

Growth and development of rice moth, *Corcyra cephalonica* (Stainton) on different rearing media

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CERTIFICATE-I

This is to certify that the thesis entitled "**Growth and development of rice moth, *Corcyra cephalonica* (Stainton) on different rearing media**" submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)** to the Odisha University of Agriculture and Technology is a faithful record of *bona fide* and original research work carried out by **Smaranika Behera**, Adm. No. 18122F14 under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

It is further certified that the assistance and help received by her from various sources in the course of investigation have been duly acknowledged.

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CERTIFICATE II

This is to certify that the thesis entitled “**Growth and development of rice moth, *Corcyra cephalonica* (Stainton) on different rearing media**” submitted by **Smaranika Behera**, Adm. No.18122F14 to the Odisha University of Agriculture and Technology, Bhubaneswar, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)** has been approved/disapproved by the student’s Advisory Committee and the external examiner.

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ABSTRACT

Experiments were conducted in the Biological Control Laboratory, Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar during August 2019 to February 2020. The effect of different rearing media on growth and development of rice moth, *Corcyra cephalonica* (Stainton) were evaluated in completely randomized design (CRD) with six treatments and four replications. The treatments comprised T₁ (Rice: Maize: Groundnut=10:10:1), T₂ (Rice: Groundnut=20:1), T₃ (Maize: Groundnut=20:1), T₄ (Rice: Maize=20:1), T₅ (Rice) and T₆ (Maize as control). Among these six treatments, T₃ (Maize: Groundnut=20:1) was proved to be the best for all the parameters tested. This treatment (Maize: Groundnut=20:1) produced the stoutest larvae (15.16 mm in length, 2.81 mm in breadth and 57.75 mg in weight in the fourth week of larval growth), pupae (10.79 mm, 2.91 mm and 49.75 mg), adult male (11.98 mm, 2.87 mm and 24.67 mg), adult female (14.67 mm, 3.24 mm and 33.64 mg) and F₁ egg (0.57 mm, 0.42 mm and 9.75 mg/ 100 eggs). This treatment (Maize: Groundnut=20:1) recorded the shortest period from egg to adult emergence (48.36 days), highest adult male longevity (7.47 days), highest adult female longevity (8.65 days) and highest adult emergence (773). Highest fecundity (187eggs/female) and most favourable female-biased sex ratio (male: female =1:1.18) were also observed in this treatment (Maize: Groundnut=20:1). This treatment (Maize: Groundnut=20:1) produced highest quantity of egg (3.70 cc/ 525 g rearing media), highest profit (Rs. 148.68/ 525 g rearing media) and highest benefit- cost ratio (4.09:1). This treatment (Maize: Groundnut=20:1) was closely followed by T₁ (Rice: Maize: Groundnut=10:10:1) and was statistically at par in all the parameters tested. T₁ (Rice: Maize: Groundnut=10:10:1) produced 3.26 cc egg/525 g rearing media, earned a profit of Rs.129.68/ 525 g rearing media and produced the benefit - cost ratio of 3.89:1. These two treatments, Maize: Groundnut=20:1 and Rice: Maize: Groundnut=10:10:1 were significantly superior to all other treatments. From the results, it may be concluded that combination of maize grain and groundnut kernel @ 20:1 form the most effective and economic media for rearing rice moth in the biological control laboratory. If the availability of maize grain reduces during some part of the year, 50% maize grain may be replaced by broken rice which is always available plentifully in the local market. In short, Maize: Groundnut=20:1 is the best rearing media followed by Rice: Maize: Groundnut=10:10:1.

CHAPTER-I

INTRODUCTION

INTRODUCTION

In order to meet the requirements of the ever growing population, the production of agricultural commodities needs to be increased. To boost up the production, growers often rely heavily on chemical pesticides and increase the quantities beyond recommendations. However, the misuse and excessive use of these agrochemicals has created a plethora of environmental problems. Some of these are development of resistance in insect pests against insecticides, residue hazard on the treated products, large scale destruction of beneficial insects including predators and parasitoids and destruction of terrestrial and aquatic ecosystems.

Biological control by deploying natural enemies *viz.*, predators, parasitoids and pathogens provides a cheap, sustainable and efficient approach of insect pest management. Since, it uses living organisms instead of toxic chemical components, it renders a pollution free and environmentally safe method. Though natural biological control is operational from time immemorial in agriculture, more and more emphasis is being given to applied biological control in the current era.

Applied biological control has been a valuable tool in insect-pest management practices around the world for many years but has undergone degrees of resurgence in recent decades. It may be applied as a sole practice or may be integrated with other methods of pest control to form an integrated pest management (IPM) or bio-intensive integrated pest management (BIPM) systems. Augmentation is a significant technique in applied biological control. It means mass culturing of bio-control agents and their periodic release to field for controlling pests. Mass culturing of bio-control agents requires mass multiplication of hosts in the bio-control laboratory.

Amongst different stored grain pests, rice moth is the most useful and widely used laboratory host for mass multiplication of different bio-control agents of phytophagous pests and obtains a predominant position in bio-control programme. (Ambika *et al.*, 1981; Kumar and Krishna,1991). Hence, production of bio-control agents in the laboratory mostly depends on the successful mass multiplication of the factitious hosts.

Rearing media (diets) play important role in the growth and development of the laboratory host which in turn determines the production of bio-control agents in the laboratory.

Earlier workers (Begum and Qamar, 2015; Mamung and Kumar, 2016; Kumar *et al.*, 2018 and Amadou *et al.*, 2019) evaluated different rearing media for their influences on the biological attributes and production of egg and larva of the factitious host, *Corcyra cephalonica*.

In the present investigation some rearing media composed of locally available ingredients were tested for their positive effect on the biology and sustainable and economic production of egg and larvae of the laboratory host, *Corcyra cephalonica* .

The present investigation was conducted with the following objectives.

1. Influence of diet on growth and development
2. Impact of diet on sex ratio and fecundity
3. Economics of diets.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2.1. Biology of *Corcyra cephalonica*

More (1995) studied the bionomics of *C. cephalonica* on rice and found that oviposition period ranged from 3.18 to 3.78 days, fecundity ranged from 184.26 to 263.44 eggs per female. The adult longevity was found to be 6.89 to 9.22 days in male while 6.56 to 7.89 days in case of females. The mean developmental period varied from 59.91 to 63.47 days.

Haritha (2000) studied the biology of rice moth on groundnut pods and kernels under controlled conditions. The average duration of eggs, larval and pupal stages was 4.5, 49.4 and 15.62 days, respectively on groundnut pods and moth was completed earlier on groundnut kernels (65.08days) than on pods(69.24 days).

Jagannath (2009) conducted experiment to study the biology and management of *Corcyra cephalonica* (Stainton) on broken grains of grains and forage purpose sorghum. The female moths deposited egg singly which were pearly white and oval shaped. The (average of) freshly laid eggs were 0.51 ± 0.04 and 0.52 ± 0.03 mm in length and 0.35 ± 0.03 and 0.34 ± 0.03 mm in breadth on grain and forage purpose sorghum, respectively. The incubation period was 5.04 and 4.10 days and hatchability was recorded to be 96.00 and 94.00 percent on grain and forage type of sorghum, respectively. In both type of sorghum, the male larvae passed six instars and female larvae seven instars. The average duration of 1st, 2nd, 3rd, 4th, 5th, 6th, and 7th instar larvae were 4.02, 4.12, 4.86, 5.86, 6.45, 5.71, 5.74 days, on grain purpose sorghum and 4.87, 5.17, 5.95, 6.05, 6.58, 7.02, and 6.90 days on forage purpose sorghum, respectively. The developmental period of larvae was shorter in grain purpose sorghum (Average 36.72 days) than forage purpose sorghum (Average 42.52 days). Larval mortality was higher in forage purpose(14%) as compared to grain purpose(12%). The average highest fecundity of 159 eggs was recorded on grain purpose sorghum whereas lowest of 134 eggs on forage purpose sorghum. The longevity of the male moth was higher on grain purpose sorghum (9.20 days) as compared to forage purpose sorghum (8.75days). While the longevity of female moth was longer on grain purpose sorghum(8.90days) as compared to forage purpose sorghum(7.55 days). The sex ratio (male: female) was recorded to be 1:1.278 on grain purpose and 1:1.11 on forage purpose sorghum. The growth index was 1.59 and 1.27 on grain purpose and forage purpose, respectively. The average duration of entire life span was 57.8 ± 8.5 and 61.9 ± 8.5

days for male and 61.8 ± 8.6 and 65.7 ± 10 days for female, when larvae were reared on grain purpose and forage purpose sorghum, respectively.

Jagadish *et al.* (2009) conducted an experiment on *Corcyra cephalonica* (Stainton) on foxtail millet revealing the biology of the moth. The freshly laid egg were glistening, pearly white in colour with irregular sculptured surface having small divided uneven areas on the surface. Eggs are pear shaped and gently rounded at one end and pointed at the pedicel end with brownish tinge. Egg duration ranged from 4-7 days with average of 4.66 days. The larval development occurred inside the grain cluster. Larva seemed dirty white with brownish head. The larval period ranged from 4 to 5 , 5 to 6 , 3 to 4 , 3 to 4 , 5 to 7 and 8 to 10 days with a mean of 4.13 , 5.04 , 3.73 , 3.40 , 5.46 and 9.69 days , respectively for six larval instars. Predominance of females was observed among the population raised in the laboratory culture with female: male ratio of 1.51:1 and female: male ratio of 1.79:1. Mating period ranged from 60 to 130 minutes with mean of 90.55 minutes. The pre-oviposition period ranged from 1-2 days.

Rangnath (2012) studied the biology of rice moth and percent parasitization of *T. chilonis* on eggs of rice moth reared on different food grains. The results revealed that diet consisting of maize 80% + groundnut 20% or sorghum 90% + groundnut 10% or maize 90% + groundnut 10% were found almost equally effective to standard media sorghum 80% + groundnut 20% for the mass production of *Corcyra cephalonica*. But sorghum is costly and is not readily available everywhere. Therefore , the diet of maize , bajra can be used to reduce the quantity of sorghum.

An experiment was conducted during September to November, 2012 at $28.5 \pm 2.0^\circ\text{C}$ temperature and $78.5 \pm 3.0\%$ RH to study the biology and morphometry of rice moth. The results revealed the average length and breadth of egg were 0.42 and 0.13 respectively. The mean length and breadth of 1st, 2nd, 3rd, 4th, 5th and 6th instar larvae were 2.72, 3.74, 5.63, 7.55, 9.20, 11.21 and 0.31, 0.39, 0.95, 11.16, 1.35, 1.59mm, respectively. The average length of pupa was 4.05 and breadth was 1.10mm. (Devi M B *et al.* , 2013)

Rajkumar *et al.* (2014) studied the biology of *Corcyra cephalonica* by rearing on rice, wheat and groundnut mixture for two season *i.e.* summer and winter. It was found that development period of *Corcyra cephalonica* were 36.30 ± 0.58 and 48.80 ± 0.33 in summer and winter respectively, whereas, maximum fecundity were 171.60 ± 0.13 and 157.65 ± 2.64 in both the season. The maximum fresh body weight of full grown larva was

93.85±0.56 in summer and 84.70±1.05 in winter. Among the six diets tested ,rice ,wheat and groundnut mixture (5:5:1) was found to be the superior rearing medium that enhanced quicker development period of *Corcyra cephalonica* ,maximum fecundity and maximum fresh body weight of full grown larva. Groundnut alone proved to be least preferred by the *Corcyra cephalonica*.

