Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(6): 234-240

Received: 05-09-2017
Accepted: 07-10-2017

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Effect of two cabbage cultivars on fitness of the most prevalent larval parasitoid of *P. xylostella*

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Abstract
The research was conducted to test the effect of two different cabbage cultivars on development period of larval parasitoid (*Diadegma insulare*) which were reared on cabbage pest larval population *Plutella xylostella* in biocontrol laboratory at PMAS Arid Agriculture University, Rawalpindi. The effect of two different cabbage cultivars Golden Acr and Chinese cabbage were tested on the *P. xylostella* pupae, the calculated value (28.158%) was higher than critical value (4.09%). The significant variation was found in pupal development period (days) and mean pupal population (0.85) per plant both cabbage cultivars. The higher parasitism level (59 %) was recorded on Golden Acr cultivar and the higher fecundity percentage (61%) was observed on Chinese cabbage cultivar. The total development period of female and male of *D. insular* were recorded (6.34±0.9 and 6.80±) on Golen acr and (6.73±0.20 and 7.04± 0.38 days) on Chinese cabbage. The total longevity of *D. insular* female was recorded 19.5± 4.32± and 21.32± 1.56± (days) on G. Acr and C. cabbage cultivars and male longevity period of *D. insular* was recorded (20.3± 5.18 and 21.9± 1.47 days) on both cultivars. The significant difference was observed on both female and male forewing size. The hind tibia of *D. insulare* female and male were measured (Fcal=17.6, fcri= 4.19) and (Fcal=38.8, fcri= 4.2), respectively.

Keywords: Effect, two cabbage cultivars, fitness

1. Introduction
Pakistan produces almost all vegetables including cabbage. Due to high nutrition value, cabbage crop is also attacked by a number of insect pests which affects its quality, yield and better look. The most important insect pest of cabbage crop is Diamondback moth (DBM) *P. xylostella* (Plutellidae: Lepidoptera), recorded from more than 128 countries of the world [1].
P. xylostella caterpillars mainly damage as leaf feeders. At early larval instars, damage is as small irregular holes in the leaves; however, the entire leaf may be eaten by the presence of the larger population of *P. xylostella* [2]. A lot of damage is due to the construction of tunnels in the head as in cabbage and brussel sprouts. Furthermore, crop damage is usually first evident on plants growing on ridges in the crucifier field. The heavy population of *P. xylostella* can cause more than 90% crop loss [3] and only few fourth stage larvae on a cabbage can make it unsalable [4 and 5].
Continuous efforts have been made by the breeders and growers to improve cauliflower production. Practically, all the available methods and pest control technologies have been tried at some time or another for the management of *P. xylostella* [6]. Selection of varieties and crop management practices are the main factors that contribute to growing profitable cauliflower [7].
D. insulare is the principle agent used for the control of *P. xylostella* globally and having a size of less than 6mm long with reddish brown legs and abdomen. The Female has well defined ovipositor and produce eggs in round shape which lacks projections. The Larva has segmented body with white color and narrow tail [8]. Number of generations of parasitoid in a year depends on the number of generations of the host. *P. xylostella* host larvae support only one parasitoid larvae and all the larval instars of *P. xylostella* can be parasitized by *D. insulare* [8]. The *P. xylostella* parasitized (70% to 90%) of larvae and consume (35% to 80%) less food than non-parasitized [8 and 9]. While, stages of the larval instars parasitized by *D. insulare* effect on offspring sex ratio. More males produced when 2nd instar are parasitized and more females are produced when 3rd and 4th instar are parasitized [9]. Parasitoid emerged as a mature larva from the pre-pupa stage of the cabbage host pest. Single female of *D. insulare* lays total 814 eggs at 23 °C temperature during incubation period.

