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Research Article

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Effects of Different Temperatures on the Biology of *Acyrthosiphon pisum* on Different Pea Cultivars

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Abstract

The research studies were carried out at Key Laboratory of Entomology, Northwest A & F University, Yangling, Shaanxi under 60±5% Relative Humidity, light: dark photoperiod at 14^h: 10^h to assess different range temperature effects on the population of *Acyrthosiphon pisum* on different pea cultivars during, 2018. The results indicated that the shortest pea aphid nymph development period up to (5.75±0.31 days) were lasted on cv. Feizai-3 at 36ºC and longest (9.38±0.34 days) were noted on cv. Nenzao at 30ºC. The shortest *A. pisum* adult development period (4.16±0.20 days) were recorded on cv. Hanyi-401 at 39ºC and the longest (5.72±0.33 days) on cv. Hanyi-401 at 30ºC. The shortest *A. pisum* longevity period (5.43±0.72 days) were recorded on cv. Feizai-3 at 39ºC and longest (11.83±0.72 days) on cv. Hanyi-401 at 30ºC. The shortest *A. pisum* oviposition period (3.61±0.32 days) were recorded on cv. Hanyi-401 at 33ºC and longest (4.41±0.35 days) on Guangzhong-604 at 36ºC. The minimum nymph survival period was counted (0.23±0.07) on Guangzhong-604 at 36ºC and maximum on cv. Hanyi-401 (0.73±0.08) at 30ºC. According to the DMRT-Test, non-significant difference was reported in all the above parameters between the cultivars in all temperature regimes. The present study suggests that temperature fluctuations also affect on the life expectancy of *A. pisum*. In future endeavors more work should be carried out to restrict the pest population of sap-sucking insects to secure the legumes varieties

Keywords: *Acyrthosiphon pisum*, *Biology*, *Oviposition*, *Pea cultivars*, *Temperatures.*

Introduction

The Pea aphid, *Acyrthosiphon pisum* Harris (Homoptera: Aphididae), also known as clover louse, pea louse, and green dolphin (Fakhouri *et al.*, 2021), that sap-sucking insect, fed on the Fabaceae plants, which includes several species of legumes and forages crops such as; broad bean, alfalfa, pea, and clover (Lane and Walters, 1991). There is no system existing for the predict population development of aphids and expensive crop inspections are needed for the management of this pest species (Biddle *et al*., 1994). The immature stages of the insect pests are massively voracious feeders (Mangrio *et al*., 2020). The development and effective management of pea aphid focus to understand the biology and effects of prevailing temperatures (Takemoto *et al.*, 2013). The host plant cultivars and temperature particularly affect the development, pre-reproductive behaviors, fecundity, and mortality of the insect population (Markula and Roukka, 1971). In the United Kingdom, there are several reports about the temperature and cultivar's interaction on the lifespan of the pea aphid (Blackman and Eastop, 1984). In every climatic zone of the world, peas crops are grown sufficiently and the fruits of legume plants found in the form of pods called beans (Walters *et al*., 1994). Peas are commonly consumed in the form of green grains and green peas are generally denoted as nitrogen fixation plants and regarded as friendly food (Biddle, 1985). The peas are winter vegetable crops with excellent dietary quality with a rich source of protein, lysine, and many important minerals (Campbell and Mackauer, 1975). The lower temperature adversely effects the life cycle,

survival rate, and reproduction periods of the *A. pisum* (Siddiqui *et al*., 1973). Proper insect pest management and appropriate controlling strategies can enhance the quantity and quality of the cultivar's productivity (Mangrio and Sahito, 2022). Keeping in above problematic issue the main motives of present study was to know the co-existence of pest fluctuation on different temperatures to find out the better management strategies.

Materials and Methods

Insect cultures: The population of aphid was obtained from the field of a pea, and the mixed clone culture was initiated using this pest. Insect population was maintained on the plant of *V. fabae* L. grown in pots (12 cm) plants containing potting media John Innes No.3 in a growth room at 14L: 10D photoperiod and 20±2ºC. The pots were given water daily and in the mesh-breeding cages (45x50 cm) the plants and population of the aphids were kept for further research studies.

