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BIOLOGY OF *APHIS GOSSYPII* GLOVER ON COTTON AND BRINJAL FOR MASS REARING

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ABSTRACT

The aptness of two hosts viz., cotton and brinjal for mass rearing of *Aphis gossypii* Glover under laboratory conditions was investigated using the age-stage and two-sex lifetable method. The results showed that *A. gossypii* could complete its entire lifecycle on both hosts. The total nymphal duration (7.93± 0.33 days), reproductive period (6.95± 0.60 days), adult longevity (8.11± 0.68 days) and fecundity (24.66± 2.34 days) were significantly higher on brinjal than on cotton. The differences in pre-reproductive and post-reproductive periods on both hosts were not statistically significant. The mean reproductive period was longer on brinjal (6.95± 0.56 days) than that on cotton (5.06± 0.47 days); consequently, the fecundity was also significantly high in brinjal (24.66± 2.34 nymphs/ female) compared to cotton (14.11± 1.31 nymphs/ female). The difference in an intrinsic rate of increase, infinite rate of increase and doubling time were non-significant. In contrast, the net reproductive rate, gross reproduction rate, and mean generation time on brinjal were significantly higher. Lifetable parameters such as age-stage-specific survival rates, fecundity, life expectancy and reproductive value of *A. gossypii* were higher on brinjal compared to cotton. The results of this study indicate that brinjal is a better host than cotton for the mass rearing of *A. gossypii.*

Key words: *Aphis gossypii*, lifetable, cotton, brinjal, mass rearing, fecundity, reproductive period, intrinsic rate of increase, infinite rate of increase, doubling time, mean generation time

The cotton aphid *Aphis gossypii* Glover (Hemiptera: Aphididae) is a cosmopolitan, polyphagous species found in tropical, subtropical and temperate climates (Kersting et al., 1999). It has a wide host range, perhaps 900 species from 116 plant families, including Cucurbitaceae, Malvaceae, Solanaceae, Rutaceae, and Asteraceae, among others (Blackman and Eastop, 2000). *A. gossypii* causes direct and indirect damage; they reduce crop yield and quality through sap feeding, disease transmission, and the excretion of honeydew. It transmits several plant viruses, including Potato Virus Y (PVY), Cucumber Mosaic Virus (CMV), Tobacco Etch Virus (TEV), Zucchini Yellow Mosaic Virus (ZYMV), and Papaya Ringspot Virus-Type W (PRV-W) that cause economically significant damage to crops (Pinto et al., 2008). Thus, it is critical to control this pest and keep its number below the economic threshold level (ETL). In many agricultural locations, the cotton aphid has reportedly evolved a high resistance to several regularly used insecticides, including organophosphates, carbamates, pyrethroids, and neonicotinoids (Wang et al., 2007). Various studies are being conducted around the world to find effective chemical/botanical pesticides and biological control agents for managing this notorious pest. There is a need for mass rearing of *A. gossypii* for finding an alternative effective control measure for testing xenobiotic and transgenics for managing this notorious pest.

Insect rearing and multiplication techniques are crucial for biological research on insect pests and the development of management strategies. Humans have learned the art of rearing insects under laboratory conditions. A great deal about the biology of insects was known by introducing insects from the field into the lab and maintaining big colony sizes on natural or artificially developed diets. Insect mass rearing allows researchers to conduct experiments without the seasonal limitations that typically restrict the insect's life history. Mass rearing of insects in protective and controlled laboratory conditions prevents biotic and abiotic stresses, producing nominally healthy insects more likely to perform accurately in the bioassays. It is essential to provide insects with a nutritionally complete diet and a less expensive, quickly produced or procured diet to minimize the cost of multiplication

(Huynh et al., 2021). Rearing on a natural host is always advantageous as it provides complete nutrition. In this study, two natural hosts of *A. gossypii* were tested for their suitability for aphid mass production.

