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# EFFECT OF DIFFERENT BRASSICA VEGETABLES ON BIOLOGY AND DEMOGRAPHIC PARAMETERS OF *BREVICORYNE BRASSICAE* (HOMOPTERA: APHIDIDAE) UNDER LABORATORY CONDITIONS

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## ABSTRACT

Biological and demographic parameters of cabbage aphid, *Brevicoryne brassicae* (L.) were studied on four different Brassica hosts; Cabbage, Broccoli, China cabbage, and Knol khol under laboratory conditions. Age-stage, two-sex life table studies showed significantly higher intrinsic rate of increase ($r_m$) and finite rate of increase (**λ**) on China cabbage followed by Broccoli and Cabbage. Performance of cabbage aphids remained comparatively low on Knol khol in terms of intrinsic rate of increase ($r_m$), finite rate of increase (**λ**) and net reproductive rate. Total duration of immature stages was significantly longer on Knol khol than Cabbage and China cabbage, however, adult pre-reproductive period showed non-significant variation. Reproductive period, adult longevity and female fecundity upon all the studied plant species were significantly different. The minimum fecundity and adult longevity were observed on Knol khol. The probability of surviving nymph to adult female was 0.25, 0.35, 0.50 and 0.60 on Cabbage, Knol khol, Broccoli and China cabbage, respectively. The gross reproductive rate, life expectancy and age stage reproductive values were also minimal on Knol khol. On the basis of present life table studies, China cabbage remained the most susceptible host followed by both Broccoli and Cabbage while Knol khol proved to be the most unsuitable host. Present studies confirm Knol khol as comparatively more resistant against cabbage aphid and suitable to be cultivated as important vegetable crop in Pothwar region of Punjab.

**Keywords:** *Brevicoryne brassicae*, Brassica, life table, development, fecundity, age-stage two-sex

## INTRODUCTION

Cabbage aphid, *Brevicoryne brassicae* (L.) is one of the most serious pests of cruciferous crops like cabbage, broccoli, cauliflower, kale and knol khol (Bashir et al., 2013). Being highly host specific insect, it feeds exclusively on the phloem sap of brassica and closely related plants (Cole, 1996). Feeding sap from phloem causes stress in host plants, (Will et al., 2007) curling and chlorosis of leaves and transmission of different disease causing viruses (Raybould et al., 1999).

Different morphological and bio-chemical characteristics of host plants affect the survival rate, fecundity and mean generation time of herbivore insects (Awmack and Leather, 2002). Shiny and smooth surface of cabbage and cauliflower accessions exert antibiosis effects on cabbage aphid in field conditions (Ellis, 1996). High lectin contents in brassica sap can cause high mortality in *B. brassicae* due to binding with its stylets and foregut (Cole, 1994).The profile and concentration of glucosinlates and free amino acids in wild brassica species have significant effect on intrinsic rate of increase of cabbage aphid (Cole, 1996). Phenylalanine contents of brassica plants have negative effect on the aphid development (GaBrys, 2008).

To assess the impact of different morphological, physiological and biochemical characteristics of host plant on the biology and life history of insects, life table studies are too much necessary. Life table is a powerful tool to determine survival rate, net reproductive rate, mean generation time and intrinsic rate of increase of any insect to elucidate the existence of antibiosis in host plants (Chi and Su, 2006). Intrinsic rate of increase (rate of increase of females/female/day) is most useful life table parameter to compare the fitness of populations of a specific species across different food resources (Southwood, 1966). Present studies were conducted to explore the effect of different brassica vegetables on biological and demographic parameters of cabbage aphid and to find out the overlaps between different stages of insect development regarding age-stage specific survival rate, life expectancy and age-stage reproductive value on the basis of age-stage, two-sex life table theory. Because

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the cabbage aphid produces only females through parthenogenesis during active season, therefore only one sex was used in the analysis of life table. This study will be helpful for the researchers to devise push and pull strategy for ecological management of cabbage aphid on brassica vegetables depending on the host suitability through intercultural practices.