Menge and Naik (2017) studied the biology of Rice moth under controlled conditions of 28±2.33°C temperature and 64±6.33% RH in laboratory conditions using Groundnut variety Konkan Gaurav. Results revealed that the average egg laying was 336eggs deposited by the female moth. Average oviposition period, incubation period and hatching percentage were 4.10 days, 4.35 days and 93.20% respectively. Average larval and pupal period were 37.90 days and 10.10 days. The total development period was 51.40 days. The average weight, length and breadth of larva were 26.00 mg, 12.60 mm and 1.65 mm respectively, while average weight, length and breadth of pupa was 23.42 mg, 9.20 mm and 1.80 mm respectively. The average weight, length and wingspan of adult male was 11.77 mg, 7.30 mm and 15.10 mm respectively, while it was 18.96 mg, 9.40 mm and 17.55 mm in female moth. The average longevity of male and female was 9.00 days and 6.10 days, while sex ratio of rice moth was 1:1.15.

Sowjanya *et al.* (2018) studied the developmental biology of *Corcyra cephalonica* (Stainton) (Lepidoptera: pyralidae).Both male and female larvae passed 7 to 8 instars. However, most of them passed 7 instars. Male instar took an average of 31.3 ± 1.8 days and female larvae completed development in 32.5 ± 3 days. Male completed pupal period in an average of 9.3 ± 1.1 days and female pupae took an average of 11.3 ± 0.94 days to complete its development. This study revealed, the longer development period of females as compare with the females. Females completed total developmental period from egg to adult; ranged from 42 to 55 days with average of 48.6 days. Male took 42 to 51 with an average 45.3 days for completion of total development at 27 ± 1.6° C and 46 ± 5 percent.

2.2. Effect of rearing media on *Corcyra cephalonica*

As per the reports of Swamy and Sreenivasaya (1940), the *C. cephalonica* had a special reference to the starch rich cereals. Further they reported that the carbohydrate metabolism must dominate its life process and vitamin B₁ requirements for the insect must be indispensable and substantial.

Krishnamurti and Rao (1945) worked out the effect of addition of yeast (a source of vitamins) to rearing media of *C. cephalonica* and found to improve the nutritional quality of diets.

Uberoi (1960) conducted feeding trials on rice moth larvae using wheat which showed that growth was very satisfactory when cereal was offered in form of broken grain, and the growth index (2.00) excelled that obtained with broken sorghum. Growth index decreased with decrease in size of particle. Whole rice proved almost of the same nutritive value as broken sorghum. Rice flour was inadequate for growth. The feeding behavior of larva with maize was interesting. All the three different physical forms, were almost of the same nutritive value and proved fairly satisfactory. The flour of pearl millet and broken grain of wheat proved the most satisfying feeding media, superior even to sorghum. Growth on the whole grain of wheat, barley or pearl millet was inferior to that on these commodities when offered in flour form. In the case of rice or sorghum however, the whole grain proved better than the flour.

Daya Bhanu (1961) studied the effects of three antibiotics (penicillin, oleandomycin and terramycin) at different levels (50, 100, 500 and 1000 ppm) of application on the fecundity and longevity of *C. cephalonica* and conducted that oleandomycin and terramycin had no effects on the fecundity at 50 ppm level while penicillin gave a significant increase in the number of eggs laid per female. Terramycin proved ineffective at all levels of application. Life span and female moths remained unaffected by the administration of any of the antibiotics.

Urs and Mookherjee (1966) studied the development of *C. cephalonica* on groundnut, *Arachis hypogaea*, and til, *Sesamum indicum*. The percentage development of *C. cephalonica* on groundnut is higher (90.13%) compared to til (66.85%). The no. of eggs laid per female on groundnut and til is 255 and 159, respectively.

El-Buzz *et al.* (1967) studied the effect of six diets *viz.*, whole wheat meal, wheat bran and sifted flour alone mixed with 5% yeast, 5% casein or both on biology of *C. cephalonica*. They found that the whole wheat meal appeared to be the most suitable diet for development giving highest number of eggs and percentage hatching. The number of larval molts and percentage mortality was also shortest in this diet.

Sharma *et al.* (1978) determined comparative host preference of *C. cephalonica* on sorghum, rice, maize, wheat and groundnut. They observed that sorghum was the most

preferred host as the larva of *Corcyra cephalonica* had higher percentage of survival, higher pupal weight and significant faster development. Sorghum was followed by maize, groundnut, rice and wheat. Male: female ratio was minimum in sorghum, the most preferred host. The ratio increased on less preferred host, maximum being on wheat.

Sharma *et al.* (1978) revealed results regarding the survival results of *Corcyra cephalonica* on sorghum, maize and groundnut to be 93.33, 81.67, 81.67 days, respectively. Average larval duration for male on sorghum, maize, and groundnut was observed to be 26, 28, 32 days, respectively and average larval duration for female on sorghum, maize and groundnut to be 32,33,40, respectively. They also reported that the male: female ratio on sorghum, maize and groundnut was 1:1.14, 1:1.22, 1:1.22, respectively.

Nasiruddin and Shahjahan (1981) studied the extend of lifecycle of the rice moth *C. cephalonica* (Stainton) on different food grains. The lifecycle was observed to be longest in husked pea (121.5 days) while the shortest in case of gram (50.7 days).

Medina and Cadapan (1982) tested six rearing media for rice moth. A mixture of 50 per cent fine rice with rice germ and 50 per cent rice bran resulted a lifecycle of 32 days while in wheat it was 42.7 days.

Rose *et al.* (1982) reported that the sorghum with and without 5% yeast provided maximum dietary requirements for the larval development of *C. cephalonica* as compared to other foods. Duration of life-cycle of the insect ranged from 94 to 52 days without yeast and 40 to 50 days with 5% yeast in different foods. The percentage of adult emergence was 60 incase of sorghum without yeast and 80 with 5% yeast, whereas it was only 40% incase of groundnut, wheat and biscuits without yeast and 80, 60, and 60 % with 5% yeast, respectively. In case of walnut, gram and rice, the adult emergence was 20% without yeast and 60, 40 and 20 % with 5 % yeast, respectively. Results indicated that addition of 5% yeast had shortened the duration of lifecycle of *C. cephalonica* in all the tried food.

Tauthong (1984) reported broken maize and broken rice were the best media for growth and development of rice moth. The order of relative degree of preference of rice moth to different media was broken maize> broken rice > rice >groundnut >broken mung bean>maize >mung bean> broken kidney bean.

The development of rice moth in millet, sorghum, corn, wheat and milled rice, both as whole kernels and coarsely ground media was studied by Noorma Osman (1986). The parameters observed were percentage adults that emerged, average development time for oviposition to adult emergence and the fresh body weight of females. The results obtained were more satisfactory in case of ground kernels as compared to whole kernels. The best ground and whole kernel media were milled rice and millet, respectively.

Jacob *et al.* (1988) carried out an experiment with wheat, maize and rice to find a good medium that would yield more number of *Corcyra* larva in short span of time. Maize was found to be better food medium than rice and wheat.

Rai and Sattagi (1988) took detailed study on biology of rice moth on wheat and sorghum to test the suitability of the food materials. They reported that eggs were white, more or less oval in shape and measured about 0.48 to 0.55mm with an average of 0.51mm in length and 0.30 to 0.39 mm with a average of 0.35mm in width. They also reported that the pupa was oblong and measured 4.90 to 6.35mm and 1.00 to 1.35mm with an average of 5.20 and 1.20 mm in length and width, respectively. The pre-oviposition period on both wheat and sorghum occupied 1 to 2 days with a mean of 1.2 and 1.6 days, respectively. The oviposition period was 2 to 4 and 3 to 6 days with an average of 3.2 and 4.5 days on wheat and sorghum, respectively. The average post-oviposition period was higher (5.4 days) on wheat and lower (3.43 days) on sorghum.

Bernardi *et al.* (2000) evaluated different artificial diets for rearing *Corcyra cephalonica* (Stainton) for *Trichogramma* mass production. The research was conducted at 25 ± 1 °C, RH $60 \pm 10\%$ and photophase of 14 hours. Six artificial diets were compared (a) whole wheat flour (48.5%), ground rice (48.5%) and sugar (3%); (b) ground rice (97%) and sugar (3%); (c) whole wheat flour (48.5%), rice flour (48.5%) and sugar (3%); (d) whole wheat flour (97%) and yeast (3%); (e) wheat germ (97%) and yeast (3%); (f) rice bran (94%), sugar (3%) and yeast (3%). All of the diets studied permitted the development of *Corcyra cephalonica* although the diets with wheat germ and yeast and that consisting of rice bran, sugar and yeast proved to be the most adequate for rearing the moth.

Ingle *et al.* (2000) studied the performance of *C. cephalonica* on different diets. They reported that total moth emergence on Bajra+ groundnut and maize+ cotton seeds was 590 and 401, respectively.

Kumar and Shenhmar (2001) studied the utilization of different cereal grains for the mass production of *C. cephalonica*. They stated that total moth emerged on different cereal grains viz., maize, rice, sorghum and wheat were 1036.83, 745.58, 1013.99 and 956.24, respectively. They also found the peak adult emergence period on maize, rice, sorghum and wheat as 57-75, 61-108, 61-84 and 80-98 days, respectively.

To determine the suitable food media for the mass production of *C. cephalonica*, eleven types of food media viz., sorghum, pearl millet, maize, coarse rice, wheat bran, rice husk, sorghum + rice husk (9:1), pearl millet + rice husk (9:1), pearl millet + rice husk + wheat bran (5:1:1), maize + rice husk (9:1) and rice + rice husk (9:1) were tested by Kumar and Kumar (2002). Observations were taken on average developmental period, percentage of moth emergence and weight of eggs. Food efficiency index (FEI) was calculated by dividing the product of percent emergence and egg weight by average developmental period. The FEI was highest in case of sorghum followed by pearl millet, maize, pearl millet + rice husk + wheat bran, sorghum + rice husk, wheat bran and rice, while in other food media it was extremely low.

Bunker and Bhargava (2003) studied twelve diet components viz., sorghum + groundnut, sorghum + mustard, sorghum + cotton seed, bajra + groundnut, bajra + mustard, bajra + cotton seeds, maize + groundnut, maize + mustard, maize + cotton seeds, rice + groundnut, rice + mustard and rice + cotton seeds to know the diet suitability for mass rearing of rice moth, *Corcyra cephalonica* (Stainton). Among the various diets, bajra + mustard or groundnut or cotton seeds was the most promising diet which favourably influenced larval duration and weight, pupal period and weight, total developmental period, adult emergence, fecundity and longevity of male and female adults.

Kumar and Jain (2003) studied the developmental parameters such as incubation, larval and pupal period, larval and pupal weights, larval survival, adult emergence and longevity of rice moth. Out of the tested diets, sorghum was found to be the most preferred as the insect took minimum period to complete its lifecycle (50.98 days) while maximum period was observed in case of gram (60.84 days).

The effect of different rearing media on certain biological parameters of *C. cephalonica* was studied by Sathpathy *et al.* (2003) and reported that higher the carbohydrate and protein content in diet was unfavourable. Sorghum, wheat or maize based media supplemented with groundnut enhanced fecundity compared to yeast fortified

media. The biological parameters were positively correlated with carbohydrate and protein content of the rearing media.