MATERIALS AND METHODS

The culture of *A. gossypii* was obtained from cotton fields of ICAR-Indian Agricultural Research Institute (IARI), New Delhi, India. Cotton (RCH- BG II)/ brinjal (Bhagyamathi) leaves were excised from plants, washed with tap water and air dried. The leaf petioles were dipped in a small glass vial (3 cm dia; 5 cm height) filled with fresh water. The leaf was affirmed into the bottle with a cotton plug and parafilm, and the whole set-up was placed into a cylindrical plastic container (15cm in height x 10cm in diameter). Individual aphid-rearing chambers were set up by a single cotton/ brinjal leaf. The gravid females were released on fresh cotton/ brinjal leaves, i.e., five females per leaf for producing nymphs. After releasing gravid females, the container was covered with a single layer of muslin cloth to prevent aphid migration. The aphid culture was maintained in a BOD incubator on cotton/ brinjal leaves at 18± 2°C, 16:8 hr, light: dark photoperiod, and 70± 10% RH. The females were inspected after 24 hr for fecundity to have a cohort of the first nymphal stage with the same age (<24 hr); all the aphids except one new born nymph/leaf were removed using a camel's hair brush (45 nymphs on cotton and 45 on brinjal). Fresh leaves were provided after every six days in cotton and four days in brinjal. These nymphs were observed every 24 hr till their death; the duration of each instar, pre-reproductive, reproductive and post-reproductive periods, adult longevity, total life cycle and fecundity were recorded and analyzed.

According to the age-stage, two-sex lifetable principle (Chi et al., 1985) and method (Chi et al., 2006), twelve parameters; Age-stage-specific survival rates (*Sxj*), Age-specific maternity (*lx*mx*), Age-specific survival rate (*lx*), Age-stage-specific fecundity (*fx*), Age-stage-specific life expectancy (*exj*), Finite rate of increase (λ) and Age-stage-specific reproductive value (*Vxj*), Intrinsic rate of increase (*r*), Net reproductive rate (*R0*) and Mean generation time (*T*) were calculated, and the age-stage, two-sex lifetables of *A. gossypii* on two hosts were established. Each parameter was calculated using the TWOSEX-MSChart 2020 software (http://140.120.197.173/Ecology/prod02.htm); the standard errors were estimated using bootstrapping with 100,000 repetitions. The figures were plotted using Sigmaplot v12.5 software (Systat Software, San Jose, CA, USA), and the statistical significance of the observed differences was assessed using TWOSEX-MSChart software. $P<0.05$ was considered statistically significant when evaluating differences between groups using paired bootstrapping. The differences in biological parameters of cotton aphids on two hosts were analyzed by t-test using WASP version 2.0 (Web Agri Stat Package., ICAR-CCARI, India).

RESULTS AND DISCUSSION

The duration of each developmental stage of *A. gossypii* on selected hosts are presented in Table 1. Duration of 1st, 2nd and 3rd nymphal instars and adult longevity were significantly longer on brinjal as compared to cotton. The mean reproductive period (6.95± 0.60 days) and mean fecundity (24.66± 2.34 nymphs/ female) were higher on brinjal than on cotton. The lifecycle duration was 16.04± 0.97 days on brinjal, whereas in cotton it was 12.27± 0.75 days. The fecundity was significantly higher on brinjal than on cotton, which could be attributed to a more extended reproductive period and adult longevity on brinjal. In the present study, mean fecundity of *A. gossypii* on cotton was 14.11± 1.31 nymphs/ female, which is in line with the findings of Razmjou et al. (2006) reported as 15.30 nymphs/ female and Nimbalkar et al. (2010) reported 17.32 nymphs/ female as mean fecundity of *A.gossypii* on cotton. Higher fecundity on brinjal suggests that brinjal provides better nutrients and less resistance to aphids. Saha et al. (2016) also reported that developmental time and fecundity of *A. gossypii* were significantly higher when fed on the brinjal plant compared to the cotton plant, which is consistent with our findings. The development of insects generally depends on the quality of the diet in the first few instars, which was different among the host (Barros et al., 2010). The longer nymphal duration on brinjal than cotton might have helped aphids take up more nutrients in the nymph stage which helped robust ovary development and fecundity during the adult stage on brinjal.

