Journal of Plant Protection Research ISSN 1427-4345

ORIGINAL ARTICLE

Biological parameters of onion thrips, *Thrips tabaci* Lindeman on onion cultivars

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Vol. 57, No. 2: 120–128, 2017

DOI: 10.1515/jppr-2017-0016

Received: November 22, 2016
Accepted: May 10, 2017

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Abstract

Biological parameters of the onion thrips, *Thrips tabaci* Lindeman were studied on the following onion (*Allium cepa* L.) cultivars: Nasik Red Plus N-53, Onion Dr-301 (Krishna), Onion White, and Nasik Red, at 25±1°C and 65±5% RH. Significant ($p < 0.05$) differences were found in the life stages and fertility life tables on different cultivars except in the pupal stages. More information about the biological parameters of *T. tabaci* on onion cultivars can help in designing Integrated Pest Management programs for onion thrips.

Key words: *Allium cepa*, biology, life table, *Thrips tabaci*

Introduction

Onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) is a major insect pest of onion throughout the world. Both adults and larvae are feeding stages; they suck sap from the leaves, giving them a silver patchy appearance due to the reduction in the quantity of chlorophyll and the rate of photosynthesis (Boateng 2012). This insect can cause crop losses of up to 90% in Maharashtra, India (Pandey *et al.* 2011) and >50% in the USA (Diaz-Montano *et al.* 2011; Boateng 2012). *Thrips tabaci* is also a major vector of *Iris yellow spot virus* (IYSV) that can cause yield losses of up to 100% (Diaz-Montano *et al.* 2011; Birithia *et al.* 2013). Onion thrips can reproduce asexually (parthenogenesis) and sexually and the most common reproductive mode is thelytoky, a parthenogenesis in which females are produced from unfertilized eggs (Gill *et al.* 2015).

Knowing the biology of an insect pest can help in developing control strategies for future Integrated Pest Management (IPM) programs (Arrieche *et al.* 2006; Pourian *et al.* 2009). To make reliable decisions, and to reduce the application of insecticides for the management of thrips, it is necessary to fully understand their biology, ecology, and population structure, and to distinguish their biotypes (Brunner *et al.* 2004). One study was conducted on the life table of *T. tabaci* in relation to two different hosts, onion and tobacco (Fekrat *et al.* 2009), but most studies on the biology of *T. tabaci* have been on the single host plant, onion (Salmasi *et al.* 2003; Arrieche *et al.* 2006; Tara *et al.* 2012; Patel *et al.* 2013). In the present study, four cultivars: three red and one white onion were selected to study the life table of *T. tabaci*. The aim of this study was to understand how different onion cultivars affect the biological parameters of *T. tabaci*. The data obtained can be useful for IPM and/or plant breeding programs in the management of *T. tabaci*.

Materials and Methods

Rearing of *Thrips tabaci*

Culture of hosts

Seeds of four cultivars: Onion White (OW), Nasik Red (NR), Nasik Red Plus N-53 (NR-53), and Onion Dr-301 (Krishna) (ODK-301) from local markets in Aligarh, India were sown in protected nursery beds at the Department of Plant Protection, Aligarh Muslim

University (AMU) on October 30, 2013. Seedlings of each cultivar were transplanted into pots after 35 days (December 4) and covered with nylon mesh cages having 210 µm apertures and maintained under protected conditions. The leaves of healthy plants were used as food for rearing *T. tabaci*. The pots were irrigated by using a 10 l water sprinkler can when it was necessary.

Stock cultures of T. tabaci

To establish a stock culture, *T. tabaci* adults were collected using an aspirator from an onion field at the Department of Plant Protection, AMU on February 14, 2014. *Thrips tabaci* females are usually found at the bases of the host plant leaves, where they lay their eggs into leaf tissue. Therefore, 20 adults were enclosed into each glass test tube (50 ml) containing a fresh, thick and healthy leaf of each cultivar directly after collection for oviposition. The open end of the test tube was covered with wet soft tissue paper and held in place with a rubber band for ventilation and to prevent escape. They were kept at 25±1°C and 65±5% relative humidity (RH) in a Bio-chemical Oxygen Demand (BOD) Incubator for 24-h. The leaves harboring eggs were transferred to other test tubes (50 ml) individually. When larvae emerged they were reared in groups (20 larvae per 50 ml test tube), and provided with food until the adult stage. Twenty replicates were made for each cultivar. The adults were used for further investigations. Identifying *T. tabaci* in the stock culture or during the study was done after the adult's death using standard techniques according to Hoddle *et al.* (2012).