## MARERIALS AND METHODS

### Host plants

Different varieties of brassica viz., Cabbage (*B. oleracea* var. capitata), Broccoli (*B. oleracea* var. italica), China cabbage (*B. rapa* var. pekinensis) and Knol khol (*B. oleracea* var. gongylodes) were sown in pots containing equal proportion of soil, sand and rotten farmyard manure to ensure the availability of the leaves for the experiment. The pots were kept in green house of Department of Horticulture, PMAS-Arid Agriculture University Rawalpindi during cropping season 2012-13 to provide suitable condition for development of plants.

### Aphid Culture

Cabbage aphid population was reared and maintained in Biocontrol laboratory, Department of Entomology, PMAS-Arid Agriculture University Rawalpindi for one month on the leaves of respective host plants to be tested in the experiment. For this purpose, leaves of uniform age (four-to-six leaf stage) were detached from the plants and placed in petri dishes and 20-30 adults of *B. brassicae* were placed on leaves for 24 hours. Newly emerged nymphs were separated on the next day using camel hair brush and placed on leaf discs in plastic petri dishes (10 cm diameter) with lids having small hole in the centre. The petri dishes were lined with filter paper. Forty aphids (one aphid per petri dish) were used for each host plant. The leaves were changed daily and nymphs were again placed on them in natural position (Madahi and Sahragard, 2012). The culture was maintained under controlled laboratory conditions at 22±1ºC, 75±5% relative humidity and a photoperiod of 16:8 (L: D).

### Development time, survival, adult longevity and reproduction

Forty newly emerged nymphs of *B. brassicae* were transferred in petri dishes (one aphid per petri dish) and data were recorded daily for survival and molting up to $4^{th}$ instar. After reaching the adult stage, the data for each female were recorded regarding total pre- and post-reproductive period, adult longevity and fecundity until it died.

### Life table construction and statistical analysis

We constructed age-stage, two-sex life table following to the method described previously by Chi (1988). Both adult females and individuals dying at immature stages were considered in life table construction. Raw data of all individual aphids were analyzed in accordance with age-stage, two-sex life table theory (Chi and Liu, 1985) by using a program package TWOSEX-MS Chart (Chi, 2012) to calculate life table parameters like, age-stage specific survival rate ($S_{xj}$) (where x=age in days and j= stage and reflects the probability that a newly emerged nymph will survive to age x while in stage j), age-stage specific fecundity ($f_{xj}$), age-specific survival rate ($l_x$), age-specific fecundity ($m_x$), age-stage specific life expectancy ($e_{xj}$) (expected life time that an individual of age x and stage j may be expected to live. ), age-stage specific reproductive value ($V_{xj}$) (the contribution of age 'x' stage 'j' to the further population) and the population dynamics parameters ($r_m$, the intrinsic rate of increase; λ, the finite rate of increase; Ro, the net reproductive rate; T, the mean generation time).

Differences in the development time, longevity, reproduction and population dynamic parameters among *B. brassicae* on four Brassica species were analyzed using one way ANOVA followed by multiple comparison with Tukey-Kramer test (P<0.05). Moreover Bootstrap techniques was used to estimate the means/ and standard errors of population paramaters (Huang and Chi, 2013).

## RESULTS

### Development and survival of cabbage aphid

Maximum immature duration of cabbage aphid was observed on Knol khol (7.45 days) and minimum on both cabbage (6.64 days) and China cabbage (6.33 days) (Table 1).The survival curves illustrated in detail the survivorship and stage differentiation and depicted clear overlaps within different instars of immature stage and adult stage of cabbage aphid. The probability that a newly emerged nymph will survive to adult stage varied highly as 0.25, 0.35, 0.50, and 0.60 on Cabbage, Knol khol, Broccoli, and China cabbage, respectively (Fig 1).

