INFLUENCE OF NITROGEN FERTILIZATION ON BIOLOGY OF *APHIS GOSSYPII* (HEMIPTERA: APHIDIDAE) REARED ON *CHRYSANTHEMUM IINDICUM* (ASTERACEAE)

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Abstract: The experiment studied the effect of different nitrogen levels on the biology and life table parameters of the cotton aphid, *Aphis gossypii* Glover reared on *Chrysanthemum indicum* Kitan. The fertilizer treatments were administered at 0, 25, 50, 100 and 150% of the agronomic recommended concentration. The aphids were collected from greenhouses in Mahalat and transported to pots. The different nitrogen fertilizer levels did not show a specific effect on the potassium and phosphorus content in leaves. The intrinsic rate of increase and net reproductive rate ranged from 0.173 to 0.225, and 15.47 to 28.28, respectively, at different tested fertilizer levels. The aphids showed the significantly lowest mean generation time and the highest finite rate of increase when fed on chrysanthemum fertilized at a 150% fertilizer level. The aphids fecundity and survival showed a positive correlation when the fertilizer concentration was increased. On the other hand, the highest life expectancy was obtained for the aphids fed on chrysanthemum with a 25% nitrogen level. The present data suggest that plant nitrogen content is an important factor contributing to the increase severity of the cotton aphid as a pest of chrysanthemum.

Key words: *Aphis gossypii*, *Chrysanthemum indicum*, demography, development, survival, nitrogen fertilizer

INTRODUCTION

Aphis gossypii Glover (Homoptera: Aphididae) is a cosmopolitan, polyphagus species widely distributed in different habitats worldwide. This pest has a broad range of hosts and has been discovered feeding on fiber and ornamental crops in 88 plant families (Gissella *et al*. 2006). *Chrysanthemum indicum* (Kitan) (Asteraceae) is one of the major floricultural crops grown in greenhouses throughout the world and cotton aphids are important pests of this flower. *A. gossypii* are phloem-feeding insects which cause direct and indirect damage because physical contamination with their honey dew may transmit viruses (Blackman and Eastop 2000). In greenhouse, ornamental production, fertilizers are being extensively used to produce high quality yields (Chau *et al*. 2005). The relationship between plant physiology and insect biology is a field of research which has not been given much previous attention. One particular phase of plant physiology, which seems to be most promising in this respect, is plant nutrition (Cisneros 1999). Nutrient status, an indicator of host plant quality, among cultivars of Chrysanthemum, has been shown to play an important role in population dynamics and demographic parameters of *A. gossypii* (Chau *et al*. 2005). Nevertheless, one of the major nutrient parameters for increasing aphids fecundity and reproduction is nitrogen fertilizer (Bentz *et al*. 1995; Nevo and Coll 2001). Thus, in this study we used *A. gossypii* and *C. indicum* as our experimental system, in order to determine the effects of different levels of nitrogen fertilizer on the biology, survival and fecundity of *A. gossypii.*

MATERIALS AND METHODS

Insect and plant culturing

The experimental plants were grown in pots containing soil, sand, and trap fertilizer using rooted seedlings kept in a climate controlled chamber at 22±1°C, with a relative humidity of 65±5% and a photoperiod of 16L : 8D hours. Cotton aphids were collected from commercial greenhouses in Mahalat (south-west of Tehran) in Iran and were put into the pots, using a smooth hair-brush. The levels of nitrogen, potassium, phosphorus and carbon requirements in Chrysanthemum, were demonstrated by analyzing the planting soil (Table 1). According to our estimation, this plant needs 200 kg of nitrogen per hectare which must be used in two steps (at the 10–12 leaves stage, and two weeks after the first application), for proper vegetative growth.

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Table 1. The results of soil analysis before the use of nitrogen fertilizer

Absorbance potassium [ppm]	Absorbance phosphorus [ppm]	Total nitrogen [%]	Inorganic carbon [%]
915	> 50	0.09	0.95

Effects of different fertilizer levels on *A. gossypii*

We manipulated the host plant quality by applying fertilization across a level ranging from low to high: 6, 12, 24 and 36 mg of nitrogen fertilizer per kg of planting soil (according to the above mentioned schedule), which is 25, 50, 100 and 150% of the standard level. In addition, some plants with no fertilization were considered as control treatment. We used a complete randomized design with 60 replications per treatment. Fifteen days later, 60 fresh leaves from each treatment were infested by two female apterus adult aphids at 25±1°C, relative humidity of 65±10% and a photoperiod of 16L : 8D hours. After 2 hours, the adults and nymphs on each leaf were removed except for one nymph. The number of nymphs was counted until the last aphid died.

Statistical analysis

All data of survival, fecundity and stable population growth parameters were analyzed for each treatment with equations provided by Carey (1993). The jackknife method was applied to evaluate the differences in population growth parameter values by estimating the variances (Meyer *et al*. 1986; Maia *et al*. 2000). A Student-Newman-Keuls (SNK) multiple range test was run after one-way ANOVA, to compare means. Statistical analyses were carried out using Statistical Package for the Social Sciences (SPSS 2004).

