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Rajkumari

Department of Entomology,
College of Agriculture, Indira
Gandhi Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Dr. Jayalaxmi Ganguli

Department of Entomology,
College of Agriculture, Indira
Gandhi Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Dr. RN Ganguli

Department of Entomology,
College of Agriculture, Indira
Gandhi Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Mamta Bhagat

Department of Entomology,
College of Agriculture, Indira
Gandhi Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Corresponding Author:

Rajkumari

Department of Entomology,
College of Agriculture, Indira
Gandhi Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Tri-trophic interaction of *T. japonicum* on eggs of *Corcyra cephalonica* reared on different diets

Rajkumari, Dr. Jayalaxmi Ganguli, Dr. RN Ganguli and Mamta Bhagat

Abstract

The present studies on tri-trophic interaction included *C. cephalonica* reared on five different cereal diets viz., maize, sorghum, pearl millet, rice and mixture of grains (maize+ sorghum+ pearl millet) and the direct effect of these diets on the growth, development and reproductive parameters of *C. cephalonica* and to evaluate its indirect impact on the biology and parasitism of the egg parasitoid, *Trichogramma japonicum* on the eggs obtained from *Corcyra* reared on different diets. Results revealed that, *T. japonicum* exhibited best performance on *Corcyra* eggs obtained from *Corcyra* reared on maize, which was found highly significant with respect to per cent parasitization (76.85%) male emergence (71.2%), female emergence (77.65%), male longevity (3.55 days), female longevity (4.7 days), fecundity (90.35%) and sex ratio (1.15). Thus, the obtained results indicated that nutritional content of the host egg can be considered as an important decisive parameter in terms of percentage parasitism, longevity and sex ratio of the emerged parasitoids.

Keywords: *Trichogramma* spp., parasitization, *Corcyra* eggs, Tri-trophic interaction

Introduction

The use of biological control is widely recognised as a crucial element of any Integrated Pest Management (IPM) programme. This is because it has a number of advantages over other pest management strategies, prevents the emergence of insect-pest resistance, and works in harmony with other environmentally friendly methods (Dent, 2000) [2]. The state of Chhattisgarh is quickly converting to organic farming, which has increased the opportunity for biological control.

Insect pests are naturally controlled by a variety of biological control agents, including predators, parasitoids, and microbes (Bhandari, 2014) [1]. One of them, parasitoids, is crucial to the agricultural ecology. The rice yellow stem borer, rice leaf folder, rice case worm, the polyphagous tobacco caterpillar, *Spodoptera* spp., many semiloopers, and hairy caterpillars are just a few of the economically significant lepidopteran pests that the egg parasitoid *Trichogramma* is particularly effective against. To prevent the pest from passing the economic threshold, enhanced inundative releases 3–4 times throughout a cropping season are advised as the quantity of eggs killed by natural *Trichogramma* is inadequate.

Trichogramma spp. has produced significant ecological and economic benefits in locations where they have been dispersed consistently for years (Ullah *et al.*, 2012) [6]. It is a tiny (0.3 mm long) parasitoid, which attacks the eggs of its host. The larva (*T. evanescens*) goes through three developmental stages and pupate inside the host egg that cause host eggs turn black (Hassan *et al.*, 1981) [4].

The present study on tri-trophic interaction was undertaken to study the preference and non-preference, overall stage wise growth and developmental durations of *T. japonicum* on the *Corcyra* eggs obtained from *Corcyra cephalonica* reared on different diets, ultimately aiming to develop an 'improved diet' that could extensively raise the parasitization potential of *T. japonicum* for production of trichocards.

Material and Methods

The present experiment was conducted in the Biological Control laboratory, Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya (IGKV) Raipur, Chhattisgarh during the year 2021-2023.

To study the parasitization potential of *T. japonicum*, the sterilized eggs of *Corcyra* reared on different diets and were sprinkled uniformly on three different egg cards (3× 2 cm) yellow, pink and blue pasted with thin layer of *Acacia* gum at the rate of 100eggs per card.

Such eggs cards were kept separately in each petridish and were exposed to 10 adult of three different species of *Trichogramma* in separate petridishes. Each experiment was replicated 5 times.