Plant plays an important role in the bio-ecology processes of parasitoid and visual cues associated with plant are also important in host location by parasitoid. While, developmental biology of *P. xylostella*, reproductive potential and body size of the parasitoids are important in determining effectiveness of parasitoids designing pest management practices.
According to [10] plant volatiles are among the most important factors which play an important task for the selection of host by parasitoids, while there are various factors connected to attracting and searching by host. Plant volatile (HIPVs) not only attract parasitoids but also protect the crop from the insect pest.
Present study was designed for understanding the tritropic interaction of cabbage cultivars, its pest *P. xylostella* and parasitoid *D. insulare*. Different parameters of life history of *D. insulare* was compared when *P. xylostella* were reared on two cabbage cultivars.

2. Materials and Methods

2.1 Plant Culture of Cabbage Cultivars

Nursery of two common cabbage cultivars viz. Golden acre (*Brassica oleracea*) and Chinese cabbage (*Brassica rapa*) was grown in the glass house of the Department of Entomology PMAS-Arid Agriculture University Rawalpindi. The seedlings were cultivated in separate trays during 2011-12. These seedlings were grown in the first week of September (2011) whereas the second seedlings during February 2012.
Total number of trays were six each three (3 × 3) for separate cultivar with 15 rows of seedlings. Row to row distance was 4 inch (10cm) and 80-100 plants in a single row. After 3-4 weeks seedlings became matured and the number of leaves per plant was 3-4 with an average height of healthy plant 5-6 inches (12.5cm to 15cm). These plants were transplanted singly into 15cm diameter plastic pots. The plants were raised as described in [11].

2.2 *P. xylostella* Culture on Cabbage Cultivars

For rearing a homogeneous culture of *P. xylostella*, larvae and pupae of *P. xylostella* were collected from the farmer's field of cabbage crop at Taxila site. The specimens of larvae and pupae were transferred and reared in growth chamber. A colony of *P. xylostella* was established and maintained in the glasshouse on cabbage cultivar i.e. Golden acre. *P. xylostella* larvae were released and moths were reared following [12].
Sub-colonies were established on the two test cultivars. During study period two generations of *P. xylostella* were maintained on both cultivars viz. (Golden acre and Chinese cabbage) on the mean development period of larval stages (1st instar - 4th instar), pre-pupae and pupae of *P. xylostella* in the growth chamber operating at 23±2°C temperature, relative humidity 70±10% and 16: 8 (L: D) hour photoperiod.
P. xylostella larvae were reared on fresh one month old Chinese cabbage plants, raised in plastic pots, kept in (50 × 50 × 45cm) plastic cages, fitted with muslin net. Potted cabbage plants were placed for oviposition and replaced with fresh plants daily. Duration of lifecycle was dependent on various factors, the most important being temperature and availability of food. The hatched larvae were provided with more plants in several cages for mass culturing.

2.3 Parasitoid Culture on Cabbage Host (*P. xylostella*)

On potted cabbage plant, 100 2nd instar larvae of *P. xylostella* were released from plastic cages (20 × 20 × 40cm). Ten pairs of 3 days mated larval parasitoid were released in each cage. The most prevalent were introduced into the cage to oviposit freely. Wasps were provided with 10% honey solution. After 24 hours, the exposed larvae were removed and put in a container (20 × 10 × 5cm) lined with tissue paper at the bottom. Fresh cabbage leaves were added as required till pupation. At the requisite timing, the required number of larvae and pupae were harvested. At pupation of parasitized larvae, cocoons were harvested and kept at 23±2°C for adult emergence.

2.4 Parameters Studied

Development of larval parasitoid
Reproductive potential of larval parasitoid
Wing and tibia size of the parasitoid

2.5 Development of larval parasitoid (*D. insulare*)

Studies were conducted in laboratory at 25±1ºC. Each test plant was infested with one cohort of 200 third instars larvae. Potted plants of each cultivar were kept in individual cages (muslin cloth). Six pairs of one day old female and three days old male parasitoids were introduced in each cage (45 × 45cm).
They were allowed to mate for 48 hours and then were removed from each cage. All exposed *P. xylostella* larvae from each host plant were picked up and placed individually in plastic containers (5 × 4cm) with a leaf of each cabbage cultivar. These containers were kept in Growth Chamber. Leaves were changed at every two days interval until the larvae pupated. At pupation cocoons were weighed within 24 hours of formation with an electronic scale. Then, pupae were kept in individual plastic vials for adult emergence. Egg to larval period and pupal period of the parasitoid were recorded. At wasp emergence the time of aggression and sex was recorded.

