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Short Communication

Pea Aphid (Hemiptera: Aphididae) Population Responses to Selected Pea Cultivars and High Temperatures

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Authors' Contribution
X-SH and T-XL present the concept of the study and supervised it. AHM planned methodology, curated, and validated the data and wrote the manuscript. MRN and SAM did investigation. AHM and JJ performed formal analysis. T-XL managed project administration and funding acquisition.

Key words
Pea aphid, Pea cultivars, Population parameters, Temperature

ABSTRACT

The response of *Acyrthosipon pisum* (Harris) (Hemiptera: Aphididae) population parameters to selected high temperatures (27, 30, 33, 36, 39°C) on 5 cultivars of pea, *Pisum sativum* L., was determined in laboratory testing. Of the 5 pea cultivars and 5 temperature levels included in our study, the highest values of the population parameters of net reproductive rate, intrinsic rate increase, finite rate increase, generation time, and fecundity of *A. pisum* was observed at 27°C, regardless of pea cultivar. In decreased as temperature increased at and above 30°C for each cultivar. Furthermore, differences among cultivars were often detected at 27°C and 30°C, but not at higher temperatures. Our results indicated that.

Pisum sativum L. (Leguminosae: Fabaceae) is an important crop grown worldwide primarily as a vegetable crop serving as a source of protein and a number of essential amino acids and minerals (Roy *et al*., 2010; Rebello *et al*., 2014). Its nitrogen fixation activities also amends soils where grown (Graham and Vance, 2000; Anglade *et al*., 2015). A universal insect pest of *P. sativum* is the pea aphid, *Acyrthosipon pisum* (Harris) (Hemiptera: Aphididae), which attacks a number of leguminous crops.

Management programs for *A. pisum* must be based on a comprehensive understanding of the biology of the aphid, including its performance on host plants and to environmental conditions. Previous studies have investigated the effects of high temperatures (Lamb, 1992; Campbell and Mackauer, 1975; Siddiqui *et al*., 1973; Frazer, 1972) and host cultivar (Bieri *et al*., 1983; Markula and Roukka, 1971) on pea aphid development, but no investigations have apparently focused on the interaction of high temperatures with host cultivars on pea aphid development, reproduction, and survival (Blackman and Eastop, 1984). In this study, we defined the response of pea aphid population parameters on various cultivars of pea held under selected high temperatures.

Materials and methods

Aphids used in this study were from a laboratory colony initiated from a field population infesting pea. Mixed clone cultures were then established on faba bean, *Vicia fabae* L., grown in 12-cm diameter pots, which contains media (John Innes No. 3). Plants and aphid colonies were maintained in a growth chamber held at 20±2°C on a 14L:10D photoperiod at 5500 lux. Pots were watered as needed, and aphids and plants were kept in mesh-covered breeding cages (45 × 45 × 50 cm).

Pea cultivars selected for the study were Hanyi-401, Qizhen-76, Guangzhong-604, Feizai-3, and Nenzao. Seeds of each cultivar were planted in 7.5-cm pots with potting media which were then held in an aphid-free greenhouse maintained at 18°C. Pots were watered daily and remained in the greenhouse for 3 weeks and then were transferred to 1 of 5 growth chambers set at the selected temperatures of 27, 30, 33, 36, and 39°C. Each pot was enclosed in a mesh-covered breeding cage as previously described.

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Delta-T data loggers (Delta-T Devices, Ltd., London, UK) with sensors placed in the cages continually monitored temperature levels within each treatment chamber.

Plants of each cultivar were randomly assigned to the different temperature treatments. Five separate cabinets were set at 27, 30, 33, 36, and 39°C; all were maintained on a 14L:10D photoperiod at 5500 lux. Plants of 5 pea cultivars were placed in each of the growth chambers. A single apterous adult of *A. pisum* from the stock colony was placed on each cultivar plant in each chamber. Neonates (<12 h) produced by these adults were shifted to the underside of a detached pea leaf and placed individually in Petri dishes with a piece of moistened filter paper. Only one 1st instar aphid was permitted to remain in each Petri dish, thus leaving 30 Petri dishes and a total of 30 aphids for each temperature treatment. Aphids were monitored daily until all had completed their life cycle. Development time and offspring produced by each aphid after the aphid emergence were recorded allowing for the calculation of net reproductive rate (R_0), intrinsic rate of increase (r_m), finite rate of increase (λ), generation time (T), and fecundity (F) at each temperature and on each cultivar as per methods of Birch (1948) and Watson (1964). All analysis done by TWOSEX-MS Chart, for the age-stage two-sex life table analysis in VISUAL BASIC (version 6, service pack 6) for the Windows system, available on http://140.120.197.173/Ecology/ (National Chung Hsing University) were used (Huang *et al*., 2012) Therefore, the technique of bootstrap we used along-with re-sampling of 200,000 for the estimation of population parameters standard error and the variances of the (Efron and Tibshirani, 1993). Polat-Akköprü *et al*. (2015), explained bootstrap technique advantages. Comparing various treatments, at 5% significance level, we used the paired bootstrap test.

