Society for Advancement of Wheat and Barley Research
ICAR-Indian Institute of Wheat & Barley Research
Karnal - 132 001, India

Journal of Cereal Research
11(2):147-151

Research Article

Homepage: http://epubs.icar.org.in/ejournal/index.php/JWR

Comparative biology and population build-up of corn leaf aphid, *Rhopalosiphum maidis* Fitch. on barley genotypes

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Article history

Received: 14 Nov., 2018
Revised : 10 Jul., 2019
Accepted: 16 Jul., 2019

Citation

Singh Sandeep, B Singh, and J Jindal. 2019. Comparative biology and population build-up of corn leaf aphid, Rhopalosiphum maidis Fitch. on barley genotypes. *Journal of Cereal Research* 11(2): 147-151 doi. org/10.25174/2249-4065/2019/84867

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ABSTRACT

The corn leaf aphid (CLA), *Rhopalosiphum maidis* is one of the most serious insect-pests of barley, *Hordeum vulgare L.* in northern plains of India. The resistance to CLA has been identified in both double and six-rowed barley genotypes. Comparative biology and population build-up were investigated to find out the level of aphid resistance in five selected barley genotypes BCU 2806, BK 9816, CIHO 6264, BCU 4507 and IC 434880 along with susceptible check PL 426. The nymphal duration and adult longevity of CLA was significantly higher on resistant barley genotypes whereas these genotypes has relatively lower fecundity and mean reproductive potential. BK 9816 (15.07 ± 1.44 days) and IC 424880 (15.08 ± 1.73 days) has the longest nymphal duration and BCU 2806 has the longest adult longevity (19.63 ± 1.20 days) of CLA. The reproductive potential of CLA was minimum on BCU 2806 (2.24 ± 0.19 nymphs/day) and fecundity was lowest on BK 9816 (31.10 ± 1.60 nymphs). It was found the population build-up of CLA was delayed by a week on resistant genotypes. Higher mortality (up to 83.25 %) and early alate formation in no-choice test indicated the presence of both antixenosis and antibiosis type of resistance in tested resistant barley genotypes.

Keywords: Comparative biology, barley, corn leaf aphid, genotypes, *Rhopalosiphum maidis* (Fitch)

1. Introduction

Barley is an important cereal crop of India, which is mainly grown in Uttar Pradesh, Rajasthan, Punjab and Haryana. Among the several constraints affecting the barley yield, corn leaf aphid (CLA), *R. maidis* has been recognized as the single most important biotic stress in north-western plains of India (Singh and Singh, 2009). The aphids cause 29.61 per cent yield losses in barley crop (Sharma and Bhatnagar, 2004). The nymphs and adults of CLA cause damage by sucking sap from the leaves, stem and earheads (Kaur and Deol 1999). Due to rapid multiplication, the aphids cover large areas on the surface of the shoots. The continuous desaping by a large aphid population cause yellowing, curling and subsequent drying of leaves which ultimately lead to reduction in number and size of earheads (Dedryver *et al.,* 2010). The mild climate from end of January to the beginning of March is highly favourable for CLA infestation in barley. The populations build up of aphids peaks in mid-February coinciding with the flowering to grain filling stage of barley crop (Verma *et al.,* 2011).

Although a complex of natural enemies including lady bird bettle *Coccinella septumpunctata,* green lacewing *Chrysoperla carnea* and syrphid flies are present in barley ecosystem, yet the aphids control is largely dependent on application of insecticides. Therefore incorporation of genetic resistance in cultivated barley varieties is the best alternative (Singh, 2011). The large scale screening of barley germplasm consisting of about 5000 lines has led to the identification of nine barley genotypes with high level of resistance (Singh *et al*., 2006; Singh and Singh, 2009). Now with the availability of new sources of resistance, there is a need to study genetics as well as mechanism and basis of resistance in these barley genotypes. Thus the

present studies were undertaken to compare the biology and population build-up of CLA on selected resistant barley genotypes so that information generated could be utilized for developing effective breeding strategy for the management of this pest.

2. Materials and methods

The aphid resistance studies were carried in the Screen house located in Experimental area of Department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana (30° 55' N and 75° 54' E, 247 m above the sea level) during 2015-16. The region has a sub-tropical climate with hot, wet summers and cool, dry winters. The soil was Typic Ustochrept having low organic carbon (4-4.5 g C/Kg at 0-15 cm).

2.1. Plant material:

The seeds of five aphid resistant barley genotypes viz. BCU 2806, BK 9816, CIHO 6264, BCU 4507 and IC 434880 along with susceptible check (PL 426) were grown in earthen pots filled with 1:1 mixture of soil and farm yard manure.

