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Biology of Cabbage Butterfly, *Pieris brassicae* (Linnaeus) on three Cruciferous crops under Laboratory Conditions

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ABSTRACT

The impact of 3 different cruciferous crops was investigated on the biological parameters of *Pieris brassicae* (L.) under laboratory conditions at 27±1 ˚C, 60-70 % RH and 14L:10D photoperiod. The results demonstrated that host plants showed a significant difference in certain growth parameters of *P. brassicae*. Comparative investigations on 3 different host plants revealed that *P. brassicae*, on average required a maximum of 54 days to complete a generation on cauliflower but only 40 days on cabbage. Fecundity of *P. brassicae* on its different hosts ranged from 41.00 eggs (cauliflower) to 100.80 eggs (cabbage). The egg period of *P. brassicae* was recorded as lowest (1.80 days) on cabbage and highest on mustard (3.60 days). However, the average larval (16.40 days) and pupal (12.20 days) period was recorded as significantly shortest on cabbage with less variation in mortality among the three hosts. The longevity of *P. brassicae* male and female adults varied significantly on its different hosts. The highest male and female longevity of *P. brassicae* was recorded as 10.60 and 10.40 days on mustard and cabbage respectively. On average, the sex ratio was computed as 1:1.15 on mustard, 1:1.14 on cauliflower and 1:1.33 on cabbage. Overall, *P. brassicae* showed a high preference for cabbage when compared to the other two by revealing its shorter developmental period on cabbage.

1. Introduction

Cole crops are one of the most important vegetable groups in the world. Some of the brassicaceous crops such as cabbage, mustard, cauliflower, knol khol, broccoli *etc.*, are widely grown around the world. *Brassica oleracea* var. *capitata*, which is grown throughout India from the cooler northern half to the warmer southern part, is most frequently grown during the winter season and occupies an area of 4 lakh hectares. It stands in the 2nd position after China. In Meghalaya, the cabbage crop ranks second after potato and is grown in an area of 1960 hectares with a production of 42,783 MT (Anonymous, 2019). The full yield potential of cabbage is severely hampered due to the attack by various insect pests – Cabbage white butterfly, DBM, Flea beetle, Leaf webber, Tobacco caterpillar, Aphids & some other minor insect pests. *Pieris brassicae* (Linnaeus), often known as the cabbage white butterfly, is regarded as one of the most dangerous pests of cabbage and other crucifers in temperate, tropical, and subtropical areas of India. Since it is an oligophagous species, it substantially impairs the crop during different stages (Sachan and Gangwar, 1980) and alone causes more than 40 % yield reduction in the crop and makes most of the produce unfit for the human consumption (Ali and Rizvi, 2007). Germany suffered a complete failure of cole crops due to the noxious role played by this pest. All the stages of this pest are recorded throughout the year in Meghalaya and are reported to pass four generations on cabbage (Thakur and Deka, 1996) causing damage to the cole crops.

Large white cabbage butterfly, *P. brassicae* being an oligophagous pest preferred to attack only cole crops of families Brassicaceae and Tropaeolaceae. In the course of its

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life cycle, females deposit clusters of yellowish conical eggs on the upper and lower edges of the host plant's leaves. At the post-hatching, newly emerging, light-yellow neonates, begin by eating their own eggshell. In the course of its life cycle, females deposit clusters of yellowish conical eggs on the upper and lower edges of the host plant's leaves. Young neonates, which are light yellow in colour when they hatch, begin by eating their own egg shell. In the course of its life cycle, females deposit clusters of yellowish conical eggs on the upper and lower edges of the host plant's leaves. Young neonates, which are light yellow in colour when they hatch, begin by eating their own egg shell. In the course of its life cycle, females deposit clusters of yellowish conical eggs on the upper and lower edges of the host plant's leaves. Young neonates, which are light yellow in colour when they hatch, begin by eating their own egg shell. In the course of its life cycle, females deposit clusters of yellowish conical eggs on the upper and lower edges of the host plant's leaves. Young neonates, which are light yellow in colour when they hatch, begin by eating their own egg shell. In the course of its life cycle, females deposit clusters of yellowish conical eggs on the upper and lower edges of the host plant's leaves. Young neonates, which are light yellow in colour when they hatch, begin by eating their own egg shell. The most destructive stage *i.e.*, larva, gradually turns greenish yellow after feeding the host plant foliage gregariously (I-III instar) leaving the veins intact and later IV-V, disperse over the plant in course of time. At the end, the 5th instar caterpillar appearing greenish with black head and dorsum showing a black spot and short hairs distributed throughout the body becomes very destructive and sometimes even bore into heads (Sharma and Gupta 2009) resulting the death of the plant. Younus, 2004 recorded that a single larva of *P. brassicae* consumed 74-80 cm^2 of cole crops leaves, 85-87 % of which was consumed by the fifth instar. These larvae begin wandering and overwinters in the pupal stage on the walls, roofs, fence posts. The butterflies after coming out of the pupa search for oviposition sites.