Results

Table I shows net reproduction rate (R_0), intrinsic rate increase (r_m), finite rate of increase (λ) and fecundity (F) of *A. pisum* on selected pea cultivars at different temperature. The highest mean (±SE) net reproductive rate of *A. pisum* was observed in this study was on cv. Hanyi-401 at 27°C (15.70±2.95), while the lowest mean net reproductive rate was observed on cv. Guangzhong-604 at 36°C (2.50±0.85) and cv. Nenzao at 39°C (2.50±0.78) (Table I). Statistical significance (P>0.05) among the 5 cultivars was observed only at 27°C with a relationship of greatest to least R_0 as Hanyi-401 = Qizhen-76 = Guangzhong-604 = Nenzao > Feizai-3. Net reproductive rate did not differ among the five cultivars at 30, 33, 36, and 39°C. For each cultivar tested, R_0 was highest at 27°C with significant decreases when subjected to temperatures ≥30°C.

The highest intrinsic rate increase was observed on cv. Hanyi-401 at 27°C (0.27±0.02), and the lowest observed on cv. Nenzao and Guangzhong 604 at 36°C (0.08±0.03). Statistical significance (P>0.05) among the 5 cultivars tested was detected at 27°C and 30°C; however, comparisons must be made between two means to determine specific differences (Table I). For each cultivar, r_m was significantly higher at 27°C and 30°C than at the remaining temperatures tested (Table I).

The highest finite rate of increase was observed on cv. Hanyi-401 at 27°C (1.31±0.03), while the lowest infinite rates of increase were observed on cv. Nenzao (1.09±0.03) and cv. Guangzhong 604 (1.09±0.04) at 39°C (Table I). Statistical significance (P>0.05) among the 5 cultivars tested was detected at 27°C and 30°C. For each cultivar, λ was significantly higher at 27°C that at the remaining temperatures tested (Table I).

The highest generation time was observed on cv. Nenzao at 30°C (11.39±0.39), and the lowest generation time was observed on cv. Feizai-3 at 39°C (8.20±0.46) (Table I). There were no statistically significant differences observed among the cultivars at each of the temperature levels. Some statistical differences were found among the temperature levels within each cultivar (Table I).

The highest level of fecundity (F) observed in this study was on cv. Hanyi-401 at 27°C (27.70±2.77), while the lowest level of fecundity was observed on cv. Hanyi-401 at 33°C (7.84±0.90) (Table I). At 27°C, fecundity of aphids on cv. Hanyi-401 was significantly higher (P>0.05) that that observed for the other 4 cultivars tested (Table I). We also observed statistically significant differences among cultivars at 30°C and 33°C, but not at 36°C or 39°C. For each cultivar, fecundity differed among the temperature levels tested.

Discussion

Of the 5 pea cultivars and 5 temperature levels included in our study, the highest values of the population parameters of net reproductive rate, intrinsic rate increase, finite rate increase, generation time, and fecundity of *A. pisum* was observed at 27°C, regardless of pea cultivar. In general, these values decreased as temperature increased at and above 30°C for each cultivar. Furthermore, differences among cultivars were often detected at 27°C and 30°C, but not at higher temperatures. These results are similar to those of Morgan *et al*. (2001), Siddiqui *et al*. (1973), Campbell and Mackaeur (1975), Lamb (1992), and Frazer (1972) from Europe and North America. In general, those studies reported consistently longer duration of development of the pea aphid on pea cultivars at temperatures approaching a minimum developmental threshold and a maximum

Table I. Net reproductive rate (R_0) intrinsic rate of increase (r_m), finite rate of increase (λ), generation time (T) and fecundity (F) of *A. pisum* on selected pea cultivars and at selected temperatures.