Tiwari and Khan (2003) studies the efficacy of three diets *viz.*, broken maize alone, broken maize + yeast (2%) for rearing *Corcyra cephalonica* (Stainton) , a laboratory host for mass production of *Trichogramma spp.* and other other bio-control agents. Maize + yeast combination gave the best results in terms of mean total adults in terms of mean total adult emergence (2211), mean total females (985),mean fecundity (397.85) and mean duration of moth emergence (52.31 days),while average developmental period was lowest(36 days) when compared with other two diets.

Herlinda *et al.* (2005) evaluated the growth and development of *Corcyra cephalonica* reared on local feed. Numerical index for growth (NIG) was computed from product of linear dimensions and larval weights. The highest NIG(1945.83) was produced by larvae reared on the combination of corn meal and rice bran, but not significant than those (1581.31) reared on combination on chicken feed and corn meal were the highest (433.81 eggs/female).Thus, the most suitable media for growth and development of *C. cephalonica* was the combination of chicken feed and corn meal.

Kadam *et al.* (2006) investigated the suitability of different combinations of dietary ingredients with yeast and vitamin E for *C. cephalonica* and concluded that out of 17 dietary treatments evaluated, sorghum 1kg+maize 1kg+yeast 2g+vitamin E 0.2g emerged as the best diet for getting high yield of *Corcyra* eggs. The next highly promising treatments were bajra 1kg+yeast 2g+vitamin E 0.2g.The cereals fortified with yeast and vitamin E reduced the duration of life-cycle, increased moth emergence and sex ratio of the factitious host.

Growth and development of *Corcyra cephalonica* as monitored on diets consisting of four cereals-finger millet, soft white wheat ,short-grained white rice and durra sorghum. For *C. cephalonica*, the percentage adult emergence and several fifth instar food use indices were significantly higher for millet-reared than for sorghum-reared larvae. The nutritional indices for wheat and rice- reared *C. cephalonica* larvae was intermediate between the indices for larvae reared on millet and sorghum. The percentage adult emergence and percentage 24h survival of *T. chilonis* were significantly higher on eggs of *C. cephalonica* hosts reared on millet than on eggs of those reared on sorghum. The rearing of *C. cephalonica* larvae on high quality nutritional source resulted in high

quality eggs, which ultimately resulted in high quality *T. chilonis* reared on those eggs. Such an effort had been modeled in ecological theory as a “bottom up cascade” (Nathan *et al.*, 2006).

Rajasekhar *et al.* (2006) attempted to study the effect of different rearing media and their combinations to determine the economic efficiency of rearing media for *Corcyra* using sorghum, pearl millet, finger millet, broken rice and foxtail millet. With the objective to study the effect on growth and development of *Corcyra cephalonica* considering economy. Seven different rearing media were prepared using cereal grains in different combinations. Seven different parameters were considered. Most of the parameters were found significantly higher in bajra based medium *i.e.* bajra and sorghum which can be profitably in mass multiplication of *C. cephalonica* and the next alternative being bajra+ ragi as well as bajra+ broken rice .

Patel and Patel (2007) reported that maximum fecundity of rice moth was obtained when reared in sorghum (159) as compared to wheat, pearl millet and rice. The longevity of male moth was found to be longer (9.53 days) in rice, while it was shorter (8.18 days) when reared on wheat. The sex ratio observed was in the range of 1:1.09 to 1:1.22 on rice, pearl millet, wheat, and sorghum. The highest growth index (1.62) was observed in sorghum.

Patil (2009) reported growth index of rice moth as 1.59 and 1.27 on grain and forage sorghum, respectively. The longevity on sorghum for male and female was 9.20 and 8.90 days, respectively. Sex ratio reported was 1:1.28 and 1:1.11 on grain and forage sorghum, respectively. The duration of entire life span of male was 49 to 72 days with an average of 57.8 ± 8.5 days, while life span of female was 52 to 77 days with an average of 61.8 ± 8.6 days on grain purpose sorghum.

Murlidhar (2010) worked on the assessment of different diets for the rearing of rice moth. The diets consisted of combinations of maize, sorghum, bajra and groundnut laid out in CRD with 9 treatments and 3 replications. The least developmental period of 38-33 days was recorded on rearing of the moths on bajra 2.5kg+ groundnut 100g. The least larval development period of 30.86 days and pupal period of 4.70 days , along with maximum percent pupation (85.02%) were observed on bajra based diet, bajra 2.5kg+ groundnut 100g. In case of eggs, more fecundity was recorded on diets consisting of bajra 2.5kg+groundnut 100g, whereas maize based diet proved less influential among the test

diets .The data on economics of diets revealed that the total cost as lowest (Rs.250.5) for sorghum based diets ,while bajra 2.5kg + groundnut 100g .Incase of eggs, more fecundity was recorded on diet consisting of bajra 2.5kg+groundnut 100g, whereas maize based diet proved less influential among the test diets. The data on economics diets revealed that the total coast was lowest (Rs.250.5) for sorghum based diet, while bajra 2.5kg + groundnut 100g, being little costly gave maximum economic returns. Hence, from the above analysis , it was concluded that bajra 2.5kg + groundnut 100g treatment was superior to all.

Seven types of food media combinations were evaluated for optimal rearing of *Corcyra cephalonica* for its parasitoid, *Trichogramma* by Pathak *et al.* (2010).Food efficiency index was computed to determine the best medium. Results clearly established the superiority of sorghum over other media.

Saneera (2013) studied the suitability of whole and broken grains and fortified diets for the rearing of *C. cephalonica*. It revealed that broken or coarsely milled grains of sorghum found to be more suitable than whole grains for rearing of *C. cephalonica* in terms of number of adults obtained, fecundity, duration of immature stages and weight of eggs. Considering the same biological traits ,coarse sorghum grains fortified with yeast @5% proved the best diet supplement for *C. cephalonica* followed by groundnut kernel(10%).Fortification of rearing media with protinex @5% was found unsuitable for mass rearing of the laboratory host as it resulted in low adult emergence, fecundity and prolonged developmental period.

Bhandari *et al.* (2014) conducted experiment using diets consisting of four cereals namely corn, rice, millet and wheat, which was tested solely and by mixing with groundnut .Among the eight treatments corn+ groundnut was superior diet in almost all biological parameters of *Corcyra cephalonica* followed by millet +groundnut .The experiments showed that the corn+ groundnut was biologically better option for production of robust eggs of *Corcyra cephalonica*.

Mahendale *et al.* (2014) reported about the effect of rearing media to improve the mass production of *C. cephalonica* as a factitious host. Among the various combinations of grains tested, revealed three promising media viz., T₃ (sorghum+ groundnut+ powdered yeast), T₄ (sorghum+ gram+ powdered yeast),and heavier larvae in T₃(53.33mg) ,T₄(52.50mg), and T₆ (54.50mg) respectively. Similarly, heavier pupae were also recorded.

Begum and Qamar (2015), prepared five experimental dietary formulations (D1-D5) which composed of sorghum, millet and maize as base diet to rear and maintain the rice moth, *Corcyra cephalonica* under laboratory conditions. The base composition was supplemented with groundnut incase of D2; and with vitamin B,H AND E in D3 , D4 , and D5 respectively. The Diet D5 was found to outperform other dietary formulations as it resulted in highest larval weight (60.4 mg), adult male weight (17.2 mg), adult female weight (38.4 mg) , fecundity (399.2) and food efficiency index (8.42) .Diet D2 was also found to yield better result when other parameters, like total developmental period and percentage of moth emergence were taken into consideration. The obtained results provided suitable diets for mass rearing, thus contributing significantly for large scale production of *C. cephalonica*.

Variation in biological parameters of *C. cephalonica* with quality rearing media was studied against four different types of locally available grains namely maize, wheat, Italian millet and scented rice as solo and fortified with 3% dextrose and yeast. The insect had significantly shorter larval– pupal period when the food grains were fortified with dextrose followed by yeast and the period was longest in solo grains. The period was longest in scented rice (64.71 days) and shortest in maize-dextrose (45.00 days). Adult emergence was maximum in wheat (solo as well as fortified) (82.29 to 86.01%). Fortification of 3% dextrose and yeast increased female percent and thereby fecundity in Italian millet. Hence, Italian millet alone or fortified with dextrose and yeast can be used as alternative food as rearing media for *Corcyra* (Chaudhuri *et al.*, 2015).

Wadaskar *et al.* (2015) evaluated rearing media to improve mass production of *C. cephalonica* as a factitious host. It revealed two promising media *viz.*, sorghum and pearl millet based diets. Twelve combinations of diets were used for the rearing of *C. cephalonica*. Among all the diets, diets containing sorghum+ yeast+ protinex gave maximum percentage moth emergence (62.86%) and highest fecundity (188.19 eggs per female). The maximum weight of *Corcyra* eggs (100eggs) was recorded (5.62mg) on maize+ yeast based diets and broken sorghum+ yeast+ protinex was having the maximum (Rs.443.5) net profit as more effective on accounts of more fecundity and higher percentage of egg production whereas, the highest CBR(1:13.64) was obtained in diet containing sorghum alone.

Mamung and Kumar (2016) carried out a study to access for fecundity, emergence, percentage and longevity of *Trichogrammatoidea bactrae* Nagaraja on eggs of

rice moth which was obtained by rearing rice moth larvae on different cereals as diets and its combinations. The maximum number of *Corcyra* egg was parasitized when the parasitoid was reared on host eggs produced from job's tears + rice bran (61.30) and minimum parasitism was when the *Trichogramma* was produced from host egg reared on rice bran (42.70). Maximum female longevity of 9.1 days was observed on host egg reared on rice+ maize; while minimum was 4.8 days on host egg reared on maize. Highest number of *Trichogramma* adult emergence was observed on *Trichogrammatoidea bactrae* fed on host egg reared on maize + rice bran (77.17) and lowest emergence observed on rice bran (57.82). Combined diet with rice bran seems to have positive effect on development of the parasitoid. Hence, mixing 50% rice bran with different cereal is more suitable as well as economical for mass production of *T. bactrae*. This also implies that the quality of host diet had considerable effect on quality and efficiency of the egg parasitoid, *Trichogrammatoidea bactrae*.

Nacrin *et al.* (2016) studied the effect various cereals on the development of *Corcyra cephalonica* (Stainton) and its egg parasitoids, *Trichogramma chilonis* (Ishii). Eight different types of cereals *i.e.*, wheat grains, chopped wheat, paddy grain, rice grain, maize grains, chopped maize, rice bran, mixture of rice bran and chopped rice were fed to observe the development parameters like egg, larva, pupa and adult stages. The studies were conducted for three consecutive generations. The parasitism efficiency of *Trichogramma chilonis* (Ishii) was evaluated on the resultant host eggs of rice moth. Result revealed that the highest percentage egg parasitization was done by the *T. chilonis* on the host eggs reared on chopped wheat (94.8±0.075%) followed by wheat grain (82.5±0.08%) and chopped maize (73.8±0.09%). On the other hand, the lowest parasitism was obtained when the larvae were reared on paddy husk (42.2±0.14%) and paddy grain (48.8±0.05%).

Chaudhuri and Senapati (2017) evaluated the different rearing media for mass production of *Corcyra cephalonica*. The development and performance as tested on 12 different combinations of food containing - maize, Italian millet, and scented rice alone and fortified with 3% dextrose and yeast. Results showed that the net reproductive rate, innate capacity for increase, number of hypothetical female, daily finite rate of female, weekly multiplication, and potential fecundity were highest and true generation time and doubling time were shortest in Italian millet (alone/fortified). Hence, Italian millet alone or

fortified with 3% dextrose and yeast was the most suitable rearing media for mass production of *Corcyra*.