The adults were fed with 50 per cent honey solution and were allowed to parasitize the eggs. After 5 days of exposure the egg cards were taken out and observed for the parasitization. On the basis of total number of parasitized eggs (eggs turned to black) by *T. japonicum*, was calculated separately and the data thus obtained were analyzed statistically by method suggested by Gomez and Gomez, 1984^[7].

Freshly emerged adult moths (20 number) male and (20 number) of female were collected in separate oviposition cages, treatment wise, and maintained until their death by feeding them with 50% honey solution along with vitamin E. Mean longevity of male and female were calculated in days and compared in different treatments.

Observations recorded

A. Per cent parasitization

Black coloured eggs were considered as the parasitized eggs, on the basis of which, per cent parasitization was calculated.

B. Per cent adult (male & female) emergence

Out of total parasitized eggs, the number of parasitoids emerged on the basis of male and female adults from the parasitized eggs, were counted and per cent adult emergence was determined.

C. Fecundity

Number of host eggs parasitized by the individual gravid female emerged from parasitized eggs on different treatments were counted and fecundity was determined.

D. Adult (male & female) longevity

Newly emerged five female adult parasitoids were kept individually in a small glass vials provided with food. The adult longevity was worked out from their emergence till death in days.

E. Sex ratio

To determine sex ratio, the emerged adults were first stunned/freeze by keeping them under refrigerator at 0°. From those stunned/freeze adults, sexing was done by observing individual parasitoid under a high power stereoscope based on the morphological characters.

Results and Discussion

Parasitization potential of *T. japonicum* on eggs of *Corcyra cephalonica* reared on different diets.

The percentage of eggs that were parasitized, the lifespan of the male and female parasitoids, and the sex ratio of the parasitoids that emerged from the *C. cephalonica* eggs that were parasitized by female *Trichogramma japonicum* were used to test the tritrophic interaction of *Trichogramma* spp. on eggs of *C. cephalonica* obtained by rearing on different diets. The outcomes of the experiments are covered under the following headings.

❖ Per cent parasitisation in eggs of *C. cephalonica* reared on different

In this experiment, eggs of *C. cephalonica* reared on various diets were exposed to *T. japonicum* for parasitization during the years 2021–2022 and 2022–2023.

During 2021-22, as per the data presented in Tables (1) and Figure (1), maximum per cent parasitisation was observed on *Corcyra* eggs obtained from *C. cephalonica* reared on maize (76.2%) which was significantly superior than *Corcyra* eggs reared on jowar (74.4%) followed by eggs reared on bajra (72.2%), Mix grain *Corcyra* eggs (68.2%) and lowest parasitisation (65.5%) was recorded on *Corcyra* eggs obtained from rice.

From the data obtained from second trial during 2022-23, again it was found that highest per cent parasitisation (78.1%) of *Corcyra* eggs were recorded in maize followed by jowar (75.6%), mix grain (67.8%) per cent egg parasitisation, whereas lowest per cent parasitisation was again recorded in rice (62.1%) as presented in Table (2).

Pooled data of 2021-22 and 2022-23, revealed that all the treatments were effective in parasitisation of *Corcyra* eggs by *T. japonicum* but *Corcyra* eggs obtained from maize (76.85%) was found to be superior over rest of the treatments, followed by jowar (76.3%), bajra (73%), and mix grains (69.9%) as presented in Table (3).

This study aligns with the findings of Tiwari and Khan (2003)^[5], who also observed the highest average percentage of parasitisation (51.96%) by *T. chilonis* when reared on a maize + yeast diet.

❖ Effect of different diets on longevity of the emerged adults egg parasitoid, *T. japonicum*

a) Effect on longevity of female parasitoid of *T. japonicum*

The findings on the longevity of female parasitoid on *Corcyra* eggs reared on different diets for during two consecutive season trials and in pooled form are presented in Tables 1, 2, and 3 and illustrated in Figure 1.

The results of the first investigation, carried out during 2021-22, revealed that maximum longevity in females was recorded in maize (4.6 days), which significantly superior to (4.2 days), (3.6 days), (3.1 days) in jowar, bajra and mixed grains respectively and the shortest life span was observed on rice (2.1 days).

