Field Assessments of Antibiotic Resistance to *Myzus persicae* (Sulzer) in Different Potato Cultivars

A. U. R SALJOQI[1], H. F. van EMDEN[1], HE Yu-rong[2]

(1 Department of Horticulture, School of Plant Sciences, University of Reading, Whiteknights P. O. Box 221, Reading, RG6 6AS, England, UK; 2 Department of Entomology, South China Agric. Univ., Guangzhou 510642, China)

Abstract: Eight potato cultivars i. e. Cardinal, Ultimus, Cosima, Mansur, Monaliza, Ajax, Diamant and Desiree were screened for their relative antibiosis in the potato field to peach-potato aphid, *Myzus persicae* (Sulzer). Among all the tested cultivars, Cardinal showed comparatively high resistance and showed the lowest r_m, followed by Ultimus. The r_m for Cardinal was 1.6 times lower than that of r_m on Desiree, which was found consistently the most susceptible cultivar.

Key words: *Myzus persicae*; antibiosis; plant resistance; potato cultivars

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Myzus persicae (Sulzer), the peach-potato aphid, is a major pest of wide range of crops, including potatoes, in Pakistan. Resistance to different groups of insecticides has been demonstrated in *M. persicae* collected from sugar beet[1] and potatoes[2]. This suggests that other control measures will assume increasing importance in the future.

In the literature various reports indicate potato varietal differences to aphid infestation[3,4]. Taylor[5] also reviewed the differences in potato cultivars with respect to aphid infestation. However, very little is known about the extent and biological components of host plant resistance to *M. persicae* in the existing potato cultivars. The important mechanisms of plant resistance to aphid growth include antibiosis[6].

The aims of our investigation were to evaluate the level of antibiotic resistance in different potato cultivars to *M. persicae*. For this purpose eight different potato cultivars were tested in a field experiment and compared their survival schedule, development time, fecundity and the intrinsic rate of increase of *M. persicae*[6].

1 Materials and Methods

1.1 Growing the plants

Cardinal, Ultimus, Cosima, Mansur, Monaliza, Ajax, Diamant and Desiree potato cultivars were tested. All the potato cultivars were obtained from the Potato Research Center Abbottabad, Pakistan. These cultivars were grown during autumn season of 1995 in the Agricultural Research Farm, NWFP Agricultural University Peshawar, Pakistan. The experiment was laid out in a randomized complete block design of 32 plots, representing eight treatments (the potato cultivars) in four replicate blocks. Each plot having six rows. Plant to plant and row to row distance was 20 cm and 75 cm respectively. At the time of sowing, diammonium phosphate (DAP) and farmyard manure were applied at the recommended rates, while after one month urea fertilizer was applied. Other agronomic practices i.e. irrigation, hoeing, weeding and earthing-up were done as necessary.

1.2 *M. persicae* culture

Aphids were collected from the potato plants in the field when the infestation started. *M. persicae* was cultured on Desiree. The culture was maintained at a photoperiod of 14 hours light : 14 hours dark regime. The minimum temperature fluctuated between 16.0-21.5 ℃ while the maximum temperature ranged between 23.0-46.5 ℃. Cultures were maintained in muslin cages and Perspex cages, each containing two pots. One pot, con-

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taining the oldest plants, was removed at weekly intervals and replaced with a new one. The frequent replacement of pots of seedlings was to avoid overcrowding of the aphids. Care was also taken to keep the stock of *M. persicae* free from other aphid species, parasitoids and predators. *M. persicae* was moved from plant to plant with a fine brush, which was wetted with distilled water. To avoid damage to the aphids, care was taken to make sure the stylets were withdrawn before the aphids were removed. Sometimes a leaf with a healthy population was placed on the leaves of the new plants. When dried, this leaf portion was removed from the cage, the aphids having moved from it to the new leaves to start new colonies.

1.3 Antibiosis test

The antibiosis test was conducted after seven weeks of sowing potatoes. Four plants from each plot were selected as showing equal growth. Individual apterous adults were put in clip cages (d=20 mm, h=10 mm) on the middle leaves of each plant. Twenty four hours after caging, the apterous adults were removed and a single first instar nymph was retained in two separate cages on two different leaves of the same plant. One cage was regarded as the cage from which the data for that plant would be taken, and the additional cages were kept to replace any nymph that died before reproduction. Whenever a dead nymph was observed, it was replaced by another nymph of the same age. The nymphs retained on the leaves were allowed to feed, develop and reproduce.

1.3.1 Survival of nymphs on the crop Survival of nymphs to reproduction was considered by van Emden[7] as one of the parameters for measuring plant resistance. The survival rate was expressed as a percentage: (number of aphids survived to reproduction / total number of nymphs) ×100%.

1.3.2 Development time In this experiment the time from birth to reproduction was designated ' development time' and recorded in days by observing caged first instar nymphs once each day. The clip cages were kept clean throughout the experimental period to enable the aphids to be observed from outside the cage, so that they did not need to be opened every day. This greatly reduced the problem of losing aphids.