Many of the researches has been already done on the several aspects on *P. brassicae* pertaining to population dynamics, management and so on (Raquid, 2004, Ramesh et al, 2014). However, most of the earlier works focused on the pest complex, taxonomy, integrated management of *P. brassicae* but the importance for biology in management has been ignored. Using the different host plants for biology to evaluate the developmental period in different rearing conditions has been reported to study on only few of the economically important pests with polyphagous nature. However, when analyzing the damage to cole crops, oligophagous pests like *P. brassicae* were given the least emphasis, and there were few attempts to show how different host plants affected *P. brassicae*. (Saeed et al. 2010; Hasan and Ansari 2010a, b, c, 2011).

Biology studies of a pest can be useful to know the habit, habitat and important events of the life cycle. Detailed study and thorough knowledge of the various biological parameters help in understanding the pest status on the crop thus useful in determining the specific stage at which management decisions should be taken. But it is not fully understood whether host plants and rearing circumstances affect *P. brassicae* at all growth stages. Therefore, the purpose of this study is to ascertain the effects of various host plants and the environment of *P. brassicae* rearing on its biological characteristics.

2. Materials and methods

The experiments were conducted during 2021-2022 in the Entomology laboratory. Insect populations of cabbage butterfly, *P. brassicae* collected from the Experimental farm, CPGS-AS, Umiam, Meghalaya were reared in the Entomology laboratory, School of Crop Protection, CPGS-AS, Umiam, Meghalaya.

2.1 Insect strains

Insect strains from the egg stage were considered for a laboratory study on the biology of the three cole crops described above. In a similar manner, *P. brassicae* was also reared and maintained under lab conditions (temperature 27±1, 60-70 % relative humidity and 14L:10D).

2.2 Host Plants used for studying biology of *P. brassicae*

Biology of the cabbage butterfly, *P. brassicae*, on three different host plants, including mustard (Variety: Kranthi), cauliflower (Variety: White treasure), and cabbage (Variety: Golden acre), was investigated. These varieties are commonly grown in Ri-Bhoi district of Meghalaya and show high susceptibility to *P. brassicae* (Singh et al, 2020). Biological parameters of *P. brassicae* were studied under laboratory conditions.

3. Mass rearing and maintenance of the insect strains

The eggs (Plate 1a) were placed in sterilized Petri plates (9 cm diameter). The moistened filter papers were kept inside the Petri plates to prevent the desiccation of the eggs. The field-collected larvae (Plate 1b) were reared on fresh, healthy and tender leaves of cruciferous crops throughout the experiment. After complete hatching of the eggs, the larvae were kept in the Petri plates. After reaching 2nd instar, the larvae were shifted to plastic jars having a size of 15 × 10 cm^2. The jars were covered with muslin cloths with the aid of a rubber band, and pesticide-free, fresh, and sensitive leaves of crucifers were regularly offered as needed. Pupae (Plate 1c) were kept separately in a separate jar after one day of their formation. After emergence, adult insects

(Plate 3a & 3b) were released in the ratio of 1:1 (female: male) for mating in the wooden rearing cages having size of 45 × 45 × 54 cm^3 containing fresh cabbage seedlings for oviposition. Cotton swab with 20 % honey solution + Vitamin E was provided as a source of food for the adults.