### Reproduction of cabbage aphid on different *Brassica* vegetables

There were non-significant differences in adult pre-reproductive period of *B. brassicae* against all brassica vegetables species (Table 1). The maximum pre-reproductive period was observed on Knol khol (9.3 days) followed by Broccoli (8.11days), while the minimum on Cabbage (7.00 days) and China cabbage (7.42 days). The maximum adult longevity was observed on Cabbage which was significantly different from that on Knol khol. Total fecundity per female was significantly higher on Cabbage (37.8 nymphs/female) followed by Broccoli (22.0 nymphs/female) and China cabbage (20.0 nymphs/female) with the lowest on Knol khol (8.6 nymphs/female). Significantly lower age-specific survival rate ($l_x$) was observed on Cabbage than other hosts on 5th day, with $l_x$ values of 0.35, 0.6, 0.7 and 0.6 for Cabbage, Broccoli , China Cabbage and Knol khol, respectively. First nymph was laid at the age of 6, 7, 6 and 8 days on Cabbage, Broccoli, China cabbage and Knol khol (Fig.2). The fecundity curve showed two peaks both in Cabbage and China cabbage which were significantly higher than other hosts, while shortest peak was observed in case of Knol khol (Fig.2).

### Life expectancy and Reproductive value

The life expectancy of newly emerged nymphs ($e_{01}$) was 6.4, 7.95, 8.45 and 8.05 days on Cabbage, Broccoli, China cabbage and Knol khol, respectively (Fig 3). Age stage specific reproductive value ($V_{xj}$) reflects the contribution of age '*x*' stage '*j*' to the further population (Fig 4). The age-stage reproductive value of newly emerged nymph ($v_{01}$) followed the pattern of finite rate of increase (**λ**) (Fig 4). . In Cabbage, two major peaks were observed for the reproductive values of females; first at the age of 11 days and second at the age 15 days ($V_{11,5}$=5.0 and $V_{15,5}$ =5.0 ). In other host species, the peak started from the age of 9 days and remained up to 11 days as $V_{9,5}$ =2.0, $V_{9,5}$ =5.36, $V_{10,5}$ =4.87, $V_{11,5}$ =4.1 days for China cabbage, Broccoli and Knol khol, respectively. Both the number of peaks and individuals at peak reproduction contributed significantly to the population much more than any other age.

### Population Dynamics Parameters

Significantly higher intrinsic rate of increase ($r_m$) was observed on China cabbage followed by Broccoli and Cabbage, whereas lowest value was observed in Knol khol (Table 2). Finite rate of increase (λ) which reflects number of individuals added to the population per female per day reflected the same trend. Net reproductive rate ($R_o$) expresses the number of female offsprings that replace each female of previous generation. Significantly higher $R_o$ was observed on China cabbage (12.654) followed by both Broccoli (10.211) and Cabbage (9.461) and lowest on Knol khol (3.261). Significantly higher mean generation time (T) was observed for Knol khol followed by Broccoli, Cabbage and China cabbage, respectively.

**Table – 1: Developmental and Reproductive characters of *B. brassicae* on five Brassica vegetables**

| Statistics | Cabbage | Broccoli | China Cabbage | Knol Khol |
|---|---|---|---|---|
| **1st Instar** | 1.40±0.078ab | 1.5±0.095ab | 1.35±0.092b | 1.7±0.073a |
| **2nd Instar** | 1.18±0.070 c | 2.32±0.204ab | 1.7±0.144bc | 2.5±0.163a |
| **3rd Instar** | 2.08±0.123b | 1.63±0.1021b | 1.73±0.144b | 1.65±0.150b |
| **4th Instar** | 1.66±0.141a | 1.5±0.104a | 1.67±0.153a | 1.72±0.162a |
| **Total immature duration** | 6.33±0.225b | 7.17±0.115ab | 6.64±0.236b | 7.45±0.157a |
| **Adult pre reproductive period** | 0.8±0.25a | 0.78±0.18a | 0.91±0.20a | 1.3±0.41a |
| **Total pr reproductive period** | 7.0±0.21c | 8.11±0.14b | 7.42±0.18c | 9.3±0.30a |
| **Female Fecundity** | 37.80±4.16 a | 22.00±3.17 b | 20.00±2.55 b | 8.60±1.66 c |
| **Adult longevity** | 8.80±0.82 a | 6.1±0.46 b | 5.58±0.44 bc | 4.44±0.345 cd |