Development time

Development and mortality of *T. tabaci* were studied by randomly selecting 50 adult females of the same age from the stock culture, and placing these individually in a test tube (50 ml) for each cultivar. The rearing technique to study the biology of *T. tabaci* was adopted from Patel *et al.* (2013) and Fekrat *et al.* (2009). For oviposition, a 5 cm section of onion leaf was placed in each test tube with the adult thrips for 24-h. The test tubes were covered with wet soft tissue secured with a rubber band. Each test tube was considered as one replicate for each cultivar. Each leaf which was harboring eggs was removed from the test tube and labeled with the date of exposure to the female. The eggs were then monitored at 24-h intervals under a stereomicroscope to determine the date of egg hatching. Egg eclosion (incubation period) of *T. tabaci* was estimated to be the period between the laying of the first egg and the day of egg hatching. To determine development and mortality of different larval instars, 50 neonate larvae obtained from the leaf harboring eggs were selected randomly, isolated individually in a test tube (50 ml), and provided with an onion leaf of each cultivar as food (5 cm section). The onion leaf tissue in each test tube was changed with new leaf tissue every 24-h. Moulting was observed in the test tube or on leaf tissue to distinguish first and second larval stages, because the morphological difference between the two stages is not significant. Average larval period and mortality were calculated. Pre-pupal and pupal stages were kept individually in the same test tubes for emergence of adults, and leaves were removed since these are non-feeding stages. The pre-pupal and pupal periods and mortality were recorded at 24-h intervals. The pre-pupa was identified by the short wing sheaths and erect antennae. The pupa has long wing sheaths which almost reach to the end of the abdomen, and the antennae are bent backwards along the head. The development of immatures was monitored with a binocular stereo microscope up to adult emergence. The duration of the immature stage and mortality were recorded daily. Egg eclosion up to the emergence of adult (immature period) was also calculated. The percentage (%) mortality of immature stages for each cultivar was calculated as described by Fekrat *et al.* (2009).

Adult longevity, fecundity, and life table parameters

Adults that emerged from pupae were fed on onion leaf (5 cm sections) to determine longevity, fecundity, and life table parameters for each onion cultivar. Each adult was kept individually in a test tube (50 ml), provided with fresh onion leaf tissue for each cultivar, and kept at 25±1°C and 65±5% RH in a BOD Incubator for 24-h. Fresh leaves were provided daily until the adults died. Leaves harboring eggs were labeled with the date of exposure for determination of fecundity. These leaves were then monitored to determine pre-oviposition (period of adult female emergence until the commencement of egg laying), oviposition (period of egg laying commencement until ceasing of egg laying by individual females), and post-oviposition (the period after egg laying until the female died) periods for each female on each cultivar at 24-h interval. The method used to count the numbers of eggs per leaf tissue was described by Martin and Workman (2006). The leaves were observed under a stereo microscope with transmitted light, and the total number of eggs laid during the life span of each adult female was considered as well as its fecundity. Longevity of adult females was calculated separately from the date of emergence to the death of adults. The period between the date of egg laying commencement and the death of an adult was considered as the total life span of adult females. The sex ratio was determined by examining the end of the adult abdomen, to record the presence of an ovipositor (female) or an aedeagus (male).