Chandrawanshi *et al.* (2018) conducted experiment explaining effect of magnetic field and different diets on the biological parameters of *Corcyra cephalonica* in factorial complete randomized design. The four main treatments of rice moth were exposed to magnetic field for 0hrs, 2hrs, 4hrs and 6hrs duration and four sub-treatments were rearing of the larvae on different diets that is sorghum, sorghum and bajra, sorghum and maize and sorghum and wheat. Observations on larval weight, larval length and mortality of *Corcyra* were recorded. The interaction effect of magnetic field and diet indicated magnetic field plays an important role in biology and the results provide suitable diet for mass rearing ,thus contributing significantly for large scale production of Rice moth .Amongst different diets tested, the best diet for the growth and development of *Corcyra* was sorghum followed by sorghum+ bajra .

Edpuganti *et al.* (2018) experimented with three different grains and their combinations with groundnut for testing adult emergence and egg production of rice moth. Among the six treatments tested bajra + groundnut was proved to be best in both adult emergence as well as eggs production with 2868 adults and 15.8893 g of eggs followed by bajra + rice + groundnut with 2451 adults and 9.6011g of eggs .Rice + groundnut was proved to be the least effective for the production of rice moth with 416 adults and 1.681 g of eggs .The adult emergence started at the earliest in bajra + groundnut, bajra + rice + groundnut and bajra + sorghum + groundnut after 40 days of charging. The adult emergence started very late in rice + groundnut from 50 days after charging .This proved that the treatments which contained bajra were superior over sorghum and rice.

Kumar *et al.* (2018) conducted an experiment with dietary formulation composed of rice, wheat, sorghum, rice+ groundnut , wheat+ groundnut, sorghum+ groundnut , rice+ sesamum and sorghum+ sesamum as base diet to rear and maintain the rice moth, *C. cephalonica* under lab conditions. The parameters studied were total developmental period , percent adult moth emergence, percent male and female moth emergence ,male and female longevity ,fecundity , total cost for preparing diet , total egg production , total income and net profit . The diet T₆ (sorghum 1000g + groundnut 50 g) was found to outperform other dietary formulations as it resulted in lowest total developmental period (47.33 days), highest adult emergence (82%), highest adult female emergence (52.11%) , highest male longevity (8.33 days), highest female longevity (9.67 days) and highest

fecundity (312.33), highest egg production (21.73cc), highest total income (Rs.426/-) and net profit (Rs.283 /-).

The rice moth , *C. cephalonica*, an alternate host for the production of the parasitoid, *Habrobracon hebetor* was reared on different diets viz., pearl millet flour only , and in combination of flours of sorghum ,peanut and cowpea .The addition of cowpea or peanut to cereal diets slightly increased *C. cephalonica* larval development time and yielded a higher larval survival .Female moth emerging from larvae fed on cereal and legume mixed diets produced higher eggs compared to the ones fed on sole and mixed cereals. Among legumes, cowpea addition is most interesting in terms of cost /production of *C. cephalonica* larvae. However ,female moths emerging from larvae fed on different millet cowpea mix (5,25,and 50%) laid significantly more eggs than those fed on sole pearl millet (*Amadou et al. ,2019*).

The study on the influence of various diets on the lifecycle of *C. cephalonica* was carried out by Padamshali and Ganguli (2019).Twelve different cereal grain diets were prepared including solo and in combination along with and without groundnut fortification. Results revealed that rice showed longer period of development both in males and females whereas jowar + groundnut showed shortest development period of 45.67 and 48.67 days for adult male and female, respectively , with females having longer developmental period in comparison to the males.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiments were conducted in the Bio-control Laboratory, Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar from August 2019 to February 2020. The temperature and humidity of the laboratory room were maintained at $27\pm 3^{\circ}\text{C}$ and $65\pm 5\%$ RH, respectively. The materials required and methods followed for conducting the experiments are described in this chapter.

3.1. MATERIALS

3.1.1. Laboratory apparatus

- a) Aluminium trays
- b) Hot air oven
- c) Measuring cylinder: 10 ml and 100 ml
- d) Rice moth rearing jars
- e) Working table
- f) Glass/plastic tubes
- g) Oviposition cages
- h) Camel hair brush
- i) Mosquito net (Single)
- j) Scissors
- k) Refrigerator
- l) Air conditioner
- m) Room heater
- n) Light trap
- o) Trinocular stereozoom microscope with camera and fitted with computer
- p) Weighing balance
- q) Mixer grinder

3.1.2. Recurring items

- a) Milled maize grain
- b) Broken rice
- c) Groundnut kernel
- d) Formalin
- e) Yeast powder
- f) Streptomycin sulphate

- g) Rice moth eggs
- h) Muslin cloth
- i) Rubber band
- j) Cotton wool
- k) Art paper

3.2. First Experiment

3.2.1. Details of experiment

Design : CRD

Replication : 4

Treatment : 6

T₁ = Rice: Maize: Groundnut =10: 10: 1

T₂ = Rice: Groundnut =20: 1

T₃ = Maize: Groundnut =20: 1

T₄ = Rice: Maize =1: 1

T₅ = Rice

T₆ = Maize (Control)

3.2.2. Setting up the experiment

Six rearing media as mentioned above were chosen for studying the growth and development of *Corcyra cephalonica*. Plastic jars were cleaned and used for the experiment. Each treatment were replicated four times, thus there were a total of twenty four jars. Milled grains of maize, broken rice, and groundnut kernel were treated in the hot air oven at 100°C for 30 minutes to kill all the pre-existing stored grain pests. Groundnut kernels after treating in hot air oven were ground in grinder. As per the treatments (as mentioned above) the plastic jars were filled with the feed substrates. Total quantity of rearing media per jar was 525g. Water, streptomycin sulphate, and yeast powder @ 10 ml, 0.05 g, and 1g per 525g of rearing media were thoroughly mixed with the rearing media.

The surfaces of the media were levelled. Rice moth eggs (freshly laid) were added on the surfaces @ 0.1cc/jar. The mouth of the jars were covered with muslin cloths and secured with rubber bands. The jars were kept on a laboratory table in the rice moth rearing room. The temperature and humidity of the room were maintained. The jars were labelled with paper strips indicating the treatments and replications for recording observations.

3.2.3. Recording observations

At 7, 14, 21, and 28 days of adding eggs (charging), four larvae were taken out from each jar for morphometric observations. Length and breadth were measured by a trinocular stereozoom microscope with camera fitted with computer. Weight of the larvae was measured in a electric balance.

From 35th day of adding of eggs (charging), the jars were checked every day for pupation. After pupation, four pupae from each jar were taken out for morphometric observation as mentioned in case of larvae.

During adult emergence, per day emergence of male and female moths was recorded treatment and replication wise. These moths were placed in egg laying cages, treatment and replication wise. The egg laying cages were labelled accordingly. Thus the period from egg to adult emergence and number of male and female moths were recorded. Four moths each for male and female were taken separately for morphometric observations during adult stages.

Eggs were collected from each egg laying cage every day and recorded treatment and replication wise to compute fecundity. Length and breadth were recorded from four eggs. Weight of 100 eggs were taken.

3.3. Second experiment

This experiment was conducted with the same design, replication and treatment as of the first. Eggs collected from the first experiment were added treatment and replication wise to rearing jars containing 100g of milled maize grain treated in hot air oven with other required ingredients (streptomycin sulphate, yeast powder and water). During adult emergence, number of male and female moths were recorded and sex ratios were calculated.

3.4. Statistical analysis

The data obtained from different observations were analysed statistically to arrive at meaningful conclusion as suggested by Rangaswamy (2015). The treatment variations were tested for their significance by standard of mean, $SE(m) \pm$ and critical difference, CD at 5% level of significance.



FIGURE 1. MILLED CEREAL GRAINS AND GROUNDNUT KERNELS



FIGURE 2. TREATMENT OF THE SUBSTRATE IN HOT AIR OVEN



FIGURE 3. EGGS OF RICE MOTH



FIGURE 4. COUNTING OF RICE MOTH EGGS



FIGURE 5. WEIGHING OF GROUNDNUT KERNEL



FIGURE 6. PREPARED TREATMENT JARS



FIGURE 7. CLOSER VIEW OF TREATMENT JARS



FIGURE 8. COLLECTION OF ADULT MOTHS



FIGURE 9. EGG LAYING CAGES



FIGURE 10. CLOSER VIEW OF THE EGG LAYING CAGES

CHAPTER IV

RESULTS

RESULTS

Studies were conducted to evaluate the effects of different rearing media on the growth and development of rice moth, *Corcyra cephalonica* (Stainton) in the biological control laboratory of Department of Entomology, College of Agriculture, OUAT, Bhubaneswar from August 2019 to February 2020. The results obtained in the present study are briefly described in this chapter along with data presented in the tables.

4.1. Effect of different rearing media on the morphometry of larvae of rice moth

The observations on the morphometry of the rice moth larvae (length, breadth, and weight) have been recorded in the first, second, third and fourth week of larval growth and are presented in the Table 1.

First week

The data presented in Table 1 revealed that the treatment, T₃ (Maize: Groundnut=20:1) produced highest length of larvae (3.75 mm) followed by T₁ (Rice: Maize: Groundnut =10:10:1) (3.72 mm) and T₆ (Maize) (3.64 mm). These three treatments were at par and significantly superior to the other treatments. The length of the larvae in T₄ (Rice: Maize = 1:1) and T₂ (Rice: Groundnut=20:1) were 3.62 mm and 3.37 mm, respectively. The length was the least in case of T₅ (Rice) which was 2.74 mm. Similarly, the breadth of the larvae was highest in T₃ (0.66 mm) followed by T₁ (0.63 mm) and T₆ (0.59 mm). In respect of breadth of rice moth larvae, these three treatments were at par and significantly superior to others. The breadth of larvae in T₄, T₂ and T₅ were 0.58 mm, 0.54 mm and 0.44 mm, respectively.

Second week

The highest length of the larvae *i.e.* 7.21 mm was observed in T₃ (Maize:Groundnut=20:1) followed by T₁ (Rice: Maize: Groundnut =10:10:1) (7.11 mm). These two treatments were significantly at par and superior to all other treatments. The length in T₆ (Maize), T₄ (Rice: Maize = 1:1) and T₂ (Rice: Groundnut=20:1) were 6.84 mm, 6.63 mm and 6.31 mm, respectively. The shortest length was recorded in T₅ (Rice) *i.e.* 6.11 mm. The width of rice moth larvae was highest in T₃ (1.26 mm) followed by T₁ (1.24 mm) and there was no significant difference in these two treatments but these

treatments were significantly superior to all other treatments. The width in T₆, T₄, T₂, and T₅ were 1.18 mm, 1.16 mm, 1.11 mm and 1.02 mm, respectively.

Third week

The length of the larvae was observed longest in T₃(Maize:Groundnut=20:1) (13.47 mm) followed by T₁ (Rice: Maize: Groundnut =10:10:1) (13.23 mm). These were superior to all other treatments and were at par among themselves. The length in T₆ (Maize) and T₄ (Rice: Maize = 1:1) was 12.64 mm and 12.55 mm, respectively and these were statistically at par. The length recorded in T₂ (Rice: Groundnut=20:1) and T₅ (Rice) were relatively smaller *i.e.* 11.92 mm and 11.43 mm, respectively. The breadth was highest in T₃ (2.20 mm) followed by T₁ (2.18 mm). These two treatments were significantly at par and superior to all other treatments. The width of larvae in T₆, T₄, T₂ and T₅ were 1.98 mm, 1.96 mm, 1.85 mm and 1.80 mm, respectively. The heaviest of the larvae were observed in T₃ (34.50 mg) followed by T₁ (33.25 mg) and these two treatments were at par to all other treatments. The weight in T₆ (30.75 mg) and T₄ (28.75 mg) were statistically at par. The weight in T₂ and T₅ was recorded as 26.25 mg and 25.75 mg, respectively.