2.2. Aphid culture:

A colony of *R. padi* was developed from a single aphid collected from a wheat/corn field in the Experimental area, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana. These insect were reared artificially in screen house conditions and next generation nymphs/aphids were used for experimentation. The aphids were multiplied on susceptible barley variety (PL 426) grown in earthen pots and covered with split cages (Severin, 1931). The glass chimneys with muslin glues at the upper end were used for confining the aphid on to the plants.

2.3. Development period of R. maidis

The studies on the development of aphid were carried out on 15 days old barley potted plants during the month of February-March 2016 under ambient environment conditions in the screenhouse. The height of the barley genotypes was maintained to about 10 cm for experimentation. The duration of different nymphal instars was studied by releasing a batch of 10 newly emerged nymphs on plants of five resistant and one susceptible barley genotypes and the plants were then covered with glass chimneys. Daily observations were made for moulting and exuviae were removed using moist camel hairbrush. There were 10 replications for each genotype. The nymphal duration was determined from days taken by newly released nymph to its adult formation.

To determine the longevity of adults of *R. maidis* on different barley genotypes, 20 fourth instar nymphs were released on different genotypes. The number of days for which alate aphid lived was calculated as adult longevity. The fecundity was calculated by counting the number of nymphs laid per female. The mean reproductive potential was calculated by dividing the total fecundity with reproductive period. The time in days elapsing between the adult emergences and laying of first nymph was counted as pre-reproductive period. The period between the laying of first nymph to the last nymph laid was termed as reproductive period and the time between the last nymph laid and death of the adult was counted as the post- reproductive period.

The host plant preference studies were done in no-choice test. A separate batch of twenty adults of corn leaf aphid were released on 15 days old plants of each genotype during the first week of March under ambient environmental conditions. The plants were covered with glass chimneys. These plants were observed daily to record the survival of adults. The plants on which the nymphs developed to adults were taken as suitable host of this aphid.

2.4. Field trials

A separate field experiment was laid in randomized complete block design to record the first appearance and population build-up CLA on different genotypes. The first appearance of aphids was recorded from ten randomly selected tillers per plot from each of the test genoytpes. The population build-up CLA was studied by recording number of aphids/tiller from ten tagged plants randomly selected from each barley plot. These observations were recorded at weekly intervals throughout the crop season.

3. Results and Discussion

3.1. Developmental period of R. maidis

3.1.1. Nymphal duration

The duration of first instar of *R. maidis* varied from 2.26±0.38 to 2.83±0.90 days on resistant barley genotypes while it was only 2.15±0.35 days on susceptible genotypes (PL 426) (Table 1). Among the resistant genotypes, nymphal duration was significantly higher on BCU 4507 (2.83±0.90 days) as compared to all other genotypes. The duration of second instar nymphs of *R. maidis* varied from 3.27±0.64 days to 4.65±0.82 days on resistant barley genotypes whereas it was only 3.43±0.50 days on PL 426. Among the resistant genotypes, second instar nymphal duration was significantly higher on BCU 4507 (4.65±0.82 days) and (4.64±1.22 days) as compared to all other genotypes. The duration of third instar of *R. maidis* ranged from 3.49±1.11days to 4.31±0.65 days on resistant barley genotypes while it was recorded only 3.30±0.64 days on PL 426. It has been observed

Table 1: Duration of different nymphal instar of *Rhopalosiphum maidis* on barley genotype during 2016

Genotypes	1st instar (days)	2nd instar (days)	3rd instar (days)	4th instar (days)	Total nymphal duration (days)
BCU-2806	2.56±0.39	3.27±0.64	4.01±0.50	4.24±0.87	14.08±1.11
BK-9816	2.26±0.38	4.64±1.22	4.31±0.65	3.86±0.66	15.07±1.44
CIHO-6264	2.27±0.28	3.65±0.75	3.49±1.11	3.51±0.65	12.92±1.56
BCU-4507	2.83±0.90	4.65±0.82	3.61±0.52	3.96±0.67	15.06±1.42
IC-434880	2.61±0.33	4.13±0.57	3.98±0.76	4.35±0.74	15.08±1.73
PL-426	2.15±0.35	3.43±0.50	3.30±0.64	3.18±0.52	12.07±1.06
LSD (p=0.05)	0.44	0.70	0.65	0.61	1.26

Table 2: Pre-reproductive, reproductive and post-reproductive period (days) of *Rhopalosiphum maidis* on barley genotypes during 2016

