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Influence of dietary constituents on some life history parameters of melon fly, *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae)

Somala Karthik, MK Gupta, Sushmita Thokchom and Balaga Mohan Ganesh

Abstract
Melon fly, *Bactrocera cucurbitae* is a serious pest of cucurbitaceous vegetables. A study was undertaken to evaluate dietary constituents comprising of honey, water, protein hydrolysate and yeast powder. Diets for *B. cucurbitae* were prepared, consisting of protein hydrolysate (1 g, 3 g, 5 g and 7 g) and yeast powder (5 g, 10 g, 15 g and 20 g) mixed in (5 ml) honey and (100 ml) water. Diet consisting of 7 g protein hydrolysate + 5 ml honey + 100 ml water resulted in suitability, in respect of some life history parameters of the insect. The insect had shorter pre-oviposition period (17.00 days), longer oviposition period (64.48 days) and adult longevity for male (66.36 days) and female (86.28 days) and high fecundity (770eggs/female). Further, the diet consisting of 10 g yeast powder + 5 ml honey + 100 ml water was also found equality effective on some life history parameters of the insect. The insect fed on this diet resulted in shorter pre-oviposition period (16.00 days), longer oviposition period (63.76 days), and adult longevity for male (65.80 days) and female (84.26 days) and high fecundity (760 eggs/female). Both the diets containing (7 g protein hydrolysate) and (10 g yeast powder) were most suitable diets for multiplication of *B. cucurbitae* for mass rearing and continuous availability of the insect for the suppression of insect in field through Sterile Insect Release Method (SIRM).

Keywords: *B. cucurbitae*, protein hydrolysate, yeast powder, honey, diet, life history parameters

Introduction
Cucurbits are attacked by a number of insect pests but fortunately, in India only fruit flies and few species of beetles are of economic importance and some aphids and blister beetles though of regular occurrence, seldom cause severe damage, rest of the insect pests are of minor importance (Butani and Jotwani, 1984) [2]. Fruit flies belonging to the family, Tephritidae are recognized as one of the most important group of pests of cucurbits. Tephritidae consists of over 4000 species, of which nearly 700 species belongs to Dacine fruit flies (Fletcher, 1987) [8]. The fruit flies of the family Tephritidae are well-known pests of fruits and vegetables throughout the world. The devastating effects of fruit flies inflict to horticultural industry worldwide, and the transboundary nature of the problems, have placed the fruit flies on top of the world's list of key insect pests (Enkerlin, 2003) [6]. The melon fly, *Bactrocera cucurbitae* causes serious damage to cucurbits and is geographically distributed throughout the tropics and subtropics of the world (Drew, 1992) [5]. Studies related to food preferences and reproduction in various species of tephritid fruit flies is important and the relationship of food preferences and rate of ovarian development needs to be understood precisely. (Marlowe, 1945) [13] Studied the effect of various foods on the ovarian development of the melon fly and found that no ovarian development occurred when adults were fed sugars and molasses for 30 days. There is marked increase in fecundity of *B. cucurbitae*, *B. dorsalis* and *Ceratitis capitata* when fed with protein supplements (Hagen and Finney, 1950) [11]. Female tephritid fruit flies are sexually immature at eclosion and the ovarian maturation process is dependent upon temperature, photoperiod, diet (especially protein availability) and chemical cures. Several management measures involving hydrolysed protein bait spray, para-pheromone lures, botanicals, field sanitation, bagging of fruits and chemical sprays (Akhtaruzaman *et al.*, 2000) [1] have been used for the management of the pests. However, research has been continuing to identify the most effective management module. Insect diets affect the performance of insects during immature and adult stages.

Adult emergence, female size, pre-oviposition egg production and larval stage, are affected during immature stage, whereas effects on post-oviposition egg production, diet ingestion, sexual acceptance, or longevity (survival) occur during adult stage (Cangussu and Zucoloto 1997) [3]. In Sterile Insect Release Method (SIRM) of this pest, it is a pre-requisite to ensure life history parameters in terms of mass rearing with artificial diets to obtained competitive adults to bring about a successful suppression in the field population. The purposes of rearing insects in the laboratory may be, to study the insect itself, facts pertaining to its life history, habits, habitats, host relationship, and dietary requirements to facilitate the continuous availability of insect cultures for the *in-vitro* studies. The present study was undertaken to standardize different dietary constituents for the *in-vitro* rearing of melon flies. As a part of the development of a complete artificial diet for melon fly, the importance of protein hydrolysate and yeast powder has now been recognized and tested. The quantitative studies have been conducted to customize the functions of both protein hydrolysate and yeast powder in the artificial diet. The present study was undertaken to study the influence of dietary constituents on some life history parameters of melon fly.