The data in the table are values ±SE; means within a row followed by different letters indicate significant differences at 5% level by using Tukey-Kramer test.

**Table – 2: Population dynamics parameter of *B. brassicae* on different Brassica species at 22±1 °C**

| | Parameters | Cabbage | Broccoli | China cabbage | Knol khol | LSD | F Value |
|---|---|---|---|---|---|---|---|
| r | **Original** | 0.209 | 0.214 | 0.249 | 0.104 | | |
| | **Bootstrap** | 0.206±0.025b | 0.208±0.02 b | 0.247±0.02 a | 0.101±0.02 c | 0.01 | $F_{159,3}$=299.56; F≤0.00 |
| λ | **Original** | 1.232 | 1.239 | 1.283 | 1.109 | | |
| | **Bootstrap** | 1.229± 0.031b | 1.231±0.03b | 1.280±0.03 a | 1.106±0.03 c | 0.01 | $F_{159,3}$=291.29; F≤0.00 |
| $R_o$ | **Original** | 9.45 | 10.8 | 12.52 | 3.25 | | |
| | **Bootstrap** | 9.461±2.46 b | 10.211±2.31 b | 12.654±2.29 a | 3.261±0.82 c | 0.92 | $F_{159,3}$=147.891 ;F≤0.00 |
| T | **Original** | 10.76 | 11.11 | 10.14 | 11.39 | | |
| | **Bootstrap** | 10.74±0.47 ab | 11.06±0.18 b | 10.22±0.18 a | 11.43±0.31b | 0.14 | $F_{159,3}$=110.66; F≤0.00 |

Values (means ±SE) within a row followed by different letters indicate significant differences at 5% level by using Tukey-Kramer test.