2.6 Reproductive potential of larval parasitoid

The reproductive potential of the parasitoid was determined by counting the number of eggs in the ovaries. Twenty-five, 3-days old female larval parasitoids from each test plant (from the above experiment) was picked at random and killed by keeping them in the freezer at -20ºC for half an hour. Each female was then placed in a petri dish with 10% honey solution and the abdomen was split open using a pair of dissecting pins to expose the ovaries. The ovaries were placed on a microscope slide with a 10% honey solution and were split open under the dissecting microscope (NOIF microscope) in the taxonomic laboratory in PMAS-Arid Agriculture University Rawalpindi.

2.7 Wing and tibia size of the parasitoid

Twenty-five newly emerged male and female parasitoids from each test plant were killed by placing them in the freezer at -20ºC for half an hour. Each wasp was placed in a Petri dish with 70% alcohol and left forewing and left hind tibia were removed using a pair of forceps under the dissecting microscope. The fore wing and hind tibia were placed on a microscope slide using a soft camel hair brush and a drop of water added to spread the wings. Their lengths were measured to the nearest 0.01mm utilizing an ocular micrometer fitted on the dissecting microscope.

2.8 Statistical Analysis

In this experiment, data were analyzed using mean, percent parasitism, ANOVA and Tukey test. ANOVA was applied to find the variation between different developmental stages, egg incubation and forewing size, length of hind tibia and pupal weight of *P. xylostella*. Tukey test was applied to find the least significant difference and pair wise comparison of the development period between male and female and egg incubation period of *P. xylostella*. To check the fecundity of the parasitoids mean number of eggs was calculated in the female ovary.

3. Results and Discussion

3.1 Developmental Period of Different Stages and Egg Incubation Periods of *P. xylostella* in two Brassica Cultivars

Regarding the eggs mean incubation period, it was observed greater on Golden acre (3.45±0.51 days) as compared to Chinese cabbage (3.2±0.41 days). This result was significant economically but not statistically (Table 1). While, eggs once in life cycle, the number of eggs was laid singly or in groups (2-12n). It was yellowish white in color and cylindrical to diamond in shape.

Total larval period (1st instar - 4th instar) was monitored at both cultivars and found relatively higher in Chinese cabbage (11.35±0.99 days) than Golden acre (10.80±0.95 days). Data showed no significant difference in pre-pupal developmental period (days) at both cultivars. While, the pupal period (4.55±0.51 and 5.40±0.50 days) was recorded at Golden acre and Chinese cabbage, respectively. Total developmental periods (16.35±0.93 and 16.75±1.07 days) were observed at Golden acre and Chinese cabbage, respectively and showed slight difference among them.

3.2 Effect of cabbage cultivars on egg incubation period of *P. xylostella*

Results showed the variation between incubation period of egg and development period (days) of different stages of *P. xylostella* in relation to two cabbage cultivars (Golden acre and Chinese cabbage). $F_{cal.}$ (2.91) and F_{cri} (4.09) values were observed and there found no significant difference between the incubation period of eggs. In this case, the calculated value is less than the critical value as given (Table 9).

3.3 Effect of cabbage cultivars on total larval development period of *P. xylostella*

The result accepted null hypothesis insignificantly, the mean calculated (3.215%) and critical value (4.09%) was observed in the case of Golden acre and Chines cabbage on the development of the total larval period. There was no difference in larval period on both cabbage cultivars (Table 2).

3.4 Pupal development period of *P. xylostella* on two cabbage cultivars

The result showed the effect of cabbage cultivars (Golden acre and Chinese cabbage) on development period of larvae (*P. xylostella*). Because the calculated value (28.158%) was higher than the critical value (4.098%), here found a significant variation in pupal development period and also mean number (0.85) of pupae per plant were different on both cultivars.