Analysis of the second-year data of 2022-23 also revealed that significantly longer female longevity was found in maize (4.8 days) followed by jowar (4.1 days), bajra (3.9 days), and mix grains (3.2 days). The shortest longevity was again noted in rice (1.8 days) Table (2).

Perusal of the pooled data showed that maize grain supported maximum female longevity of *T. japonicum* emerged from *Corcyra* eggs (4.7 days) followed by bajra (4.15 days), jowar (3.75 days), and mix grains (3.15 days). The lowest longevity of *T. japonicum* was noticed in rice (1.95 days) as given in Table (3).

b) Effect on longevity male *T. japonicum*

The data on the lifespan of male parasitoids, which were nourished with *Corcyra* eggs obtained from *C. cephalonica* feeding on different diets, are depicted in Tables 1, 2 and 3. Furthermore, these results are visually graphically represented in figure 1 for both consecutive season trials.

The preliminary trial conducted 2021-22 provided evidence that the life span of freshly emerged male egg parasitoid of *T. japonicum* from *Corcyra* eggs obtained from *C. cephalonica* reared on different diets differed significantly.

The results indicated a noticeable increase in the lifespan of male parasitoid on *Corcyra* eggs obtained from maize (3.6 days), which were significantly superior to *Corcyra* eggs from

bajra (3.3 days) followed by *Corcyra* eggs from jowar (3.2 days), *Corcyra* eggs from mix grains (2.3 days) lowest longevity of male *T. japonicum* was observed in rice (1.4 days), as presented in the Table (1).

As per the data of the second year 2022-23, it was observed that the longevity of *T. japonicum* varied significantly across different treatment. Similar trend was seen with maximum longevity of male *T. japonicum* on *Corcyra* eggs from maize (3.5 days) followed by jowar (3.2 days), bajra (2.9 days) and mix grains (2.9 days) and the shortest female lifespan of only 1.6 days as presented in the table (2).

The analysis of the combined data indicated that the highest male longevity of *T. japonicum* was found on *Corcyra* eggs obtained from maize (3.55 days) followed by jowar (3.2 days), bajra which was significantly lower than that of rice which exhibited the lowest longevity for *Trichogramma*, lasting only 1.5 days as presented in the table (3).

❖ **Per cent adult emergence of *T. japonicum* from the eggs *C. cephalonica* reared on different diets.**

a. Effect on adult female emergence of *T. japonicum* emerged from the *C. cephalonica* eggs reared on different diets.

The emergence of adult egg parasitoids of *T. japonicum* from the *Corcyra* eggs reared on different diets was determined meticulously by distinguishing individuals based on sexual dimorphism.

The data regarding the emergence of parasitoids for two consecutive years i.e. 2021-22 and 2022-23, as well as the combined data, are presented in Table 1. Table 2, Table 3, and fig. 1.

The majority of female emergence was observed in the treatments of *Corcyra* eggs obtained from maize (80.1%) which was significantly higher as compared to *Corcyra* eggs from jowar (79.4 %), *Corcyra* eggs (71.4%), followed by and *Corcyra* eggs from mix grains (67.8 percent). The lowest emergence of *T. japonicum* was observed in *Corcyra* eggs obtained from rice (61.0%), as presented in Table (1).

Perusal of the data from the second-year trial conducted during 2022-23, depicted that *Corcyra* eggs obtained from maize exhibited significantly higher emergence of (79.6%) followed by *Corcyra* eggs obtained from bajra (75.4%), jowar (74.6%) and mix grains (69.3%). Lowest emergence of *T. japonicum* was noted in rice (54.4%) Table (2).

From the pooled data of two years, it was evident that *Corcyra* eggs reared on maize resulted in the highest percentage of emergence in female *T. japonicum* (77.65%) with *Corcyra* eggs showing a significant rate followed by jowar (76.0%). The subsequent treatments in order of effectiveness were bajra (74.9%) followed by M mix grains (68.55%). Significantly lowest emergence per cent (57.7%) observed in rice as presented in Table (3).

b. Effect of adult male of *T. japonicum* emerged from the eggs of *C. cephalonica* reared on different diets.

