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Sree Latha Edpuganti
National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Veena Y
National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Swathi Yadav Kattula
National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Correspondence
Sree Latha Edpuganti
National Institute of Plant Health Management, Rajendranagar, Hyderabad, Telangana, India

Suitability of different diets and their combination for rearing of laboratory host, *Corcyra cephalonica*

Sree Latha Edpuganti, Veena Y and Swathi Yadav Kattula

Abstract
Corcyra cephalonica is one of the major stored grain pests which attack many products. This pest is being very widely used in the bio control laboratories to develop parasitoids and predators. The diet which is being provided to the *C cephalonica* is also very important as it directly affects the number of biocontrol agents that can be produced. In this experiment, three different grains and their combinations with groundnut were tested for adult emergence and egg production. Among the six treatments tested T1 (bajra + groundnut) was proved to be best in both adult emergence as well as number of eggs produced with 2868 adults and 15.8893 g of eggs. This was followed by T4 (bajra + rice + groundnut) with 2451 adults and 9.6011 g of eggs. T2 (rice +groundnut) was proved to be the least effective for the production of *C cephalonica* with 416 adults and 1.681 g of eggs. The adult emergence started at the earliest in T1 (bajra +groundnut), T4 (bajra +rice +groundnut) and T6 (bajra +sorghum +groundnut) after 40 days of charging. The adult emergence started very late in T2 (rice +groundnut) from 50 days after charging. This proves that the treatments which contain bajra are superior over sorghum and rice.

Keywords: rice moth, *Corcyra cephalonica*, diet combinations, bajra, sorghum, rice

Introduction
It is estimated that in India, insect pests lead to an approximate economic loss in yield of 15% of worth $ 36 billion (Dhaliwal *et al.* 2015) [1]. Biological control is one of the most important and effective means of achieving insect control in integrated pest management. The key success of mass production of natural enemies depends on quality host production at faster and cheaper rate. The quality of the biocontrol agents, ultimately depends on the quality of the host nourishment (Hunter, 2003 and Mehendale *et al.* 2014) [2, 3]. The rice meal moth, *Corcyra cephalonica*, which is an economically important stored grain pest, is the factitious host for 75 natural enemies of which 60 are parasitoids and 15 are predators. (Manjunath, 2014) [4]. In India, the rice meal moth is mass produced as a laboratory host for rearing several natural enemies (Lalitha and Chandish, 2014) [5]. Improved knowledge of the nutritional ecology of parasitoids and hosts can lead to improved understanding of the host plant, host, and parasitoid abundance, as well as to improved efficiency and quality of natural enemies production in mass rearing programs (Senthil *et al.* 2006) [6]. Hence, in this trial, three different grains and their combinations were tested to know the egg laying capacity and adult emergence in different treatments. With objective to find best media with low cost for *C. cephalonica* rearing, the present study was carried out.

Materials and Methods
The research was carried out at biological control laboratory, NIPHM, Hyderabad from 13.12.2017 to 10.03.2017. The experiment was conducted in laboratory by maintaining the same temperature (25 °C) throughout the experiment. Three different grains sorghum *(Sorghum vulgare*), pearl millet/bajra (*Pennisetum glaucum*) and rice, *Oryza sativa* were used separately and in combination with groundnut, *Arachis hypogaea* to estimate the production potential of *C cephalonica* from different raw materials. The details of the treatments were given in the table 1.

Rearing Procedure: The C *cephalonica* rearing containers (basins-size-16" or 18"dia) used for multiplication were thoroughly cleaned with 0.5% detergent and rinsed in tap water

followed by treatment with 2% formaldehyde and dried. The requisite quantum (2.5 Kgs) of sorghum/bajra/rice/ combinations was milled to make 3-4 pieces of each grain. The grains were heat sterilized in oven at 100 °C for 30 minutes and sprayed with 0.1% formalin to prevent the growth of moulds as well as to increase the grain moisture to the optimum (15-16%), which was lost due to heat sterilization. Groundnut powder (100 grams), yeast (5 grams), Sulphur (1 gram) and streptomycin sulphate (1 gram) were added to all the containers as additives. Groundnut and yeast were added for enriching the diet to enhance egg laying capacity of the adult moths. Sulphur was added to control predatory mites, streptomycin sulphate was added to prevent bacterial diseases and formalin to arrest mold development. 0.25 g eggs of *C cephalonica* were sprinkled in each basin (One g of eggs is known to contain approximately 16000-18000 eggs). The basins were then covered with clean khadi cloth and held tightly with rubber fasteners.