Statistical analysis

The data were analyzed using one-way analysis of variance (ANOVA). Tukey's Honestly Significant Difference (Tukey-HSD) was used to compare between the means of cultivars in relation to development time, mortality, longevity, and fecundity of *T. tabaci*, which were counted for each cultivar using the Statistical Analysis System (SAS) software program version 9.1.3. (SAS 2012). The following data were used to construct age specific survival and fecundity, and to calculate fertility life table (FLT) parameters: the pivotal age for the female age class in units of time (x), the number of individuals dying during the age interval x (d_x), the total number of female eggs laid in age class x ($l_x m_x$), the proportion of population surviving to age x (l_x), the number of female offspring per female aged x per day (m_x), the net reproductive or replacement rate (R_0), the intrinsic rate of increase (r_m), the finite rate of increase (λ), the mean generation time (TG), and the doubling time (DT) of the population (Southwood 1978) for each cultivar, the period of development and survival of immature stages, longevity, and daily fecundity. A computer program with the code sheet of lifetable.r in the open source, a free software programming environment R version 3.0.3 (R Development Core Team 2014), developed by Maia *et al.* (2000, 2014), was used to calculate and compare between FLT parameters of thrips population on cultivars.

Results and Discussion

Development time

The results (Table 1) revealed significant differences between cultivars in the development time of eggs (F = 71.03; df = 3, 196; p = 0.0001) with a mean of 3.76 days. The incubation period was prolonged to 5.06 days on NR, followed by 4.12 days on OW, and 3.68 days on ODK-301, but shortened to 2.16 days on NR-53. The incubation period found by Fekrat *et al.* (2009) was non-significantly longer than our findings, both on Khorasan Razavi (4.97 days) and Golestan (4.63 days). Moreover, Patel *et al.* (2013) reported that the average period of egg hatching was 4.52 days but prolonged to 7.40 days (Tara *et al.* 2012).

The development of first larval instar took significantly (F = 10.44; df = 3, 180; p < 0.0001) longer on OW (2.50 days) than NR (1.89 days), NR-53

Table 1. Mean development time of immature *Thrips tabaci* populations (±SE) on onion cultivars

Cultivar	Egg	I instar	II instar	Pre-pupa	Pupa	Total (immature)
Onion White (OW)	4.12±0.18 b (n = 50)	2.50±0.11 a (n = 50)	2.76±0.16 ab (n = 44)	1.41±0.10 ab (n = 42)	1.54±0.10 a (n = 41)	12.38±0.33 a (n = 37)
Range	(2–7)	(1–3)	(2–5)	(0–2)	(0–2)	(8–18)
Nasik Red (NR)	5.06±0.17 a (n = 50)	1.89±0.10 b (n = 50)	3.00±0.16 a (n = 45)	1.21±0.06 b (n = 42)	1.69±0.08 a (n = 42)	12.75±0.30 a (n = 36)
Range	(3–7)	(1–3)	(1–4)	(1–2)	(1–2)	(8–16)
Nasik Red Plus N-53 (NR-53)	2.16±0.11 c (n = 50)	1.86±0.09 b (n = 50)	2.42±0.11 b (n = 49)	1.70±0.10 b (n = 43)	1.45±0.12 a (n = 37)	9.82±0.24 b (n = 33)
Range	(1–3)	(1–3)	(1–4)	(1–3)	(1–4)	(7–13)
Onion Dr-301 (Krishna) (ODK-301)	3.68±0.10 b (n = 50)	1.83±0.09 b (n = 50)	1.79±0.11 c (n = 46)	1.71±0.11 a (n = 42)	1.617±0.08 a (n = 38)	10.74±0.24 b (n = 34)
Range	(3–5)	(1–3)	(1–3)	(1–3)	(1–2)	(8–14)
Total mean	3.76±0.10	2.01±0.05	2.41±0.08	1.50±0.50	1.58±0.49	11.47±0.17
Range	(1–7)	(1–3)	(1–5)	(0–3)	(0–4)	(7–18)
df	3, 196	1, 180	1, 65	3, 154	1, 81	3, 136
F	71.03***	10.44***	14.71***	6.52***	1.10 ns	23.3***
p	0.00	0.00	0.00	0.00	0.35	0.00
HSD	0.53	0.36	0.50	0.35	0.36	1.05