The emergence of males of *T. japonicum* was recorded in almost all of the diets but varied significantly among them. Among the treatment, *Corcyra* eggs reared on jowar exhibited highest emergence rate (74.2%). The subsequent treatments in terms of effectiveness were bajra with a rate of (68.7%), and mix grain with 61.6. Lowest male emergence of *Trichogramma* was observed in rice *Corcyra* eggs with (58.3%) as given in table (1).

Perusal the data from the second year's trial in 2022-2023, it

was found that among the treatments, *Corcyra* eggs obtained from jowar had the highest emergence rate (69.8%), followed by maize (67.4%). The subsequent treatments in terms of effectiveness were bajra (66.2%), and mix grain (60.2%). Moreover, the lowest male emergence of *Trichogramma* was observed rice (53.2%) presented in table (2).

Upon analyzing the pooled data, it was observed that *Corcyra* eggs obtained from Jowar resulted in highest male emergence (71.2%), followed closely as the second significantly superior treatment, maize (70.7%). The subsequent treatments in terms of effectiveness were bajra (65.7%), and mix grain (61.3%). Lowest male emergence of *T. japonicum* was noticed in rice 52.25% as indicated in table (3).

❖ **Sex ratio (F:M) of *T. japonicum* emerged from the eggs of *C. cephalonica* reared on different diets.**

The sex ratio was determined by calculating the number of emerged adults and categorizing them as males and females.

In the first experiment, analysis of the sex ratio (F:M) showed that higher proportion of females were observed, resulting in a sex ratio of 1:11 (F:M) in eggs obtained from maize followed jowar, exhibiting a sex ratio of 1:1.08 (F:M). The subsequent treatments in terms of sex ratio (F:M) were mix grain with sex ratio of 1:1.10 (F:M) and bajra with a sex ratio of 1:1.05 (F:M). The lowest sex ratio of *T. japonicum* was observed in rice with a sex ratio of 1:1.03 (F:M) as given in table (1).

In the second year, 2022-2023, significantly superior treatments in terms of sex ratio (F:M) were observed in *Corcyra* eggs reared on maize with a sex ratio of 1:1.18, followed by mix grain with a sex ratio of 1:1.15, bajra with a sex ratio of 1:1.13, and jowar with a sex ratio of 1:1.07. Lowest sex ratio of *T. japonicum* was noticed in *Corcyra* eggs from rice 1:1.03 as shown in table (2).

In pooled results also a similar trend in sex ratio of *T. japonicum* were noticed. Maximum sex ratio (1:1.15F:M) was observed in maize followed by mix grain (1:1.13 F:M), bajra (1:1.11F:M) and jowar (1:1.07 sex ratio), respectively. Lowest sex ratio was noticed in *Corcyra* eggs obtained from rice (1:1.03 F:M) as provided in table (3).

❖ **Total fecundity/ female on *C. cephalonica* eggs based on per cent parasitization**

During the experimental period 2021-2022, the total fecundity per female was recorded eggs of *Corcyra*. and presented in Table 1 and presented graphically in fig. 2. Highest fecundity were observed in the *Corcyra* eggs obtained from maize (88.6%) being parasitized. The second-best treatment for *Corcyra* eggs was jowar with 86.6% of parasitized eggs, followed by bajra with 84.2%. The treatment of mix grains exhibited a fecundity rate of 76.4%, while the least performing treatment was rice with only 69.2% of parasitized. In the second year, 2022-2023, significant differences were observed among various treatments. The treatment (jowar) exhibited the significantly highest fecundity with 98.6% of the host *C. cephalonica* eggs being parasitized. It was followed by maize reared (*Corcyra* eggs) with 90.1% parasitized eggs, followed by bajra reared *Corcyra* eggs with 82.8% parasitized eggs, and *Corcyra* eggs reared on mix grain with 76.4% parasitized eggs. Least performing treatment was *Corcyra* eggs, reared on rice with 70.2% of parasitization as shown in the provided table (2).