The basins were transferred to the racks and after about 40 days of charging, moths started emerging. The moths were collected daily and transferred to the specially designed oviposition cages. The adults were provided with feed containing equal amounts of honey and water; capsules of vitamin E (Evion) were also added to enhance fertility. Piece of cotton wool tied with a thread is soaked in feed solution and inserted into the drum through the slot at the top. The feed was changed for every two days. Daily morning the oviposition cages were lifted up and eggs were collected. Then they are passed to sieves in series and finally clean eggs were obtained. The eggs were quantified using weighing balance (NIPHM).

Table 1: Details of the different diets and their combination for the rearing *Corcyra cephalonica*, NIPHM, Rajendranagar

Sl. No	Treatment	Details
1	T1	Bajra (2.5kg) + Groundnut (100g)
2	T2	Sorghum (2.5kg) + Groundnut (100g)
3	T3	Rice (2.5kg) + Groundnut (100g)
4	T4	Bajra (1.25kg) + Rice (1.25 kg) + Groundnut (100g)
5	T5	Sorghum (1.25kg) + Rice (1.25 kg) + Groundnut (100g)
6	T6	Sorghum (1.25 kg) + Bajra (1.25 kg) + Groundnut (100g)

Results and Discussion

From the present study, results (Table No. 3 and Fig 1) revealed that the total number of adults emerged and eggs harvested are highest from T1 (bajra + groundnut) with 2868 adults and 15.8893 g of eggs followed by T4 (bajra + rice + groundnut) with 2451 adults and 9.6011 g of eggs. This was followed by T5 **(**sorghum+ rice+ groundnut) with 1730 adults and 8.8612 g of eggs followed by T2 (sorghum+ groundnut) with 1421 adults and 6.7794 g of eggs. The least number of adults were recorded in T3 (rice + groundnut) with 416 adults and 1.681 g of eggs.

The tubs were charged on 13th Dec 2017 and the adults started emerging from different treatments from 22-01-2018 and lasted till 10-03-2018 (Table No.2). Adults started emerging from T1, T4 and T6 after 1 month and eight days after placing the trays with different diets. Adult emergence was fastest in all the three treatments which contained Bajra. The adult emergence started very late in T3 from 02-02-2018. The number of adults emerged also very less in the T3 which contained Rice+ groundnut.

The results are in line with Manjunath (2014) [4] who found that among various food grains tested coarsely crushed bajra (pearl millet) was the most economical and effective diet over groundnut, sorghum, rice and wheat. Bhandari and Regmi (2014) [7] stated that mixed diet of groundnut and corn was highly superior compared to rice, wheat, millet and their combinations for mass production of *C. cephalonica*. The results are also in coordination with Senthil *et al.* 2006 [6] who stated that for *C. cephalonica*, the percentage of adult emergence was higher for millet-reared than for sorghum-reared larvae. Gopal Bhandari *et al.* (2014) [8] documented that among the eight diets tested, mixed diets gave superior results than solo cereals and also corn + groundnut was found superior biologically and economically followed by millet + groundnut. Michi and Awadhesh (2016) [9] reported that food source of *C. cephalonica* had affected biological parameters of *Trichogrammatoidea bactrae* like parasitizing ability, emergence percentage and longevity and highest parasitizing ability of *T. bactrae* was observed in *C. cephalonica* reared on jobs tear/adlay millet. Chaudhuri and Senapati (2015) [10] found that net reproductive rate and potential fecundity of *C. cephalonica* were highest when reared on Italian millet/ Foxtail millet (alone/fortified).

Nasrin *et al*. (2016) [11] documented that among eight types of cereals tested, highest number of eggs, higher hatchability and extended larval duration were found when *C. cephalonica* were reared on chopped wheat. The results are in contradictory with Kalyanakumar *et al.* (2017) [12] who stated that total moth production was significantly higher when *C. cephalonica* was reared on sorghum + bajra followed by Sorghum alone. Mehendale *et al.* (2014) [3] documented that maximum moth emergence and maximum fecundity was found in the diet mixture of sorghum + groundnut + powdered yeast, sorghum + gram + powdered yeast and sorghum + cowpea + powdered yeast. Rajkumari and Sharmah (2014) [13] found that among the six diets tested by them, rice, wheat and groundnut mixture (5:5:1) was found to be the superior rearing medium that enhanced quicker development period, maximum fecundity and maximum fresh body weight of *Corcyra cephalonica*. Jyoti *et al*. (2017) [14] who found that moths reared on mixed diet with a combination of (rice + jowar + maize) had maximum body weight, body length and fecundity when compared to bajra, wheat, maize, rice and their combinations.