RESULTS

The effect of different nitrogen treatments on the percentage of nitrogen, potassium and phosphorus in leaf tissues taken from the apical part of plants (leaves No. 4 and 5) is summarized in table 2. According to the data, nitrogen fertilization had no specific effect on potassium and phosphorus levels. The nitrogen percentage simply increased when the fertilizer concentration was increased. Among the various nitrogen levels, aphid population attained higher densities on those plants which were fertilized with the highest level (150%) of nitrogen (Table 3). The intrinsic rates of natural increase (r_m) ($F = 10.29$; $d_f = 4.295$; $p < 0.0001$) and R_0 ($F = 7.29$; $d_f = 4.295$; $p < 0.0001$) were significantly increased by raising the nitrogen fertilizer level from 0 (the control) to 150%. Furthermore, the aphids significantly showed the lowest doubling time (D_t) ($F = 8.52$; $d_f = 4.295$; $p < 0.0001$) and mean generation time (T_c) ($F = 8.15$; $d_f = 4.295$; $p < 0.0001$) when fed on plants treated with the highest fertilizer level. Whereas, the finite rate of increase (λ) was significantly the highest at the 150% nitrogen level ($F = 10.40$; $d_f = 4.295$; $p < 0.0001$). The survival of the aphids on all five fertilizer levels was high and the most mortality occurred late in the adulthood stage. The age specific fecundity rates (m_x) tended to be zero, early in the beginning of the reproductive period and then increased sharply with the increase of the individual's age from the 8th day of reproduction. The highest daily number of offspring per female was observed on

Table 2. Influence of nitrogen fertilization on percentage of some important mineral components of leaves

Treatments	Nitrogen [%]	Potassium [%]	Phosphorus [%]
Control	2.4	0.33	3.3
25% RC	2.6	0.33	3.3
50% RC	2.8	0.33	3.3
100% RC	2.9	0.33	3.3
150% RC	3.1	0.33	3.3

RC – recommended concentration

Table 3. Population growth parameters (mean ±SE) of *A. gossypii* reared on *Ch. indicum* in which the *Chrysanthemum* had been fertilized with five different concentrations of nitrogen

	Nitrogen fertilizer concentration				
	control	25% RC	50% RC	100% RC	150% RC
r_m	0.173±0.007 c*	0.174±0.007 c	0.187±0.006 bc	0.202±0.007 b	0.225±0.006 a
R_0	15.47±1.64 c	16.15±1.54 c	19.23±1.81 bc	23.12±2.14 ab	28.28±2.58 a
D_t	3.99±0.16 a	3.97±0.15 a	3.71±0.14 ab	3.42±0.11 bc	3.08±0.09 c
T_c	15.81±0.18 a	15.86±0.12 a	15.86±0.16 a	15.54±0.17 a	14.87±0.12 b
λ	1.19±0.06 c	1.19±0.01 c	1.20±0.01 bc	1.22±0.01 b	1.25±0.01 a

RC – recommended concentration

*for each parameter, differences were determined by a Student-Neuman-Keuls tests, within rows, means followed by different letters are significantly different ($p < 0.05$)

r_m – intrinsic rate of natural increase; R_0 – net reproductive rate; D_t – doubling time; T_c – mean generation time; λ – finite rate of increase

plants treated with the 150% nitrogen level (4.2 nymphs/female/day). The life expectancy (e_x) of the one day old nymphs at the beginning was estimated to be 20.2 days for the aphids on plants receiving 25% fertilizer level, but it was estimated to be 20 days for the other percentages of recommended concentration (Fig. 1).