The intrinsic rate of increase (r) and finite rate of increase (λ) of the *A. gossypii* population were > 0 and > 1, respectively, for both cotton and brinjal, indicating that aphids could survive on both the hosts (Table 1). The differences in r, λ and doubling time (DT) were non-significant in the two hosts. The net reproductive rate (R_0), gross reproduction rate (GRR), and mean generation time (T) were significantly higher on brinjal as compared to cotton. The "r" represents

Table 1. Biological and population parameters of *A. gossypii* (mean± SE) on brinjal and cotton under laboratory conditions

Biological parameters			
Stage/ duration	Cotton (days)	Brinjal (days)	t value
1st instar duration	1.62± 0.07	2.29± 0.09	-5.43**
2nd instar duration	1.64± 0.13	2.04± 0.12	-2.33*
3rd instar duration	1.53± 0.12	1.98± 0.16	-2.15*
4th instar duration	1.38± 0.15	1.62± 0.16	-1.11
Total nymphal duration	6.18± 0.26	7.93± 0.33	-4.13**
Pre-reproductive period	0.47± 0.07	0.40± 0.07	0.63
Reproductive period	5.06± 0.47	6.95± 0.60	-2.34*
Post-reproductive period	0.55± 0.09	0.51± 0.09	0.36
Adult longevity	6.09± 0.56	8.11± 0.68	-2.29*
Total life cycle	12.27± 0.75	16.04± 0.97	-3.07*
Fecundity	14.11± 1.31	24.66± 2.34	-3.93**

Population parameters						
Host	Intrinsic rate of increase (r/ day)	Finite rate of increase (λ/ day)	Net reproductive rate (R_0)	Gross reproduction rate (GRR)	Mean generation time (T/ day)	Doubling time (DT)
Brinjal	0.25± 0.0023	1.28± 0.0029	24.67± 0.0047[a]	36.37± 0.034[a]	12.97± 0.01[a]	2.81± 0.0074
Cotton	0.26± 0.0029	1.28± 0.0024	14.16± 0.0020[b]	21.61± 0.048[b]	10.79± 0.91[b]	2.82± 0.0080
	NS	NS	0.0001	0.003	0.021	NS

*Samples significantly different (p= 0.05); **Samples significantly different at p= 001; t- value greater than +2 or less than – 2 is acceptable; Means followed by different letters in the same column are significantly different by using a paired bootstrap test based on the CI of difference. Standard errors estimated by using 100000 bootstrap resampling.

the growth potential of insect populations; a larger value reflects more rapid development (Xie et al., 2021). The differences of r and λ were non-significant on the two hosts, whereas the value of R_0 and GRR were higher for *A. gossypii* fed on brinjal than cotton. Based on these parameters, brinjal was found to be more conducive to the growth and development of *A. gossypii* than cotton under laboratory conditions. The seasonal nature of aphids, their migration, and parasitoids' attack pose the biggest challenges for the mass-rearing of aphids under field conditions. All these hurdles were solved by rearing aphids under controlled conditions in the laboratory. *A. gossypii* reared on *Hibiscus syriacus* under laboratory conditions had a greater survival rate, fecundity, and longevity than those reared under field conditions. The lifetable parameters, such as intrinsic rate of increase (r), net reproductive rate (R_0), and finite rate of increase (λ), were higher under laboratory conditions compared to the field conditions (Hosseini et al., 2015).

