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SCREENING OF DIFFERENT WHEAT GENOTYPES AGAINST *DIURAPHIS NOXIA* AND IT'S POPULATION DYNAMICS ON WHEAT (*TRITICUM AESTIVUM* L.) AND BARLEY (*HORDEUM VULGARE* L.) IN QUETTA

Zuhra Bibi[1], Gul Makai[1]*, Abdul Hanan Buriro[2], Spozmai Tareen[1], Ambreen Ijaz[1], Yasmeen Rehmat[3]

[1]**Department of Zoology,** Sardar Bahadur Khan Women's University (SBKWU), Quetta, Pakistan
[2]**Balochistan Agriculture Research and Development Centre** (BARDC),Quetta, Pakistan
[3]**Department of Botany,** Government Girls Degree College, Quarry Road, Quetta, Pakistan

***Corresponding Author:** Dr. Gul Makai Panezai. E. mail: g.makai@yahoo.com

Abstract

Russian wheat aphid, Diuraphis noxia (Kurdjumov) is a main pest of wheat and barley in several regions of the world. This study was conducted on the population dynamics of Russian wheat aphid for screening the resistance of different wheat genotypes at the experimental field of Balochistan Agricultural Research Centre (BARDC), Quetta during two consecutive years (2013-2014 & 2014-2015), comprising of two experiments. In the first experiment, the resistance of 12 wheat genotypes, KRWA-9, PI-1572652-1, PI-6264656-3, PI-626580-4, PI-162HISI-1, CI-2401-A3, KRWA-25, KRWA-28, KRWA-103, CIMMYT-7, KRWA-8 and KRWA-36 and four released varieties (NARC-11, Zardana, Tijaban-10 and AZRC-1) for Balochistan. The first experiment was laid out in a randomized complete block design (RCBD) with three replications. In the second experiment, the comparison between the population dynamics of aphids on wheat and barley was made. The Aphid population that appeared on all varieties/lines in the 2nd week of March increased gradually and reached its peak in the 4th week of April on all the varieties/lines. However, an abrupt drop in the aphid population was recorded after the 1st week of May. The mean aphid population/tiller was lower on KRWA-9 (0.2, 0.3) during the study period, which was recorded as the maximum resistant genotype to Russian wheat aphids under the field environment. In contrast, AZRC-1 & NARC-11 (14.9) & Tijaban-10 (14.5) appeared to be the most susceptible varieties. The second experiment showed that the D. noxia, population was significantly greater on local barley (31.82± 2.43/tiller) as compared to the wheat variety Pirsabak-2013 (21.55±1.64/tiller) during both years.
Key words: *Aphids population per tiller, BARDC, Plant resistance, Russian wheat aphid, Wheat genotypes*

INTRODUCTION

Wheat adds 10 percent of Pakistan's agricultural value, being Pakistan's chief diet and adding 2 percent to its GDP. In 2017-18, an average yield of 2893 kg per ha was produced, and the product was cultivated on over 9 million ha. This produced 26.3 million tons of grain during this time period. The annual yield is reduced due to several factors, one of which is insect pests, which are attributed to regular pest status in the country. Aphids are responsible for reducing the grain size, sap-sucking, and yellowing thus, direct damaging reduction occurs. They are also attributed to transmitting plant viruses, thus causing indirect damage. The indirect loss due to aphids can range from 20-80%, while that of direct damage ranges from 35-40% (1).

The Islamic state of Pakistan is mainly dependent on the agricultural section, which is the main earning and employment-generating state of the republic (2). Wheat (*Triticum aestivum* L.) is the essential commonly developed plant species universally. Wheat (*Triticum* spp.) belongs to the family *Poaceae* (grasses), tribe *Triticeae*, and genus *Triticum*, a self-pollinating annual plant. Wheat (*Triticum aestivum* L.) is the principal food grain crop and actuality expended as a staple food of the individuals of Pakistan (3). The most advanced one is general/bread wheat (T. *aestivum*), a hexaploid having 42 chromosomes.