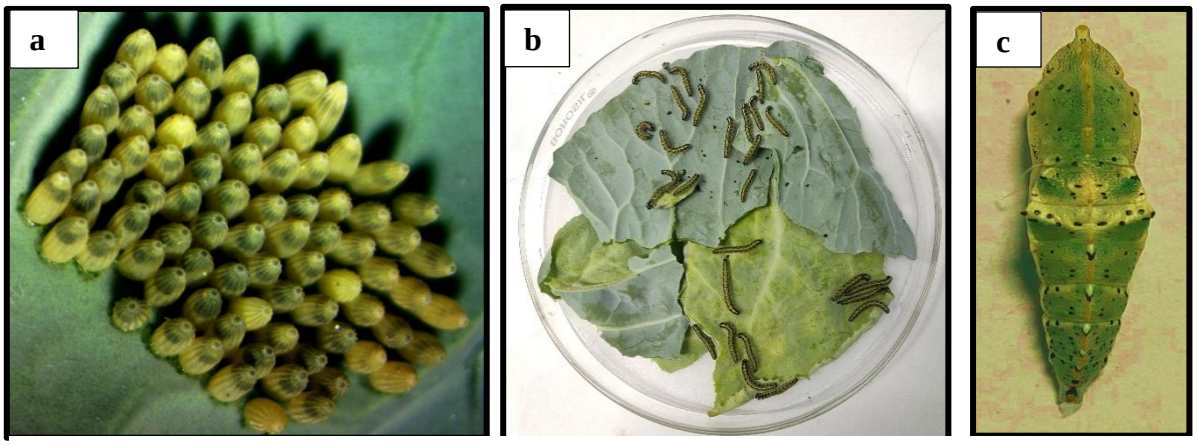

Plate 1(a). Eggs of *Pieris brassicae* **1(b)** Larvae of *Pieris brassicae* **1(c)** Pupa of *Pieris brassicae*