The age-stage specific survival rate (S_{xj}) of *A. gossypii* on cotton (A) and brinjal (B) are shown in Fig. 1. The survival rate differed and overlapped across the developmental stages on both the hosts. The S_{xj} was highest among first instar nymphs on both hosts. The S_{xj} of third and fourth instar nymphs was higher on brinjal (0.8666 and 0.6444, respectively) as compared to cotton (0.6590 and 0.5454, respectively). The aphids could survive up to 18 days maximum on cotton, whereas they survived up to 22 days on brinjal. The age-specific survival rate (l_x), female age-specific fecundity (f_x), and age-specific maternity ($l_x.m_x$) of *A. gossypii* on cotton and brinjal are depicted in Fig. 2. The l_x showed a downward trend as age increased, death of the last adult occurred on 18th day on cotton whereas it was on 20th day on brinjal. The other two parameters, f_x and $l_x.m_x$ reached maximum values at 10 day on cotton (3.81 nymphs and 2.681 nymphs/ female/ day, respectively) and at 11 days on brinjal (5.09 nymphs and 3.84 nymphs/ female/ day, respectively). The higher values of f_x and $l_x.m_x$ on brinjal indicates that brinjal is more suitable for the development and reproduction of *A. gossypii* (Saha et al., 2016).

The e_{xj} values for all the ages and stages were higher on brinjal as compared to cotton, indicating that aphids developed slowly on brinjal. The age-specific life expectancy was also higher on brinjal throughout the aphid life cycle (Fig. 3a). The variation in l_x, f_x and $l_x.m_x$

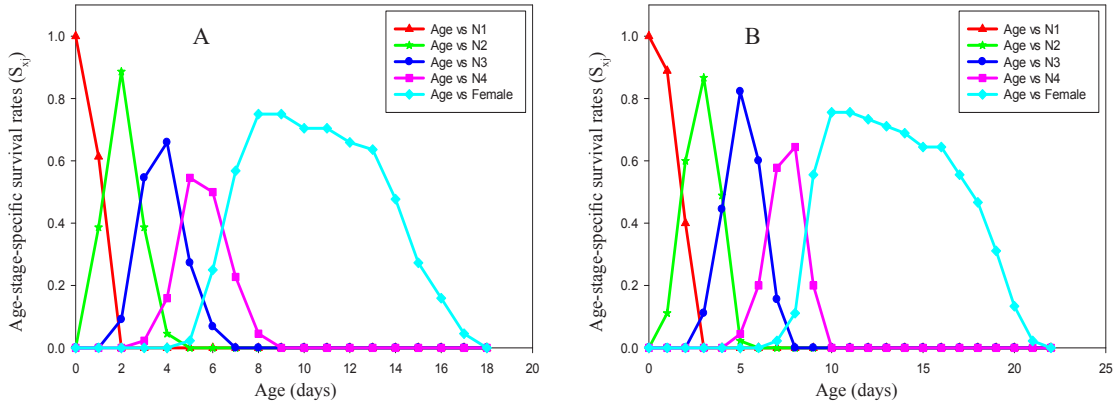

Fig. 1. Age-stage-specific survival rate (S_{xj}) of *A. gossypii* on cotton (A) and brinjal (B)

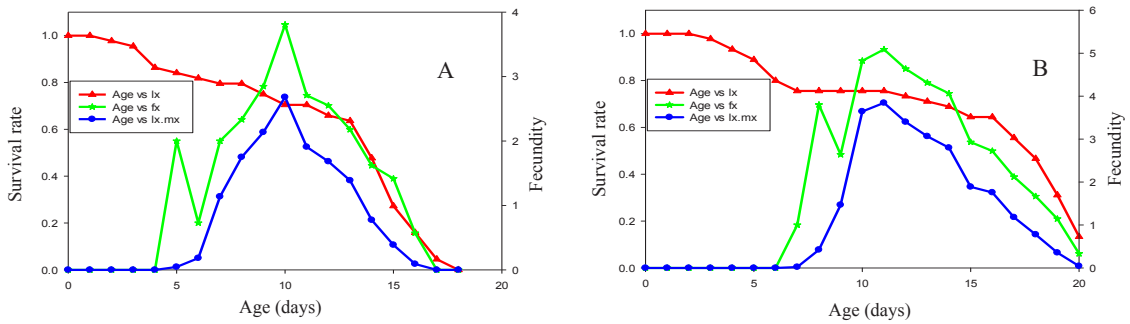

Fig. 2. Population survival rate and fecundity of *A. gossypii* on cotton (A) and brinjal (B).
The age-specific survival rate (l_x), female age-specific fecundity (f_x), and age-specific maternity ($l_x.m_x$).