Table 1: Mean (S.E) developmental period (days) of different stages of *P. xylostella* (ten pairs released) in each brassica cultivar in laboratory under controlled conditions

Brassica cultivars	Incubation of egg (days)	Larval period (days)				Total larval period (days)	Pre pupa (day)	Pupal period (days)	Total developmental Period (days)
		I instar	II instar	III instar	IV instar				
Golden acre	3.45±0.51	3.35±0.49	2.40 ± 0.50	2.35 ± 0.49	2.70± 0.47	10.80±0.95	1 ± 0	4.55 ± 0.51	16.35 ± 0.93
Chinese cabbage	3.2±0.41	3.55±0.51	2.45 ± 0.51	2.50 ± 0.51	2.85± 0.37	11.35±0.99	1 ± 0	5.40 ± 0.50	16.75 ± 1.07

3.5 Total development period of *P. xylostella*

In this study, results showed no variation in total development period of *P. xylostella* by the effect of both cultivars (Golden acre and Chinese cabbage), as calculated value (1.587) is less then critical value (4.098), it is non-significant.

Table 2: ANOVA and Tukey t-test on the development stages of *P. xylostella* on cabbage cultivars

Compare varieties	F_{cal}	F_{cri}	Result	Mean difference	Tukey Critical	Result
Incubation of egg	2.914 (0.0959)***	4.098	ANH	-	-	-
Total larval period (days)	3.215 (0.0809)***	4.098	ANH	0.55	0.62	ANH
Pupal period (days)	28.158 (0.0000)*	4.098	RNH	0.85	0.32	RNH
Total developmental Period (days)	1.587467 (0.2153)	4.098	ANH	-	-	-

Note: in () there is a p-value. *** and * are the level of significances at 10%, 5% and 1% respectively.

When, observed the development time from egg to adult, it was found that in two cultivars this was significantly different. The incubation of egg, larval period, pupal period and total developmental period of *P. xylostella* was observed on both cultivars viz. Golden acre and Chinese cabbage. It was found that all the factors were same in both cases except the pupal period, which was significantly different in two cultivars. Moreover, pupal period was observed to be greater in the case of Chinese cabbage. This was due to the allelochemicals in host plant which interact with the haemolymph of *P. xylostella* as suggested by [12].

3.6 Parasitism and Fecundity of First Generation Progeny of *D. insulare* in Growth Chamber under Laboratory Conditions

3.6.1 Parasitisation of larvae (*P. xylostella*)

Figure (1) showed that *D. insulare* (larval parasitoid) was reared on second larval instars of *P. xylostella* on infested cabbage cultivars. The higher parasitism level (59%) was monitored on Golden acre, while lower parasitism level (41%) was observed in case of Chinese cabbage in the experiment performed under controlled conditions.

3.6.2 Percent parasitism and fecundity of *D. insulare*

The larval parasitoids reared on both of the cabbage cultivars were observed in fecundity rates under controlled conditions. Results showed higher fecundity (61%) in case of Chinese cabbage whereas lower fecundity (39%) was observed in