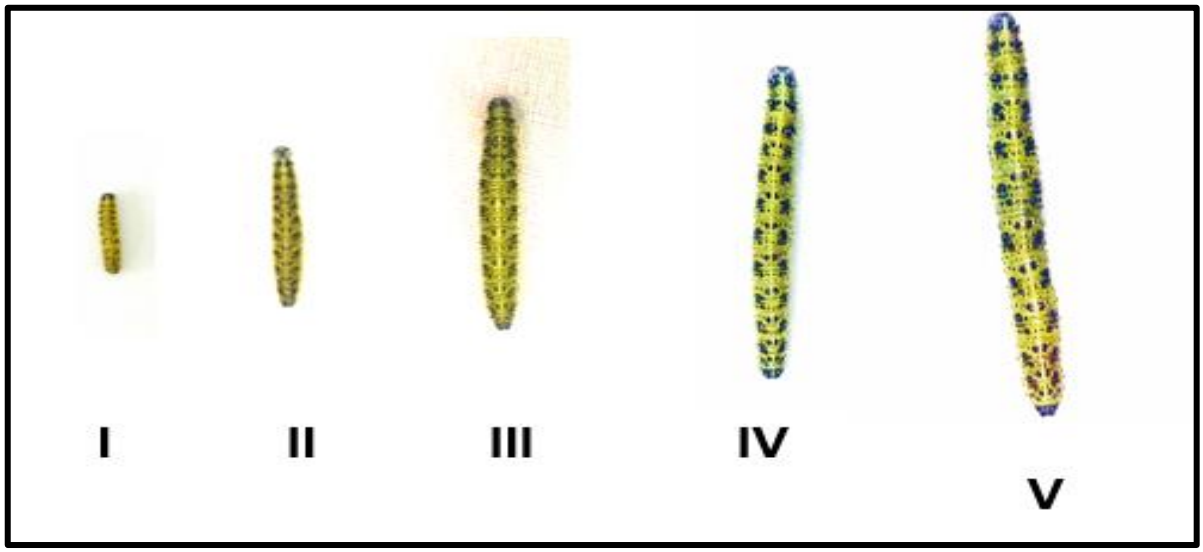

Plate 2. Five larval instars of *Pieris brassicae*

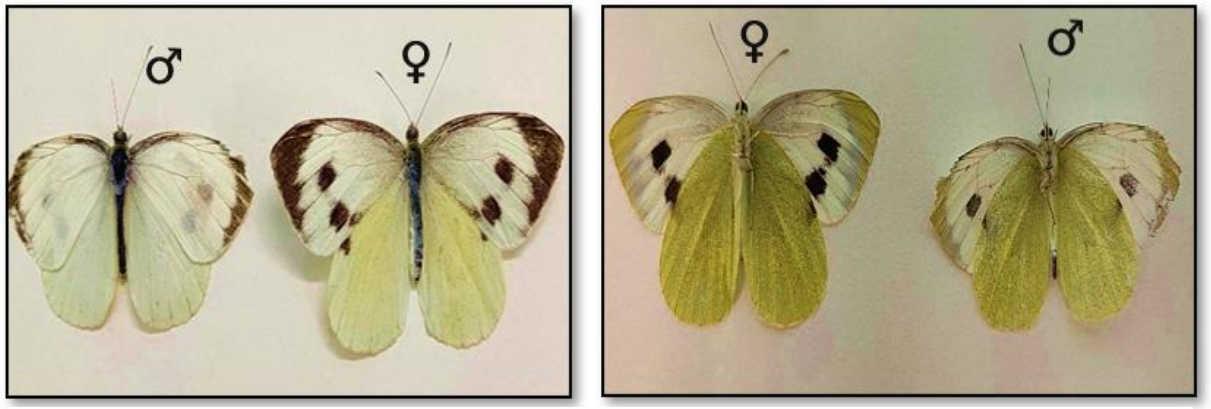

Plate 3(a) Dorsal view of adult male and female **3(b)** Ventral view of adult male and female

2.4 Experimental conditions

The experiment started from the egg stage of the test insects. Until hatching, the eggs were collected and placed in a clean plastic containers. Upon hatching the larvae of uniform age were provided with fresh leaves for the second generation. The experiment was carried out in a completely randomized design (CRD), and each treatment was replicated five times. A number of 10 larvae were used for each replication. Observations were taken on the developmental period (incubation, larval and pupal period in days) and weight (g) of different life stages of *P. brassicae*. Data obtained were utilized for the comparison of the effect of rearing conditions on the biology of insects.

2.5 Statistical Analysis

All data were subjected to ANOVA (analysis of variance) for evaluating the of host plants influence on the biological parameters of *P. brassicae*, and the differences between treatments were analyzed at a significance level of 0.05. Statistical analysis was done using Software package, SPSS v 13 Lal and Ram (2004).

3 Results and discussion

According to the findings, the number of days taken for the development of *P. brassicae* on cabbage was significantly lower as compared to the other two. The shorter development period and higher fecundity of cabbage indicate its host preference for *P. brassicae*.

3.1 Effect of different host plants on the biology of Cabbage butterfly, *P. brassicae* under laboratory conditions

The egg period of *P. brassicae* was recorded daily till all the eggs hatched. The average egg period varied from 1.80-3.60 days. The egg period was observed to be maximum on mustard (3.60 days) and the minimum was found to be on cabbage (1.80 days) (Table 1, Fig. 1). Thapa (1987) and Thakur and Deka (1997) reported that the average egg period to reach maximum up to 3.51 days which are at par with our findings. The egg period was found to be minimum for cabbage among the three hosts (cabbage, cauliflower and mustard) which is in agreement with the findings reported by Kamboj *et al.* (2005) in their respective biology studies of *P. brassicae*. The larval period was recorded from the neonates reared in petriplates which passes through five instars (Plate 2) to pupate. The larval period varied from 16.40-18.40 days. The larval period was observed to be maximum on cauliflower (18.40 days) followed by mustard (16.80 days) and the minimum was found to be on cabbage (16.40 days) (Table 1, Fig. 1). Chen *et al.* (2004) and Chahil and Kular (2013) in their biology studies of *P. brassicae* reported that the respective larval period of *P. brassicae* on cabbage and mustard varied in the range of 14.30-19.69 days which shows slight similarity with our findings.

The 5th instar larvae of *P. brassicae* feed more and suddenly stops feeding by shrinking in size which is called pre-pupa. *P. brassicae* was observed to pupate on the muslin cloth and on the walls of plastic jar. The prepupal and pupal period from our study were in the range of 1.40-2.60 days and 12.20-19.60 days respectively. Maximum pupal period was recorded on cauliflower (19.60 days) and minimum on cabbage (12.20 days). Chahil (2006) reported that mean pre-pupal and pupal period was 2.09 days and 12.82 days, respectively suggesting similarities with our study. The pupal period varies accordingly with the host chosen, temperature and relative humidity of the rearing atmosphere. The above results on the pupal period are at par with the findings given by Thakur and Deka (1997) and Mehrkhou and Sarhozaki (2013). In addition, it was observed that the lowest pupal period (11.10 days) was recorded on cabbage which is also reported in the findings by Wilbur (2011) and Kamboj *et al.* (2005)