Experimental design: Within 24 hours in each temperature experiment the newly emerged nymph population was selected and shifted to the other inferior detached leaves end of the pea cultivars, kept in Petri dishes, and given moist filter papers at the bottom of the dishes. In each Petri dish, only one aphid was permitted individually at 27ºC, 30^0C, 33ºC, 36ºC, 39ºC at a fixed temperatures, and all the aphids were kept in environmental chambers with 60±5% RH and 14^h: 10^h light: dark photoperiod. The thirty Petri dishes were arranged and in every Petri dish single nymph was kept as per temperature requirement. The nymph mortality within 24 hours in each replication was omitted, the filter papers were moistened and kept inside the Petri dishes and after 2 days the aphid was transferred to a new leaf disk of pea cultivars. Each treatment was replicated five times. The nymph population was observed on daily basis, molting, number of nymphs, and till the complete mortality occurred, the data was gathered. For sample collection and application of variable temprature against the population of *A. pisum* (Stacey and Fellowes, 2002) described methodology was applied.

Data analysis: The data was analyzed through the application of student package SWX software 8.1 USA, and the LSD Test was applied among the treatment means to check the significance level at (P<0.05).

Results

Nymph development period (days): The results in regards to the nymph development period of pea aphids in five different temperatures reared on different pea cultivars. The shortest nymph development period of *Acyrthosiphon pisum* (5.75±0.31 days) was recorded on cv. Feizai-3 at 39ºC and the longest development period of *Acyrthosiphon pisum* (9.38±0.34 days) was noted on cv. Nenzao at 30ºC. The overall maximum to minimum mean days of nymph development period at all temperatures was recorded on Nanzao at (7.93±0.39) followed by Guanghzhong-604 at (7.83±0.41), Feizai-3 at (7.71±39), Qizhen-76 at (7.69±0.45) and Hanyyi-401 at (7.33±0.41), respectively. According to the DMRT-Test between all cultivar's temperature regimes in the development period of the nymph found with the significant differences hence shown in (Table-1).

Table-1. Nymph development period (days) of *Acyrthosiphon pisum* on different cultivars of peas under various temperatures

Temperatures	Cultivars				
	Hanyi-401	Qizhen-76	Guanghzhong-604	Feizai-3	Nenzao
27ºC	7.88±0.37^a	8.05±0.40^a	8.00±0.35^a	8.11±0.35^a	7.88±0.34^a
30ºC	8.13±0.31^a	8.38±0.39^{ab}	8.94±0.31^{ab}	9.00±0.40^{ab}	9.38±0.34^b
33ºC	8.38±0.43^a	8.23±0.44^a	7.92±0.46^a	8.15±0.44^a	8.00±0.40^a
36ºC	7.70±0.60^a	7.50±0.59^a	7.85±0.45^a	7.55±0.44^a	8.12±0.39^a
39ºC	6.58±0.35^a	6.30±0.44^a	6.44±0.46^a	5.75±0.31^a	6.25±0.48^a
Overall mean	7.33±0.41^{ab}	7.69±0.45^{ab}	7.83±0.41^c	7.71±0.39^a	7.93±0.39^a

Adult development period (days): The results in regards to the adult development period of pea aphids in five different temperatures reared on different peas cultivars. The shortest adult development period of *Acyrthosiphon pisum* (4.16±0.20 days) was recorded on cv. Hanyi-401 at 39ºC and the longest adult development period of *Acyrthosiphon pisum* (5.72±0.33 days) was noted on cv. Hanyi-401 at 30ºC. The overall maximum to minimum mean days of adult development period among all applied different temperatures was counted on Hanyi-401 at (4.96±0.40), followed by Feizai-3 at (4.92±0.42), Qizhen-76 at (4.89±0.35), Guangzhong-604 at (4.87±0.39), and Nenzao at (4.77±0.39), respectively. According to the DMRT-Test between regimes in the development period of adults found with the non-significant difference thus, it was recorded and further justified in (Table- 2).