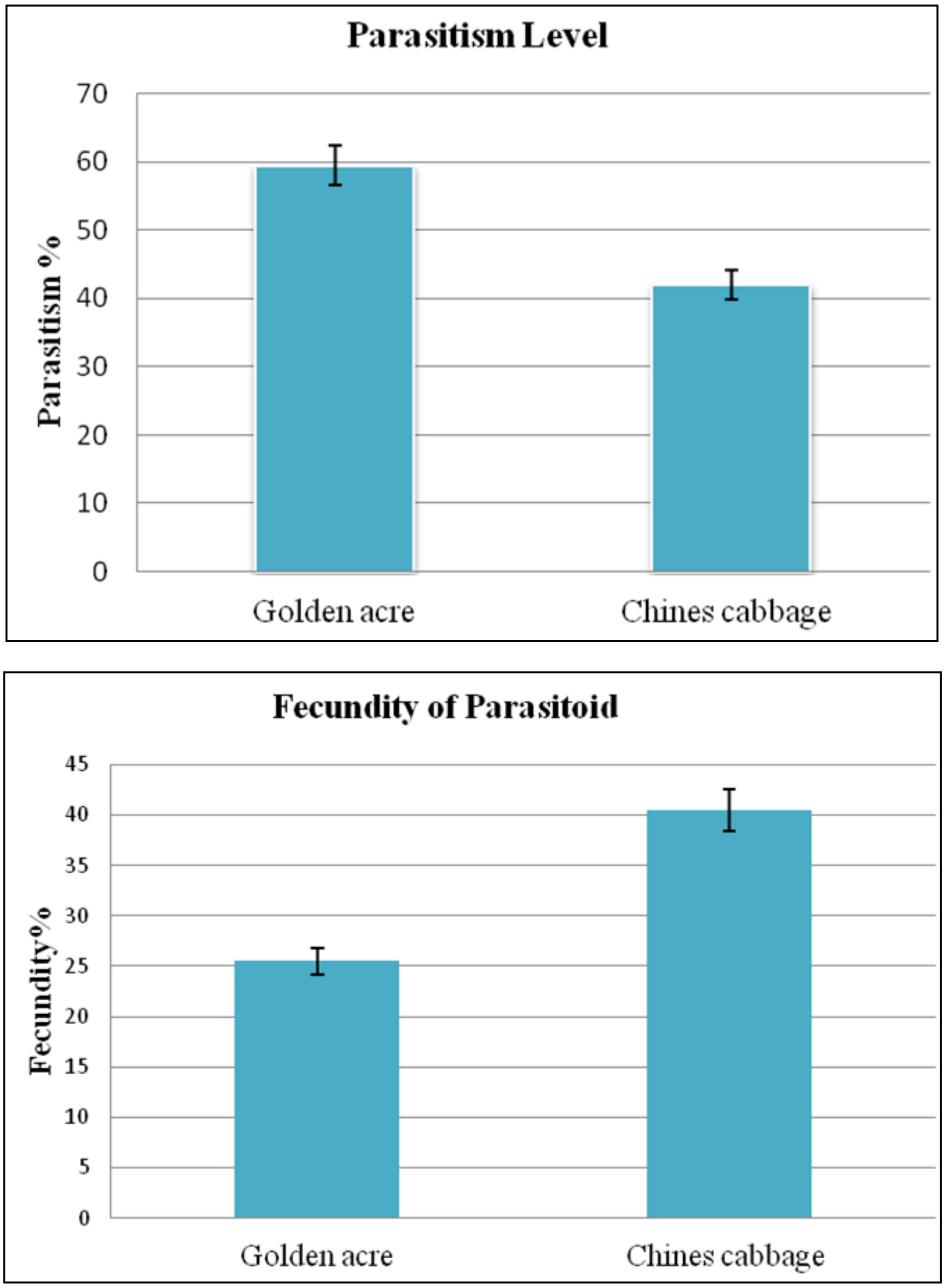

Fig 1: Comparative parasitism level and fecundity of D. insulare on P. xylostella in two cultivars of cabbage crop in laboratory. case of Golden acre, when *P. xylostella* was reared on these cultivars. Thus, Chinese cabbage affected more positively the next generation of parasitoid as compared to Golden acre.

3.6.3 Developmental Period of Different Stages and Adult Longevity of D. insulare (Female and Male) in two Brassica Cultivars under Laboratory

Results (Table 3) showed that D. insulare reared on cabbage species (P. xylostella larvae). Female and male egg-larval development period (6.34±0.49 and 6.5±0.81 days) was observed, respectively on Golden acre. The female and male egg-larval period (6.74±0.21 and 7.04±0.22 days) was recorded on P. xylostella on Chinese cabbage. Pupal period of female and male (6.81±0.74 and 7±0.68 days) was perceived on Golden acre. While on the Chinese cabbage pupal period of female and male (7.84±0.25 and 7.83±0.23 days) was recorded, respectively. Total longevity of females was 19.5±4.32 (days) on Golden acre and 21.32±1.56 (days) on Chinese cabbage. Male longevity on Golden acre and Chinese cabbage was found 20.3±5.18 and 21.92±1.47 days, respectively.