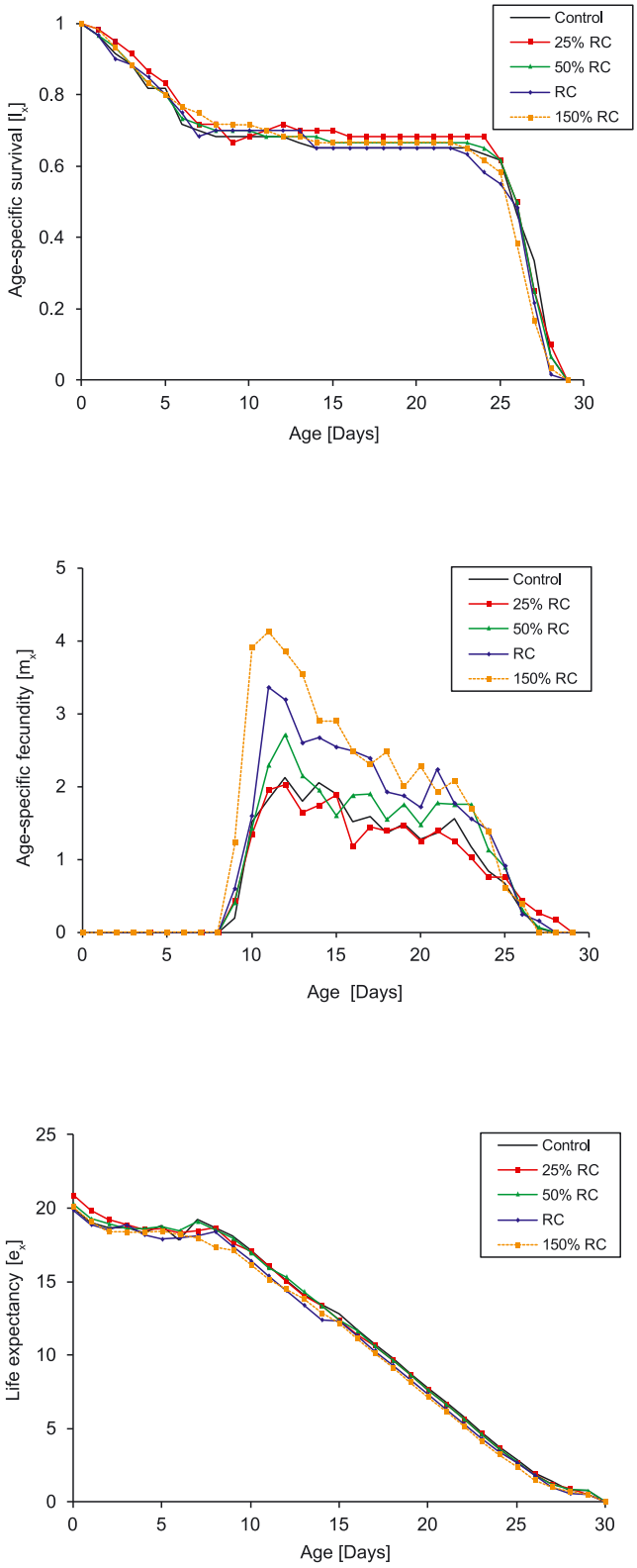

Fig. 1. Age-specific survival (l_x), age-specific fecundity (m_x) and life expectancy (e_x) of *A. gossypii* reared on *Ch. indicum* fertilized with five different concentrations of nitrogen

DISCUSSION

Host plant quality is known to be an important factor affecting aphid demography, survival, fecundity and life expectancy (Dixon 1987). This study illustrates that increasing the nitrogen fertilization level, does not have a specific effect on the percentage of potassium and phosphorous, but does increase the nitrogen content in tested plants. Such results did not confirm those reported by Davis *et al.* (2004). The effects of different levels of nitrogen fertilizer on some important characters of aphids, such as growth parameters, body size and weight, and their host performance have been previously investigated in numerous studies. According to Petitt *et al.* (1994), Nevo and Coll (2001) and Chau *et al.* (2005), the aphid's weight, size, color, and fecundity are enhanced by the nitrogen level. But the positive reaction to the nitrogen level that had been observed in aphid populations was consistent across the fertilization levels in our experiments. The r_m and R_0 were increased and D_t was decreased by increasing the fertilization level, but significant differences in aphid population growth parameters occurred at the two highest levels of nitrogen fertilizer use in Chrysanthemum. The intrinsic rate of increase reported in our study for *A. gossypii*, is considerably lower compared with the rate reported by Nevo and Coll (2001) for the same species reared on cotton plants at a 150% fertilization level (0.8). Furthermore, a similar increasing trend was observed for both the mentioned experiments by raising the fertilizer level. Additionally, our obtained data showed a significant reduction in aphid age specific fecundity on the nutrient deficient plants. That was not in agreement with Bethke *et al.* (1998), who demonstrated that the fecundity of *A. gossypii* is affected by plant cultivar, not fertilizer level. According to figure 1, the age specific fecundity of *A. gossypii* declined slowly after the 10th day, for all tested treatments. The current data provide evidence about the effect of nitrogen fertilizer increasing aphid fecundity that confirms the findings of Nevo and Coll (2001). The aphid's age specific survival and life expectancy values were high at the beginning of their life span, for all the tested nitrogen levels, and all figures showed a similar trend of deceases in all experiments by increasing the age. Therefore, aphids achieved the highest r_m and R_0 because of their relatively high m_x at 150% of the recommended concentration of nitrogen. There is a substantial difference in r_m values between aphid populations on plants fertilized with the 150% nitrogen level versus plants fertilized with the 100% nitrogen level or less. Thus, careful application of nitrogen fertilizer of up to 100% of the recommended concentration will not cause significant population outbreaks and will reduce nitrogen pollution. In the mean time, this level of nitrogen seems to be sufficient for fast growth of Chrysanthemum and for decreasing the time needed for flowering. Therefore, as a conclusion, our data can provide fundamental information for forecasting the effect of different nitrogen fertilizer concentrations on the aphid's population growth. However, more investigations on the relationship between the moderate reductions in plant nitrogen content for reduction of the aphid densities and the acceptable plant growth and yield are recommended.

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