Egg production gradually increased from 1st week to 4th week after emergence and reached peak production 4 WAE and gradually declined from 5th week onwards (Table 5 & Fig 3). Based on the results the tubs are to be charged 2 months before the requirement of eggs for the production of egg parasitoids and predators that depend on eggs for their survival. If larvae are required for the production of bio control agents the rearing has to be initiated in advance to get required number of larvae. The high correlation (0.95) between adult emergence and egg production indicates the diet which produces more adults is preferable. Bajra based diet is highly preferred and economical for production of host and in turn bio control agents.

Table 2: Number of adults colected and eggs (g) harvested daily from *Corcyra cephalonica* developed on different diets at NIPHM, Rajendranagar

Diet	Bajra		Rice		Sorghum		Bajra+Rice		Bajra+Sorghum		Sorghum+Rice	
Date	No. of adults/ Tub/day	Wt. of eggs/ Tub (g)/day	No. of adults/ Tub/day	Wt. of eggs/ Tub (g)/day	No. of adults/ Tub/day	Wt. of eggs/ Tub (g)/day	No. of adults/ Tub /day	Wt. of eggs/ Tub (g)/day	No. of adults/ Tub/day	Wt. of eggs/ Tub (g)/day	No. of adults/ Tub/day	Wt. of eggs/ Tub (g)/day
22-01-18	40	0	0	0	0	0	20		23	0	0	0
23-01-18	60	0	0	0	0	0	30		27	0	0	0
24-01-18	110	0.4415	0	0	0	0	50	0.3648	67	0.3098	0	0
25-01-18	100	0.4345	0	0	0	0	80	0.1812	98	0.2345	0	0
26-01-18	90	0.5987	0	0	0	0	80	0.1812	105	0.3609	0	0
27-01-18	87	0.4231	0	0	0	0	70	0.3629	96	0.5236	0	0
29-01-18	75	0.6757	0	0	0	0	90	0.4237	89	0.5097	0	0
30-01-18	105	0.4789	0	0	0	0	95	0.4239	67	0.4354	0	0
31-01-18	105	0.3679	0	0	4	0	100	0.5236	104	0.2543	2	0
01-02-18	78	0.2436	0	0	10	0	100	0.5238	187	0.5465	8	0
02-02-18	108	0.1501	1	0	20	0.0345	90	0.4237	85	0.639	15	0
03-02-18	65	0.1505	0	0	35	0.0703	62	0.1008	34	0.3519	4	0
05-02-18	111	0.6695	0	0	152	0.6382	210	0.5712	157	0.4107	66	0.0769
06-02-18	149	0.5653	0	0	131	0.5472	151	0.4648	138	0.4105	64	0.0761
07-02-18	142	0.5238	0	0	19	0.3256	38	0.4042	19	0.2941	58	0.0786
08-02-18	34	0.3976	2	0	24	0.2776	37	0.3227	26	0.2117	61	0.0878
09-02-18	64	0.4238	9	0	22	0.3649	54	0.4156	47	0.4513	15	0.0434
10-02-18	30	0.312	0	0	11	0.1724	26	0.1261	20	0.2213	8	0.0121
12-02-18	152	0.3509	19	0	40	0.0447	127	0.1813	89	0.1593	31	0.0424
13-02-18	87	0.5007	6	0	9	0.1068	56	0.2225	19	0.3201	10	0.0219
14-02-18	134	0.6931	0	0	20	0.1189	76	0.3629	39	0.3215	13	0.0703
15-02-18	108	0.9821	0	0	12	0.1467	90	0.4237	38	0.3145	27	0.0723
16-02-18	136	1.8656	29	0.0163	15	0.1098	101	1.0452	32	0.1559	60	0.2397
17-02-18	101	1.5732	18	0.0109	43	0.1294	80	0.1872	35	0.1673	30	0.1254
19-02-18	156	0.4812	36	0.0275	90	0.1075	130	0.1586	41	0.359	90	0.1075
20-02-18	49	0.4124	14	0.0231	27	0.1211	36	0.1224	5	0.1123	27	0.1211
21-02-18	34	0.4125	15	0.0223	29	0.1212	34	0.0123	6	0.1135	29	0.1212
22-02-18	35	0.2112	16	0.0212	31	0.1322	24	0.1233	7	0.1124	31	0.1322
23-02-18	40	0.4401	16	0.0235	29	0.2134	32	0.1315	8	0.1032	29	0.2134
24-02-18	49	0.145	14	0.0111	35	0.1234	30	0.2535	5	0.0985	20	0.1254
26-02-18	91	0.2061	72	0.1082	69	0.2534	59	0.1301	13	0.2109	69	0.2534
27-02-18	27	0.0121	26	0.1213	42	0.1212	26	0.1207	2	0.1342	42	0.1212
28-02-18	18	0.1956	18	0.073	37	0.1502	21	0.0991	1	0.0134	37	0.1502
01-03-18	14	0.1826	12	0.1734	29	0.1301	12	0.0112	1	0	29	0.1601
02-03-18	16	0.1838	11	0.1142	30	0.1777	11	0.0014	0	0	30	0.1777
03-03-18	22	0.1122	15	0.1679	62	0.1812	29	0.0463	0	0	62	0.1883
05-03-18	20	0.063	45	0.4114	115	0.583	46	0.1313	0	0	118	0.583
06-03-18	15	0.0094	14	0.2014	89	0.4365	12	0.0111	0	0	26	0.125
07-03-18	5	0	5	0.1045	32	0.3897	14	0.0113	0	0	32	0.312
08-03-2018	6	0	3	0.0498	59	0.2234	10	0	0	0	14	0.2659
09-03-2018	0	0	0	0	34	0.1327	9	0	0	0	8	0.1654
10-03-2018	0	0	0	0	15	0.0945	3	0	0	0	3	0.0435