Materials and Methods

A culture of *B. cucurbitae* was maintained in the laboratory, Department of Entomology, College of Agriculture, Central Agricultural University, Imphal, during 2017 in Completely Randomized Design (CRD) with five replications. Infested fruits of cucurbits were collected from the field and kept in 20 x 20 x 8 cm plastic trays on a 5 cm thick layer of sieved sterilized sand to facilitate pupation. After 3-4 days, sand was sieved and newly formed pupae were collected. The pupae were kept in 10 cm diameter petri dishes lined with moist filter paper. The newly emerged adult flies were collected and placed inside the rearing cages 35 x 30 x 35 cm, which have wire mesh on 3 sides and also one door of wire mesh on one side to facilitate the collection of adult flies. On the bottom of the cage, a layer of 2 cm thick sand with 5% moisture was maintained. The flies were provided with food and water kept in a 5 ml beaker, a water soaked cotton swab was laid in such way that half of it was immersed in food solution and remaining half stayed above rim of the beaker to reach of the adult fruit flies. Slices of cucumber were kept inside the cage for oviposition and were replaced by fresh ones daily to avoid decay. After egg hatching, fresh cucumber slices were kept in petri dish for feeding the young larvae. The culture, so obtained was used for various studies. From 12th day of the adult emergence, a slice of cucumber was supplied inside the glass chimney for egg laying. The cucumber slice was checked for eggs every day and the number of eggs laid were recorded. The cucumber slice was replaced with a new one every day. Following observations were recorded: pre-oviposition period, oviposition period, post-oviposition period, incubation period, larval period, pupal period, adult longevity of male and female and fecundity/female.

Results and Discussions

Effect of different diets on the pre-oviposition, oviposition and post-oviposition of *B. cucurbitae* are depicted in (Table 1 and Fig 1). The pre-oviposition of the insect, when fed on protein hydrolysate varied from 23.00 days (protein hydrolysate 1 g + honey 5 ml + water 100 ml) to 17.00 days (protein hydrolysate 7 g + honey 5 ml + water 100 ml). While in case of yeast powder it was in the range of 22.00 days (yeast powder 20 g + honey 5 ml + water 100 ml) to 16.00 days (yeast powder 10 g + honey 5 ml + water 100 ml). The oviposition period showed an increasing trend with the increase in quantity of the protein hydrolysate, which recorded 36.80 days, 47.40 days, 50.00 days and 64.48 days when fed on 1 g, 3 g, 5 g and 7 g protein hydrolysate respectively. The oviposition period of the insect was also influenced greatly by different quantity of yeast powder in the insect diet. The oviposition period recorded longest 63.76 days, when treated with 10 g yeast powder. Similarly, shortest oviposition period was recorded (44.00 days) at 20 g yeast powder. The post-oviposition period of the insect ranged between (2.00 days to 4.80 days), in case of different diets consisting of different amount of protein hydrolysate and yeast powder. (Vargas *et al*., 1984) [16]; (Carey *et al.*, 1988) [4] reported, shorter pre-ovipopsition and longer oviposition period for melon fly, which is similar to the present findings, showing shorter pre-oviposition period and longer oviposition period. Similarly, (Mahfuza *et al*., 2000) [12] also obtained shorter pre-oviposition period of 14-16 days in case of casein: yeast extract: sugar (1:1:2) and autolyzed brewer's yeast: sugar (1:4). It was 18-24 days in case of yeast: sugar (1:3), while in case of exclusively sugar fed insect, the pre-ovipoition period was prolonged to 46-50 days. In the present investigation, the pre-oviposition period was shortened to 16 days in case of yeast powder 10 g + honey 5 ml + water 100 ml and 17 days in case of protein hydrolysate 7 g + honey 5 ml + water 100 ml, which was similar with the findings of (Mahfuza *et al.*, 2000) [12].