3.6.4 Pair-Wise Comparison of Development Periods between Female and Male D. insulare when Parasitoid Reared on P. xylostella Larvae on Different Cabbage Cultivars

This (Table 4) described the biology of P. xylostella which were reared on Golden acre and Chinese cabbage cultivars in a growth chamber under controlled conditions. In this experiment results showed a pair-wise comparison of life cycles

Table 3: Mean (S.E) developmental period (days) of different stages and adult longevity of *D. insulare* (female and male) in two cabbage

cultivars in laboratory under controlled conditions.

Host Cultivars	Egg to larval periods		Pre pupae to pupae period		Egg to Adult Period		Adult Period		Longevity	
	Female	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**
Golden Acre	6.34±0.49	6.5±0.81	6.81±0.73	7.00±0.68	13.15±0.0	13.50±2.60	6.34±0.9	6.80±0.1	19.5±4.32	20.3±5.18
Chinese Cabbage	6.73±0.49	7.04±0.21	7.84±0.25	7.83±0.23	14.57±0.70	14.87±0.54	6.73±0.20	7.04±0.38	21.3 ± 1.56	21.9±1.47

Table 4: Mean (S.E) development period (days), longevity, pupal weight, size of forewing and hind tibia of *D. insulare* on each cultivar

	Golden acre							Chinese cabbage						
Comparison	**Mean ± S.E**	**$F_{cal.}$**	**$F_{cri.}$**	**Result**	**Mean Differ.**	**Tukey Critical**	**Result**	**Mean ± S.E**	**$F_{cal.}$**	**$F_{cri.}$**	**Result**	**Mean Difference**	**Tukey Critical**	**Result**
Egg + Larval Period	6.86^f, 6.85^m ± 0.61f, 0.52^m	2.50	3.92	ANH	-	-	-	6.95^f, 7.6^m ± 0.52^f, 0.67^m	24.3	4.0	RNH	0.65	0.27	RNH
Pupal period	7.10^f,7.20^m ± 0.22f, 0.31^m	0.92	3.92	ANH	-	-	-	8.04^f,7.92^m ± 0.56^f, 0.52^m	1.0	4.0	ANH	-	-	-
Egg to adult period	13.8^f, 14.1^m ± 0.94f, 0.95^m	2.18	3.92	ANH	-	-	-	15^f, 15.52^m ± 0.94^f, 0.98^m	6.2	4.0	RNH	0.53	0.43	RNH
Adult period	6.7^f, 7.0^m ± 0.5^f, 0.4^m	6.5	3.92	RNH	0.24	0.19	RNH	6.97^f, 6.77^m ± 0.76^f, 0.61^m	1.8	4.0	ANH	-	-	-
Total longevity	20.5^f, 21.0^m ± 1.33^f, 1.31^m	4.12	3.92	RNH	0.49	0.49	RNH	21.9^f, 22.3^m ± 1.64^f, 1.55^m	0.9	4.0	ANH	-	-	-
Pupal weight	3.92^f, 4.10^m ± 0.26^f, 0.31^m	5.25	4.04	RNH	0.19	0.17	RNH	4.43^f, 4.46^m ± 0.31^f, 0.31^m	0.1	4.0	ANH	-	-	-
Forewing size	3.65^f, 3.31^m ± 0.00^f, 0.11^m	12.0	4.19	RNH	0.34	0.07	RNH	3.65^f, 3.27^m ± 0.00^f, 0.03^m	1.6	4.2	RNH	0.38	0.02	RNH
Hind tibia length	1.25^f, 1.18^m ± 0.46^f, 0.49^m	17.6	4.19	RNH	0.07	0.04	RNH	1.23^f, 1.14^m ± 0.04^f, 0.02^m	38.8	4.2	RNH	0.09	0.03	RNH

and pupal weight. The size of forewing and hind tibia length were also measured. Accordingly, development time from egg to larval stage was 6.68±0.61 and 6.85±0.52 days in the case of Golden acre and Chinese cabbage, respectively. Similarly, adult development time of female and male parasitoid was 13.80±0.94 and 14.05± 0.95 days, respectively.

