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# Biological Responses of Russian Wheat Aphid, *Diuraphis noxia* (Mordvilko) (Homoptera: Aphididae) to Different Wheat Varieties

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## ABSTRACT

**In recent years, the Russian Wheat Aphid, has been included worldwidely in the list of the important pests of cereals, particularly wheat plants. In addition to direct serious damage, the aphid is the main vector of Barley Yellow Dwarf, Barley Mosaic, and Sugarcane Mosaic Viruses. The pest was reported from East Azarbaidjan province (Iran) a few years ago and it is now widespread in Tabriz, Ahar and Kaleybar wheat fields. In the present study, the possibility of any resistance was looked for at the tillering stage in Sardari, Sabalan, Alvand, Zarrin and Alamoot, the most extensively planted varieties in the province. The experiment was conducted under glasshouse conditions of 24.4±1.6 $^{o}$C with 50-60% R.H. and a photoperiod of 14:l0(L:D). Antibiosis was determined by studying the percentage survival of the nymphs, their developmental time, and fecundity (total number of progeny per /female produced within the first 10 and 15 days of the reproductive cycle) calculating the relevant intrinsic rate of natural increase ($r_m$ values). The analysis of variance indicated that, regarding the last two parameters, there were significant differences ($P<0.05$) between the varieties. The highest (43.21±5.45) and the lowest (34.43±8.91) average numbers of progeny within the first 10 days were observed in those reared on the Sardari and Zarrin varieties respectively but the figures obtained within the first 15 days were found to be 49,43±13.31 on Alamoot and 58.86±9.45 on Sardari. Also the highest mean "$r_m$" value (0.3399±0.01) was estimated for rearings on Sardari with the smallest (0.2889±0.03) on the latter. At present, Sardari seems to be more likley susceptible to the aphid amongst the others. Field trials and experiments on later phenological stages of the wheats and potential role of other resistance mechanisms is going on.**

**Keywords**: Host plant resistancc,Russian wheat aphid ,Wheat varieties.

## INTRODUCTION

The Russian Wheat Aphid, was first reported by Mordvilko in 1900 from barley fields in southern Russia and between the years 1945-1988 in Spain (Jones *et al.*, 1989). It has also been reported in: North Africa, South Africa, Central Asia and the Middle East (Blackman and Eastop, 1984); Mexico (Robinson, 1993); U.S.A. (Kindler and Springer, 1989; Archer and Bynum, 1992) and Canada (Jones *et al.*, 1989; Kindler and Springer, 1989).

Its damage pattern differs from those of the other cereal aphids so that one can identify its occurrence by means of the resulting damage. White or yellow longitudinal bands appear on the leaves due to the feeding effects and injection of salivary toxins which, in colder climates, become red or pinkish due to the existing antocyanic pigments. The

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individual aphids feed on the upper surfaces of curled leaves.Young plants become stunted under heavy aphid attacks and pre-panicle infestations can result in curling of the flag leaves and panicle deformations (Jones *et al*., 1989; Kindler and Hammon, 1996).

The Russian Wheat Aphid can also be damaging as a vector of plant pathogenic viruses including Barley Yellow Dwarf Virus, Barley Mosaic Virus, and Sugarcane Mosaic Virus (Damsteegt *et al.,* 1992). On grasses, the aphid is regarded as a monoecious species with populations composed of only parthenogenetic viviparous individuals. The overwintering takes place as parthenogenetic females and different instar nymphs on individual wheat, barley and other grasses left in the field (Archer *et al*., 1998). The aphid feeds on wheat, barley, rye, triticales, oat and a number of grass weeds, amongst which barley, wheat and triticales are highly susceptible to its attack, with oat and rye showing less susceptibility (Melaku *et al.*, 1993; Webster *et al*., 1993).

In recent years, due to the economic importance of this aphid in most parts of the world certain studies have been directed towards the introduction of resistant varieties (Du Toit, 1989; Kindler and Springer, 1989; Webster, 1990; Kindler *et al.*, 1992; Robinson, 1992; Kindler *et al*., 1993; Robinson, 1993; Webster *et al*., 1993; and Dolati *et al,* 1995).

The pest was first reported in Iran by Davatchii (1954) (cited by Rassoulian and Doulati 1995). Zareh *et al*. (1995) and Rassoulian and Doulati (1995) have noted the occurrence of the aphid in East Azarbaidjan. Based on the observations made during this investigation, the highest level of aphid infestation has been observed in wheat fields of the Tabriz, Ahar and Kaleybar areas. Thus, the present study was aimed at evaluating the exitsance of any resistance at the tillering growth stage of Alvand, Alamoot, Zarrin, Sabalan and Sardari varieties to which, the highest acreages are being devoted in the wheat planting areas of East Azarbaidjan province (Mansouri, personal communication, 1999).