Analysis of the pooled data revealed that the treatment of *Corcyra* eggs obtained from maize provided the highest level

of female fecundity of 92.1 percent. This was followed by *Corcyra* eggs obtained from jowar with a fecundity rate of 87.0 percent. The subsequent treatments in terms of effectiveness were bajra *Corcyra* eggs (82.8 %) and mix grains at 78.2 percent. Among all the treatments, the lowest fecundity of *T. japonicum* was observed in *Corcyra* eggs obtained from rice (71.4%), as indicated in the table (3). Thus, from the above results it can be concluded that B best

results of mean maximum per cent emergence, higher mean F:M ratio, mean maximum per cent emergence of male and female and mean maximum longevity of male and female of *T. japonicum* was observed in maize, as compared to other grains, may be due highest carbohydrate. (FAO, Series 27,1995) [3]. Hence, *C. cephalonica* reared on maize can be the diet for obtaining eggs for production of trichocards of *T. japonicum*

Table 1: Per cent parasitisation potential of *T. japonicum* on eggs of *C. cephalonica* reared on different diets during 2021-22.

Treatments	Per cent parasitization of <i>T. japonicum</i> %	Longevity of Female <i>T. japonicum</i> (days)	Longevity of Male <i>T. japonicum</i> (days)	Emerged of <i>T. japonicum</i> female (%)	Emerged of <i>T. japonicum</i> Male (%)	Total Fecundity /Female	Sex ratio (F:M)
T ₁ (Maize)	76.2 (60.81)	4.6 (12.37)	3.6 (10.91)	80.1 (63.48)	72.2 (58.19)	88.6 (70.28)	1.11
T ₂ (Jowar)	74.4 (59.62)	4.2 (11.71)	3.2 (10.21)	79.4 (62.64)	74.4 (59.66)	86.6 (68.59)	1.08
T ₃ (Bajra)	72.2 (58.19)	3.6 (10.91)	3.3 (10.44)	71.4 (57.67)	68.7 (55.32)	84.2 (66.56)	1.05
T ₄ (Rice)	65.5 (54.08)	2.1 (8.21)	1.4 (6.69)	61 (51.36)	58.3 (47.78)	69.2 (56.29)	1.03
T ₅ (Mix grain)	68.2 (55.72)	3.1 (10.02)	2.3 (8.69)	67.8 (55.42)	61.6 (51.69)	76.4 (60.98)	1.1
SEm±	0.831	0.638	0.489	0.861	0.641	0.933	0.71
CD at 5%	3.778	1.895	1.453	2.559	1.905	2.773	1.78

(Figures in parentheses arc sin transformed values)

Table 2: Per cent parasitisation potential of *T. japonicum* on eggs of *C. cephalonica* reared on different diets during 2022-23

Treatments	Per cent parasitization of <i>T. japonicum</i> %	Longevity of Female <i>T. japonicum</i> (days)	Longevity of Male <i>T. japonicum</i> (days)	Emerged of <i>T. japonicum</i> female (%)	Emerged of <i>T. japonicum</i> Male (%)	Total Fecundity/Female	Sex ratio (F:M)
T ₁ (Maize)	78.1 (62.09)	4.8 (12.65)	3.5 (10.42)	79.6 (60.11)	67.4 (56.89)	92.1 (73.94)	1.18
T ₂ (Jowar)	75.6 (60.46)	4.1 (11.66)	3.2 (10.10)	74.6 (59.73)	69.8 (56.64)	87.0 (71.27)	1.07
T ₃ (Bajra)	73.4 (58.94)	3.9 (11.38)	2.9 (9.79)	75.4 (62.29)	66.2 (55.62)	82.8 (65.50)	1.13
T ₄ (Rice)	62.1 (52.02)	1.8 (7.37)	1.6 (6.95)	54.4 (47.51)	53.2 (46.81)	71.4 (57.66)	1.03
T ₅ (Mix grain)	67.8 (55.42)	3.2 (10.19)	2.9 (8.89)	69.3 (56.35)	60.2 (50.86)	78.2 (62.20)	1.15
SEm±	1.06	0.641	0.573	0.707	0.351	2.606	0.8
CD at 5%	3.149	1.905	1.701	2.099	1.041	7.742	2.21