The longevity of *P. brassicae* male and female butterflies ranged from 5.60 days-10.60 days and 7.80 days-10.40 days respectively. The male butterflies obtained from the culture reared on mustard lived for 10.60 days whereas the culture reared on cabbage and cauliflower lived for 8.80 days and 5.60 days, respectively (Table 1 Fig. 1). The female butterflies obtained from the culture reared on cabbage lived for 10.40 days whereas the culture reared on mustard and cauliflower lived for 8.40 days and 7.80 days, respectively (Table 1, Fig. 1). The females lived longer when compared to males which are in agreement and in conformity with the findings of Pandey *et al.* (2015). Adult male and female longevity was found to be longer on cabbage as compared to the other two hosts in our study which is in agreement with the findings reported Kamboj *et al.* (2005) and Khan and Kumar (2017). Hasan *et al.* (2008) recorded that the male and female longevity (8.98 days and 10.30 days) respectively on cabbage which is similar with our results.

Table 1. Comparative effect of different host plants on the biology of Cabbage butterfly, *P. brassicae* under laboratory conditions

Biological Parameters	Host		
	Cabbage (Mean± SD) *	Cauliflower (Mean± SD) *	Mustard (Mean± SD) *
Egg period	1.80±0.84	3.40±0.55	3.60± 0.55
Hatching %	96.20±1.30 (78.87)	88.80±2.38 (70.51)	86.20±3.63 (68.26)
Larval period (Days)	16.40± 0.55	18.40 ± 1.52	16.80 ± 0.82
Prepupal Period	1.60 ± 0.89	1.40 ± 0.89	2.60 ± 1.14
Pupal period (Days)	12.20 ± 0.45	19.60 ± 0.89	19.00 ±1.58
Male longevity (Days)	8.80 ± 3.21	5.60 ± 0.55	10.60 ± 4.04
Female longevity (Days)	10.40 ± 2.59	7.80 ± 3.21	8.40 ±3.05
Fecundity	100.80 ± 9.76	41.00 ±0.71	49.00 ±2.74
Oviposition Period	2.20 ±1.30	5.00 ± 1.10	1.80 ± 0.84
Total life cycle duration	26.60 ±1.67	34.00 ±1.41	30.40 ±2.19

Note: (Mean± SD) * is the mean of five replications and standard deviation, Figures within parenthesis are angular transformed values

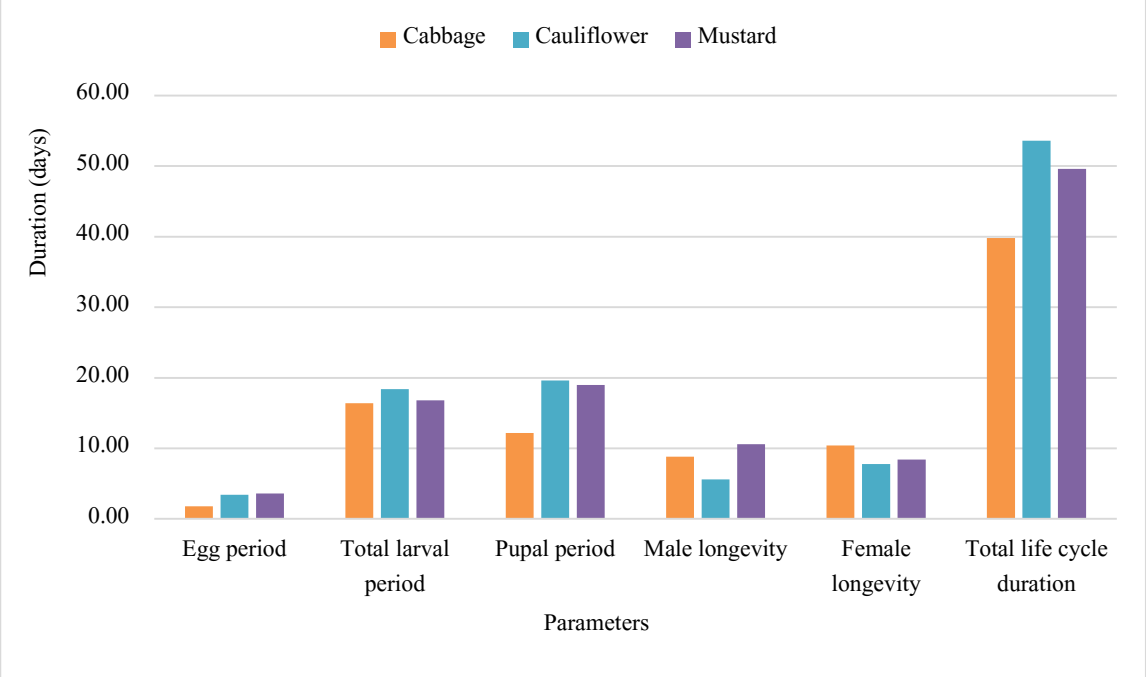

Figure 1. Effect of different host plants on the life cycle duration of *P. brassicae*