The wheat crop cultivation needs cool, moist weather for a longer period of time, which must be followed by dry, warm weather to ripe the grain properly. Triticum aestivum L (wheat) plant is not free from arthropod pest damage at any stage of life. These pests could either be oligophagous (feeding on a few species of plants), polyphagous (feeding on a variety of plant species), or very rarely monophagous to wheat crops only (4).

Wheat grain comprises great carbohydrates, proteins, lipids, and vitamins. It is the most vital diet in the universe as a great nutrient substance, mainly carbohydrates (5). Protein gluten makes it unique in wheat kernels of this cereal (6). This cereal has an extreme impact on bread, diet, pharmaceutics, and other trades, but moreover, it is the key product of the overall arrangement of the trendy entire marketplace (7). Altered reasons are accountable for the low crop of wheat, like abiotic features and small yielding varieties (8), inappropriate responses such as fertilizers and irrigation (9), sowing period (10), wild plant (11), and insectpests (12).

Universal pests in crop damage can report up to more than 40 percent (13). Various pests, such as wheat armyworm (*Mythimnaseparata*), wheat weevil (*Tanymecusindicus*), white ants (*Microtermesobesi*), and aphids, attack wheat (14). Wheat crops invade 29 aphid species between insect pests (15). Central species are the green bug, *Schizaphisgraminum* (Rondani), English grain aphid, *Sitobionavenae* (Fabricius), Russian wheat aphid, *Diuraphis noxia* (Mordvilko), bird cherry-oat aphid, *Rhopalosiphumpadi* (L.), and rose-grass aphid, *Metopolophiumdirhodum* (Walker) (16). Aphid species S. *graminum*, R. *padi*, and S. *avenae* are the insect pests of wheat in Pakistan (17). Aphids suck sap from leaves and shoots, which results in curling, chlorosis, and distortion of leaves, hence, reduction of growth (18).

Russian wheat aphid (*Diuraphis noxia*, *Mordvilko*) is one of the most significant severe pests on wheat, having initiated from central Asia and then dispersal to East Asia, the Middle East, Africa, North America, South America, and Central Europe. The aphid has advanced comprehensively to the common of the wheat generating sectors of the world and Pakistan (19). Shea et al., (2000) observed that the flag leaf is rolled, and increasing heads and awns were confined by aphid violence, affecting reduced pollination (20). Aphid attack starts from arrival and persists up to development. *D. noxia* feeding harm by plant leaves affects distinctive longitudinal white, yellow, or red chlorotic streaks with difficult leaf rolling. Rolling of the leaves drops photosynthetic area and protects aphids from exchanging insecticides and innate enemies (21).

Aphids are among the most notorious, posing great damage to cereal crops, especially Triticum aestivum, which belongs to the Poaceae family. The reason Aphids (Hemiptera: Aphididae), especially Russian wheat aphid (RWA), *Diuraphis noxia* (Kurdjumov), are so disreputable is that they grow exponentially by parthenogenesis in a short time, thus leading to exceeding the economic threshold IPM (integrated pest management) (22). Russian wheat aphid, considered Palearctic in origin, feeds on cool-season grasses (Wheat, barley) on the upper surface of younger leaves. Their life span is 60- 80 days, during which they produce up to 80 offspring per day at an average temperature of 20 °C. They can withstand temperatures aslow as -25 °C (23).

Resistance has been documented in frequent wheat lines, and presently, about 300 varieties are familiar to comprise resistance genes. (24) Showed population dynamics of wheat aphid (*Diuraphisnoxia*) on sixteen varieties/lines of wheat (*Triticum aestivum* L.). The mean aphid population/ tiller of a wheat plant during the whole period were lower on Tw 69002 & 69003 (3.83). Tw 69002 & Tw 69003 were extremely resilient, and Tw69012 was the best susceptible varieties/lines among sixteen confirmed varieties/lines.