Table-2. Adult development period (days) of *Acyrthosiphon pisum* on different cultivars of peas under various temperatures

Temperatures	Cultivars				
	Hanyi-401	Qizhen-76	Guangzhong-604	Feizai-3	Nenzao
27ºC	5.17±0.48^{a}	5.17±0.49^{a}	5.70±0.48^{a}	4.77±0.39^{a}	5.35±0.43^{a}
30ºC	5.72±0.33^{a}	4.94±0.40^{ab}	4.57±0.26^{b}	5.00±0.33^{ab}	4.47±0.26^{b}
33ºC	4.76±0.37^{a}	4.61±0.32^{a}	4.84±0.42^{a}	4.92±0.42^{a}	4.64±0.48^{a}
36ºC	5.00±0.46^{a}	5.12±0.22^{a}	5.00±0.48^{a}	4.55±0.49^{a}	4.50±0.37^{a}
39ºC	4.16±0.20^{a}	4.60±0.33^{ab}	4.22±0.32^{ab}	5.37±0.49^{b}	4.87±0.43^{ab}
Overall mean	4.96±0.40^{a}	4.89±0.35^{b}	4.87±0.39^{a}	4.92±0.42^{a}	4.77±0.39^{a}

Longevity period (days): The results in regards to the longevity period of pea aphids in five different temperatures reared on different peas cultivars. The shortest longevity period of *Acyrthosiphon pisum* (5.43±0.72 days) was recorded on cv. Feizai-3 at 39ºC and the longest longevity period of *Acyrthosiphon pisum* (11.83±0.72 days) was noted on cv. Hanyi-401 at 30ºC. The overall maximum to minimum mean days of longevity period in days in given temperatures was recorded on Hanyi-401 at (8.63±0.81), followed by Nenzao at (8.02±0.84), Qizhen-76 at (7.94±0.83), Guangzhong-604 at (7.88±0.84), and Feizai-3 at (7.82±0.84), respectively. According to the DMRT-Test, there was a non-significant difference in longevity period between the cultivars in all temperature regimes detail shown in (Table- 3).

Table-3. Longevity period (days) of *Acyrthosiphon pisum* on different cultivars of peas under various temperatures

Temperatures	Cultivars				
	Hanyi-401	Qizhen-76	Guangzhong-604	Feizai-3	Nenzao
27ºC	8.96±0.96^{a}	8.96±0.96^{a}	8.90±1.06^{a}	9.00±0.95^{a}	8.73±1.03^{a}
30ºC	11.83±0.72^{a}	10.43±0.79^{a}	10.80±0.77^{a}	10.23±0.84^{a}	11.23±0.82^{a}
33ºC	8.80±0.80^{a}	8.20±0.86^{a}	8.23±0.84^{a}	8.03±0.89^{a}	8.10±0.84^{a}
36ºC	7.20±0.84^{a}	5.96±0.81^{a}	5.83±0.81^{a}	6.43±0.79^{a}	6.43±0.79^{a}
39ºC	6.36±0.73^{a}	6.16±0.71^{a}	5.66±0.70^{a}	5.43±0.72^{a}	5.60±0.71^{a}
Overall mean	8.63±0.81^{ab}	7.94±0.83^{a}	7.88±0.84^{a}	7.82±0.84^{a}	8.02±0.84^{a}

Oviposition period (days): The results in regards to the oviposition period of pea aphids in five different temperatures reared on different peas cultivars. The shortest oviposition period of *Acyrthosiphon pisum* (3.61±0.32 days) was recorded on cv. Hanyi-401 at 33ºC and the longest longevity period of *Acyrthosiphon pisum* (4.58.±0.33 days) was noted on Nanzao at 27ºC. The overall maximum to minimum mean oviposition period in days was recorded at different temperatures on Guanghong-604 at (4.10±0.34), followed by Feizai-3 at (4.09±0.34), Qizhen-76 at (3.97±0.30), Hanyi-401 at (3.96±0.26), and Nanzao at (3.94±0.31), respectively. According to the DMRT-test thus, there was non-significant differences found in longevity period between the cultivars in all temperature regimes as justified in (Table- 4).