1.3.3 Fecundity Fecundity is another important element of antibiosis[8]. Oakes[9] considered the mean aphid fecundity for the first ten days of aphid reproduction as the most reliable measure of fecundity differences in cereal aphids. In this experiment the number of nymphs born by an aphid was recorded from the day the aphid started reproducing. For a standard period of time of 10 days, the number of nymphs produced daily by the viviparous female was recorded. After recording the numbers, all the nymphs produced for that particular day were removed, leaving the gravid female aphid in the cage to produce new nymphs for the next day. The cumulative figure obtained at the end was the datum used for analysis. After every three days the position of the clip cage on the leaf was changed to avoid damage to the leaf[10].

1.3.4 Intrinsic rate of population increase (r_m) Intrinsic rate of population increase is one of the basic parameters used to measure growth of insect populations[11]. The r_m formula combines the survival, development time to reproduction and fecundity into a single value. The value of r_m is greatly influenced by the rate of reproduction in early adult life[12]. Birch,[11] published the first formula for the calculation of r_m for insect population i.e. $e^{(-r_{mx})} I_x m_x = 1$, where I_x= age specific rate of survival and m_x= age specific rate of fecundity. This equation uses the pre-reproductive time, and chances of survival and fecundity of an insect at specific time intervals of its whole reproductive life. A very much simpler formula was proposed by Wyatt and White[13] for aphids and mites i.e. $r_m = 0.74 (\log_e Md)/d$, where Md is the effective number of progeny (the number of progeny produced by mature aphids surviving to reproduction) produced over the time from birth to reproduction (d).

In this instance the value of r_m was calculated by using a computer programme 'Statspak'[14] based on Birch's[11] equation and using an iterative calculation procedure. The input values consisted of: number of aphids started as nymphs; number of nymphs surviving to reproduce; number of days over which reproduction was measured (10 days in this case); mean number of days from birth to reproduction and the daily fecundity.

2 Results

2.1 Survival schedules

On Cardinal, *M. persicae* showed the lowest survival i.e. 68.8%. Five of the sixteen adults released died. Desiree showed 100% survival of *M. persicae*. This was followed by Mansur, Monaliza, Ajax and Diamant cultivars, showing 87.5% survival of *M. persicae*. Ultimus and Cosima cultivars were next to Cardinal with 81.3% survival of *M. persicae* [Fig. 1(A)].

2.2 Development time

The detail of significant differences between the individual differences is shown in Fig. 1 (B). All cultivars had a significantly larger aphid development time as compared with the Desiree. Maximum mean development time, i.e. 7.81 days was recorded for aphids on Cardinal, while the shortest (5.31) was for Desiree ($P<0.05$). *M. persicae* showed 6.63, 6.31, 6.25, 6.19, 6.38 and 6.12 mean development time on Ultimus, Cosima, Mansur, Monaliza, Ajax and Diamant respectively, which were statistically similar to one another but significantly different from Desiree ($P<0.05$).

2.3 Fecundity

Fig. 1 (C) shows the mean fecundity over ten days of *M. persicae*. Aphids on Desiree had a significantly larger fecundity than those on all other cultivars. Highest fecundity (42.6) of *M. persicae* was observed on Desiree and the lowest (30.2) was on Cardinal ($P<0.05$). Fecundity of *M. persicae* on Ultimus was significantly higher than on Cardinal, but there was no significant difference between the fecundities on Monaliza, Ajax and Diamant. High fecundities on Cosima and Mansur overlapped statistically with fecundity on Ultimus.

2.4 Intrinsic rate of multiplication (r_m)

All three elements of r_m measured separately showed a consistent pattern for the relative antibiosis of Desiree, Ultimus and Cardinal ($P<0.01$). Fig. 1 (D) shows the intrinsic rate of increase (r_m) of *M. persicae* for different potato cultivars. As expressed from the individual elements, the intrinsic rate of increase was highest for *M. persicae* reared on Desiree (0.41). All other cultivars showed a lower r_m by comparing with Desiree. The lowest r_m was measured on Cardinal (0.25) ($P<0.05$). r_m of aphids on Ultimus (0.31) was found next lowest to Cardinal and statistically separable from it. Aphids on the other cultivars were intermediate between Ultimus and Desiree, and statistically inseparable from each other.