RWA, organized by eleven genes, has been considered and presented. Resistance in Halt rises from a specific, most significant gene called Dn4 (25). Discovery of a new biotype of *D. noxia*, interrupting resistance in cultivars with Dn2 and Dn4 resistance genes (26). Distinctive resistance-breaking aphid biotypes can range from *D. noxia* plant resistance to be generally based on antibiotic effects but relate to different categories.

MATERIALS AND METHODS

EXPERIMENTAL SITE AND CLIMATIC CONDITIONS

The research was conducted at the field of Balochistan Agricultural Research and Development Centre (BARDC), Quetta, during the years 2013-2014 and 2014-2015. Quetta is at a regular altitude of 1,680 meters (5,510 feet) above sea level, making it Pakistan's only high-altitude main city. Summer starts almost late May and goes on till initial September with average temperatures fluctuating from 24–26 °C (75–79 °F).

The studies were comprised of two experiments. In the first experiment, the resistance of 16 wheat genotypes, KRWA-9, PI-1572652-1, PI-6264656-3, PI-626580-4, PI-162HISI-1, CI-2401-A3, KRWA-25, KRWA-28, KRWA-103, CIMMYT-7, KRWA-8 and KRWA-36 by which 4 varieties, NARC-11, Zardana, Tijaban-10 and AZRC-1 were kept as control and obtained from Pakistan.

Fig. 1. Picture showing the infestation of *Diuraphis noxia*

1ST EXPERIMENT

SCREENING OF DIFFERENT WHEAT VARIETIES AGAINST RUSSIAN WHEAT APHID

The experiment was laid out in a randomized complete block design (RCBD). Every treatment was replicated three times (Fig. 2, 3, 4). The 10 grams seed were sown in plots, measuring 112.5 m2 (7.5x15m) and each genotype sown in two lines. The row to row distance of 30 cm was maintained in both experiments. The 25 grams of seed was applied @ 100 Kg/ha with a soaking dose of irrigation and a basal dose of fertilizer @ 20, 20, 0 NPK.

2ND EXPERIMENT

POPULATION DYNAMICS OF RUSSIAN WHEAT APHID ON WHEAT AND BARLEY

In the second experiment, the comparison between the population dynamics of aphids on wheat genotype (Pirsabak-2013) and barley (*Hordeum vulgare.* L) was carried out. The row to row distance of 30 cm was maintained in both experiments. The 25 grams of seed was applied @ 100 Kg/ha with a soaking dose of irrigation and a basal dose of fertilizer @ 20, 20, 0 NPK. No insecticide was applied on the crops in both experiments.

SAMPLING TECHNIQUES/DATA COLLECTION AND STATISTICAL ANALYSIS

The data of aphids and its yield losses was noted throughout the total experimental period from (February to May) during the both years. Data collection on population dynamics was immediately initiated after germination at a weekly interval till the harvesting of the crop. Three plants from each variety were examined at random during the vegetative stage, five tillers at tillering stage, while at later stage (ear head/spikes of three plants) were observed. The counting was performed of the number of nymphs and adults of aphids present on each plant/tiller/spike. The identification of aphids was carried out using keys for identification (27). Then the mean number of aphids/plant for each variety/line was calculated. The data was subjected to statistical analysis using M. Stat C for 1st experiment& Minitab 14 for 2nd experiment.

RESULTS

1ST EXPERIMENT

Table I revealed the significant difference between the resistant and control varieties. In the years 2013-2014, the overall mean number of Russian wheat aphids per plant was higher on wheat lines NARC-

11 and AZRC-1(14.9), while wheat line KRWA-9(0.2) was comparatively resistant with a minimum population of aphids per plant. However, 2014-2015 showed no significant difference between resistant varieties except KRWA-36 but significantly different from local varieties.