***significant at p < 0.001; ns – non-significant

Means followed by the same letter in a column are not significantly different (p > 0.05)

(1.86 days) and ODK-301 (1.83 days). In contrast, Fekrat *et al.* (2009) recorded developmental times of first instars as 2.28 and 2.21 days on Khorasan Razavi and Golestan cultivars, respectively. Patel *et al.* (2013) recorded that the first instar larva completed their development in 2.52 days but it was prolonged to 3.95 days (Tara *et al.* 2012). In the present study, a significant ($F = 14.71$; $df = 1, 65$; $p < 0.0001$) difference was found between cultivars in second larval instars. The longest period of second larval instars was recorded on NR (3.00 days) followed by OW (2.76 days) and NR-35 (2.42 days), while the shortest period was on ODK-301 (1.79 days) with a total mean of 2.41 days. This was dissimilar to results of Fekrat *et al.* (2009) who found that there was no significantly difference between Khorasan Razavi (3.11 days) and Golestan (2.89 days), whereas Patel *et al.* (2013) recorded 3.41 days and it was prolonged to 4.72 days (Tara *et al.* 2012).

The pre-pupal period was significantly ($F = 6.52$; $df = 3, 154$; $p = 0.0004$) longer on ODK-301 (1.71 days) and NR-53 (1.70 days) than OW (1.41 days) and NR (1.21 days). Fekrat *et al.* (2009) recorded pre-pupal durations of 2.08 and 2.07 days (non-significant difference) on Khorasan Razavi and Golestan, respectively, whereas Patel *et al.* (2013) recorded an average pre-pupal duration of 1.96 and Tara *et al.* (2012) 4.20 days. These were longer than what was found in the present study.

A non-significant ($F = 1.10$; $df = 1, 81$; $p = 0.35$) difference was found in the pupal stages (means of 1.58 days) between cultivars. Similarly, Fekrat *et al.* (2009) found a non-significant difference between Khorasan Razavi and Golestan, which lasted 2.69 and 2.92 days, respectively. However, pupal development was 3.56 days as observed by Patel *et al.* (2013), and 2.88 days (Tara *et al.* 2012).

The overall immature developmental time was significantly ($F = 23.30$; $df = 3, 136$; $p < 0.0001$) longer on NR (12.38 days), while shorter on NR-53 (9.82 days). Similarly, Fekrat *et al.* (2009) found that 15.22 and 14.66 days were required for immatures on Khorasan Razavi and Golestan onion, respectively. These were longer than the cultivars in the present experiment. Tara *et al.* (2012) reported the longest period of 20.52 days. This variation in values may not depend only on host plants (Fekrat *et al.* 2009), but could reflect inherent differences in the thrips populations.

Mortality

A non-significant ($p > 0.05$) mortality difference was recorded among the populations of immatures on the different cultivars (Table 2). Similar results were found by Fekrat *et al.* (2009).

Table 2. Mean mortality of immature *Thrips tabaci* populations (±SE) on onion cultivars

Cultivar	I instar	II instar	Pre-pupa	Pupa	Total (immature)
Onion White (OW)	12.00±3.74 (n = 50)	4.22±2.59 (n = 44)	2.22±2.22 (n = 42)	10.00±4.68 (n = 41)	28.44±6.08 (n = 37)
Range	(0–20)	(0–11.11)	(0–11.11)	(0–25)	(10–46.11)
Nasik Red (NR)	10.00±3.16 (n = 50)	7.22±4.94 (n = 45)	0.00±0.00 (n = 42)	14.28±1.76 (n = 42)	31.50±7.95 (n = 36)
Range	(0–20)	(0–25)	(0–0)	(11.11–20.00)	(20–61.67)
Nasik Red Plus N-53 (NR-53)	2.00±2.00 (n = 50)	12.22±1.96 (n = 49)	14.17±2.72 (n = 43)	12.02±6.12 (n = 37)	40.41±10.85 (n = 33)
Range	(0–10)	(10–20)	(11.11–25)	(0.00–33.33)	(21.11–79.44)
Onion Dr-301 (Krishna) (ODK-301)	8.00±3.74 (n = 50)	8.94±2.27 (n = 46)	8.67±6.46 (n = 42)	8.89±8.89 (n = 38)	34.50±6.47 (n = 34)
Range	(0–20)	(0–11.11)	(0–11.11)	(0–25)	(10–46.11)
Total mean	8.00±1.72	8.15±1.60	6.26±2.12	11.30±2.77	33.71±3.83
df	3, 16	3, 16	3, 16	3, 16	3, 16
F	1.78 ns	1.11 ns	3.05 ns	0.16 ns	0.40 ns
p	0.19	0.37	0.06	0.92	0.75
HSD	13.11	12.8	14.88	24.05	32.61