Where, r = Intrinsic rate of increase  **λ**= Finite rate of increase

$R_o$ = Net reproduction rate  T = Mean length of a generation

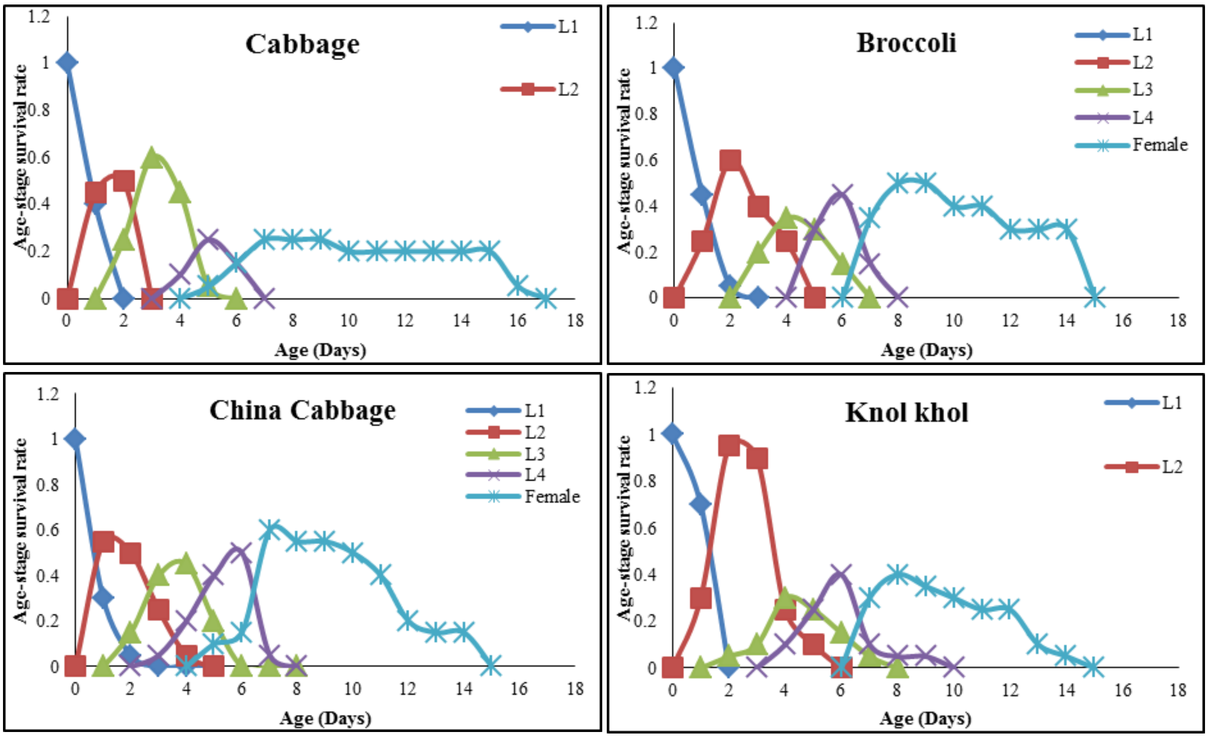


**Fig – 1: Age-stage survival rate (days) of B. brassicae reared on different Brassica species at 22±1°C, 70±5% relative humidity, photoperiod 16 : 8 (L : D).**