Table I. Mean population of *Diuraphis noxia* on different wheat varieties

S. No	Varieties	Means 2013-2014	2014-2015
1	KRWA-9	0.2 B	0.33 D
2	PI-1572652-1	0.6 B	0.55 D
3	PI-6264656-3	0.7 B	0.48 D
4	PI-626580-4	0.6 B	0.87 D
5	PI-162HISI-1	0.8 B	0.64 D
6	CI-2401-A3	0.8 B	1.23 D
7	KRWA-25	0.8 B	1.32 D
8	KRWA-28	0.9 B	0.78 D
9	KRWA-103	1.1 B	0.76 D
10	CIMMYT-7	1.2 B	1.00 D
11	KRWA-8	1.2 B	1.92 D
12	KRWA-36	2.0 B	10.18 C
13	Tijaban-10	14.5 A	18.56 BC
14	NARC-11	14.9 A	18.57 B
15	Zardana	13.0 A	13.05 A
16	AZRC-1	14.9 A	13.94 A
LSD		2.456	2.77

Table II presents 2013-2014 relation of the average maximum number of Russian wheat aphids with date and the varieties indicates a higher number of aphids (6.4) in the 4*th* week of April 2014 but the least number of aphids (2.8) in the 4*th* week of March while the population of aphids (5.7), (4.7), (4.4), (4.3), (3.8), (3.4) and (2.9) on weekly intervals respectively. The relation of the average maximum number of aphids with weeks and all varieties indicates a higher number of aphids (7.02) in 1*st* week of May 2015 but least number of aphids (2.84) in 5*th* week of March 2015 while the population of aphids (7.0), (6.7), (5.64),(5.12), (5.17), (3.86) and (3.18) on weekly intervals respectively.

Table II. Mean population of *Diuraphis noxia* on different wheat varieties

S. No	No. of weeks	Mean year 2013-2014	2014-2015
1	2nd week of March	4.3	6.78
2	3rd week of March	3.8	7.00
3	4th week of March	2.8	3.18
4	5th week of March	2.9	2.84
5	1st week of April	3.4	3.86
6	2nd week of April	4.4	5.12
7	3rd week of April	4.7	5.17
8	4th week of April	6.4	5.64
9	1st week of May	5.7	7.02
LSD		2.456	2.77

RESISTANT VARIETIES OF WHEAT GENOTYPES AGAINST DIURAPHISNOXIA

A maximum number of Russian wheat aphids per tiller was recorded in control varieties as compared to treated varieties throughout both of the study years. The growth of plants increased gradually with the aphid population. It is observable that during the vegetative growth stage, the aphid multiplication rate was advanced. (Fig. 2A) shown that aphids arrived in the second week of March (10-03-014/015) with an early mean population of (0.33) (0.00) aphid's leaf-1 on variety KRWA-9 during both years 2014 & 2015, but the overall mean number of *D. noxia* per plant was higher on wheat line AZRC-1 (26.99) throughout 2014 and NARC-11 (30.99) in 2015.

During 3*rd* week of March 2014, & 2015, after every seven days intervals, a maximum number of Russian wheat aphids per plant in (Fig. 2B) was recorded (25.99) (28.2) on the wheat line AZRC-1 & NARC-11 and the lowest on varieties PI-1572652-1 & KRWA-9 (0.33, 0.00 aphids per plant) was noted. Fig. 2C shows the weekly intervals during the 4*th* week of March. The results showed that the overall mean *D. noxia* density tiller-1 on different wheat varieties was highest and was recorded on wheat line NARC-11 (10.77) followed by Tijaban-10 (10.66) than the other varieties. This observed change in the date of peak level and zero population may be due to the alteration in the weather causes of different situations.