Table-4. Oviposition of *Acyrthosiphon pisum* on different cultivars of peas under various temperatures

Temperatures	Cultivars				
	Hanyi-401	Qizhen-76	Guanghong-604	Feizai-3	Nenzao
27ºC	4.41±0.35^{a}	4.05±0.35^{a}	4.35±0.34^{a}	4.16±0.28^{a}	4.58±0.33^{a}
30ºC	4.40±0.21^{a}	4.22±0.25^{a}	4.00±0.19^{a}	4.31±0.27^{a}	3.85±0.20^{a}
33ºC	3.61±0.32^{a}	3.76±0.25^{a}	4.23±0.35^{a}	4.00±0.31^{a}	3.92±0.32^{a}
36ºC	3.70±0.25^{a}	4.00±0.26^{a}	4.14±0.45^{a}	3.88±0.41^{a}	3.62±0.32^{a}
39ºC	3.66±0.18^{a}	3.80±0.38^{a}	3.77±0.36^{a}	4.12±0.43^{a}	3.75±0.40^{a}
Overall mean	3.96±0.26^{bc}	3.97±0.30^{b}	4.10±0.34^{a}	4.09±0.34^{a}	3.94±0.31^{b}

Nymphal survival: The maximum fecundity was determined on cv. Hanyi-401 (0.73±0.08) at 30ºC and minimum fecundity was observed on Guangzhong-604 (0.23±0.07) at 36ºC. It was observed that fecundity was linearly increased by increasing temperatures ranging between 27ºC to 39ºC. The overall maximum to minimum nymph survival period in days on different temperatures was recorded in Hanyi-401 at (0.51±0.08), followed by Nanzao at (0.44±0.09), Guangzhong-604 at (0.43±0.8), Feizai at (0.42±0.08), and Qizhen-76 at (0.33±0.08), respectively. According to the DMRT, Test in all temperature regimes, there was the non-significant difference was observed in generation time between the cultivars further as justified in (Table-5).

Table-5. Nymph survival of *Acyrthosiphon pisum* on different cultivars of peas under various temperatures

Temperatures	Cultivars				
	Hanyi-401	Qizhen-76	Guangzhong-604	Feizai-3	Nenzao
27°C	0.65±0.09[a]	0.56 ±0.09[a]	0.56±0.09[a]	0.60±0.08[a]	0.56±0.09[a]
30°C	0.73±0.08[a]	0.06±0.08[a]	0.63±0.08[a]	0.53±0.09[a]	0.70±0.09[a]
33°C	0.43±0.09[a]	0.43±0.09[a]	0.43±0.09[a]	0.43±0.09[a]	0.43±0.09[a]
36°C	0.33±0.08[a]	0.26±0.08[a]	0.23±0.07[a]	0.30±0.08[a]	0.26±0.08[a]
39°C	0.40±0.08[a]	0.33±0.08[a]	0.30±0.08[a]	0.26±0.08[a]	0.26±0.08[a]
Overall mean	0.51±0.08[a]	0.33±0.08[a]	0.43±0.08[a]	0.42±0.08[a]	0.44±0.09[a]

Discussion

The study of the developmental stages of *A. pisum* was carried out on different pea plants cultivars at 27°C, 30°C, 33°C, 36°C, and 39°C. The population of the pea aphid successfully developed at all temperatures and as the temperature increased the developmental rate also increased. Our results are more or less comparable with the work of (Stacey and Fellowes, 2002), who documented that greater temperature alters the interaction between entomopathogen and *A. pisum* but there is little evidence that smaller changes occur between the natural enemy and *A. pisum* at low temperature (Jeong *et al*., 2020) at 30°C, the high pre-adult mortality and lower fecundity rate was recorded.