ns – non-significant

Adult stage and life span

Significant differences were found in pre-oviposition ($F = 3.63$; $df = 3, 103$; $p = 0.02$), oviposition ($F = 38.07$; $df = 3, 103$; $p < 0.0001$), and post-oviposition ($F = 3.86$; $df = 3, 103$; $p = 0.0115$) periods of *T. tabaci* populations reared on the different cultivars (Table 3). The pre-oviposition period lasted 2.00 days on ODK-301, followed by 1.69, 1.54, and 1.29 days on NR, OW, and NR-53, respectively. However, Fekrat *et al.* (2009) reported pre-oviposition periods of 2.35 and 3.00 days on Khorasan Razavi and Golestan onion, respectively. Moreover, females oviposited for 19.31 and 16.46 days on NR and OW, respectively compared to 8.41 and 7.12 days on NR-53 and ODK-301 (Fig. 1). The post-oviposition was 1.39 days on NR followed by OW (1.19 days), NR-53 (0.76 days) and ODK-301 (0.47 days). Bagheri (2000) found a post-oviposition period of 2.50 days.

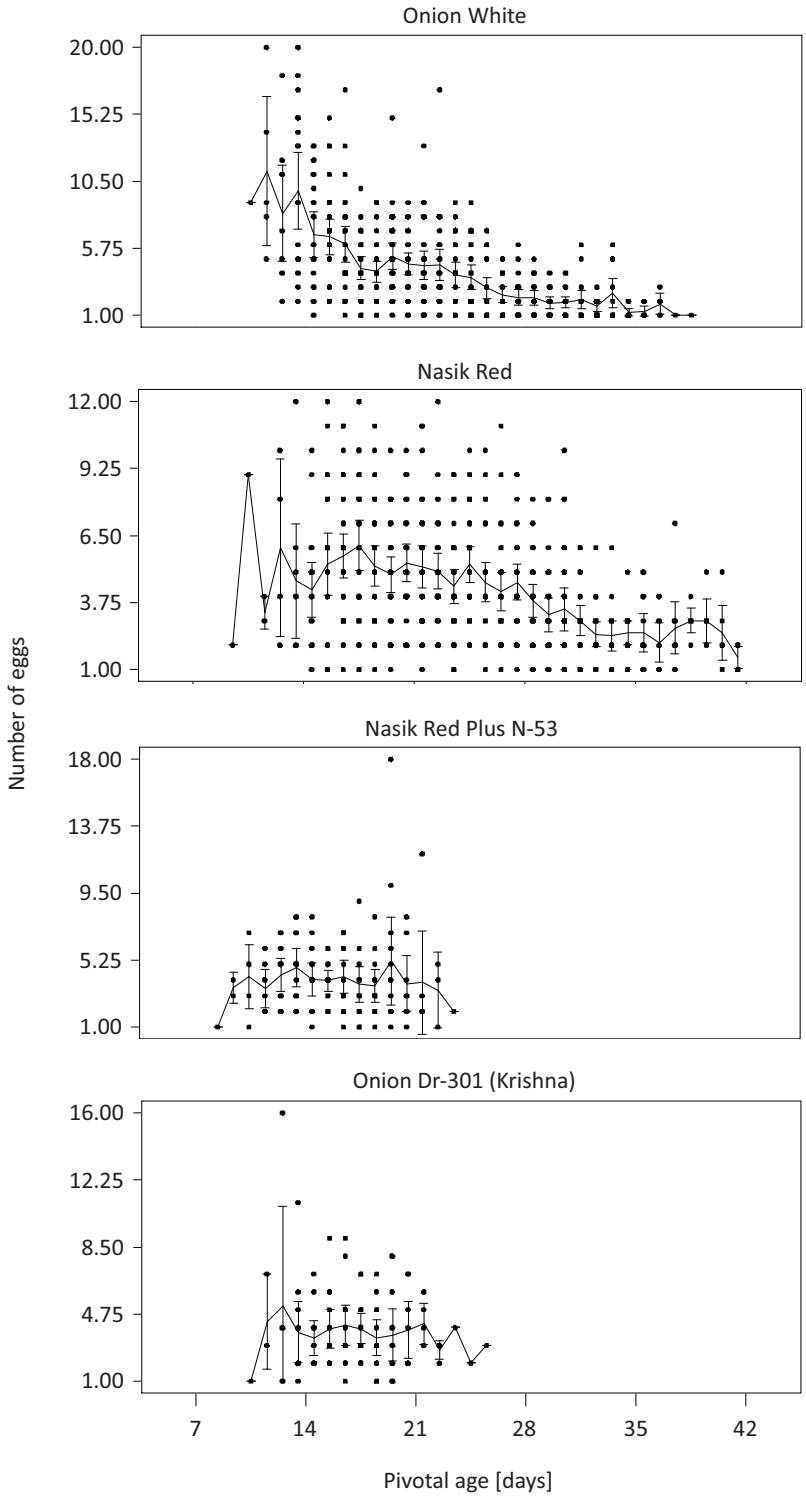

Fig. 1. Fecundity of *Thrips tabaci* on onion cultivars

Table 3. Biological parameters of female *Thrips tabaci* populations (mean±SE) on onion cultivars

Cultivar	Pre-oviposition	Oviposition	Post-oviposition	Adult longevity	Total life span	Mean total eggs	Mean daily eggs