Fourth week

The length of the larvae was highest in T₃(Maize:Groundnut=20:1) (15.16 mm) followed by T₁(Rice: Maize: Groundnut =10:10:1) (14.99 mm). These were superior to all other treatments and were at par among themselves. The length in T₆ (Maize) and T₄ (Rice: Maize = 1:1) was 13.87 mm and 13.26 mm, respectively and these were statistically at par. The length recorded in T₂ (Rice: Groundnut=20:1) and T₅ (Rice) were relatively smaller *i.e.* 12.64 mm and 12.35 mm, respectively. The breadth was highest in T₃ (2.81 mm) followed by T₁ (2.75 mm). These were significantly at par and superior to all other treatments. The width of larvae in T₆, T₄, T₂ and T₅ were 2.51 mm, 2.25 mm, 2.16 mm and 2.07 mm, respectively. The larvae was heaviest in T₃ (57.75 mg) followed by T₁ (57.00 mg) and these treatments were at par among themselves and superior to other treatments. The weight in T₆ (53.25 mg) and T₄ (52.75 mg) were statistically at par. The weight recorded in T₂ and T₅ were 51.25 mg and 48.50 mg, respectively.

Increase (%) in length, breadth and weight

The increase (%) in length, breadth and weight of rice moth larvae in different treatments over control *i.e.* T₆ (Maize) (calculated on the mean data of four weekly

observations) are presented in Table 1. The highest increase in length over control *i.e.* 7.03% was observed in T₃(Maize:Groundnut=20:1) followed by T₁ (Rice: Maize: Groundnut =10:10:1) (5.57%). The increase(%) in length in other three treatments were negative that means there was decrease in larval length instead of increase. The increase in larval length over control in the treatments, T₄ (Rice: Maize = 1:1), T₂ (Rice: Groundnut=20:1) and T₅ (Rice) were (-) 2.51%, (-)7.41% and (-)11.73%, respectively. Highest increase in breadth of 10.70 % was observed in T₃ followed by T₁ (8.63%). The increase in breadth in the treatments, T₄, T₂ and T₅ were (-) 4.95%, (-) 9.58% and (-) 14.86%, respectively. The treatment T₃ produced highest increase in weight *i.e.* 9.82% followed by T₁ (7.44%). In the treatments, T₄, T₂ and T₅ the increase in weight

Treatment	First week		Second week		Third week			Fourth week			Increase (%) (on mean data) over control		
	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Length (mm)	Breadth (mm)	Weight (mg)	Length (mm)	Breadth (mm)	Weight (mg)	length	breadth	Weight
T1= Rice: Maize: Groundnut =10:10:1	3.72	0.63	7.11	1.24	13.23	2.18	33.25	14.99	2.75	57.00	5.57	8.63	7.44
T2= Rice: Groundnut =20:1	3.37	0.54	6.31	1.11	11.92	1.85	26.25	12.64	2.16	51.25	(-)7.41	(-)9.58	(-)7.74
T3= Maize: Groundnut =20:1	3.75	0.66	7.21	1.26	13.47	2.20	34.50	15.16	2.81	57.75	7.03	10.70	9.82
T4= Rice: Maize =1:1	3.62	0.58	6.63	1.16	12.55	1.96	28.75	13.26	2.25	52.75	(-)2.51	(-)4.95	(-)3.69
T5= Rice	2.74	0.44	6.11	1.02	11.43	1.80	25.75	12.35	2.07	48.50	(-)11.73	(-)14.86	(-)11.61
T6= Maize(Control)	3.64	0.59	6.84	1.18	12.64	1.98	30.75	13.87	2.51	53.25	-	-	-
SE(m)±	0.040	0.024	0.083	0.017	0.165	0.044	0.774	0.360	0.054	1.110	-	-	-
CD(0.05)	0.12	0.07	0.25	0.05	0.49	0.13	2.30	1.07	0.16	3.30	-	-	-

Table 1. Effect of different rearing media on morphometry of larvae of rice moth

were calculated as (-)3.69%, (-)7.74% and (-)11.61%, respectively.

4.2. Effect of different rearing media on morphometry of pupae of rice moth

The data on the morphometry of pupae of rice moth, *Corcyra cephalonica* (Stainton) have been presented in Table 2.

Length, breadth and weight

Among the six treatments with different rearing media, the pupal length was highest in T₃(Maize :Groundnut=20:1)(10.79 mm) which was followed by T₁(Rice :Maize :Groundnut=10:10:1)(10.48 mm).These treatments were significantly at par and superior to the other treatments .The length of pupa in T₆(Maize) ,T₄(Rice :Maize=1:1) and T₂(Rice :Groundnut=20:1) were 9.81 mm ,9.62 mm and 9.47 mm , respectively. The length was shortest in T₅ *i.e.* 9.28 mm.

The breadth was highest *i.e.*2.91 mm and was observed in T₃ which was followed by T₁(2.88 mm) which are significantly at par to all other treatments .The breadth in T₆(2.75 mm) and T₄(2.72 mm) were statistically at par .In T₂ and T₅, breadth recorded were 2.54 mm and 2.33 mm.

The pupa heaviest in T₃ (49.75 mg) followed by T₁(48.25 mg).These treatments were comparatively better than other treatments and were at par .The next order of pupal weight was noticed in T₆ (45.25 mg) which was statistically at par with T₄(43.50 mg).The weight in case of T₂ was 42.25 mg and least in T₅ *i.e.*40.00 mg.

Increase (%) in length, breadth and weight

The increase (%) in length, breadth and weight of rice moth pupae in different treatments over control *i.e.* T₆ (Maize) are presented in Table2. The highest increase in length over control *i.e.* 9.99 % was observed in T₃(Maize:Groundnut=20:1) followed by T₁ (Rice: Maize: Groundnut =10:10:1) (6.83%). The increase (%) in length in other three treatments were negative that means there was decrease in pupal length instead of increase. The increase in pupal length over control in the treatments, T₄ (Rice: Maize = 1:1), T₂ (Rice: Groundnut=20:1) and T₅(Rice) were (-) 1.94%, (-)3.47% and (-)5.40%, respectively.Highest increase in breadth of 5.82 % was observed in T₃ followed by T₁ (4.73%). The increase in breadth in the treatments, T₄, T₂ and T₅ were (-) 1.09%, (-) 7.64% and (-) 15.27%, respectively. The treatment T₃ produced highest increase in weight *i.e.* 9.94% followed by T₁(6.63%). In the treatments, T₄, T₂ and T₅ the increase in weight were calculated as (-)3.87%, (-)8.34% and (-)11.60%, respectively.

Table 2. Effect of different rearing media on morphometry of pupae of rice moth

Treatment	Length (mm)	Breadth (mm)	Weight(mm)	Increase (%) over control		
				Length	Breadth	Weight
T ₁ = Rice: Maize: Groundnut =10:10:1	10.48	2.88	48.25	6.83	4.73	6.63
T ₂ = Rice: Groundnut =20:1	9.47	2.54	41.25	(-)3.47	(-)7.64	(-)8.34
T ₃ = Maize: Groundnut =20:1	10.79	2.91	49.75	9.99	5.82	9.94
T ₄ = Rice: Maize =1:1	9.62	2.72	43.50	(-)1.94	(-)1.09	(-)3.87
T ₅ = Rice	9.28	2.33	40.00	(-)5.40	(-)15.27	(-)11.60
T ₆ = Maize (Control)	9.81	2.75	45.25	-	-	-
SE(m)±	0.145	0.050	0.808	-	-	-
CD(0.05)	0.43	0.15	2.40	-	-	-

4.3. Effect of different rearing media on morphometry of adult males of rice moth

The data in the Table 3 depict the morphometric observations of the adult male rice moth.

Length, breadth and weight

The length of the adult moth was recorded highest in T₃ (Maize:Groundnut=20:1) (11.98 mm) followed by T₁ (Rice:Maize: Groundnut=10:10:1) (11.55 mm). These treatments are significantly at par and superior to all other treatments. The length of adult male in T₆ (Maize), T₄ (Rice :Maize =1:1) and T₂ (Rice :Groundnut=20:1) were 10.80 mm, 10.43 mm and 10.28 mm , respectively .The length was shortest in T₅(Rice) i.e.9.63 mm.

The breadth was maximum in T₃(2.87 mm) which as followed by T₁(2.64 mm).These two treatments were significantly at par to all other treatments .The breadth recorded in T₆(2.41 mm),T₄ (2.29 mm) and T₂(2.18 mm) were statistically at par.The least breadth was observed in T₅(2.03 mm).

The adult male moth were heaviest in T₃ (24.67 mg) followed by T₁(23.84 mg).These treatments were comparatively better than other treatments and were at par

.The next order of weight was noticed in T₆ (22.29 mg) which was statistically at par with T₄(21.76 mg).The weight in case of T₂ was 20.31 mg and least in T₅ i.e.19.85 mg.

Increase (%) in length,breadth and weight

The increase (%) in length, breadth and weight of rice moth adult (male) in different treatments over control *i.e.* T₆ (Maize) are presented in Table3. The highest increase in length over control *i.e.* 10.93% was observed in T₃(Maize:Groundnut=20:1) followed by T₁ (Rice: Maize: Groundnut =10:10:1) (6.94%). The increase(%) in length in other three treatments were negative that means there was decrease in adult length instead of increase. The increase in length over control in the treatments, T₄ (Rice: Maize = 1:1), T₂ (Rice: Groundnut=20:1) and T₅(Rice) were (-) 3.43%, (-)4.81% and (-)10.83%, respectively.Highest increase in breadth of 19.09 % was observed in T₃ followed by T₁ (9.54%). The increase in breadth in the treatments, T₄, T₂ and T₅ were (-) 4.98%, (-) 9.54% and (-) 16.18%, respectively. The treatment T₃ produced highest increase in weight *i.e.* 10.68% followed by T₁ (6.95%). In the treatments, T₄, T₂ and T₅ the increase in weight were calculated as (-)2.38%, (-)8.88% and (-)10.95%, respectively.

Table 3. Effect of different rearing media on morphometry of adult males of rice moth

Treatment	Length (mm)	Breadth (mm)	Weight (mg)	Increase (%) over control		
				Length	Breadth	Weight
T₁= Rice: Maize: Groundnut =10:10:1	11.55	2.64	23.84	6.94	9.54	6.95
T₂= Rice: Groundnut =20:1	10.28	2.18	20.31	(-)4.81	(-)9.54	(-)8.88
T₃= Maize: Groundnut =20:1	11.98	2.87	24.67	10.93	19.09	10.68
T₄= Rice: Maize =1:1	10.43	2.29	21.76	(-)3.43	(-)4.98	(-)2.38
T₅= Rice	9.63	2.03	19.85	(-)10.83	(-)16.18	(-)10.95
T₆= Maize (Control)	10.80	2.41	22.29	-	-	-
SE(m)±	0.243	0.081	0.502	-	-	-
CD(0.05)	0.72	0.24	1.49	-	-	-

4.4. Effect of different rearing media on the morphometry of adult females of rice moth

The morphometric observations in the adult female moth have been depicted in the Table 4.