(Figures in parentheses arc sin transformed values)

Table 3: Per cent parasitization potential of *T. japonicum* on *Corcyra* eggs obtained from *C. cephalonica* reared on different diets during 2021-22, 2022-23

Treatments	Per cent parasitization of <i>T. japonicum</i> %	Longevity of Female <i>T. japonicum</i> (days)	Longevity of Male <i>T. japonicum</i> (days)	Emerged of <i>T. japonicum</i> female (%)	Emerged of <i>T. japonicum</i> Male (%)	Total Fecundity /Female	Sex ratio (F :M)
T ₁ (Maize)	76.85 (61.22)	4.7 (12.51)	3.55 (10.85)	77.65 (61.76)	71.2 (57.52)	90.35 (71.92)	1.15
T ₂ (Jowar)	76.3 (60.89)	4.15 (11.71)	3.2 (10.25)	76 (60.65)	70.7 (57.20)	86.8 (69.02)	1.07
T ₃ (Bajra)	73 (58.69)	3.75 (11.15)	3.1 (10.12)	74.9 (59.91)	65.7 (54.13)	83.5 (66.02)	1.11
T ₄ (Rice)	66.95 (54.93)	1.95 (7.91)	1.5 (6.95)	57.7 (49.41)	52.25 (46.27)	70.3 (56.98)	1.03
T ₅ (Mix grain)	69.9 (56.72)	3.15 (10.12)	2.6 (9.25)	68.55 (56.35)	61.3 (51.51)	77.3 (61.582)	1.13
SEm±	0.954	0.504	0.387	0.449	0.301	1.216	
CD at 5%	2.835	1.497	1.151	1.333	0.893	3.612	

(Figures in parentheses arc sin transformed values)

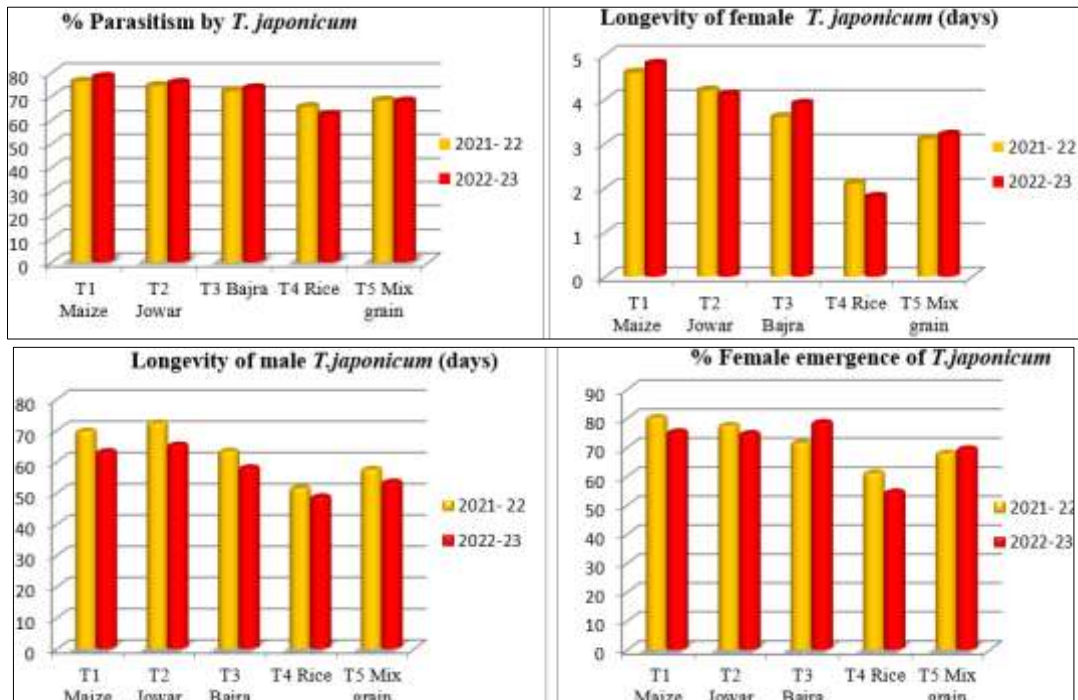


Fig 1: Per cent parasitization, longevity of male and female, per cent female emergence of *T. japonicum* on eggs of *C. cephalonica*