3.2 Effect of different hosts on larva and pupa of *P. brassicae* under laboratory conditions

In the present investigation, the percentage larval mortality of *P. brassicae* studied on three different hosts revealed the lowest mortality was on mustard (2.54 %) and the highest mortality was on cabbage (2.82 %). This may be attributed to the hard tissue texture and trichomes on leaves for the variety chosen. The larval mortality in cabbage was recorded as a minimum which is in agreement with the results of Hasan and Ansari (2010a). Larval mortality recorded on cabbage was found to be narrowly significant when compared to the other two hosts (Table 2.) The larval length (5th instar) was in the range of 24.66-30.34 mm which is in near conformity with the results of Sadozai and Khan (2014) in which larval length was reported at maximum to reach 32.00 mm. The larval length (size) varied from 24.66-30.34 mm in length. The longest larval length was observed to be (30.34 mm) on cauliflower followed by mustard (24.66 mm) and the smallest larval length was found to be on cabbage (29.60 mm) (Table 2, Fig. 2). This is due to the difference in the leaf thickness of

cabbage from cauliflower and mustard and the ease in feeding the cauliflower leaves of slender thickness.

The maximum pupal length was found to be 20.82 mm on cabbage followed by cauliflower (20.18 mm) which was statistically at par with mustard (20.14 mm). The pupal weight was taken for a day-old pupa. The average pupal weight ranged between 0.27 and 1.91 mg. The maximum pupal weight was observed on mustard (1.91 mg) followed by cabbage (0.33 mg) which was statistically at par with mustard (0.27 mg). The pupal recovery percentage was taken from the number of pupae survived to the total number of pupae formed from the 5th instar larvae. The average percentage pupal recovery was observed to be minimum on cabbage (47.20 %) followed by mustard (53.60 %) and cauliflower (73.60 %) (Table 2, Fig. 2).

The pupal recovery from our studies was observed to be in the range of 47.20 %-73.60 % and similar results were also identified and reported by Aslam and Suleman (1993) showing similar range of pupal recovery % when worked out on the different cruciferous crops (cabbage, sarson, turnip and radish). Pupal length (> 20 mm) was recorded significantly higher for cabbage and is in conformity with the studies of Wilbur (2011). Significantly lower pupal weight was observed on cabbage and cauliflower which are associated with rapid developmental period on the hosts which are in similar to the findings of Hasan and Ansari (2011).

Table 2. Comparative effect of different hosts on larva and pupa of *P. brassicae* under laboratory conditions

Biological Parameters	**Host**		
	Cabbage (Mean± SD) *	Cauliflower (Mean± SD) *	Mustard (Mean± SD) *
Larval length (mm)	24.66 ± 2.08	30.34 ± 0.08	29.6± 0.25
Larval mortality (%)	2.82±0.04 **(10.78)**	2.58±0.02 **(10.37)**	2.54±0.10 **(10.23)**
Pupal length (mm)	20.82± 0.17	20.18± 0.04	20.14± 0.02
Pupal weight (mg)	0.33± 0.01	0.27± 0.02	0.29± 0.01
Pupal recovery (%)	47.20±0.86 **(43.38)**	73.60±0.40 **(59.06)**	53.60±0.51 **(47.05)**

Note: (Mean± SD) * is the mean of five replications and standard deviation, Figures within parenthesis are angular transformed values