Table 1: Effect of different diets on Pre-oviposition, Oviposition and Post-oviposition of *B. cucurbitae.*

Treatments		Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)
T_1	Protein hydrolysate 1 g + Honey 5 ml + Water 100 ml.	23.00	36.80	2.00
T_2	Protein hydrolysate 3 g + Honey 5 ml + Water 100 ml.	22.00	47.40	2.40
T_3	Protein hydrolysate 5 g + Honey 5 ml + Water 100 ml.	20.00	50.00	3.50
T_4	Protein hydrolysate 7 g + Honey 5 ml + Water 100 ml.	17.00	64.48	4.80
T_5	Yeast powder 5 g + Honey 5 ml + Water 100 ml.	21.00	48.00	3.00
T_6	Yeast powder 10 g + Honey 5 ml + Water 100 ml.	16.00	63.76	4.50
T_7	Yeast powder 15 g + Honey 5 ml + Water 100 ml.	18.00	53.48	3.20
T_8	Yeast powder 20 g + Honey 5 ml + Water 100 ml.	22.00	44.00	2.20
T_9	Honey 5 ml + Water 100 ml.	25.00	20.56	1.40
T_{10}	Water (Control).	*	*	*
S.E. (d)		0.87	0.57	0.29
C.D(p=0.05)		1.76	1.16	0.60

* Insects were dead in time gap of 2 to 4 days.

Data are mean of five replications.

Means followed by different letters are significantly different at 5 % level of significance.

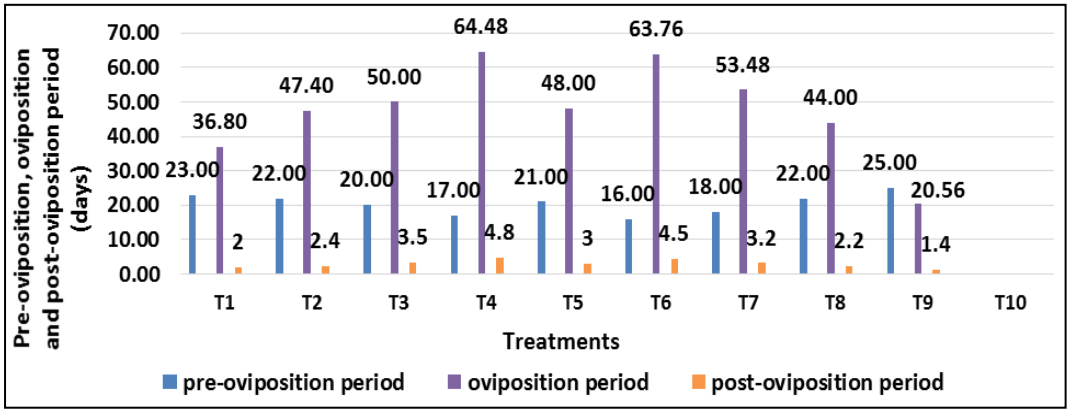

Fig 1: Effect of different diets on pre- oviposition, oviposition and post-oviposition period of *B. cucurbitae.*

Effect of different diets on the incubation, larval and pupal period of *B. cucurbitae* are presented in (Table 2, Fig 2 and Fig 3). The incubation period showed a decreasing trend, which recorded 54.00 hrs, 47.40 hrs, 39.80 hrs and shortest of 34.80 hrs, when fed on 1 g, 3 g, 5 g and 7 g protein hydrolysate respectively. The incubation period was shortest (34.00 hrs), when 10 g yeast powder was fed to the insect and showed longest (48.00 hrs) in a diet, consisting of 20 g yeast powder. The incubation period was recorded longest (56.40 hrs), when only honey and water was fed to the insect. The larval period was longest (12.20 days) when fed on the diet consisting of 1 g protein hydrolysate and 10.00 days when fed on diet consisting of 10 g yeast powder which gradually increased to 11.00 days at 15 g and 11.20 days at 20 g yeast powder. The larval period recorded longest (12.80) among all the treatments, when only honey and water was given as a diet. The pupal period was longest (10.40 days), when fed with 1 g protein hydrolysate. Similarly, the pupal period was 9.20 days, when fed with 10 g yeast powder, which gradually increased with the increase in quantity of yeast powder in the diet i.e., (9.80 days) at 15 g yeast powder and (10.60 days) at 20 g yeast powder. When the insect was given only honey and water, longest pupal period was recorded (11.60 days). Literature, related to influence of different diets on the incubation period, larval period and pupal period is scanty. The present study showed the different diets had influenced on the different stages of the life cycle of the insect, to feed on different quantity of protein hydrolysate and yeast powder. (Rabab *et al.*, 2016) [14] reported larval duration and pupal duration of *B. zonata* to be 10 days and 8 days respectively, when reared on diet consisting of soybean flour and gelatin as protein source.