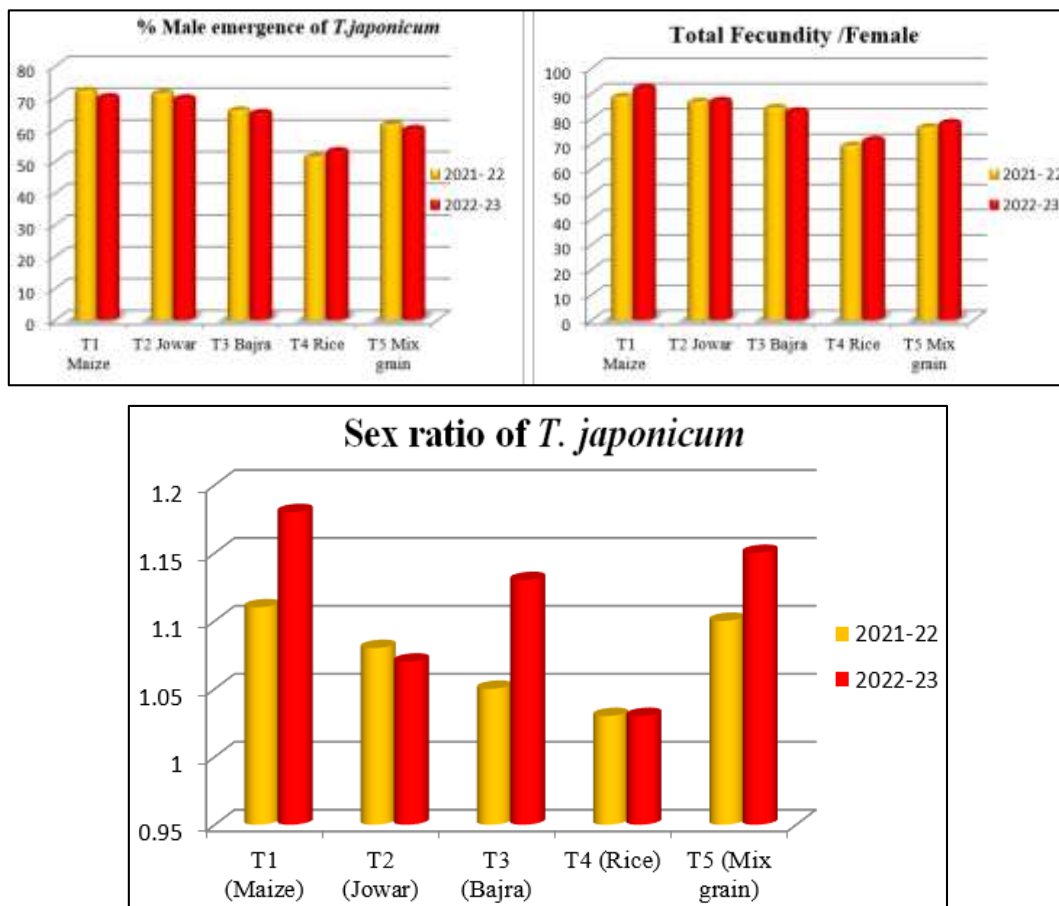


Fig 2: Per cent male emergence, total fecundity, sex ratio of *T. japonicum* on eggs of *C. cephalonica*

Conclusion

From the present studies on tri-trophic interaction, it can be concluded from the that *Trichogramma japonicum* can be best multiplied on *Corcyra* eggs obtained from *C. cephalonica* reared on maize, as it recorded maximum parasitization, maximum longevity of male and female, maximum emergence of male and female, highest F:M sex ratio and

maximum fecundity. Among other treatments tested the next in the order was jowar, followed bajra, and mix grains. *Corcyra* eggs obtained from *C. cephalonica* reared on rice depicted poorest performance on all parameters tested. Hence, maize can be suggested as the best diet for rearing *C. cephalonica* which will further provide eggs for producing trichocards of *T. japonicum*.

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