on two hosts could be due to nutrient content of the host as all other experimental conditions were uniform for both hosts. The differences in nutrient content in host plants greatly influence the life cycle of herbivorous insects and affect the changing trend of their populations (Obopile and Ositile, 2010, Polat, 2018).

The reproductive value (v_{xj}) of *A. gossypii* feeding cotton (A) and brinjal (B) at age zero (v0,1) was 1.27 and 1.28, respectively, which were both close to λ. The peak value of the v_{xj} showed an upward trend with advancing age and developmental stage, with the highest value at 8 days on cotton (9.47 nymphs/ day) and 10 days on brinjal (16.59 mean nymphs/ day). The highest v_{xj} was in female adults reared on brinjal. The clear distinction between age-specific reproductive values on cotton and brinjal are depicted in (Fig. 3b). Previous studies on *A. gossypii* by Alizadeh (2016) and Satar (1999) also found that the development and reproductive value of *A. gossypii* were affected by host plants. The aphids were successfully cultured on leaves of cotton and brinjal; this helps in space utilization and maintaining culture in BOD throughout the year (Li and Akimoto, 2018). Though the mean generation time is

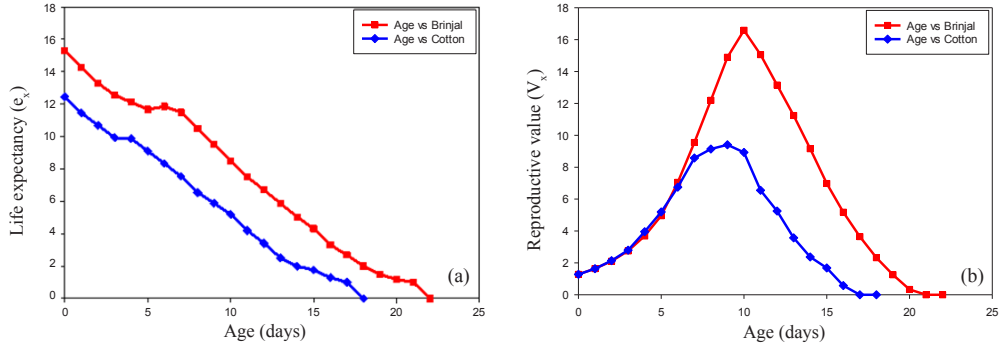

Fig. 3. Comparative age-specific life expectancy (a) and age-specific reproductive value (b) of *A. gossypii* on cotton and brinjal

slightly longer on brinjal, it could still be a better host for aphid mass production as the higher reproductive rate, approximately twice as on cotton, compensates for the increased time.

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AUTHOR CONTRIBUTION STATEMENT

GSU contributed to experimentation, data collection and original draft writing. KMC analyzed the data. VKK contributed to conceptualization, planning, supervision and manuscript editing. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

REFERENCES

Alizadeh Z, Haghani M, Sedaratian A. 2016. Biology and reproduction parameters of *Aphis gossypii* Glover, 1877 (Hemiptera, Aphididae) on five sweet pepper cultivars under laboratory conditions. Entomofauna 37(40): 617-628.

Barros E M, Torres J B, Ruberson J R, Oliveira M D. 2010. Development of *Spodoptera frugiperda* on different hosts and damage to reproductive structures in cotton. Entomologia Experimentalis Applicata 137: 237-245.