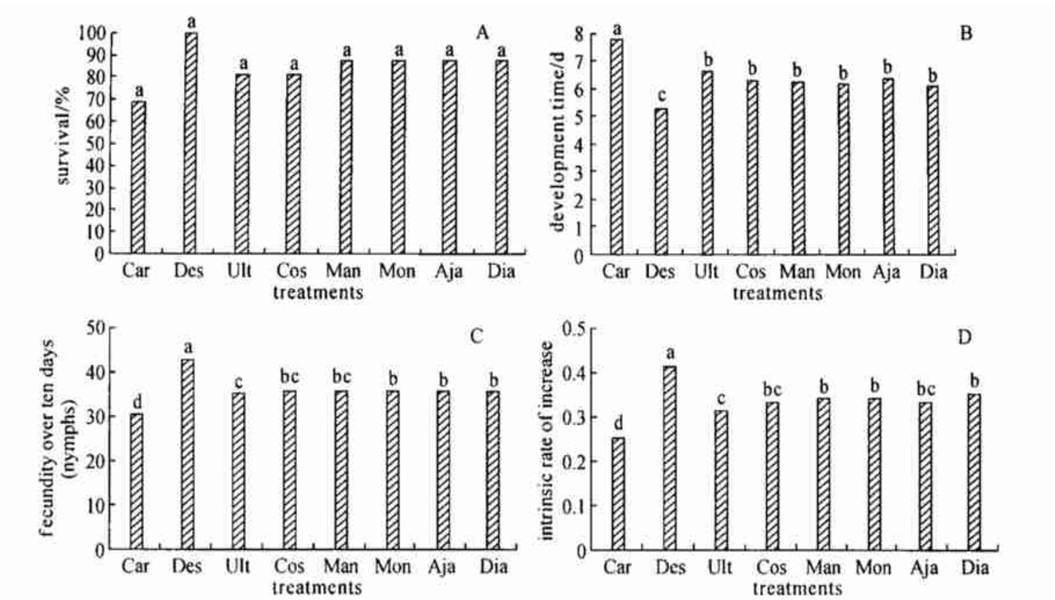

Fig. 1 Survival (A), development time (B), fecundity (C) and the intrinsic rate of increase (D) of *M. persiceae* on eight potato cultivars [Means with the same letter are not significantly different in level of 0.05 (DMRT method)]

3 Discussion

The screening of eight potato cultivars showed a range of antibiotic resistance to *M. persicae*. Examination of several components of antibiotic resistance, in combination with the calculated intrinsic rates of increase[11], showed that development time was increased and fecundity was reduced on cutivars where survival was reduced, and all three measures acted together to reduce potential population increase rate. Cardinal showed the highest relative resistance followed by Ultimus. Desiree was found to be the most susceptible cultivar.

The results of the present investigations could be attributed to a number of reasons, the confirmation of which is possible only by further work. Different performance of insects on different plant species or varieties/cultivars can be due to the influence of secondary compounds in the plant and/or the nutritional status of the plant. Plants contain a large number of secondary substances, including alkaloids, flavonoids, glycosides, tannins, betanins, saponins, oils and organic acids[15]. Several of these compounds, i.e. phenolics and cyclic hydroxamic acids (DIMBOA) have been shown adversely to affect the development of aphids[16] on wheat and corn. Fraenkel[17] believed that the primary function of secondary compounds in evolution was related to defense mechanisms against herbivores. Adams[3] reported the immunity of *Solanum polydenium* (Greenman) to *M. persicae* attributed it to the presence of a repellent secondary substance on the foliage of the wild potato species. Besides secondary plant substances, the proportion of nutrients in the plant determines its metabolic quality, which is manifested in insect growth and development. Among these, carbon and nitrogen are important[18]. Any excesses or limitations of these two substances may affect resistance to insects[19]. van Emden[20] found increased susceptibility to *Brevicoryne brassicae* (L.) by increasing the concentration of soluble nitrogen in the leaves of Brussels sprouts by the application of fertilizer. van Emden[21] also showed that variation in the concentrations of individual amino acids could be correlated with the performance of *M. persicae* and *B. brassicae*.

Host-plant resistance at the levels discussed in this paper may become an important component of an integrated control system because of its compatibility with the use of insecticides, a feature not always shared by the use of natural enemies[22]. Methods based on partial host-plant resistance may help limit aphid populations to acceptable levels on ware potato crops, as well as imposing less selection pressure for the development of resistant aphid biotypes[23].

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不同马铃薯品种对桃蚜抗生性的田间评价

A. U. R. SALJOQI[1], H. F. van EMDEN[1], 何余容[2]

(1 英国里德大学 植物科学院园艺系, 英国; 2 华南农业大学 昆虫学系, 广东 广州 510642)

摘要: 在田间评价了8个马铃薯品种Cardinal, Ultimus, Cosima, Mansur, Monaliza, Ajax, Diamant和Desiree对桃蚜*Myzus persicae*(Sulzer)的抗生性. 结果表明在所有品种中, Cardinal对桃蚜表现出相对较高的抗生性, 用其繁殖的桃蚜具有最低的内禀增长率(r_m), 其次为品种Ultimus; 在品种Cardinal上繁殖的桃蚜其内禀增长率(r_m)比在最敏感的品种Desiree上小1.6倍.

关键词: 桃蚜; 抗生性; 植物抗性; 马铃薯品种

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