Genotypes	Pre-Reproductive Period (days)	Reproductive Period (days)	Post -Reproductive Period (days)	Adult longevity (days)	Fecundity (nymphs/female)	Mean reproductive potential (nymphs/day/female)
BCU-2806	3.01±0.63	14.00±1.15	2.62±0.45	19.63±1.20	31.20±2.70	2.24±0.19
BK-9816	2.12±0.50	12.60±1.26	2.28±0.37	17.00±1.33	31.10±1.60	2.48±0.20
CIHO-6264	1.89±0.23	15.50±1.96	1.97±0.66	19.60±1.82	37.50±1.27	2.45±0.26
BCU-4507	2.76±0.92	13.30±0.67	2.70±0.20	18.76±1.32	34.90±0.74	2.65±0.09
IC-434880	2.90±0.54	12.50±1.27	2.21±0.41	17.37±1.65	32.30±1.77	2.60±0.28
PL-426	1.84±0.39	11.30±1.06	1.92±0.38	15.06±1.30	42.20±4.69	3.75±0.41
LSD (p=0.05)	0.52	1.14	0.39	1.30	2.23	0.23

that nymphal duration of third instar got prolonged maximum on BK 9816 genotype. The fourth instar nymphs of *R. maidis* took 3.51±0.65 days to 4.35±0.74 days to become adults on resistant barley genotypes. The duration of fourth instar nymphs was maximum on IC 434880 followed by BCU 2806, BCU 4507 and it was minimum on PL 426 (3.18±0.52 days).

The total nymphal duration of *R. maidis* was significantly higher on all resistant barley genotypes except CIHO 6264 (12.92±1.06 days) and susceptible check PL 426 (12.07±1.06). The increase in nymphal duration of *R. maidis* on resistant lines has been previously reported as well (Bayhan, 2009; Ali *et al,* 2005; Kennedy and Ghadir, 1979). It was reported in previous studies that nymphal duration can adversely be influenced by the higher levels of secondary metabolites (hydroxymic acid) produced in phloem exudates of resistant genotypes (Niemeyer 1988). A pest needs to accmulate certain number of degree-days to complete it's life cycle (Herms, 2004) which might get prolonged while it was feeding on resistant plants.

Table 3: Host preference in terms od survival and alate formation of *Rhopalosiphum maidis* on different barley genotype under no choice test during 2016

Genotypes	Mortality (%)	Alate formation (%)	Days after which alate formed
BCU-2806	80.75±5.14 (9.04)	31.67±6.14 (5.69)	7
BK-9816	83.25±4.72 (9.17)	18.33±6.25 (4.33)	6
CIHO-6264	57.00±3.68 (7.61)	15.00±4.74 (3.97)	7
BCU-4507	73.75±6.89 (8.64)	20.00±6.25 (4.56)	6
IC-434880	84.5±4.83 (9.24)	35.00±7.37 (5.99)	8
PL-426	32.75±5.32 (5.79)	0.00±0.00 (1.00)	0
LSD (p=0.05)	0.29	1.07	

Figure in parentheses are mean of square root transformation

3.1.2. Pre-reproductive, reproductive and post-reproductive period

The adults of corn leaf aphid required relatively higher number of days to start nymphiposition on resistant genotypes as compared to susceptible genotype (Table 2). Significantly longer pre-reproductive period was recorded on resistant genotype BCU 2806 (3.01±0.63 days), IC 434880 (2.90±0.54 days) and BCU 4507 (2.76±0.92 days) as compared susceptible PL 426 (1.84±0.39 days). The reproductive period of *R. maidis* was significantly longer on all resistant barley genotypes (12.50±1.27 to 15.50±1.96 days) as compared PL 426 (11.30±1.06 days). It was longest in CIHO 6264 among the resistant genotypes. The post reproductive period of *R. maidis* varied from 1.97±0.66 to 2.70±0.20 days on resistant barley genotypes while it was 1.92±0.38days on PL 426. The non-preference/antibiosis could be a possible reason for higher reproductive periods on resistant barley genotype.

3.1.3. Adult longevity, Fecundity and mean reproductive potential

In general, adult survived for longer period on resistant plants compared to suscceptible one's. The adult longevity of *R. maidis* was significantly more on all resistant barley genotypes (17.00±1.33 to 19.63±1.20 days) as compared to susceptible PL 426 (15.06±1.50 days). Maximum adult longevity of aphids was recorded on BCU 2806 followed by CIHO 6264 and BCU 4507. Previous study on adult longevity of cotton aphid revealed that plant nutrition, leaf age, leaf surface structure and secondary plant metabolites in resistant cotton cultivar were responsible for observed resistance (Weathersbee and Hardee 1994). A possible

Table 4: Corn leaf Aphid, *Rhopalosiphum maidis* incidence on different barley genotype during 2016 under field conditions

