., 1972. Persistent toxicity of Malathion and Pyrethrins on the adult of rice weevil. Indian J. of Ento. 34:1-4.
- ali, M.E., 1987. Weight loss caused by development of Sitophilus oryzae (L.) and Sitotroga cerealella (Oliv). in sorghum grains to two size classes. J. stored prod. Res. Vol. 23(4):233-238.
- h, R. A. and Rizvi, S.M.A., 1991. Influence of certain paddy grain characters on the infestation of Sitotroga cerealella (Oliv) in storage. J. Appl. Zool. Res. 2(1):39-42.
- h, H., 1967. studies on the protection of pulse against Callosobruchus chinensis. Plant. Prot. Bull. New-Delhi 15(1):25-26.
- akar, T.R. and Pandey., 1985. Effect of parboiling rice on the infestation of Sitophilus oryzae. J. Punjab Agril. Univ. 22(4):695-699.
- ya, Rao., Mahama, M.K., Sahoo, K.M. and Sahey, M.N., 1993. Post harvest losses of some paddy varieties during farmers operations Oryza 30(2):612-613.
- iki, J.G., Oschlsager, A.C. and Borden, J.H., 1988. Aggregation pheromone to important pests of stored products in the families Tenebrionide J. Chem. Ecol. 14:2071-2098.
- ng, Jung. Wu., 1991. Evaluation of BPH and WBPH resistant hybrid rices for resistance to Angoumois grain moth. IRRINL. 16(1):12.

- Upadhyay, V.R., Shah, A.H. and Desai, N.D., 1979. Varietal resistance of paddy varieties to Sitotroga cerealella. Indian J. Ent. 41(2):190-192.
- Uttam, J. R., Nigam, P.M., Singh, Y.P., Awasthi, B.K. and Verma, R.A., 1984. Studies on resistance/susceptibility of paddy varieties to Sitotroga cerealella (Oliv.). Bull. Grain Tech. 23(3): 232-235.
- Verma, B. K. and Pandey, G. P., 1977. Annona (custard apple) seed powder as protectant of mung against pulse beetle. Bull. grain Tech. 15(2):100-104.
- Warren, L. O., 1956. Behaviour of Angoumois grain moth on several strains of corn at two moisture levels. J. Eco. Ent. 49(3):316-319.
- Wenhelz, H., 1927. Storage of Maize in coastal districts. Agri. Gaz. N.S.W. 38(3 & 5):255-261 and 367-373.

**Solomon, M.E., 1957. Control of humidity with Potassium Hydroxide, Sulphuric acid and other solution. Bull. Ent. Res., 42 : 543 - 554.**

**Avertey, J.N., 1979. Interaction between laboratory populations of Sitophilus oryzae Mots and Sitotroga cerealella olive. on stored maize with a brief study of there control by chemical means. Ph.D. Thesis, University of London.**

\* ( Original is not seen )