Table 3: Total Number of adults collected and eggs (g) harvested from *Corcyra cephalonica* developed on different diets NIPHM, Rajendranagar

Diet	Adults	eggs
Bajra (T1)	2868	15.8893
Rice (T3)	416	1.681
Sorghum (T2)	1421	6.7794
Bajra+Rice (T4)	2451	9.6011
Bajra+Sorghum (T6)	1730	8.8612
Sorghum+Rice (T5)	1168	4.3134

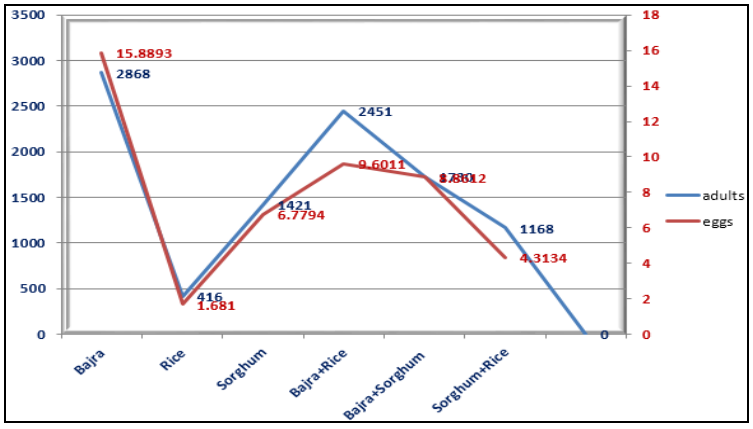

Fig 1: Total Number of adults colected and eggs harvested from *Corcyra cephalonica* developed on different diets

Table 4: Number of adults/week from *Corcyra cephalonica* developed on different diets

Diet	1 WAE	2 WAE	3 WAE	4 WAE	51 WAE	6 WAE	7 WAE
Bajra (T1)	487	536	530	718	363	188	46
Rice (T3)	0	1	11	72	111	154	67
Sorghum (T2)	0	69	359	139	241	269	344
Bajra + Rice (T4)	330	537	516	530	286	158	94
Bajra + Sorghum (T6)	416	566	407	252	72	17	0
Sorghum + Rice (T5)	0	29	272	171	226	269	201
WAE-Week After Emergence							