Onion White (OW)	1.54±0.10 ab (n = 37)	16.49±0.89 a (n = 37)	1.19±0.12 ab (n = 37)	19.22±0.86 b (n = 37)	31.60±0.95 a (n = 37)	67.22±3.74 a (n = 37)	3.89±0.18 (n = 37)
Range	(0–2)	(5–24)	(0–2)	(7–27)	(19–40)	(21–106)	(2.41–60)
Nasik Red (NR)	1.69±0.13 ab (n = 36)	19.31±0.87 a (n = 36)	1.39±0.23 a (n = 36)	22.39±0.92 a (n = 36)	35.14±1.01 a (n = 36)	83.81±4.54 a (n = 36)	3.93±0.20 (n = 36)
Range	(0–3)	(4–30)	(0–7)	(9–32)	(21–46)	(21–146)	(0.09–5.55)
Nasik Red Plus N-53 (NR-53)	1.29±0.11 b (n = 33)	8.41±0.73 b (n = 17)	0.76±0.18 ab (n = 17)	5.97±0.92 b (n = 33)	15.79±1.01 b (n = 33)	33.94±3.38 b (n = 17)	3.76±0.24 (n = 17)
Range	(1–2)	(1–11)	(0–2)	(1–14)	(8–26)	(1–57)	(1.00–5.75)
Onion Dr-301 (Krishna) (ODK-301)	2.00±0.15 a (n = 34)	7.12±0.67 b (n = 17)	0.47±0.19 b (n = 17)	5.29±0.84 b (n = 34)	16.03±0.91 b (n = 34)	27.12±3.30 b (n = 17)	3.49±0.24 (n = 17)
Range	(1–3)	(1–10)	(0–2)	(1–14)	(9–28)	(1–57)	(1.00–5.70)
Total mean	1.63±0.07 (0–3)	14.66±0.65 (1–39)	1.07±0.10 (0–7)	13.53±0.78 (1–32)	25.00±0.89 (8–46)	61.14±3.01 (1–46)	3.82±0.11 (0.9–6.00)
df	3, 103	3, 103	3, 103	3, 136	3, 136	3, 103	3, 103
F	3.63*	38.07***	3.86**	99.22**	109.13**	35.37***	0.71 ns
p	0.02	0.00	0.01	0.00	0.00	0.00	0.55
HSD	0.50	3.61	0.78	3.27	3.58	17.00	0.85