Table 2: Effect of different diets on Incubation, Larval and Pupal period of *B. cucurbitae.*

Treatments		Incubation period (hrs)	Larval period (days)	Pupal period (days)
T_1	Protein hydrolysate 1 g + Honey 5 ml + Water 100 ml.	54.00	12.20	10.40
T_2	Protein hydrolysate 3 g + Honey 5 ml + Water 100 ml.	47.40	11.40	10.20
T_3	Protein hydrolysate 5 g + Honey 5 ml + Water 100 ml.	39.80	10.60	9.60
T_4	Protein hydrolysate 7 g + Honey 5 ml + Water 100 ml.	34.80	10.00	9.40
T_5	Yeast powder 5 g + Honey 5 ml + Water 100 ml.	41.20	10.80	9.60
T_6	Yeast powder 10 g + Honey 5 ml + Water 100 ml.	34.00	10.00	9.20
T_7	Yeast powder 15 g + Honey 5 ml + Water 100 ml.	41.00	11.00	9.80
T_8	Yeast powder 20 g + Honey 5 ml + Water 100 ml.	48.00	11.20	10.60
T_9	Honey 5 ml + Water 100 ml.	56.40	12.80	11.60
T_{10}	Water (Control).	*	*	*
S.E. (d)		0.38	0.29	0.33
C.D(p=0.05)		0.76	0.59	0.66

* Insects were dead in time gap of 2 to 4 days.
Data are mean of five replications.
Means followed by different letters are significantly different at 5 % level of significance.