Temperatures °C	Cultivars				
	Hanyi-401	**Qizhen-76**	**Guangzhong-604**	**Feizai-3**	**Nenzao**
Net reproductive rate (R_0)					
27	15.71±2.9a	10.96±2.0a	10.16±1.8a	8.90±1.5a	10.16±1.7a
30	8.96±1.1b	8.00±1.3b	7.90±1.1b	5.96±1.1b	6.83±0.9b
33	3.42±0.8c	3.70±0.8c	4.23±0.93c	4.56±0.9bc	4.20±0.9c
36	3.16±0.8c	3.00±0.9c	2.50±0.85d	3.06±0.8c	2.50±0.7d
39	4.03±0.1c	3.76±1.0c	3.16±0.89cd	2.90±0.9d	2.70±0.8d
Intrinsic rate of increase (r_m)					
27	0.27±0.02a	0.23±0.02a	0.23±0.02a	0.21±0.01a	0.23±0.01a
30	0.21±0.01b	0.19±0.01ab	0.18±0.01ab	0.16±0.01b	0.16±0.01b
33	0.12±0.02d	0.12±0.02c	0.14±0.024c	0.15±0.02b	0.14±0.02b
36	0.12±0.03d	0.11±0.03c	0.08±0.03d	0.11±0.03c	0.08±0.03d
39	0.16±0.02c	0.16±0.03d	0.13±0.03c	0.12±0.04c	0.11±0.04c
Finite rate of increase (λ)					
27	1.31±0.03a	1.26±0.02a	1.26±0.02a	1.23±0.02a	1.26±0.02a
30	1.23±0.01a	1.21±0.02ab	1.20±0.01a	1.17±0.02a	1.18±0.01b
33	1.12±0.02ab	1.13±0.02b	1.15±0.02ab	1.16±0.0ab	1.15±0.02b
36	1.12±0.03ab	1.12±0.04b	1.09±0.04b	1.12±0.0b	1.09±0.03c
39	1.17±0.03ab	1.17±0.04b	1.14±0.04ab	1.13±0.0b	1.12±0.04bc
Generation time (T)					
27	9.98±0.4ab	10.09±0.46a	9.95±0.34ab	10.21±0.31ab	9.99±0.43b
30	10.42±0.4a	10.54±0.42a	10.97±0.36a	10.92±0.38a	11.39±0.39a
33	10.18±0.5a	10.23±0.51a	10.07±0.47a	10.07±0.50ab	10.06±0.45ab
36	9.60±0.6ab	9.61±0.59ab	10.30±0.59a	9.76±0.51b	10.20±0.47ab
39	8.63±0.4c	8.21±0.49b	8.62±0.56cb	8.20±0.46c	8.33±0.46c
Fecundity (F)					
27	27.70±2.77a	19.35±2.04a	17.94±1.5a	14.83±1.2a	17.94±1.1a
30	12.22±0.71b	13.33±0.81b	12.47±0.6b	11.18±0.77b	9.76±0.5b
33	7.84±0.90d	8.53±0.42d	9.76±0.7c	10.53±0.89b	9.69±0.9b
36	9.50±0.69c	11.25±0.83bc	10.71±1.0bc	10.22±0.8b	9.37±0.8b
39	10.08±0.44bc	11.30±0.79bc	10.55±0.7bc	10.87±0.8b	10.12±0.b

Means within rows followed by the same lowercase letter are not significantly different (Boot Strap Test, $P<0.05$).

developmental threshold. Those aforementioned studies also included temperature levels below those that we tested, resulting in population parameter values higher than those we observed.

Differences in *A. pisum* fecundity among different pea farms were reported by Markkula and Roukka (1971). Yet, Bieri *et al.* (1983) found no differences among 6 pea varieties they tested. We, however, found differences in several parameters among the cultivars we tested, especially at 27°C. As might be expected, several studies reported R_m values higher than we reported. Those were at temperatures of at 20°C (Campbell and Makackaeur, 1975) and 19.6°C (Frazer, 1972; Siddiqui *et al*., 1973). Indeed, r_m has been shown to be highly sensitive to changes related to reproductive period (van Rijn *et al*., 1995). Although differences in life history parameters among these studies might be attributed to aphids adapting to changing climatic conditions (Hutchinson and Hogg, 1984; Campbell *et* *al*., 1975), they might also be caused by different aphid production methods employed (Lamb *et al*., 1987).

Conclusion

The present study highlights for the first time the practicality of using different temperature on aphid and bean crop under laboratory environment. The results of current study, indicate that tempraütre have negative effect on mortility and fecundity parameters of aphid, while at 27 and 30 °C temprautres were not negative effect on mortility and fecundity. Our study concludes that the it should be tested under natural environment and peas cultivated areas.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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