On the other hand, development time calculated value (F_{cal} = 2.50) is less than the critical value (F_{cri} = 3.92). There is no significant difference between female and male indirectly reared on a Golden acre as compared to Chinese cabbage cultivar. The highest value (24.25) and lowest value (3.95) was significantly different along with female and male development time, respectively. Accordingly, similar pupal development time F_{cal} = 0.92, F_{cri} = 3.92 and F_{cal} = 1.00, F_{cri} = 3.95 was observed for female and male on both cabbage cultivars, respectively. There found no significant difference whereas, F_{cal} = 2.18, F_{cri} = 3.92 was found on the development time of female and male on Golden acre. Contrary to this in case of Chinese cabbage, for the egg to adult development period F_{cal} = 6.23 and F_{cri} = 3.95 was observed for female and male, therefore the value showed significant difference between both cultivars.

The *D. insulare* adult female and male development time were recorded F_{cal} = 6.5 and F_{cri} = 3.92 on *P. xylostella* which was reared on Golden acre cabbage cultivar. There was a significant variation between female and male parasitism, as compared to the adult development time F_{cal} = 1.7 and F_{cri} = 3.95 of female and male. In case of total longevity time F_{cal} = 4.12, F_{cri} = 3.92 on Golden acre and total life time F_{cal} = 40.86, F_{cri} = 3.95 of *D. insulare* on Chinese cabbage was recorded, respectively. There was no significant difference was observed between female and male on Chinese cabbage cultivar.

The result was observed of *P. xylostella* pupal weight of female and male F_{cal} = 5.25, F_{cri} = 4.04 and F_{cal} = 0.07, F_{cri} = 4.04 on Golden acre and Cabbage cultivars, respectively. When compared there found significant variation, but no significant difference in pupal weight of parasitoid (female and male) on Chinese cabbage was observed, respectively. Furthermore, in case of measurement of forewing pair-wise comparison of female and male parasitoid on both cabbage cultivars (F_{cal} = 5.25, F_{cri} = 4.04 and F_{cal} = 0.07, F_{cri} = 4.04). There was significant difference between female and male on each cabbage cultivars. Similarly, in case of hind tibia measurement F_{cal} = 5.25, F_{cri} = 4.04 and F_{cal} = 0.07, F_{cri} = 4.04) of female and male length on both cultivars, as compared there was significant difference between female and male on each cabbage cultivars.

In this experiment, the trophic relationship was determined between *P. xylostella*, two varieties of Cabbage viz. Golden acre and Chinese cabbage and *D. insulare.* The effect of Golden acre and Chinese cabbage on parasitism level, development period, size, weight and longevity of *D. insulare* was revealed. These characteristics were different in the two different cultivars of Cabbage. Statistically, the development period in pupal stage was significantly different in two cultivars. There was a variation of 0.85 days between the developmental periods of pupae in the two cultivars.

Effect of Golden acre on female and male parasitoid developmental stages was also observed. As per result there was no effect of Golden acre on the developmental stages of both genders. There was a significant effect of Golden acre on the total developmental period of male and female stages. Developmental time of males on Golden acre was greater than the females. There was a significant effect of Golden acre on the total longevity of male and female life stages.

The longevity of males on Golden acre was higher than the females. The significant effect of Golden acre on the pupal weight of male and female was also found. This was greater in case of male individuals. Effect of Golden acre on the forewing and length of tibia was significant. In case of female the effect was pronounced.