Length, breadth and weight

Among the six treatments including control, the shortest length of adult female was found in T₅ i.e. 11.12 mm. The longest length of adult female was recorded in T₃ (14.67 mm) followed by T₁ (14.45 mm) and these treatments were at par. The next best performing treatments were T₆ (13.36 mm), T₄ (12.26 mm) and T₂ (12.06 mm).

The breadth of adult female was observed longest in T₃ (3.24 mm) followed by T₁ (3.16 mm). These treatments were at par and significantly superior to all other treatments. The next best performing treatments were T₆ (2.95 mm), T₄ (2.71 mm) and T₂ (2.62 mm). The treatments T₄ and T₂ were statistically at par. The breadth was shortest in T₅ i.e. 2.40 mm.

The adult female moth was heaviest in T₃ (33.64 mg) followed by T₁ (32.87 mg). These treatments were comparatively better than other treatments and were at par. The next order of weight was noticed in T₆ (30.68 mg), T₄ (28.27 mg) and T₂ (27.91 mg). The treatment T₄ and T₂ were statistically at par. The lowest weight was observed in T₅ i.e. 2.40 mg.

Increase(%) in length, breadth and weight

The increase (%) in length, breadth and weight of rice moth adult (female) in different treatments over control *i.e.* T₆ (Maize) are presented in Table 4. The highest increase in length over control *i.e.* 9.81% was observed in T₃ (Maize:Groundnut=20:1) followed by T₁ (Rice: Maize: Groundnut =10:10:1) (8.16%). The increase(%) in length in other three treatments were negative that means there was decrease in adult length instead of increase. The increase in length over control in the treatments, T₄ (Rice: Maize = 1:1), T₂ (Rice: Groundnut=20:1) and T₅ (Rice) were (-) 8.23%, (-)9.73% and (-)16.77%, respectively. Highest increase in breadth of 9.83 % was observed in T₃ followed by T₁ (7.12%). The increase in breadth in the treatments, T₄, T₂ and T₅ were (-) 8.14%, (-) 11.19% and (-) 18.64%, respectively. The treatment T₃ produced highest increase in weight *i.e.* 9.65% followed by T₁ (7.14%). In the treatments, T₄, T₂ and T₅ the increase in weight were calculated as (-)7.86%, (-)9.03% and (-)16.98%, respectively.

Table.4. Effect of different rearing media on morphometry of adult females of rice moth

Treatment	Length (mm)	Breadth (mm)	Weight (mg)	Increase (%) over control		
				Length	Breadth	Weight
T₁= Rice: Maize: Groundnut =10:10:1	14.45	3.16	32.87	6.94	9.54	6.95
T₂= Rice: Groundnut =20:1	12.06	2.62	27.91	(-)4.81	(-)9.54	(-)8.88
T₃= Maize: Groundnut =20:1	14.67	3.24	33.64	10.93	19.09	10.68
T₄= Rice: Maize =1:1	12.26	2.71	28.27	(-)3.43	(-)4.98	(-)2.38
T₅= Rice	11.12	2.40	25.47	(-)10.83	(-)16.18	(-)10.95
T₆= Maize (Control)	13.36	2.95	30.68	-	-	-
SE(m)±	0.326	0.063	0.652	-	-	-
CD(0.05)	0.97	0.19	1.94	-	-	-

4.5. Effect of different rearing media on morphometry of F₁ eggs of rice moth

The morphometric observations on the F₁ eggs of rice moth have been depicted in the Table 5.

Length,breadth and weight

The length of the egg is highest in T₃ (0.57 mm) followed by T₁(0.56 mm) and T₆(0.54 mm) .These treatments are significantly superior and at par to all other treatments.The length recorded in treatment T₄ , T₂ and T₅ were 0.52 mm ,0.51 mm and 0.50 mm ,respectively.

The breadth was highest i.e.0.42 mm and was observed in T₃ which was followed by T₁(0.41mm) and T₆(0.38 mm) which were significantly at par to all other treatments .The breadth in T₄ , T₂ and T₅ were 0.36 mm, 0.35 mm and 0.33 mm , respectively .The treatments T₂ and T₅ were statistically at par.

The weight was highest in T₃ (9.75 mg) followed by T₁(9.50 mg) which are significantly at par .These treatments were comparatively better than all other

treatments. The weight observed in the treatments T₆, T₄, T₂ and T₅ were 9.00 mg, 8.50 mg, 8.25mg and 8.00 mg, respectively.

Increase (%) in length, breadth and weight

The increase (%) in length, breadth and weight of rice moth eggs in different treatments over control *i.e.* T₆ (Maize) are presented in Table 4. The highest increase in length over control *i.e.* 5.56% was observed in T₃ (Maize:Groundnut=20:1) followed by T₁ (Rice: Maize: Groundnut =10:10:1) (3.70%). The increase(%) in length in other three treatments were negative that means there was decrease in egg length instead of increase. The increase in length over control in the treatments, T₄ (Rice: Maize = 1:1), T₂ (Rice: Groundnut=20:1) and T₅ (Rice) were (-) 3.70%, (-)5.56% and (-)7.41%, respectively. Highest increase in breadth of 10.53 % was observed in T₃ followed by T₁ (7.89%). The increase in breadth in the treatments, T₄, T₂ and T₅ were (-) 5.26%, (-) 7.89% and (-) 13.16%, respectively. The treatment T₃ produced highest increase in weight (100 eggs) *i.e.* 8.33% followed by T₁ (5.56%). In the treatments, T₄, T₂ and T₅ the increase in weight were calculated as (-)5.56%, (-)8.33% and (-)11.11%, respectively.

Table 5. Effect of different rearing media on morphometry of F₁ eggs of rice moth

Treatments	Length (mm)	Breadth (mm)	Weight of 100 eggs (mg)	Increase (%) over control		
				Length	Breadth	Weight
T ₁ = Rice: Maize: Groundnut =10:10:1	0.56	0.41	9.50	3.70	7.89	5.56
T ₂ = Rice: Groundnut =20:1	0.51	0.35	8.25	(-)5.56	(-)7.89	(-)8.33
T ₃ = Maize: Groundnut =20:1	0.57	0.42	9.75	5.56	10.53	8.33
T ₄ = Rice: Maize =1:1	0.52	0.36	8.50	(-)3.70	(-)5.26	(-)5.56
T ₅ = Rice	0.50	0.33	8.00	(-)7.41	(-)13.16	(-)11.11
T ₆ = Maize(Control)	0.54	0.38	9.00	-	-	-
SE(m)±	0.013	0.013	0.242	-	-	-
CD(0.05)	0.04	0.05	0.72	-	-	-



FIGURE 11. MORPHOMETRY OF LARVA OF RICE MOTH



FIGURE 12. MORPHOMETRY OF PUPA OF RICE MOTH



FIGURE 13. MORPHOMETRY OF ADULT MALE (LEFT) AND ADULT FEMALE (RIGHT) OF RICE MOTH

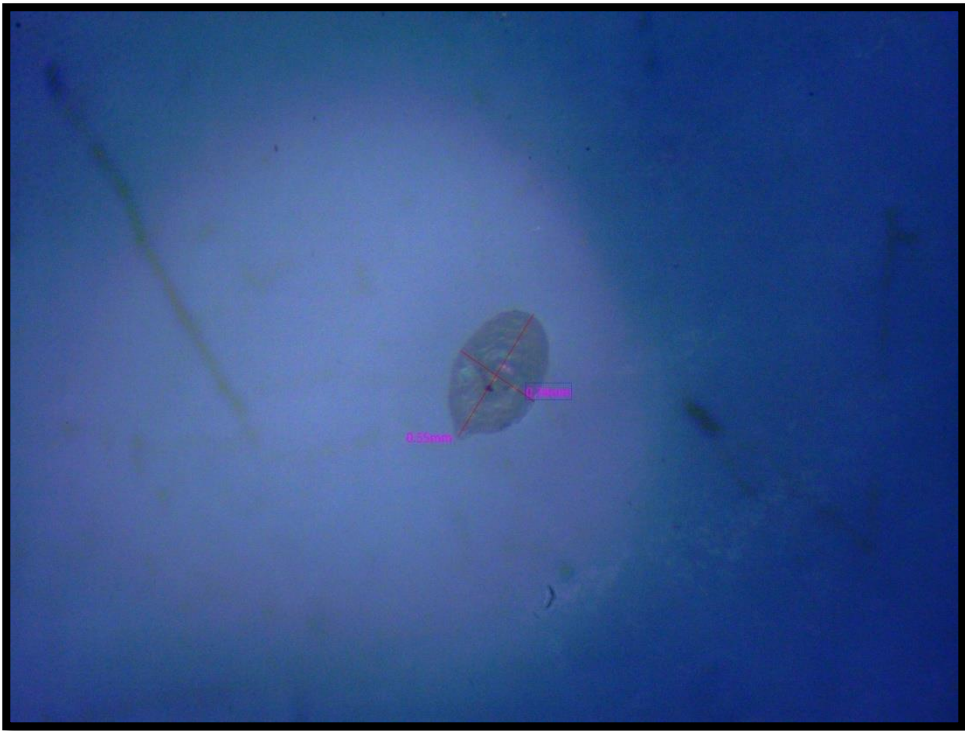


FIGURE 14. MORPHOMETRY OF EGG OF RICE MOTH

4.6. Effect of different rearing media on duration of life stages and population growth (adult emergence)

The data on the duration of life stages and population growth of the rice moth have been presented in Table 6.

Egg to adult emergence

The duration from egg to adult emergence was the shortest in T₃ (Maize: Groundnut=20:1) (48.36 days) followed by T₁ (Rice :Maize :Groundnut =10:10:1) (49.72 days) .These two treatments were comparatively better performing than the other treatments and significantly at par .The observed durations in T₆ (Maize) and T₄ (Rice :Maize=1:1) were 51.66 days and 53.03 days which were statistically at par.T₂ (Rice :Groundnut=20:1) recorded a duration of 54.50 days while duration in T₅ (Rice) (57.21 days) was the highest.

Decrease (%) in duration (egg to adult emergence)

The decrease (%) in the duration of egg to adult emergence in the different treatments including the control *i.e.* T₆ (Maize) has been given in the given Table6.The highest decrease in duration over the control was observed in T₃ (Maize :Groundnut=20:1) *i.e.* 6.39 % which was followed by T₁ (Rice :Maize :Groundnut=10:10:1) (3.76 %).The decrease (%) in the other three treatments were negative depicting that there was a increase in duration of the development period which is not desirable .The decrease (%) in duration over the control in the treatments, T₄ (Rice :Maize=1:1) ,T₂ (Rice :Groundnut=20:1) and T₅ (Rice) were (-)2.71 % ,(-)5.50 % and (-)10.74 % , respectively.

Adult longevity

The longevity of adult male moth was highest in T₃ (Maize :Groundnut=20:1) *i.e.* 7.47days and was at par with T₁ (Rice :Maize :Groundnut=10:10:1) (7.09 days). Longevity recorded in the other treatments *viz.* T₆ (Maize), T₄ (Rice :Maize=1:1) and T₂ (Rice :Groundnut=20:1) were 6.65 days ,6.41 days and 5.82 days .The least was observed in T₅ *i.e.*5.23 days .In case of the adult female moths, highest longevity was recorded in T₃ (8.65 days) which was significantly at par with T₁ (8.24 days) .Treatments T₆ (7.92 days) and T₄ (7.76 days) were statistically at par. Longevity in T₂ and T₅ were 7.13 days and 6.59 days , respectively.