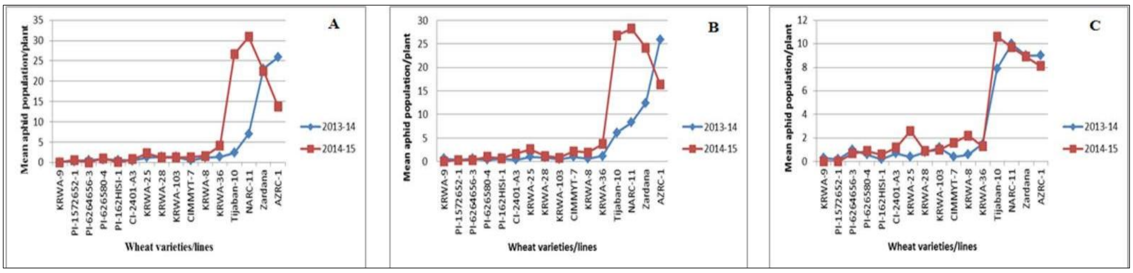

Fig. 2. Mean population of Russian wheat aphid on (A, B, C) 2nd, 3rd & 4th week of March

Fig. 3D showed the per plant mean number of Russian wheat aphids on different wheat varieties, which was significantly greater on NARC-11 followed by KRWA-9 (13.33, 9.6) while lower on KRWA-9 (0.33, 0.00). Temperature ranges from approximately 10 to 33 C° during the trial, which appeared favorable for increasing pest population development. (Fig. 3E) denoted the incidence of Russian wheat aphids during 1st week of April (13.33, 12.11) on different wheat varieties NARC-11 was observed while the minimum attack of aphids, *Diuraphis noxia* (0.00, 0.00), was observed on variety KRWA-9. The 2nd week of April showed an increased number of Russian wheat aphids on variety NARC-11 (18.77, 17.55) and a decreased number on variety KRWA-9 (0.33, 0.00) and PI-1572652-1 (0.33) in (Fig. 3F). The aphid population increased and decreased significantly from the 1st to the 3rd week of April because of temperature, humidity, rainfall, and maturity.

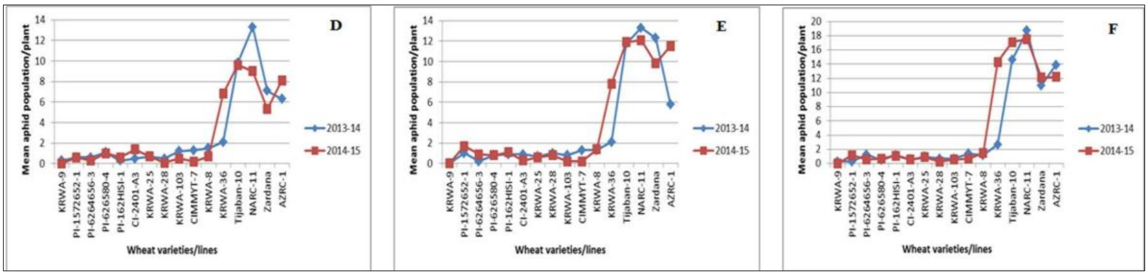

Fig. 3. Mean population of Russian wheat aphid on (D, E, F) 5th (March), 1st & 2nd week of April

Fig. 4G shows the peak population of aphids on genotype Tijaban-10 (16.88), which showed the least resistance related to the genotype KRWA-9 and PI-1572652-1 (0.33, 0.00). The local variety indicated the minimum resistance against resistant varieties. On the maturity of wheat genotypes, the number of aphids starts to disappear because of low chlorophyll contents and predators attacks. The overall per tiller mean number of aphids, *Diuraphis noxia*, was significantly maximum on wheat line NARC-11 and Tijaban- 10 (22.99, 20.11) but lowest on the varieties KRWA-9 and PI 1572652-1 (0.00, 0.00) mean number of aphids (Fig. 4H). RWA best grows above the temperature of 25°C, and in the 3rd week of April, the maximum temperature of Quetta was 27.95 (°C). On the last sampling date, 05-05-2014 (Fig. 4I), the least number of Russian wheat aphids was observed on resistant genotypes KRWA-25 and KRWA-9 (0.1, 0.00) but highest on the variety Tijaban-10 (28.33, 26.55).