## MATERIALS AND METHODS

### Plant and Aphid Culture

The degrees of resistance of five wheat varieties (Alvand, Alamoot, Zarrin, Sabalan and Sardari) were evaluated at their tillering growth stage (21-22) against the Russian Wheat Aphid, *Diuraphis noxia* (Zadoks *et al.,* 1974). The seeds of the Sardari variety were obtained from the Institute for Dry Farming Studies and those of the remaining varieties from the Agriculture Organization of East Azarbaidjan province.

The aphid clones were collected from the Kaleybar wheat fields and transferred to the laboratory for morphological identification according to the relevant sources (Blackman and Eastop, 1984; Jones *et al*., 1989). Stock cultures of aphids were reared under glasshouse conditions on Durum and *Agropyron* sp. plants which are highly susceptible to the aphid (Jones *et al.,* 1989) and kept in a 100×70×70 cm screen cage. The seeds were then put in a jar fully covered with aluminium foil and containing a few drops of distilled water and vernalized in the refrigerator at $4\pm1^{o}$C for seven to eight weeks (Kazemi, 1988). Five seeds of each variety were sown in 20 cm diameter plastic pots at a depth of 2 cm and thinned to three plants per pot after germination (van Emden *et al.*, 1991). A total of 12 pots were devoted to each variety. The soil used, was a mixture of garden soil, compost and manure at a rate of 7:1:1 obtained from Khalate-pooshan agricultural experiment station.

### Plant Infestation

Aphids reared on the stock culture were individually confined in clip cages on the upper leaves of experimental plants. Since the culture plant may influence the performance and preferences of the aphids, they were reared on the experimental plants for at least one generation before the main experiments. For the main experiments, one adult apterous aphid from the appropriate culture was confined in a clip cage on the upper leaf of the experimental plant. After 24 hours, the adult was removed, and one newly born nymph was retained to develop to an adult and reproduce (Kazemi and van Emden, 1992). The position of the cages was changed once every three to four days to avoid local leaf damage. The experimental plants were kept under glasshouse conditions of 24.4±1.6°C, 50-60% relative humidity and a 14:10 (L:D) light regime. The experimental design was a completely randomized block design with five treatments (varieties) and each variety with 14 replicates using individual clip-on leaf cages as experimental units, set up on the last fully grown leaves of the main plants in 12 pots.

In order to determine the maturation time and survival rate of encaged progeny, each individual nymph was allowed to develop into an adult. The fecundity of the resultant adults was determined by daily counts of their progeny between 9 and 11 a.m. for periods of 10 and 15 days. All the progeny were removed from caged leaves after completion of the counts. To calculate the daily intrinsic rate of natural increase ($r_m$ value), nymphal survival on each variety (age specific survival rate: $l_x$), developmental time and daily fecundity of individual aphids (age specific fecundity: $m_x$) were used in the equation $\Sigma e^{-r_m} l_x m_x = 1$ (Birch, 1948), using van Emden's STATSPAK version 8.00 based on Mallard Basic.

## RESULTS AND DISCUSSION

### Maturation Time and Survival Rate of Nymphs

The data obtained on duration of developmental period indicated that there was no significant difference between treatment means. Comparisons made between treatment means using Duncan's multiple range test showed no significant differences ($P \leq 5\%$). The data presented in Table 1 show that the highest and lowest nymphal survival rates occurred on the Sardari and Zarrin varieties respectively. The effect of feeding on the various wheat varieties on the damage potential of the aphid (Du Toit, 1989 and Moharramipour *et al.,* 2001) and on its fecundity (Springer *et al.,* 1992) has been studied. Obviously, determining the nature of the effects of defence mechanisms (physical and chemical) at the host plants on the survival rate of the aphid requires further complementary studies.

### Fecundity

Trends in the aphid's larviposition on five wheat varieties within 10 and 15 day periods (Kazemi and van Emden (1992)) have been shown as daily cumulative means in Figure 1. It is obvious that, until the fourth day of the reproductive period, the rate of larviposition remained more or less the same on all

**Table 1**. Mean maturation time and survival rate of Russian Wheat Aphid nymphs on five wheat varieties under glasshouse conditions.

| Variety | Mean maturation time (days) $\overline{X}$ ±SD | Range | Survival rate (%) |
|---|---|---|---|
| Alamoot | 5.93±0.62 a[a] | 5-7 | 85.7 lab |
| Alvand | 5 .93±0.4 7 a | 5-7 | 92.86ab |
| Zarrin | 6.07±0.73 a | 5-7 | 71.43b |
| Sabalan | 6.43±0.85 a | 6-7 | 78.57ab |
| Sardari | 6.2 1±0.58 a | 5-7 | 100a |