Population growth

The number of male moths emerged were highest in T₃ (Maize :Groundnut=20:1) (377) followed by T₁(Rice :Maize :Groundnut=10:10:1) (355). These two treatments were at par among themselves and significantly superior to all other treatments .The number of males observed in T₆ (Maize) (317) was statistically at par with T₄ (Rice :Maize=1:1) (304). Number of males decreased in the treatments T₂ (Rice :Groundnut=20:1) and T₅ (Rice) which were 282 and 252 , respectively. Among all the treatments, number of female moth was highest in T₃ *i.e.* 396 followed by T₁ (371).The treatments T₆ (336) was followed by T₄ (321) and T₂ (302).The lowest number of female moths emerged from T₅ (268). Total number of adults (male and female) emerged was maximum in T₃ (773). Total emerged adults in treatment T₁, T₆ ,T₄ ,T₂ and T₅ were 726 ,653 ,625 ,584 and 520 ,respectively.

Increase (%) in population

The increase (%) in number of adults over control *i.e.*T₆ (Maize) are presented in Table 6. The increase (%) over control was observed maximum in T₃ (Maize :Groundnut=20:1) (18.38 %) followed by T₁(Rice :Maize :Groundnut =10:10:1) (11.18 %).The treatments T₄ (Rice :Maize=1:1) ,T₂ (Rice :Groundnut=20:1) and T₅ (Rice) recorded negative increase (total number of adults produced were less than control) .The increased (%) over control in T₄ ,T₂ and T₅ were (-)4.29 % ,(-)10.57 % and (-)20.37 % , respectively.

Table 6. Effect of different rearing media on duration of life stages and population growth (adult emergence)

Treatments	Egg to adult emergence		Adult male (Days)	Adult Female (Days)	Population growth (Adult emergence)/525 g of rearing media			
	Days	Decrease (%) over control			Male	Female	Total	Increase (%) over control
T ₁ = Rice: Maize: Groundnut =10:10:1	49.72	3.76	7.09	8.24	355	371	726	11.18
T ₂ = Rice: Groundnut =20:1	54.50	(-)5.50	5.82	7.13	282	302	584	(-)10.57
T ₃ = Maize: Groundnut =20:1	48.36	6.39	7.47	8.65	377	396	773	18.38
T ₄ = Rice: Maize =1:1	53.06	(-)2.71	6.41	7.76	304	321	625	(-)4.29
T ₅ = Rice	57.21	(-)10.74	5.23	6.59	252	268	520	(-)20.37
T ₆ = Maize (Control)	51.66	-	6.65	7.92	317	336	653	-
SE(m)±	0.518	-	0.164	0.209	10.771	11.345	-	-
CD(0.05)	1.54	-	0.49	0.62	32.00	33.70	-	-

4.7. Effect of different rearing media on fecundity and sex ratio of rice moth

The data on fecundity and sex ratio of rice moth in F₁ generation influenced by different rearing media are presented in Table 7.

Fecundity

Among all the treatments, female moth of the treatment T₃ (Maize :Groundnut=20:1) produced maximum number of eggs (187) followed by T₁(Rice :Maize :Groundnut=10:10:1) (176). These were significantly at par and superior to all other treatments. The fecundity of T₆ (Maize) ,T₄ (Rice : Maize=1:1) and T₂ (Rice : Groundnut=20:1) were 163 ,147 and 128 , respectively .The number of eggs deposited were lowest in T₅(Rice) (109).

Increase (%) in the fecundity

The increase (%) in the fecundity over control was highest in T₃(Maize :Groundnut=20:1) *i.e.* 14.72 % followed by T₁(Rice :Maize :Groundnut=10:10:1) (7.98 %). The treatments T₄(Rice :Maize=1:1) ,T₂(Rice :Maize :Groundnut=10:10:1) and T₅(Rice) recorded negative increase (%) depicting decrease in the number of egg laid in comparison to control instead of increase .The decrease in fecundity recorded in treatments ,T₄,T₂ and T₅ were (-)9.82 % , (-)21.47 % and (-)33.13 % ,respectively.

Number of adult males and females

The number of adult males recorded in F₁ generation in T₃ (Maize :Groundnut=20:1) (57.75), T₁ (Rice :Maize :Groundnut=10:10:1) (58.50) and T₆(Maize) (64.50) were significantly at par. Less number of adult male moth in comparison to female depicts more desirability of the rearing medium . Number of adult male in T₄ (Rice :Maize=1:1) ,T₅(Rice) and T₂(Rice :Groundnut=20:1) were 63.25 ,64.50 and 65.00 ,respectively .These treatments were statistically at par with each other.

F₁ female moths were recorded highest in T₃ (69.25) followed by T₁(65.00) .These treatments were superior and at par to all other treatments .Number of females in treatment T₆ and T₄ recorded were 63.25 and 61.00, respectively .These two treatments were statistically at par .The treatments T₂ (56.25) and T₅ (53.75) produced lesser number of female moths.

Sex ratio

Most favourable (female biased) sex ratio was observed in T₃(Maize :Groundnut=20:1) *i.e.* 1:1.18 (male :female) followed by T₁(Rice :Maize :Groundnut=10:10:1) (1:1.11). These two treatments were superior to all other treatments. Sex ratio of T₆ (Maize), T₄ (Rice :Maize=1:1) and T₂ (Rice :Groundnut=20:1) were 1:1.05, 1:0.96 and 1:0.87 .The lowest sex ratio was recorded in T₅(Rice) *i.e.* 1:0.83 .

Table 7. Effect of different rearing media on fecundity and sex ratio of rice moth

Treatments	Fecundity		No. of F ₁ male/100 g of rearing medium	No. of F ₁ female/100 g of rearing medium	Sex ratio of F ₁ generation (M:F)
	No. of egg/female	Increase (%) over control			
T ₁ = Rice: Maize : Groundnut =10:10:1	176	7.98	58.50	65.00	1:1.11
T ₂ = Rice: Groundnut =20:1	128	(-)21.47	65.00	56.25	1:0.87
T ₃ = Maize: Groundnut =20:1	187	14.72	57.75	69.25	1:1.18
T ₄ = Rice: Maize =1:1	147	(-)9.82	63.25	61.00	1:0.96
T ₅ = Rice	109	(-)33.13	64.50	53.75	1:0.83
T ₆ = Maize (Control)	163	-	60.00	63.25	1:1.05
SE(m)±	4.025	-	1.094	1.443	-
CD(0.05)	11.96	-	3.25	4.29	-

4.8. Economics of different rearing media for production of rice moth egg (in 525 g rearing media)

The data on production of egg of rice moth, income, cost of production, profit and benefit -cost ratio has been presented in Table 8.

Production of egg, income and cost

The treatment, T₃ (Maize: Groundnut=20: 1) produced the highest quantity of egg (3.70 cc/ 525 g rearing medium) and gave maximum income (Rs.185.00/ 525 g rearing media) followed by the treatments, T₁ (Rice: Maize: Groundnut=10: 10: 1) (3.26cc and Rs.163.00), T₆ (Maize) (2.74cc and Rs.137.00), T₄ (Rice: Maize=1: 1) (2.36cc and Rs.118), T₂ (Rice: Groundnut=20: 1) (1.93cc and Rs.96.50) and T₅ (Rice) (1.46 cc and Rs.73.00). However, slightly higher cost of production was calculated from T₃ (Maize: Groundnut=20: 1) (Rs. 36.32/ 525 g rearing medium) followed by T₆ (Maize) (Rs.34.57), T₁ (Rice: Maize: Groundnut=10: 10: 1) (Rs.33.32), T₄ (Rice: Maize=1: 1) (Rs.31.42), T₂ (Rice: Groundnut=20: 1) (Rs.30.32) and T₅ (Rice) (Rs. 28.27).

Profit and benefit- cost ratio

The data on profit indicated that the highest profit was obtained from treatment, T₃ (Maize: Groundnut=20: 1) (Rs.148.68) followed by T₁ (Rice: Maize: Groundnut=10: 10: 1) (Rs.129.68), T₆ (Maize) (Rs.102.43), T₄ (Rice: Maize=1: 1) (Rs.86.58), T₂ (Rice: Groundnut=20: 1) (Rs.66.18) and T₅ (Rice) (Rs. 44.73).

Data presented in Table 8 depicted that the highest benefit-cost ratio (4.09:1) was obtained in treatment T₃ (Maize: Groundnut=20: 1) followed by T₁(Rice: Maize: Groundnut=10: 10: 1) (3.89:1), T₆(Maize) (2.96:1), T₄(Rice: Maize=1: 1) (2.76:1), T₂(Rice: Groundnut=20: 1) (2.18:1) and T₅(Rice) (1.58:1) .

Table 8. Economics of different rearing media for production of rice moth egg (in 525 g rearing media)

Treatments	No. of female moth	Fecundity	Production of egg in number	Production of egg in cc	Income (Rs.)	Cost of production (Rs.)	Profit	Benefit: Cost
T ₁ = Rice: Maize: Groundnut =10:10:1	371	176	65296	3.26	163.00	33.32	129.68	3.89:1
T ₂ = Rice: Groundnut =20:1	302	128	38656	1.93	96.50	30.32	66.18	2.18:1
T ₃ = Maize: Groundnut =20:1	396	187	74052	3.70	185.00	36.32	148.68	4.09:1
T ₄ = Rice: Maize =1:1	321	147	47187	2.36	118.00	31.42	86.58	2.76:1
T ₅ = Rice	268	109	29212	1.46	73.00	28.27	44.73	1.58:1
T ₆ = Maize (Control)	336	163	54768	2.74	137.00	34.57	102.43	2.96:1

- Cost of inputs: 1. Maize grain with milling charge = Rs.30/kg
 2. Broken rice =Rs.18/kg
 3. Groundnut =Rs.100/kg
 4. Yeast powder =Rs.150/kg
 5. Streptomycin sulphate =Rs.10/0.75 g
 6. Labour =Rs.300/day
- Sale price of rice moth egg: Rs.50/cc

CHAPTER V

DISCUSSION

DISCUSSION

5.1. Morphometry of larva of rice moth

Results of the present investigation depicted that the stoutest larvae of rice moth were obtained from the rearing medium, Maize: Groundnut = 20:1 (15.16 mm in length, 2.81 mm in breadth and 57.75 mg in weight at fourth week of larval growth) followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (14.99 mm, 2.75 mm and 57.00 mg, respectively).

These results can be explained by the status of the major nutrients of rice grain, maize grain and groundnut kernel. Rice grain contains 78.2% carbohydrate, 6.8% protein and 0.5% fat. The corresponding figures for maize grain are 66.2 %, 11.1 % and 3.6% and for groundnut kernel are 16%, 26% and 49%. Maize is a better food for *Corcyra cephalonica* Stainton than rice as maize contains more quantity of protein and fat than rice. When groundnut is added to maize or rice + maize, the contents of protein and fat in the rearing media further increase. Hence, as the larvae are getting better food, they are becoming stouter. Devi *et al.* (2013) reported larval length of 11.21 mm and breadth 1.59 mm in the sixth instar. Menge and Naik (2017) observed average length, breadth and weight of rice moth larvae as 12.60 mm, 1.05 mm and 26.00 mg in groundnut. These earlier findings partially support the findings of the present investigation.

5.2 . Morphometry of pupa

In the present research work, the stoutest pupae of rice moth were obtained from the rearing medium, Maize: Groundnut = 20:1 (10.79 mm in length, 2.91 mm in breadth and 49.75 mg in weight) followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (10.48 mm, 2.88 mm and 48.25 mg, respectively).