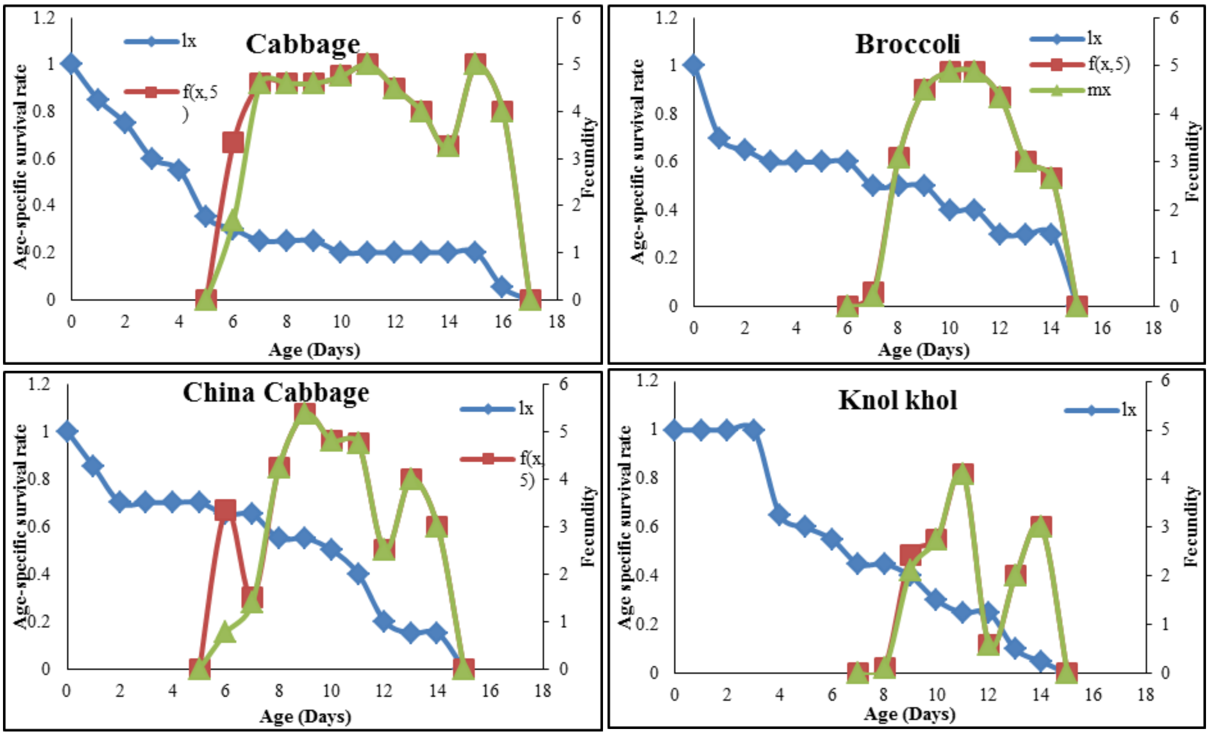


**Fig – 2: Gross Reproductive rate of *B. brassicae* reared on different Brassica species at 22±1°C, 70±5% relative humidity, photoperiod 16 : 8 (L : D).**

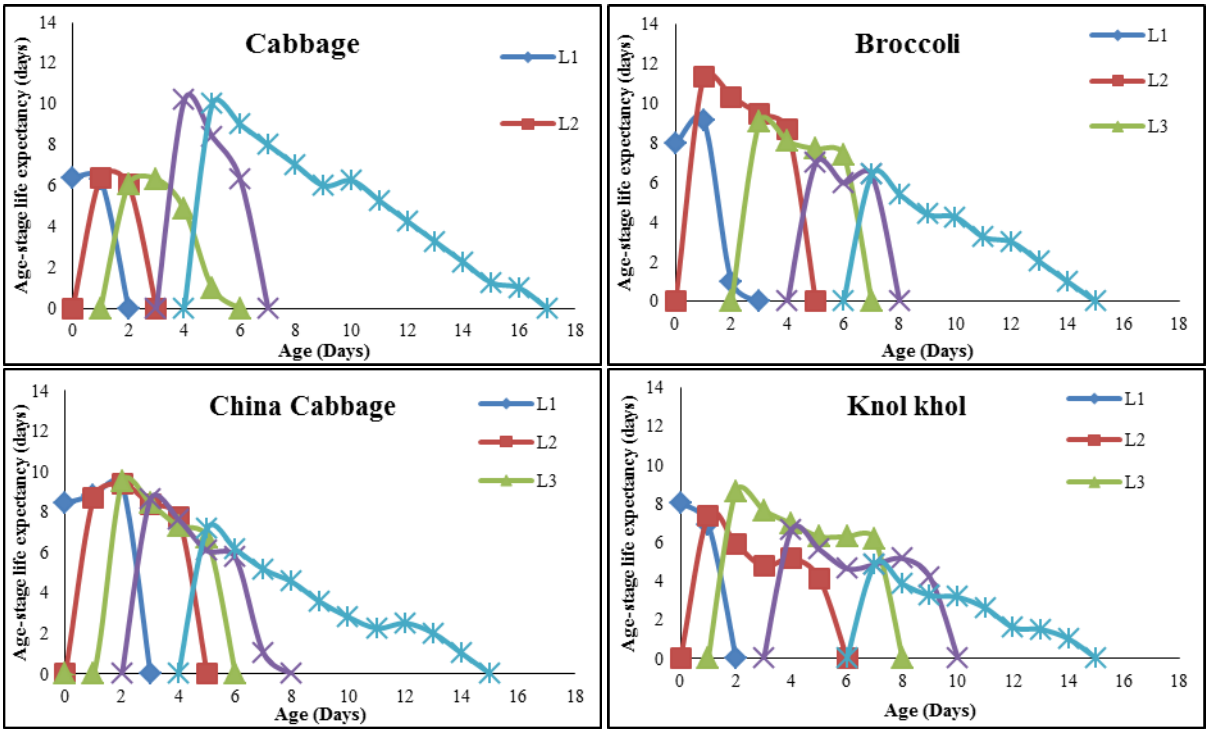


**Fig 3 Life expectancy of *B. brassicae* reared on different Brassica species at 22±1°C, 70±5% relative humidity, photoperiod 16 : 8 (L : D).**