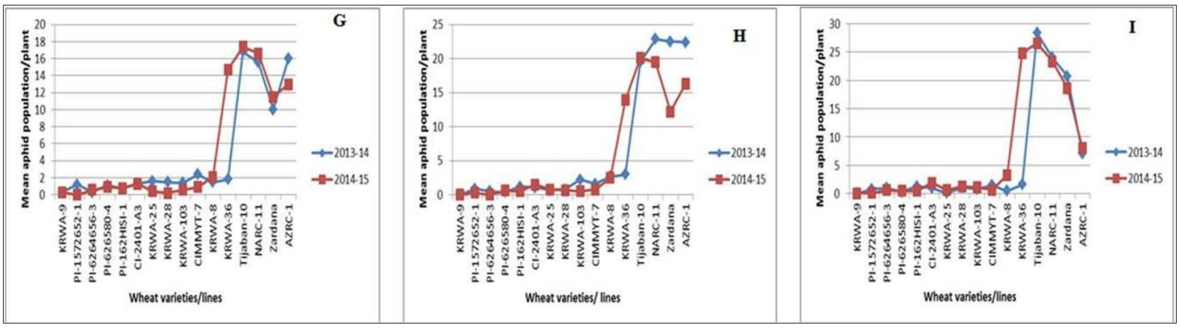

Fig. 4. Mean population of Russian wheat aphid on (G, H, I) 3rd & 4th week of April and 1st week of May

2ND EXPERIMENT

Diuraphis noxia, the population was significantly greater on barley (*Hordeum vulgare* L.) than local wheat Pirsabak-2013 during 2013-2014 (Table III). Infestation started on the ends of the wheat and barley crops near ditches and channels where wild weeds were detected. Aphid influx was first witnessed on 24th March on barley (40.9/*tiller*). This was due to the start of the temperature rise. During the developing season, there was a significant rise in population density (i.e., a significant weak effect) through both crops. The peak densities of aphids on barley were noted in the 2nd week of April 2014, which was 60.2 *aphids/tiller* (Table III) 2013-014. The population of aphids dropped during the last two weeks of sampling on the 21st and 28th of April when the crop senesced and dried but for the seed in May. The aphid population on wheat was observed in the 3rd week of March and sustained up to the 4th week of April. During 2014-2015, the population of aphids started on 22nd March and continued to increase up to the 2nd week of April on wheat (35.9 plant *tiller*$^{-1}$) and barley (32.8 plant *tiller*$^{-1}$). The population was mostly observed on developing earheads and flowers. The lowest population of Russian wheat aphids on wheat was observed in the last week of April, which was 0.6/*tiller* (Table III). The overall mean population of aphids was significantly greater on barley (11.4/*tiller*) as linked with wheat (8.87/*tiller*). The population of Russian wheat aphids disappeared around the 1st week of May on barley because of the shorter durationof barley than wheat and plants becoming dry before wheat.

Table III. Average per tiller population of *Diuraphis noxiaon* wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.)

Years	Dates	Wheat	Barley	t-test
	24-03-2014	36.7 ± 2.5	40.9 ± 3.3	-3.10 *
	31-03-2014	29.8 ± 2.6	49.6 ± 2.2	-3.23 *
2013-2014	07-04-2014	43.5 ± 2.5	21.2 ± 4.9	-3.01 *
	14-04-2014	16.92 ± 1.8	60.2 ± 1.6	-0.12 N.S
	21-04-2014	1.52 ± 0.30	20.4 ± 2.3	-8.75 *
	28-04-2014	0.88 ± 0.18	1.64 ± 0.3	-2.16 N.S
		21.55+1.64	**31.82± 2.43**	
	22-03-2015	1.88 ± 0.27	3.28 ± 0.46	-2.60 N.S
2014-2015	29-03-2015	1.36 ± 0.22	3.32 ± 0.42	-4.16 *
	06- 04-2015	11.04 ± 1.0	24.3 ± 2.0	-5.87 *
	12-04-2015	35.9 ± 2.7	32.8 ± 3.4	0.72 N.S
	19-04-2015	2.44 ± 0.48	1.60 ± 0.26	1.55 N.S
	26-04-2015	0.64 ± 0.15	3.20 ± 0.57	-4.37 *
Mean		**8.87 ± 0.80**	**11.41 ± 1.18**	