The rearing medium, Maize: Groundnut = 20:1 produced the stoutest larvae of rice moth followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1. Hence, the stoutest pupae were also produced in the first rearing medium followed by the second. Menge and Naik (2017) observed average length, breadth and weight of rice moth pupae as 9.20 mm, 1.80 mm and 23.42 mg in groundnut which partially corroborate the findings of the present investigation.

5.3. Morphometry of adult male

The present research findings revealed that the bulkiest adult male of rice moth were obtained from the rearing medium, Maize: Groundnut = 20:1(11.98 mm in length, 2.87 mm in breadth and 24.67 mg in weight) followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (11.55 mm, 2.64 mm and 23.84 mg, respectively).

The rearing medium, Maize: Groundnut = 20:1 produced the stoutest larvae and in turn the stoutest pupae of rice moth followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1. Obviously, the bulkiest adult males were produced in the first rearing medium followed by the second. Menge and Naik (2017) observed the average length and weight of adult male rice moth as 7.30 mm and 11.77 mg in groundnut which were very low in comparison to the present investigation. The differences in morphometry may be due to the differences in rearing media

5.4. Morphometry of adult female

The results of the present investigation depicted that the bulkiest adult female of rice moth were obtained from the rearing medium, Maize: Groundnut = 20:1(14.67 mm in length, 3.24 mm in breadth and 33.64 mg in weight) followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (14.45 mm, 3.16 mm and 32.87 mg, respectively).

The rearing medium, Maize: Groundnut = 20:1 produced the stoutest larvae and in turn the stoutest pupae of rice moth followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1. Obviously, the bulkiest adult females were produced in the first rearing medium followed by the second. Menge and Naik (2017) observed the average length and weight of adult female rice moth as 9.40 mm and 18.96 mg in groundnut which were very low in comparison to the present investigation. The differences in morphometry may be due to the differences in rearing media.

5.5. Morphometry of F1 egg

In the present research work, the longest, broadest and heaviest F1 eggs of rice moth were obtained from the rearing medium, Maize: Groundnut = 20:1(0.57 mm in length, 0.42 mm in breadth and 9.75 mg/ 100 eggs in weight) followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (0.56 mm, 0.41 mm and 9.50 mg/ 100 eggs, respectively).

The rearing medium, Maize: Groundnut = 20:1 produced the stoutest adult female of rice moth followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1. Obviously, the longest, broadest and heaviest F1 egg of rice moth were produced in the first rearing medium followed by the second. Bhandari *et al.* (2014) reported that the rearing media, Corn (Maize) + Groundnut were superior in almost all biological parameters and produced robust eggs of rice moth. The findings of the earlier authors are in conformity with the results of the present findings.

5.6. Duration of life stages and population growth

The present research findings revealed that the shortest duration from egg to adult emergence (48.36 days) and highest adult male and adult female longevity (7.47 days and 8.65 days, respectively) of rice moth were noticed in the rearing medium, Maize: Groundnut = 20:1 followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (49.72 days, 7.09 days and 8.24 days, respectively). These two rearing media also resulted highest population growth of 773 and 726 adults per 525 g rearing media.

The rearing medium, Maize: Groundnut = 20:1 provided the best nutrition for the larvae of rice moth followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1. Obviously, the larvae gathered required nourishment for completion of larval stage in comparatively less time in these two treatments which reduced the duration from egg to adult emergence. Further, in these two treatments, the adults were of better vigour and hence, they lived longer, in particular the females to lay more number of eggs to increase the progeny population. Edpuganti *et al.* (2018) reported adult emergence after 40 days of charging and also noticed highest adult emerged in the rearing media, Bajra+ Rice+ Groundnut. Tiwari and Khan (2003) observed lowest developmental period of 36 days and highest adult emergence in the rearing media, Maize+ Yeast (2%). Kumar *et al.* (2018) reported highest male and female longevity (8.33 days and 9.67 days) in Sorghum + Groundnut. The observations of the previous workers partially support the present findings.

5.7. Fecundity and sex ratio

Highest fecundity (187 eggs/ female) and most favourable sex ratio (male: female = 1:1.18) were recorded in the rearing medium, Maize: Groundnut = 20:1 followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (176 and 1:1.11, respectively).

Stouter female moths emerged from the abovementioned two rearing media which lived longer period and hence, fecundity is more in these two treatments. Further, the robust moths in a drive to increase the progeny population might produced more female than male. The findings of Amadouet *al.* (2019) that the fecundity of rice moth increased with the addition of peanut to cereals to prepare the rearing media partially conform the present investigation.

5.8. Production of rice moth egg

The rearing medium, Maize: Groundnut = 20:1 produced the highest quantity of egg (3.70 cc/ 525 g rearing media) followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (3.26 cc).

In the abovementioned two rearing media, adult emergence and fecundity of rice moth were significantly more than the other treatments. Obviously the production of egg in these two treatments were more.

CHAPTER VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Two experiments were conducted in the Biological Control Laboratory, Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar during August 2019 to February 2020. The effect of different rearing media on growth and development of rice moth, *Corcyra cephalonica* (Stainton) were evaluated in completely randomized design (CRD) with six treatments and four replications. The treatments comprised T1 (Rice: Maize: Groundnut=10:10:1), T2 (Rice: Groundnut=20:1), T3 (Maize: Groundnut=20:1), T4 (Rice: Maize=1:1), T5 (Rice) and T6 (Maize as control). The temperature and humidity of laboratory room were maintained at $27\pm 3^{\circ}\text{C}$ and $65\pm 5\%$ RH, respectively. In the first experiment, rearing jars were prepared with the rearing media as abovementioned treatments and were added (charged) with rice moth egg collected from the rearing boxes containing maize as rearing media to record all the observations except sex ratio. In the second experiment, rearing jars were prepared with milled maize grain and charged with rice moth eggs obtained from rearing jars of the first experiment to record the sex ratio of F1 generation.

The study revealed that the stoutest larvae of rice moths were obtained from the rearing medium, Maize: Groundnut = 20:1 (3.75 mm, 7.21 mm, 13.47 mm and 15.16 mm in length and 0.66 mm, 1.26 mm, 2.20 mm and 2.81 mm in breadth in the first, second, third and fourth week of larval growth and 34.50 g and 57.75 g in weight in the third and fourth week of larval growth) closely followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (3.72 mm, 7.11 mm, 13.23 mm and 14.99 mm in length, 0.63 mm, 1.24 mm, 2.18 mm and 2.75 mm in breadth and 33.25 mg and 57.00 mg in weight). Increase (%) in length, breadth and weight were calculated on mean data of weekly observations of the treatments over control (maize). Maximum increase in length, breadth and weight *i.e.* 7.03%, 10.70 % and 9.82 % were calculated in the rearing medium, Maize: Groundnut = 20:1 followed by Rice: Maize: Groundnut = 10:10:1 (5.57 %, 8.63 % and 7.44 %, respectively).

Bulkiest pupae were observed in the treatment, Maize: Groundnut = 20:1 recording 10.79 mm in length, 2.91mm in breadth and 49.75 mg in weight followed by the treatment, Rice: Maize: Groundnut = 10:10:1 recording 10.48 mm in length, 2.88 mm in breadth and 48.25 g in weight. Increase (%) in length, breadth and weight of the pupae over control were 9.99%, 5.82% and 9.94%, respectively in the treatment, Maize:

Groundnut = 20:1 and 6.83%, 4.73% and 6.63%, respectively in the treatment, Rice: Maize: Groundnut = 10:10:1.

Stoutest adult males were recorded in the treatment, Maize: Groundnut = 20:1 (11.98 mm in length, 2.87 mm in breadth and 24.67 mg in weight) followed by the treatment, Rice: Maize: Groundnut = 10:10:1 (11.55 mm in length, 2.64 mm in breadth and 23.84 g in weight). Increase (%) in length, breadth and weight of the adult males over control were 10.93 %, 19.09 % and 10.68 %, respectively in the treatment, Maize: Groundnut = 20:1 and 6.94 %, 9.54 % and 6.95 %, respectively in the treatment, Rice: Maize: Groundnut = 10:10:1.

Stoutest adult females were also recorded in the treatment, Maize: Groundnut = 20:1 (14.67 mm in length, 3.24 mm in breadth and 33.64 mg in weight) followed by the treatment, Rice: Maize: Groundnut = 10:10:1 (14.45 mm in length, 3.16 mm in breadth and 32.87 g in weight). Increase (%) in length, breadth and weight of the adult females over control (maize) were 9.81 %, 9.83 % and 9.65 %, respectively in the treatment, Maize: Groundnut = 20:1 and 8.16 %, 7.12 % and 7.14 %, respectively in the treatment, Rice: Maize: Groundnut = 10:10:1.

Biggest (0.57 mm in length and 0.42 mm in breadth) and heaviest (9.75 mg /100 eggs) F1 eggs were obtained from the treatment, Maize: Groundnut = 20:1 followed by the treatment, Rice: Maize: Groundnut = 10:10:1 (0.56 mm, 0.41mm and 9.50 g/ 100 eggs, respectively). The increase (%) in length, breadth and weight over control (Maize) were calculated as 5.56 %, 10.53 % and 8.33 %, respectively in the treatment, Maize: Groundnut = 20:1 and 3.70 %, 7.89 % and 5.56 %, respectively in the treatment, Rice: Maize: Groundnut = 10:10:1.

The duration from egg to adult emergence was shortest (48.36 days) in the rearing medium, Maize: Groundnut = 20:1 followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1(49.72 days). Reduction (%) in duration in these two treatments over control (Maize) was 6.39 % and 3.76 %, respectively. Longevity of adult male and adult female were maximum (7.47 days and 8.65 days) in the rearing medium, Maize: Groundnut = 20:1 followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1(7.09 days and 8.24 days). Population growth was maximum in the rearing medium, Maize: Groundnut = 20:1 (773 males and females/ 525 g rearing medium) with an increase of 18.38 % over control (Maize) followed by the rearing medium, Rice:

Maize: Groundnut = 10:10:1 (726 males and females/ 525 g rearing medium) with an increase of 11.18 %.

Highest fecundity of 187 eggs/ female was noticed in the rearing medium, Maize: Groundnut = 20:1 with 14.72 % increase over control (Maize) followed by the rearing medium, Rice: Maize: Groundnut = 10:10:1 (176 eggs/ female with 7.98 % increase over control). Most favourable female-biased sex ratio (Male: Female = 1: 1.18) was calculated in the rearing medium, Maize: Groundnut = 20:1 followed by Rice: Maize: Groundnut = 10:10:1 (1:1.11).

The rearing medium, Maize: Groundnut = 20:1 produced the maximum quantity of egg *i.e.* 3.70 cc/ 525 g rearing medium with 185.00 % increase over control (Maize) followed by Rice: Maize: Groundnut = 10:10:1 (3.26 cc/ 525 g rearing medium with 163 % increase over control). Highest profit of Rs.148.68 and benefit- cost ratio of 4.09:1 were calculated from the rearing medium, Maize: Groundnut = 20:1 followed by Rice: Maize: Groundnut = 10:10:1 (Rs. 129.68 and 3.89:1).

From the results, it may be concluded that combination of maize grain and groundnut kernel @ 20:1 form the most effective and economic media for rearing rice moth in the biological control laboratory. If the availability of maize reduces during some part of the year, 50% of maize grain may be replaced by broken rice which is always available plentifully in the local market. In short, Maize: Groundnut=20:1 is the best rearing media followed by Rice: Maize: Groundnut = 10:10:1.

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