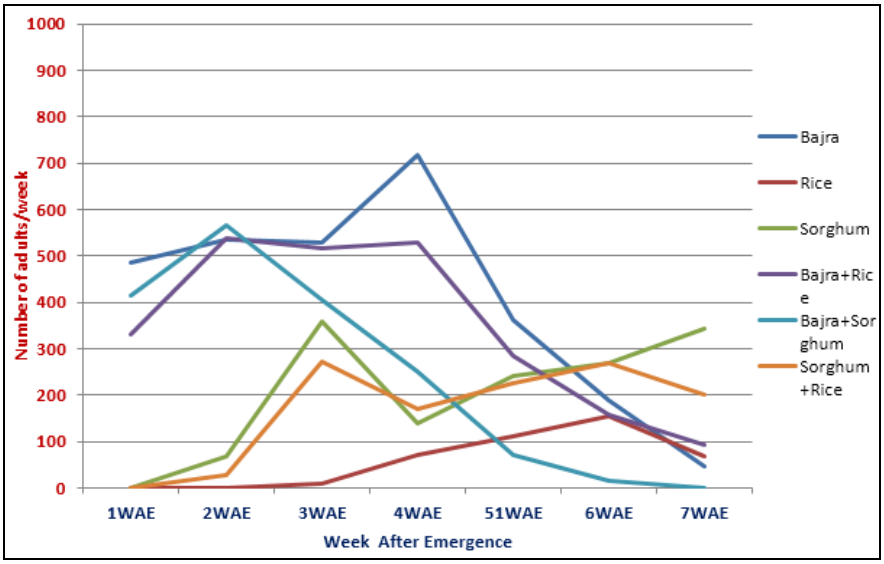

Fig 2: Number of adults/week from *Corcyra cephalonica* developed on different diets

Table 5: Eggs (g)/week from *Corcyra cephalonica* developed on different diets

Diet	1	2	3	4	5	6	7	Total
Bajra (T1)	1.8978	2.0667	2.892	5.9656	2.1024	0.8924	0.0724	15.8893
Rice (T3)	0	0	0	0.0272	0.1287	0.758	0.7671	1.681
Sorghum (T2)	0	0.1048	2.3259	0.6563	0.8188	1.0138	1.8598	6.7794
Bajra + Rice (T4)	1.0901	2.4195	2.3046	2.4228	0.8016	0.4088	0.1537	9.6011
Bajra + Sorghum (T6)	1.4288	2.7368	1.9996	1.4386	0.8989	0.3585	0	8.8612
\Sorghum + Rice (T5)	0	0	0.3749	0.572	0.8208	1.0509	1.4948	4.3134

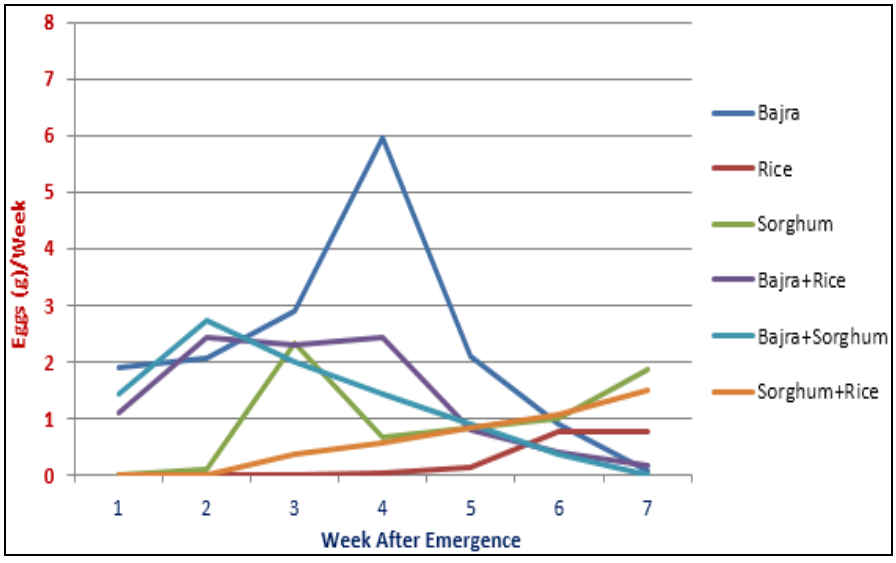

Fig 3: Eggs (g)/week from *Corcyra cephalonica* developed on different diets

Conclusion

Silent features of the results revealed that *Corcyra cephalonica* which reared on the Bajra + Groundnut (with additives) is the best food media for rearing the rice meal moth.

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