Blackman, Eastop. 2000. Aphids on the world's crops: an identification and information guide. 2nd edition Wiley.

Chi H S, Liu H S. 1985. Two new methods for the study of insect population ecology. Bulletin of the Institute of Zoology. Academia Sinica 24(2): 225-240.

Chi H, Su H Y. 2006. Age-stage, two-sex life tables of *Aphidius gifuensis* (Ashmead) (Hymenoptera: Braconidae) and its host *Myzus persicae* (Sulzer) (Homoptera: Aphididae) with mathematical proof of the relationship between female fecundity and the net reproductive rate. Environmental Entomology 35(1): 10-21.

Hosseini-Tabesh B, Sahragard A, Karimi-Malati A. 2015. A laboratory and field condition comparison of life table parameters of *Aphis gossypii* Glover (Hemiptera: Aphididae). Journal of Plant Protection Research 55(1): 1-7.

Huynh M P, Shelby K S, Coudron T A. 2021. Recent advances in insect rearing methodology to promote scientific research and mass production. Insects 2(11): 961.

Kersting U, Satar S E, Uygun N. 1999. Effect of temperature on development rate and fecundity of apterous *Aphis gossypii* Glover (Homoptera, Aphididae) reared on Gossypium hirsutum L. Journal of Applied Entomology 123(1): 23-27.

Li Y, Akimoto S I. 2018. Evaluation of an aphid rearing method using excised leaves and agar medium. Entomological Science 21(2): 210-215.

Nimbalkar R K, Shinde S S, Wadikar M S, Tawar D S, Muley S. 2010. Effect of constant temperature on development and reproduction of the cotton aphid (*Aphis gossypii*) (Glover) (Hemiptera: Aphididae) on *Gossypium hirsutum* in laboratory conditions. Journal of Ecobiotechnology 2(8): 29-34.

Obopile M, Ositile B. 2010. Life table and population parameters of cowpea aphid, *Aphis craccivora* Koch (Homoptera: Aphididae) on five cowpea *Vigna unguiculata* (L. Walp.) varieties. Journal of Pest Science 83(1): 9-14.

Pinto Z V, Rezende J A, Yuki V A, Piedade S M. 2008. Ability of *Aphis gossypii* and *Myzus persicae* to transmit Cucumber mosaic virus in single and mixed infection with two potyviruses to zucchini squash. Summa Phytopathologica 34: 183-185.

Polat E. 2018. The effect of some cucumber cultivars on the biology of *Aphis gossypii* Glover (Hemiptera: Aphididae). Phytoparasitica 46(4): 511-520.

Razmjou J, Moharramipour S, Fathipour Y, Mirhoseini S Z. 2006. Demographic parameters of cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) on five cotton cultivars. Insect Science 3(3): 205-210.

Saha J, Chakraborty K, Chatterjee T. 2016. Biology of cotton aphid *Aphis gossypii* Glover. Journal of Global Biosciences 5: 4467-4473.

Satar S, Kersting U, Uygun N 1999. Development and fecundity of *Aphis gossypii* Glover (Homoptera: Aphididae) on three Malvaceae hosts. Turkish Journal of Agriculture and Forestry 23(6): 637-644.

Wang K Y, Guo Q L, Xia X M, Wang H Y, Liu T X. 2007. Resistance of *Aphis gossypii* (Homoptera: Aphididae) to selected insecticides on cotton from five cotton production regions in Shandong. Chinese Journal of Pesticide Science 0710050003.

WASP 2.0. https://ccari.icar.gov.in/waspnew.html

Xie W, Zhi J, Ye J, Zhou Y, Li C, Liang Y, Yue W, Li D, Zeng G, Hu C. 2021. Age-stage, two-sex life table analysis of *Spodoptera frugiperda* (JE Smith) (Lepidoptera: Noctuidae) reared on maize and kidney bean. Chemical and Biological Technologies in Agriculture 8(1): 1-8.

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