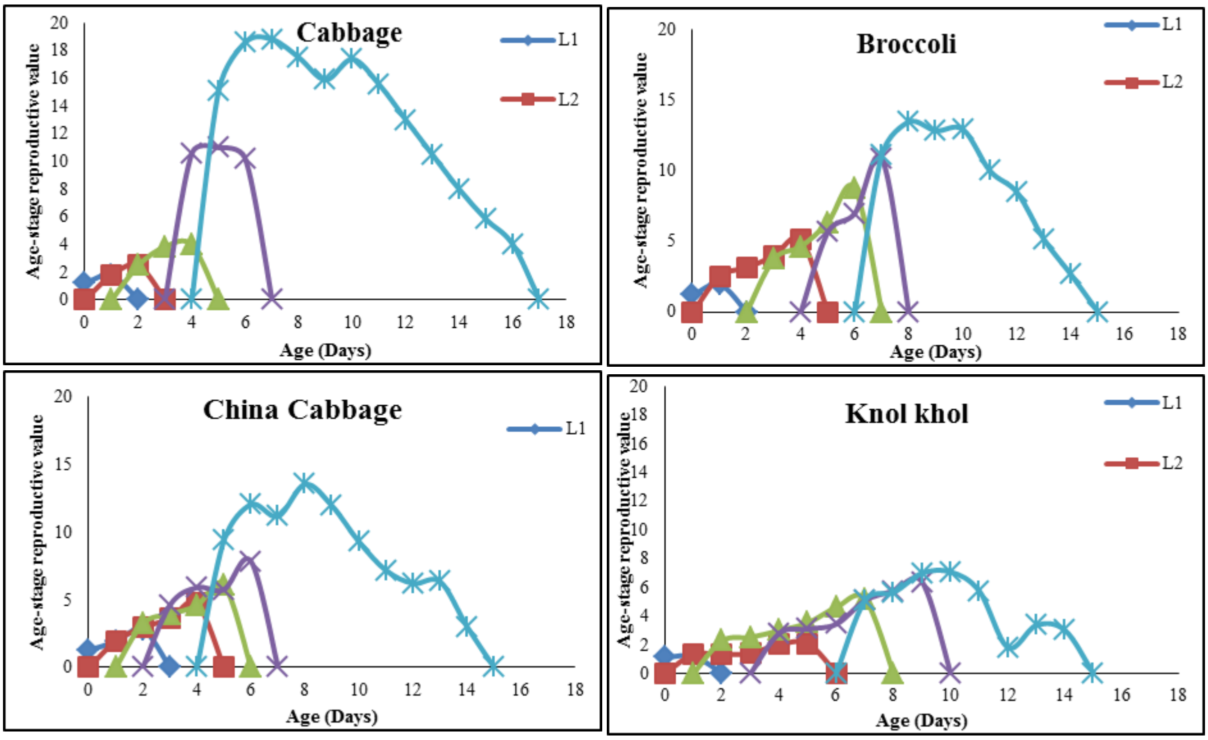


**Fig 4 Age-Stage reproductive value of *B. brassicae* reared on different Brassica species at 22±1°C, 70±5% relative humidity, photoperiod 16 : 8 (L : D).**