The adult life cycle of the *Acyrthosiphon pisum* was found by (Melaku *et al*., 2000), they documented the life cycle of *Acyrthosiphon pisum* on four different field pea, faba, grass pea, and legumes those found with the non-significant difference in molt stages and nymphal length among the tested crop varieties. The temperature and weather parameters affect the life cycle of the *A. pisum* as described by (Fakhouri *et al.*, 2021) that environmental fluctuations in different seasons hit the population fluctuation of aphids. The intensity of temperature, wind speed, and RH affect the on *A. pisum* and pea cultivars (Bieri *et al*., 1983). In North America and Europe, the high temperature badly affects all life stages of *A. pisum* (Frazer, 1972). The *A. pisum* contains several strains and subspecies which may form aphid comparison data from geographically disparate areas (Blackman and Eastop, 1984).

The nymphal development period found as the work agreement of (Lamb (1992), documented that the time of development on pea cultivars at different temperatures was longer than other reported scientific documentation such as at 20°C 6.4, 6.5, 7.6, and 8.4 days, respectively. The adult development period resembles the findings of (Siddiqui *et al*., 1973) reported the life cycle, survival rate, and reproduction periods were found to generally on lentils longer compared to other crops with three molts and nine to eleven total days but on the development rate adverse effects were observed at lower temperatures. (Bieri *et al*., 1983) reported the life cycle of pea aphids the temperature influence the higher optimal temperature for the development of pea aphids between 28°C to 30°C compared with the 23.1°C and 26.7°C reported with massive effect and required to prolong time to complete all life cycle stages as reported at 23.1°C (Hutchinson and Hogg, 1984). The oviposition and nymph survival period recorded as used (Lamb, *et al*., 1987), the variations in the parameters of life history as documented in different studies could be credited for adapting of aphids in climatic conditions but in different rearing methods, they may be influenced.

Conclusions and Recommendations

It is concluded that the maximum nymph period was recorded on Nenzao-3 at 30°C and minimum Feizai 39°C. The minimum adult development period lasts on Hanyi-401 at 39°C and maximum on the same variety at 30°C. The maximum adult longevity was found on Hanyi-401 at 30°C and the minimum Feizai-3 at 39°C. The maximum oviposition lasts on Nanzao-401 at 27°C and the minimum on Hanyi-401 at 33°C. The maximum nymph survival period counted on Hanyi-401 at 30°C and the minimum on Guangzhong-604 at 36°C, respectively. Whereas, 27°C temperature is best suited for a high fecundity rate and total pre-oviposition period in all five pea cultivars, and decreasing trend in fecundity rate and total pre-oviposition period was observed when the pea aphid was reared beyond 30 to 39°C. The overall maximum mean developmental days lasted on Hanyi-401, followed by Guangzhong-604, Nenzao, Feizai-3, and Qizhen-76. It is recommended that furthermore study on aphid pest bionomics, and developing forecasting methods should be used to combat this potential insect pest.

Authors Contribution

A.H. Mastoi is the prime author of the manuscript who conceived, experiments performed, data collected, and wrote the paper from the Ph.D research conducted at Key Laboratory of Entomology, Northwest A & F University, Yangling, Shaanxi, China. W.M. Mangrio statistically analyzed the data. H.A. Sahito point by

point reviewed the article. F.I. Sahito, F.A. Jatoi and S.P. Solangi arranged tools, materials, and played a collaborated role to finalize the research manuscript.

Impact Statement

The *A. pisum* widely destructive pest, sap-sucking insect limiting the yield of several varieties of legumes and forage crops in parts of the world, sucking its sap weakens the plants, from infested plants to healthy one's plants, and the control of this potential pest there is no effective tool available. It is necessary to bring awareness and immediately apply certain strategies through IMP to secure the legumes crops from this potential insect pest.

Declaration and Competing Interest

The authors proclaim that there is no personal relationship or financial interest regarding any part of the work which is presented in this research article.

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Data and Materials availability

Due to the ethical restriction and privacy, the findings, and data of this research paper accessible at the demand of the corresponding author.

Consent for Publication

For releasing this scientific documentary the authors accept all responsibilities.

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