DISCUSSION

The current results of 2013-2014 revealed significant differences in the number of aphids and their related dates among the wheat cultivars. The number of aphids per tiller was significantly higher on wheat lines NARC-11 and AZRC-1(14.9) cultivars and low on KRWA-9 (0.2) varieties. Thus, cultivars in NARC- 11 and AZRC-1(14.9) seem more susceptible, and KRWA-9 (0.2) is more resistant. Differences in the aphid populations between the altered cultivars have been reported by certain studies (9, 16, 28). The chemical causing resistance to cereal aphids in barley is gramine in the leaves (29). The present results are in conformity with those of Formusoh *et al.*, (1994), who reported that resistant cultivars showed the lowest population of aphids (0-5.0/tiller) as related to susceptible lines (16-20/tiller) (30). Zia *et al.*, (2010) Found non-significant differences among wheat genotypes (31). They studied the variation due to the different sets of wheat entries involved in thepresent investigation and weather circumstances.

Archer *et al.*, (1998) observed the wheat response to Russian wheat aphid, *Diuraphis noxia*, and infestation varies at different plant growth stages (32). The present results do not conform to those of Aslam *et al.*, (2005) (33). They stated that aphids rise rapidly throughout the cold weather and reach the maximum population at the end of February and early March after ears initiate repining. Wains *et al.*, (2008) found that the maximum number of aphids in March and the decline in aphid populations later in mid-March may be due to the increase in temperature, the repining of crops, and the attack of coccinellid beetles (34, 35). The population of coccinellid predators coordinated with the aphid population with the maximum synchronization through the end of February. The aphid in- vasion gradually increased up to the 4th week of March and then decreased to the 3rd week of April. The results further revealed the peak aphid population during the 4th week of March, which does not conform to those of Aheer *et al.,* (2006) (36). Significant differences were found among the average aphid population during different months (P¡0.01). The highest infestation was noted for April, followed by February, and March had the minimum aphid infestation (Table III).

Aheer *et al.,* (2006) reported cultivar alterations with respect to aphid infestation and concluded that aphid infestation was at its peak during March and monitored by February (36). The decline during March may be attributed to low temperatures, and the population increased during April because of favorable temperatures and no rainfall.

Yang (1990) reported that at low temperatures, the developmental period was delayed, whereas high temperature decreases the reproductive capacity. The author also concluded that a temperature of 25°C is favorable for population growth. In the present experiment, the highest population was recorded in 3rd week of April, which was 28.33 aphids/plant at 27.2°C. The present finding agreed with support (38), which observed that the number of aphids increased at 15- 18°C during wheat earing and flowering. The highest population density was recorded during grain development and the initiation of wax ripening. The decline in the aphid population could also be the result of crop maturity, as stated by Riedell (1990), which states that the infestation of aphids on wheat crops is abundant during the heading and flowering stages and is reduced during the maturity stage of the crop (39).

CONCLUSION

It is concluded that KRWA-9 (0.2) in years 2013-2014 and (0.3) during 2014-2015 is a resistant cultivar to Russian Wheat aphid under the field environments in contrast to the NARC-11 & Tijaban-10 which are recorded as susceptible varieties. However, the variety NARC-11 & AZRC was least preferred during the ear head stage. Moreover, in the population dynamics study, the 4th week of April was verified as the most serious period for the maximum aphid infestation on the wheat crop, from March until May under Quetta Valley conditions.

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Conflict of interest:

Authors have no conflict of interest.

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