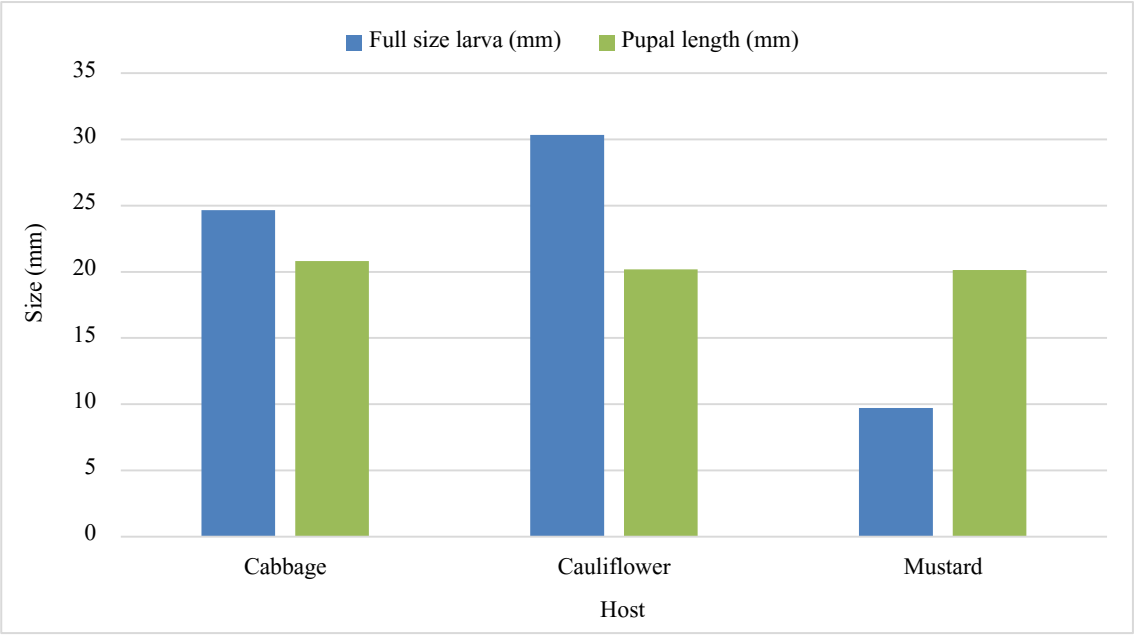

Figure 2. Effect of different host plants on larvae and pupae of *P. brassicae*

3.3 Effect of different hosts on adult emergence and sex ratio of *P. brassicae* under laboratory conditions

The adult male and female butterfly emergence percentage was calculated based on the morphological difference showed by the spots on the fore wings. The females have two black spots on the dorsal side of each forewing whereas the males do not have such black spots. The average male emergence percentage was observed to be minimum on mustard (28.20 %) followed by cabbage (34.87 %) which was statistically at par with cauliflower (37.60 %) (Table 3, Fig. 3). Similarly, the female emergence percentage was calculated and was found to be 62.47 % on cabbage, 32.80 % on cauliflower and 18.00 % on mustard (Table 3, Fig. 3). Different host plants showed significant variation on the adult emergence % which varied in the range of 28.20-37.60 % (male) and 18.00-62.47 % (female). However, the overall results suggested higher adult emergence % in the populations maintained on cabbage host plant among the three studied host plants. Higher adult emergence % was also reported on cabbage host plant in the studies of biology of *P. brassicae* on different cruciferous crops (cabbage, broccoli and mustard) conducted by Mahmood and Aslam (1984) which is similar with our findings.

Female butterflies laid eggs on the undersurface of the leaf in clusters for three different host plants. The fecundity was found to be significantly different on the three hosts (Table 1). The highest number of eggs were laid on cabbage (100.80 eggs/ female) followed by mustard (49.00 eggs/ female) and the minimum was found to be on cauliflower (41.00 eggs/ female). The average fecundity of cabbage butterfly under lab conditions was recorded higher on cabbage (100.80 eggs/female) in contrast to lower on cauliflower (41.00 eggs/female) and the highest total number of eggs and number per cluster on cabbage suggested its preference and suitability for *P. brassicae* in comparison to the other two hosts *i.e.*, cauliflower and mustard. Similar findings were also reported from the biology studies on different cruciferous crops (cabbage, sarson, turnip and radish) by Aslam and Suleman (1993) where they recorded fecundity of *P. brassicae* > 100 eggs/female on the host plants.

The average hatching percentage was observed to be maximum on cabbage (96.20 %) followed by cauliflower (88.80 %) and in contrast to minimum on mustard (86.20 %) (Table 1). The highest number of eggs were hatched to neonates on cabbage for the reason that the smooth leaf texture on the undersurface of cabbage when compared to the other two hosts. The oviposition period of *P. brassicae* female was found to be maximum on cauliflower (5.00 days) followed by cabbage (2.20 days) and mustard (1.80 days) (Table 3) which are at par with the results reported by Bhowmik and Gupta (2017). Their results were probably due to the rearing conditions maintained in the laboratory.