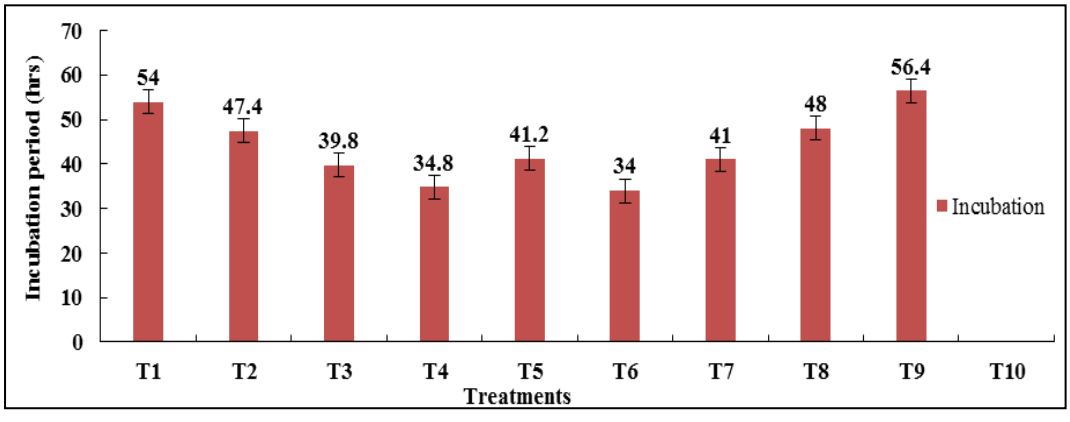

Fig 2: Effect of different diets on incubation period of *B. cucurbitae*

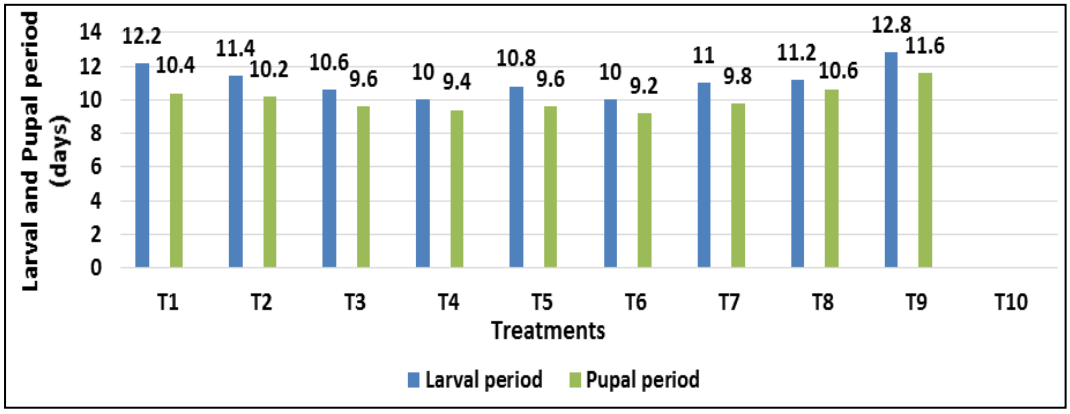

Fig 3: Effect of different diets on larval and pupal period of *B. cucurbitae.*

Effect of different diets on the male and female adult longevity and fecundity of *B. cucurbitae* are depicted in (Table 3, Fig 4 and Fig 5). The adult longevity of male was 50.00 days, when fed on 1 g protein hydrolysate + 5 ml honey + 100 ml water. Adult longevity of male was recorded (54.40 days), (59.00 days) and the longest of (66.36 days), when fed on 3 g, 5 g and 7 g protein hydrolysate respectively. The adult longevity of male was maximum (65.80 days) in case of 10 g yeast powder, which decreased to 54.88 days at 15 g yeast powder and 51.00 days at 20 g yeast powder. Further, the adult male insect survived for only 2 to 3 days, when fed on water. Similarly, adult longevity of female was (61.80 days), when fed on 1 g protein hydrolysate + 5 ml honey + 100 ml water. Female adult longevity showed increasing trend, which recorded (71.80 days), (73.50 days) and longest (86.28 days), when fed on 3 g, 5 g and 7 g protein hydrolysate respectively. The female adult longevity was maximum (84.26 days) in case of 10 g yeast powder, which gradually decreased to (74.60 days) at 15 g yeast powder and (68.20 days) at 20 g yeast powder. Further, the adult female insect survived for 3 to 4 days, when fed on only water. The fecundity of the female was lowest (348 eggs) per female, when fed on diet incorporated with 1 g protein hydrolysate + 5 ml honey + 100 ml water. Fecundity of the female was gradually increased, which recorded (440 eggs, 540 eggs and 770 eggs) per female, when fed on the diets consisting of 3 g, 5 g and 7 g protein hydrolysate respectively. In case of diets consisting of yeast powder, the fecundity of the female was maximum (760 eggs) per female in 10 g yeast powder but the fecundity was gradually decreased to 560 eggs and 521 eggs per female at 15, 20 g yeast powder respectively. In comparison of protein hydrolysate and yeast powder, the fecundity of female was only 90 eggs, when honey and water was given as a diet. (Saha *et al*., 2007) [15] Reported, longer adult longevity of *B. cucurbitae* (76 to 89 days) when fed on proteose-peptone: sugar and yeast: sugar. Similarly, in the present findings also longer adult longevity was obtained, when fed on protein hydrolysate and yeast powder. *Ceratitis capitata* produces eggs after feeding exclusively on carbohydrates during adult stage, but increases when a protein or amino acid source is also ingested (Hagen and Tasen, 1972) [10]; (Galun *et al*., 1981) [9]; (Ferro and Zucoloto, 1990) [7]. However, the present experimental results suggested that the protein hydrolysate: honey: water (7g:5ml:100ml) can be recommended for the higher egg production and longer adult longevity of the fly species which will help to boost the mass rearing directed towards Sterile Insect Technique (SIT). It needs further investigation on the relation between food and environmental condition on the development of oocyte and egg production.

Table 3: Effect of different diets on Adult longevity of Male and Female and Fecundity of *B. cucurbitae.*

Treatments		Male adult longevity (days)	Female adult longevity (days)	Fecundity (no. of eggs/female
T_1	Protein hydrolysate 1 g + Honey 5 ml + Water 100 ml.	50.00 (7.10) d	61.80 (7.88) g	348.00 f
T_2	Protein hydrolysate 3 g + Honey 5 ml + Water 100 ml.	54.40 (7.40) c	71.80 (8.49) e	440.00 e
T_3	Protein hydrolysate 5 g + Honey 5 ml + Water 100 ml.	59.00 (7.70) b	73.50 (8.60) cd	540.00 c
T_4	Protein hydrolysate 7 g + Honey 5 ml + Water 100 ml.	66.36 (8.17) a	86.28 (9.31) a	770.00 a
T_5	Yeast powder 5 g + Honey 5 ml + Water 100 ml.	54.12 (7.38) c	72.00 (8.51) de	550.00 bc
T_6	Yeast powder 10 g + Honey 5 ml + Water 100 ml.	65.80 (8.13) a	84.26 (9.20) b	760.00 a
T_7	Yeast powder 15 g + Honey 5 ml + Water 100 ml.	54.88 (7.43) c	74.60 (8.66) c	560.00 b
T_8	Yeast powder 20 g + Honey 5 ml + Water 100 ml.	51.00 (7.17) d	68.20 (8.28) f	521.00 d
T_9	Honey 5 ml + Water 100 ml.	34.60 (5.92) e	47.00 (6.88) h	90.00 g
T_{10}	Water (Control).	2.80 (1.81) f	4.00 (2.11) i	*
S.E. (d)		0.04	0.04	8.06
C.D(p=0.05)		0.09	0.09	16.36