[a] Means followed by a similar letter are not significantly different at a level of 5%

varieties. However, there were remarkable deviations later on in fecundity on the Zarrin and Sardari varieties which continued until the end of the 15-day period, whilst changes in the larviposition rate on three other varieties followed the same pattern. However, at the end of the larviposition period, the highest mean fecundity was observed on Sardari and the lowest mean fecundity on the other varieties. It should be mentioned that mean fecundity of the aphid on Zarrin, despite a low larviposition rate within the 10-day period, appeared to become ultimately the same as on Alamoot, Alvand and Sabalan. Rassoulian and Doulati (1995) also reported that the reproductive performance of the aphid on some varieties such as Shahi and Sefideh was significantly reduced.

Comparisons made on mean fecundity (Table 2) indicated significant differences (P<5%) in the mean fecundity of the aphid on five wheat varieties within the two periods. The highest mean fecundity within the first 10- and 15-day periods of larviposition was recorded on Sardari, indicating its suitability for aphid feeding or its higher susceptibility to the Russian Wheat Aphid. It is obvious that if the aphid produces more progeny at tillering stage, it can prevent plant growth.

The least progeny produced within the first 10 days of larviposition was observed on Zarrin, although there was no significant difference in aphid larviposition rate within 15-day reproduction period in comparison with the other varities, except Sardari.

The fecundity of aphids on Alamoot, Alvand, Zarrin and Sabalan within the first 10 and 15 days of reproduction was about the same and there were no significant differences in this respect between the varieties except Sardari (Table 2). Markkula and Roukka (1972) and Sotherton and van Emden (1982), studying the fecundity of *Sitobion avenae* and *Metopolophium dirhodum*, *Rhopalosiphum padi* and *Macrosiphum avenae* on other wheat varieties, have noticed certain differences.

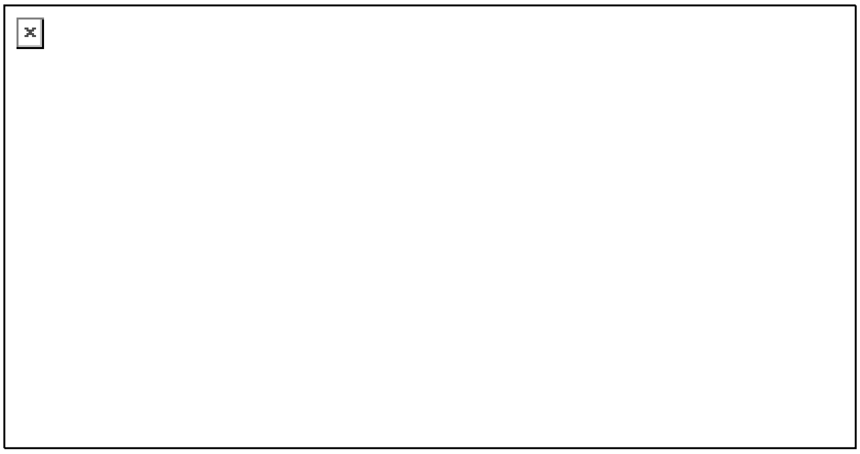

**Figure 1**. Daily cumulative means of larviposition within 10 and 15 day periods on five wheat varieties.

**The Intrinsic Rate of Natural Increase ($r_m$ value)**

Data indicated significant differences between $r_m$ values at $P \leq 5\%$. Based on the aphid's intrinsic rate of increase within 10- and 15-day periods of rearing on test varieties, the two varieties, Alvand and Sardari had the highest $r_m$ values for both rearing periods and are thus regarded as the most susceptible varieties. Zarrin had the lowest $r_m$ value and is considered to be resistant. Alamoot and Sabalan seem to be partially resistant (Table 3).

**Table 2**. Mean fecundity of adult apterae of Russian Wheat Aphid within 10 and 15 day periods of rearing on five wheat varieties.

| Variety | 10 day | | 15 day | |
|---|---|---|---|---|
| | $\bar{x}$ ±SD | Range | $\bar{x}$ ±SD | Range |
| Alamoot | 38.71±10.63ab[a] | 17-60 | 49.43±13.51b | 17-69 |
| Alvand | 37.29±10.87ab | 19-53 | 49.57±9.43b | 37-63 |
| Zarrin | 34.43±8.91 b | 21-46 | 49.86±10.46b | 33-67 |
| Sabalan | 38.14±5.92 ab, | 28-48 | 50.43±8.46b | 28-63 |
| Sardari | 43.21±5.45 a | 33-51 | 58.86±9.45a | 34-67 |

[a] Means followed by a similar letter in each column are not significantly different at a 5% level.