***significant at $p < 0.001$; **significant at $p < 0.01$; *significant at $p < 0.05$; ns – non-significant
Means followed by the same letter in a column are not significantly different ($p > 0.05$)

Long oviposition and short post-oviposition periods of 22.98 and 3.51 days were reported by Patel *et al.* (2013) compared to 14.66 and 3.82 days oviposition and post-oviposition periods in the present study.

Adult longevity was significantly ($F = 99.22$; $df = 3, 136$; $p < 0.0001$) affected by the cultivars. It was longer on NR (22.39 days), but shorter on ODK-301 (5.29 days), which was at par with NR-53 (5.97 days) and OW (19.22 days) with a total mean of 13.53 days. In contrast, Fekrat *et al.* (2009) found that female longevity was 18.00 and 17.78 days on Khorasan Razavi, Golestan onion, respectively; females lived up to 17.27 days (Bagheri 2000) and 27.97 days (Patel *et al.* 2013) on onion.

The life span of *T. tabaci* population was significantly ($F = 109.13$; $df = 3, 136$; $p < 0.0001$) longer when reared on NR (35.14 days) and OW (31.60 days) than on ODK-301 (16.03 days) and NR-53 (15.79 days), with a total mean of 25 days. However, Patel *et al.* (2013) reported a life span that was 38 to 62 days (mean of 49.66 days).

Fecundity

A non-significant ($F = 0.71$; $df = 3, 103$; $p = 0.55$) difference was found in daily fecundity between the cultivars (mean of 3.82 eggs/female/day). This was higher than the 1.56 and 1.57 eggs/female/day on Khorasan Razavi and Golestan onion recorded by Fekrat *et al.* (2009). Total fecundity significantly differed ($F = 35.37$; $df = 3, 103$; $p < 0.001$) by cultivars (Table 3). The highest number of eggs (83.81 egg/female) was laid on NR, with fewer on OW (67.22 eggs/female), followed by 33.94 and 27.12 eggs/female in NR-53 and ODK-301, respectively. On average, a single *T. tabaci* female laid a mean of 61.14 eggs in its life span. However, Fekrat *et al.* (2009) reported a mean of 29.50 and 27.71 eggs/female on Khorasan Razavi and Golestan onions. In contrast, Patel *et al.* (2013) found 56.63 eggs/female and Bagheri (2000), 36.82 eggs/female.

Maximum daily egg laying occurred on 15.50, 16.5, 17.50, and 19.5 days of age on OW (5.49 eggs/female), ODK-301 (4.13), NR (5.92), and NR-53 (4.77), and gradually decreased with advancing age (Fig. 1). A few females laid their highest number of eggs when young, but most of them were between 13.50 and 23.5 days of pivotal age.

Fertility life table (FLT) parameters

The results (Table 4) showed that the net reproductive rate (R_0) of *T. tabaci* on NR was 60.34 females/female/generation. This was significantly ($p < 0.05$) the highest, followed by OW (49.74). However, the difference was non-significant between NR-53 (11.58) and ODK-301 (9.22). The highest intrinsic rate of increase (r_m) occurred on OW (0.22 females/female/day), which was at par with NR populations. Similarly, the value of r_m was at par between the populations of NR-53 (0.16) and ODK-301 (0.14). The finite rate of increase (λ) was significantly ($p < 0.05$) higher on OW (1.25 females/female/day), which was at par with the population of NR (1.22). In the same way, the population of NR-53 (1.18) was at par with ODK-301 (1.15). Mean generation time (*TG*) was significantly different between populations of *T. tabaci* on the cultivars. It was the longest in the population on NR (20.25 days), and the shortest on NR-53 (15.28 days). The population on ODK-301 (5.00 days) had significantly ($p > 0.05$) longer double time (*DT*) than OW (3.11 days) and NR (3.42 days). On the other hand, the population on NR-53 (4.26) was at par with the populations on OW and NR.