Genotypes	Number of aphids/tillers during different SMW							
	6-SMW	7-SMW	8-SMW	9-SMW	10-SMW	11-SMW	12-SMW	Mean
BCU-2806	3.13±0.85	3.93±1.39	4.75±0.73	10.87±2.11	4.20±0.10	0.93±0.35	0.13±0.12	3.99
BK-9816	5.20±0.52	10.70±2.07	14.92±1.71	14.47±1.20	5.03±0.80	1.10±0.26	0.03±0.06	7.35
CIHO-6264	9.37±0.06	11.83±2.38	11.05±0.81	17.97±4.18	5.90±0.53	1.07±0.29	0.23±0.25	8.20
BCU-4507	8.93±0.71	10.83±0.38	11.17±0.56	16.47±2.07	6.00±0.53	1.00±0.26	0.10±0.10	7.78
IC-434880	7.77±0.90	8.40±1.21	6.90±1.40	10.67±0.91	5.40±0.44	0.60±0.20	0.00±0.00	5.67
PL-426	20.50±1.30	52.53±16.78	70.53±4.93	43.03±3.36	13.97±1.33	2.47±0.68	1.40±0.26	29.20
Mean	9.15	16.37	19.88	18.91	6.75	1.19	0.32	
LSD (p=0.05)	A(Genotype)= 1.84,		B (SMW)=1.98,	A×B=4.87				

*SMW-Standard Meteorological Week

explaination to extended period of adult logiviety could be due to slow growth rate of aphids on resistant plants that prolonged it's life cycle. Abiotic or biotic stresses lower the growth of pea aphid (Dancewicz *et al* 2018). The higher adult longevity in present study are also in agreement with Soffan and Aldawood (2014) and Razmjou and Golizadeh (2010).

The fecundity of corn leaf aphid was 42.20±4.69 nymphs/female on PL 426 whereas it varied from 31.10±1.60 to 37.50±1.27 nymphs per female on resistant barley genotypes (Table 3). The mean reproductive potential on PL 426 was 3.75±0.41 nymphs/day and it was significantly higher than all other resistant barley genotypes. Barkhordhar *et al* (2012) and Razmjou and Golizadeh (2010) also reported the lower fecundity of *Schizaphis graminum* (Rondani) on resistant cultivars.

3.1.4. Host preference

Host preference studied in no-choice test revealed a higher mortality of corn leaf aphid on resistant barley genotypes (57.00±3.68 to 83.25±4.72 %) as compared to susceptible genotype PL 426 (32.75±5.32%) (Table 4). Six to eight days after their release, the alate form (winged) appeared in 15-35 per cent of individuals fed on resistant barley genotypes whereas no alate formation was observed susceptible barley genotype (PL 426). The higher mortality and early alate formation in resistant barley genotypes are strong indicators of non-preference. Golizadeh *et al* (2016) also reported the higher mortality of nymphs on susceptible sugar beet genotypes. Similarly, Branson and Simpson (1966) reported that a higher ratio of alate to apterous morphs to resistant genotypes. Physiological factors of plant such nutrients deficiency might be responsible of more alate formation on resistant genotypes (Walters and Dixon 1983)

3.2 Field trials

The population dynamics of *R. maidis* study revealed varying level of resistance in different barley genotypes. Seasonal mean aphid population/tillers was significantly different on test barley genotypes. It was significantly higher on susceptible genotype PL 426 (29.20 aphids/tiller) as compared to all other test genotypes. The minimum aphid population was recorded on BCU 2806 (3.99 aphids/tiller) and it was at par with IC 434880 (5.67 aphids/tiller) (Table 4).

The aphid population started building up from 6-SMW (standard metrological week) and reached it's peak during 9-SMW after which it started declining on all resistant barley genotypes. The present studies confirm the studies of Rustamani *et al* (1999) and Verma (1993) which reported the peak aphid population at milky grain stage of barley crop. The interaction between the time of observation of aphid population and genotypes was significant. The aphid population declined from 8th SMW to 9th SMW on PL 426 (susceptible) while it increased on all aphid resistant genotypes during the same period. These results indicated that resistant genotypes delayed the aphid incidence by a week. This could be due to non-preference of these genotypes. The non-preference in these genotypes could be related to lower sugar, free amino acid content and higher phenol content, activity of PAL and PPO enzymes (Singh *et al*., 2016).

4. **Conclusion:** The resistant genotypes exhibited early alate formation, higher mortality, lower fecundity and reproductive potential of aphids as compared to susceptible PL 426. The results advocated the presence of both antixenosis and antibiosis type of resistance in resistant barley genotypes. There is a need to further investigate the difference in physical and bio-chemical difference in resistant and susceptible genotypes and find the gene/QTL's responsible for observed resistance in tested genotypes.

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