The results and statistical analysis indicated that, at the tillering stage, amongst the varieties studied, Sardari appeared to be susceptible one to the Russian Wheat Aphid. With extension of the studies to the other phenological stages of the test varieties, it is hoped that inclusion of the probable "antibiosis" mechanism in an integrated pest management program would be a valuable tool towards lowering the damage potential of this aphid.

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**Table 3.** Intrinsic rate of increase of the Russian Wheat Aphid in rearings on five wheat varieties for 10 and 15 day periods under glasshouse conditions.

| | Intrinsic rate of increase ($r_m$ values) | | | |
|---|---|---|---|---|
| Variety | 10- day period | | 15- day period | |
| | $\bar{x}$ ±SD | Range | $\bar{x}$ ±SD | Range |
| Alamoot | 0.326±0.03ab[a] | 0.271-0.375 | 0.329±0.02ab | 0.276-0.377 |
| Alvand | 0.330±0.03a | 0.283-0.385 | 0.334±0.03a | 0.289-0.386 |
| Zarrin | 0.289±0.03c | 0.243-0.323 | 0.294±0.03c | 0.251-0.324 |
| Sabalan | 0.305±0.02bc | 0.282-0.343 | 0.308±0.02bc | 0.286-0.341 |
| Sardari | 0.340±0.01a | 0.319-0.359 | 0.343±0.01a | 0.323-0.367 |

[a]The Means followed by similar letter in each column are not significantly different at a 5% level.

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## واکنش‌های زیستی شته روسی گندم Diuraphis noxia (Mordvilko) (Homoptera: Aphididae) نسبت به چند رقم گندم

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## چکیده

در سالهای اخیر شته روسی گندم از جمله آفات بسیار مهم غلات دانه‌ریز و به ویژه گندم در دنیا معرفی شده است. این آفت علاوه بر وارد ساختن خسارت مستقیم و شدید به غلات بخصوص گندم، ناقل بیماریهای ویروس زردی کوتولگی جو، ویروس موزائیک جو و ویروس موزائیک نیشکر نیز می‌باشد. وجود این آفت در ایران و در استان آذربایجان شرقی از چند سال قبل گزارش گردیده و براساس بررسی‌های انجام گرفته در مزارع گندم شهرستانهای تبریز، اهر و کلیبر در جمعیت‌های قابل توجهی مشاهده شده است. در این بررسی امکان وجود مقاومت در ارقام الموت، الوند، زرین، سبلان و سرداری که بیشترین سطح زیرکشت را در گندم‌کاریهای استان آذربایجان شرقی بخود اختصاص می‌دهند، در مرحله پنجه‌زنی مورد ارزیابی قرار گرفت. آزمایشات در شرایط دمایی $^{o}C$ ۱/٦± ۲٤/٤ و رطوبت نسبی ۵۰ تا ٦۰٪ تحت رژیم نوری ۱٤:۱۰ انجام شد. ارزیابی با بررسی میزان بقاء و زنده ماندن پوره‌ها، میانگین طول دوره نشو و نمایی پوره‌ها، قدرت باروری یا تعداد کل نتایج به ازای یک شته در ۱۰ و ۱۵ روز اول دوره تولید مثلی و درنتیجه با محاسبه نرخ افزایش ذاتی جمعیت (ارزش‌های $r_m$ ) عملی شد. نتایج حاصل از تجزیه واریانس داده‌ها نشان داد که از نظر قدرت باروری و نیز نرخ افزایش ذاتی جمعیت اختلاف معنی‌داری درسطح احمال ۵٪ بین ارقام وجود دارد. براین اساس بیشترین میانگین تعداد نتاج طی ده روز اول دوره تولید مثلی (۵/٤۵ ±٤۳/۲۱) مربوط به رقم سرداری و کمترین آن (۸/۹۱± ۳٤/٤۳) مربوط به رقم زرین بوده است در حالی که میانگین تعداد نتاج طی ۱۵ روز اول دوره تولید مثلی ۱۳/۳۱ ± ٤۹/٤۳ در روی رقم الموت و ۹/٤۵ ± ۵۸/۸٦ در روی رقم سرداری بود. همچنین بیشترین میانگین ارزش $r_m$ (۰/۰۱± ۰/۳٤) در رقم سرداری و کمترین آن (۰/۰۳± ۰/۲۸۹ ) در رقم زرین مشاهده گردید. نتیجه مطالعات و محاسبات مربوطه نشان داد که در مرحله پنجه‌زنی از بین ارقام موردنظر، گندم سرداری نسبت به شته ظاهراً یک رقم حساس بود. بررسی‌های صحرایی و گلخانه‌ای تکمیلی درحال انجام می‌باشد.