## DISCUSSION

A number of variations in biological and demographic parameters of cabbage aphids were observed on different brassica host crops in the present study. For example, a significantly longer duration of immature stages was recorded on Knol khol as compared to that on Cabbage and China cabbage. Moreover, total pre-reproductive period was recorded as 9.3, 8.11, 7.42 and 7.00 days on Knol khol, Broccoli, China cabbage and Cabbage, respectively. These findings are in agreement with the previous studies reflecting effect of host plants on development time of immature stages as Ulusoy and Bayhan (2006) reported shortest development time of immature stage of *B. brassicae* on cauliflower (8.9 days) and longest on cabbage (10.4 days). Recently, Jahen et al. (2014) observed immature duration of 6.7 days on Smilla and 8.10 days on White Cloud (different cauliflower cultivars). Anzabi et al. (2014) found the minimum immature duration of cabbage aphid on Geronimo (8.38 days) and the maximum on Okapi (9.16 days) genotype of canola in Iran. These variation in the rate of development may occur due to specific nutritional qualities (Zarghami et al., 2010), morphological structures (Ulusoy and Bayhan, 2006) and biochemical characters (Cole, 1997) of different host plants offered to the insects.

Mean number of nymphs of cabbage aphid/female varied from 37.80 (Cabbage) to 8.60 (Knol khol), which were less than those (52.43 to 60.8) on oilseed rape (Mirmohammadi et al., 2009). On cauliflower cultivars, mean number of nymphs laid per female ranged from 58.6 to 30.9 (Jahen et al., 2014). On canola, Aslam et al. (2011) reported 30.79 nymphs per cabbage aphid while Ulusoy and Bayhan (2006) recorded 52.91 nymph per female on cauliflower and 16.20 nymphs per female on turnip. This difference of reproductive rate on different cultivars reflects that some host plants are less suitable for *B. brassicae* than others to produce offsprings. Low level of fecundity on Knol khol in the present studies may be presumed to be the result of this factor.

Age-stage specific survival curves indicated clear overlaps between different stages of cabbage aphid i.e., at ages 4 and 7 days, we observed 2$^{nd}$, 3$^{rd}$, 4$^{th}$ instars and adult females at the same time in China cabbage (Fig 1). These overlaps document clear variations in stage differentiation and provide detailed information regarding life history of an insect. This is why age-stage, two-sex life table theory is more useful than traditional female age-specific life tables (Birch, 1948) in which variable developmental rate among individuals is ignored (Yu et al. 2005).

We observed maximum net reproductive rate on China Cabbage and minimum on Knol khol. Jahan et al. (2014) reported comparatively higher values of $R_o$ (30.83–56.550) for cabbage aphid on cauliflower cultivars. Fathipour et al. (2005) reported 15.92 females/female/day on the Green Cornet cultivar for cabbage aphid. Comparatively lower net reproductive rate on Knol khol (3.25 females/female/day) refers that it is more resistant to the cabbage aphid than China Cabbage (12.52 females/female/day).

The minimum generation time was observed in case of China cabbage (10.22 d) and the maximum on Knol khol (11.43 d). Singh and Parihar (1988) reported that faster developmental time on a particular host may allow a shorter life cycle, high reproductive productivity, more rapid population growth and reduce generation time.

In our studies, significantly higher value of $r_m$ was observed in case of China cabbage (2.47) followed by Broccoli (0.218) and Cabbage (0.209), while the minimum on Knol khol (0.104). Ulusoy and Bayhan (2006) found intrinsic rates of 0.2345, 0.2009 and 0.1976 for natural increase of cabbage aphid on Cauliflower, Cabbage, and Broccoli, respectively. Mirmohammadi et al (2009) reported $r_m$ values from 0.316 to 0.341 on Zarfam and Hyola 401 cultivars of canola. Maremela *et al.* (2013) also reported $r_m$ values (0.37-0.42) of cabbage aphid on rape, kale, Ethopian mustard and cabbage. Jahan et al. (2014) recorded the intrinsic rate of natural increase of cabbage aphid between 0.27 to 0.35 on Smilla and White Cloud cultivars of cauliflower.

Life table parameters provide deep insight to assess the fitness of insects against their particular hosts and provide more reliable information to predict the population growth potential of insects. Knol khol may provide a source of resistance for cabbage aphid in brassica vegetables. At the same time these crops may be used by the researchers to devise intercultural techniques in the vegetable cropping scheme to reduce the pest pressure on cabbage and manage it with less application of chemical pesticides.

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