From earlier results, fertility life table (FLT)/life indices parameters differed between the populations of *T. tabaci* as a result of the cultivars. However, Fekrat *et al.* (2009) did not find significant differences in FLT parameters between onion cultivars. In addition, the values of R_0, r_m and λ were higher on OW and NR,

Table 4. Life indices of *Thrips tabaci* on onion cultivars (mean±SE)

Parameter	Onion White (OW)	Nasik Red (NR)	Nasik Red Plus N-53 (NR-53)	Onion Dr-301 (Krishna) (ODK-301)
Net reproductive rate – R_0 (females/female/generation)	49.74±2.76 b	60.34±3.27 a	11.58±2.29 c	9.22±1.95 c
Intrinsic rate of increase – r_m (females/female/day)	0.22±0.01 a	0.20±0.00 a	0.16±0.01 b	0.14±0.02 b
Finite rate of increase – λ (females/female/day)	1.25±0.01 a	1.22±0.01 a	1.18±0.02 b	1.15±0.02 b
Mean generation time – *TG* (day)	17.55±0.47 b	20.25±0.50 a	15.28±0.54 c	16.37±0.64 bc
Doubling time – *DT* (day)	3.11±0.09 b	3.42±0.08 b	4.26±0.38 ab	5.00±0.59 a

Means in a row followed by the same letter in a row were not significantly different (α = 0.05) (Tukey's multiple range test)

with the exception of NR-53 and ODK-301 in the present study than the results of Fekrat *et al.* (2009). Moreover, the *TG* and *DT* values of the cultivars in the present study were lower than the *TG* and *DT* reported by Fekrat *et al.* (2009). *Thrips tabaci* males were not observed in this experiment and the population consisted only of females. This is similar to the results of Salmasi *et al.* (2003), Arrieche *et al.* (2006), and Marullo and Grazia (2012).

These data indicate that the biological parameters of *T. tabaci* are significantly influenced by onion cultivars. The OW and NR cultivars were more susceptible to thrips infestation than NR-53 and ODK-301 as the result of their short development time, fecundity, and increased FLT parameters. The variation in resistance between the cultivars may be due to morphological characteristics and/or chemical and nutritional composition of the plants (Silva *et al.* 2015). The morphological characteristics might involve thickness and rigidity of the cellular walls, the amount of epicuticular waxes, and the wider central angle between the leaves. These features increase the difficulty of attack by onion thrips on onion plants (Martin and Workman 2006; Mo *et al.* 2008; Morsello *et al.* 2008; Diaz-Montano *et al.* 2010; Silva *et al.* 2015). Chemical substances and the nutritional composition of onion plants influence the feeding rate, the development and reproduction of *T. tabaci*, resulting in plant resistance by antibiosis and antixenosis (Riefler and Koschier 2009). Leaf color may also play an important role in resistance (Diaz-Montano 2011). Part of the plant chemical defense system against insects is composed of volatiles and various allelochemicals, such as monoterpenes, which have a deterrent effect and inhibit feeding (Koschier *et al.* 2000). It is concluded that Nasik Red Plus N-53 and Onion Dr-301 (Krishna) have some antibiosis effect on the thrips' biology more than Onion White and Nasik Red cultivars. These resistant cultivars inhibit development time and reproduction of thrips. These cultivars can be used in future breeding and/or IPM programs to control onion thrips. This result agrees with our field results on screening cultivars (Moraiet 2016). However, more physiological investigation is required to understand the relationship between thrips biology and onion characteristics.

Acknowledgements

The first author is thankful to the University Grants Commission (UGC), New Delhi for the award of Junior Research Fellowship (JRF) for Foreign Nationals, which partially supported the project. We thank the Chairman of Department of Plant Protection, Faculty of Agricultural Sciences, AMU, Aligarh, India for providing the necessary facilities.

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