* Insects were dead in time gap of 2 to 4 days.

Data are mean of five replications.

Means followed by different letters are significantly different at 5 % level of significance.

Figures in parentheses are transformed (square root) values.

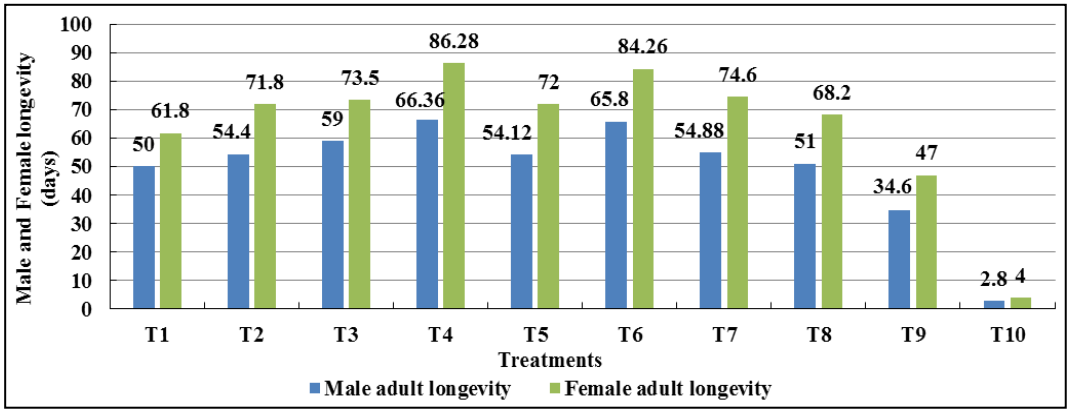

Fig 4: Effect of different diets on male and female longevity and fecundity of *B. cucurbitae*.

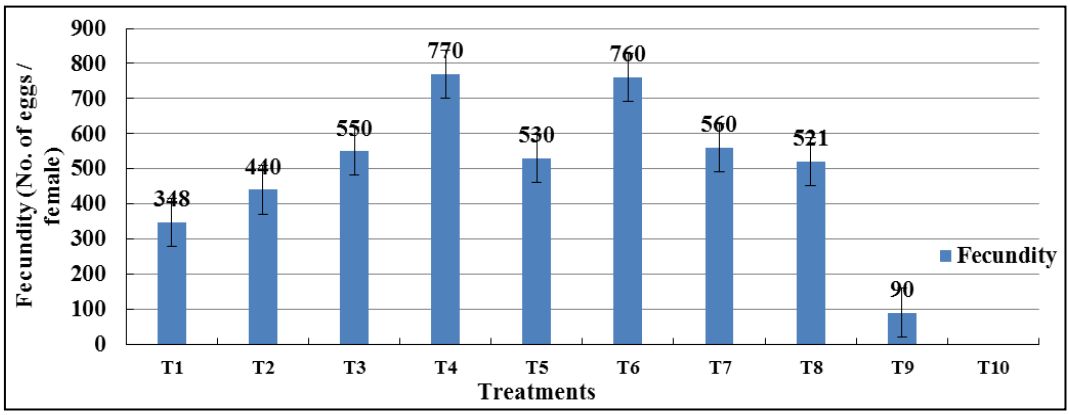

Fig 5: Effect of different diets on fecundity of *B. cucurbitae.*

Conclusion

The present experimental results suggested that the diet consisting of protein hydrolysate: honey: water (7g: 5ml: 100ml) can be recommended for the higher egg production and longer adult longevity of the fly species, followed by the diet consisting of yeast powder: honey: water (10g: 5ml: 100ml), which will help to boost the mass rearing of melon flies, directed towards Sterile Insect Technique (SIT). It needs further investigation on the relation between food and environmental condition on the development of oocyte and egg production.

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