Chinese cabbage affected the developmental time from egg to larvae significantly in male parasitoid. The period was relatively longer in females. There was no significant difference between the longevity, adult period and the pupal period of males and females. Whereas, Chinese cabbage had a significant effect on the forewing size and length of hind tibia both in males and females. Size of forewing was greater in females and so was the length of hind tibia.

The effects of two cultivars of Cabbage viz. Golden acre and Chinese cabbage were observed on development time of different life stages, total development time, total longevity, pupal weight, forewing and hind tibia of *D. insulare*. Development time from egg to larvae was significantly different in the two cultivars. It was higher in case of Chinese cabbage i.e. 6.95 and 7.6 days for females and males of *D. insulare*, respectively. The development time of pupa was non-significantly different in both cultivars. Whereas, adult development period was greater in case of Chinese cabbage, which was 15 and 15.52 days for females and males of *D. insulare*, respectively. No effect of cultivars was observed in case of adult development time and longevity of *D. insulare.* Variation was observed in case of pupal weight. It was found higher (3.92 and 4.10 for female and male, respectively) in the pupae, found on Golden acre. Golden acre and Chinese cabbage had similar effects on the size of the forewing and the length of hind tibia. This was due to the biochemical, morphology and the level of glucosinolates of the host plant as suggested by [13].

The quality of first tropic level influenced the development, fecundity, longevity, incubation period, weight, size as well as sex ratio of parasitoids [14]. Egg-larval period of *C. plutellae* was shortest on *E. arabicum* (7.4 days) and longest on *R. raphanistrum* (9.3 days) while that of *D. semiclausum* was shortest on *B. juncea* (6.7 days). *R. micrantha* and *R. raphanistrum* recorded the lowest cocoon weight of 1.67mg and 7.1mg from *C. plutellae* and *D. semiclausum*, respectively. Longest pupal period was recorded on *C. plutellae* and *D. semiclausum* reared on *B. oleracea* var. *acephala* and *R. micrantha*, respectively. Egg-adult development time of *C. plutellae* was significantly longer on *R. raphanistrum* (15.2 days) and shortest on *B. juncea* and *E. arabicum* (12.2 days) while that of *D. semiclausum* was longest on *R. micrantha* (16.1 days) and shortest on *E. arabicum* (12.4 days). Mortality was higher on wild crucifers than on the cultivated brassica species. In free choice tests, parasitism and parasitoid emergence were significantly higher on cultivated cultivars [15]. In a study conducted at Graham's town (South Africa), it was recorded that both *C. plutellae* and *D. mollipla* preferred to attack 2nd and 3rd instar hosts than 4th the instars in choice and non-choice tests. However, *D. mollipila* attacked more 4th instar hosts than *C. plutellae* [16].

3.6.5 Reproductive Potential and Mating Period of *D. insulare*

One day old adult female and three days old male mating duration was 6.40±0.09 minutes on Golden acre while, 6.53±0.09 minutes on Chinese cabbage. The ovaries of female (*D. insulare*) exposed by dissection and total number of eggs (13.32±0.9) observed in case of Golden acre while, total number of eggs (13.84±0.7) in case of Chinese cabbage (Table 5). The effect of Golden acre and Chinese cabbage was observed in the mating period and mature eggs in the ovary. The number of mature eggs of *D. insulare* was slightly higher in case of Chinese cabbage than Golden acre. The greater number of eggs was due to the healthy female, which found better nutrition on Chinese cabbage. The nitrogen contents and other compounds which affect the activities were different in the two cultivars, suggested by [17].

Table 5: Observed reproductive potential and mating period (minutes) of *D. insulare* on Golden acre and Chinese cabbage cultivars

Host cabbage cultivars	Mated age after emergence	Pre mating period	Mated period	Mature Eggs- ova
Golden acre	≤1 day old female× 3 days old Male	5.51 ±0.2	6.40 ±0.09	13.32±0.9
Chinese cabbage	≤1 day old female× 3 days old Male	5.66±0.2	6.53±0.09	13.84±0.7

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