Table 3. Comparative effect of different hosts on adult emergence and sex ratio of *P. brassicae* under laboratory conditions

Biological Parameters	Host		
	Cabbage (Mean± SD) *	Cauliflower (Mean± SD) *	Mustard (Mean± SD) *
Male emergence (%)	34.87±0.84 **(36.17)**	37.60±1.03 **(37.79)**	28.20±1.11 **(32.04)**
Female emergence (%)	62.47±0.43 **(52.20)**	32.80±0.86 **(34.91)**	18.00±0.95 **(25.06)**
Sex ratio (F:M)	1:1.33	1:1.14	1:1.50

Note: (Mean± SD) * is the mean of five replications and standard deviation, Figures within parenthesis are angular transformed values

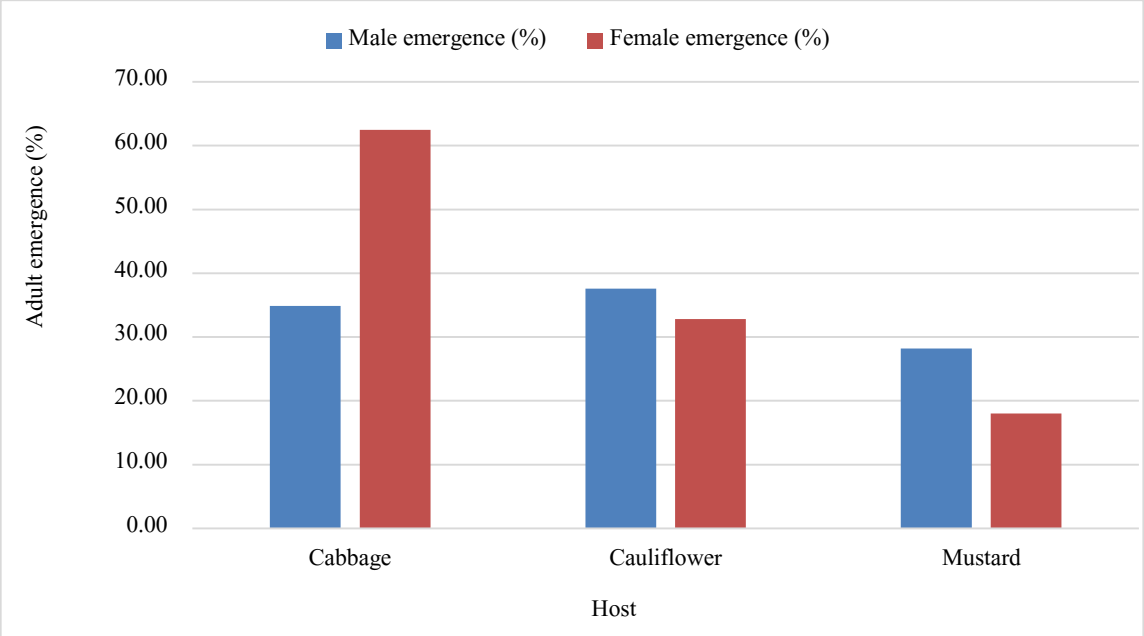

Figure 3. Effect of different host plants on the adult emergence of *P. brassicae*

The sex ratio (female:male) in cabbage, cauliflower and mustard was found to be 1: 1.33, 1:1.14 and 1:1.50, respectively. (Table 3).

Under controlled conditions, the total life cycle duration was recorded from the day of oviposition to adult emergence. The life cycle of *P. brassicae* completed within a shorter period of 39.80 days on cabbage in comparison to mustard and cauliflower where the total life cycle recorded was 49.60 and 53.60 days, respectively (Table 3, Fig. 3). Similar findings were reported by Hasan *et al.* (2008), Kamboj *et al.* (2005), Ali and Rizvi (2007) and Sood *et al.* (1994).

Therefore, our studies on biology revealed that cabbage is the most preferred host plant than other crucifers and indicates its higher suitability to *P. brassicae* which is in agreement with the findings of Hasan and Ansari (2011), Lytan and Firake (2012), Kamboj *et al.* (2005) and Rizvi *et al.* (2009). In addition, their studies also reported that among different cruciferous crops evaluated for biology, cabbage was found to be more preferred irrespective of the variety, rearing temperature and season chosen for the experiment.

4. Conclusion

These studies concluded that among the three host plants cabbage is the most preferred host by cabbage butterfly, *P. brassicae* when compared to the other two. The shorter development period and higher fecundity on cabbage indicates its high susceptibility to *P. brassicae.* Biology studies of the pest on various host plants play a vital role in the effective pest management practices.

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