SUSCEPTIBILITY OF *POPULUS NIGRA* L. TO THE WOOLLY POPLAR APHID (*PHLOEOMYZUS PASSERINII* SIGN.)

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ABSTRACT

Within the genetic improvement programme of *Populus* × *euramericana* (Dode) Guinier, 244 genotypes of the parent species *Populus nigra* L. collected in 205 different sites throughout Italy were grown in 3 localities and tested in the laboratory in order to evaluate their susceptibility to the aphid *Phloeomyzus passerinii* Sign., using a standardized methodology based on the artificial inoculation of cuttings.

The genotypic behaviour showed high variability and appeared strongly related to the latitude of the provenance site, with higher resistance of the genotypes collected in more xeric and warm habitats. On the contrary it was not influenced by the poplar cultivation environment.

Key words: *Populus nigra*, populations, genetic resistance, *Phloeomyzus passerinii*, breeding

INTRODUCTION

The destructive infestations of *Phloeomyzus passerinii* Sign. are well known to Italian poplar growers. The last one was recorded in 1994 in poplar stands of clones belonging to the hybrid species *Populus* × *euramericana* (Dode) Guinier cultivated in the Po basin. These hybrids represent over 80% of all poplars grown in Italy, and their behaviour towards the pest is extremely variable, ranging from high resistance, as for the clones 'Carpaccio','Bellini' and 'San Martino', to high susceptibility, as for 'I–214', 'Adige', 'Boccalari' and others (LAPIETRA & ALLEGRO 1990). The woolly poplar aphid damages poplars in the second half of the rotation, feeding in the parenchymatous tissues of the bark of trunk and branches. Heavily infested plants can be killed, as bark necrosis prevents the movement of water and nutrients. Young plants are unlikely to be injured, as sunlight and air ventilation are adverse factors for the pest development. In favourable conditions, the biotic potential of *Ph. passerinii* is enormous, each female partenogenetically generating a total of more than 1000 females over 10–12 generations in one year (DELLA BEFFA 1936).

Of the two parent species of *P.* × *euramericana*, namely *Populus deltoides* Bartr. (Eastern cottonwood) and *Populus nigra* L. (European black poplar), only the former was studied for its behaviour towards the Woolly poplar aphid. ARRU and LAPIETRA (1979) tested in the laboratory 411 *P. deltoides* genotypes raised from seed collected by the Poplar Council of the USA and observed a high average resistance level in all the families tested. On the contrary no information was available on the behaviour of *P. nigra*.

P. nigra is a typical pioneer species, markedly heliophilous and hygrophilous, generally living along the river banks in sporadic groups often in association with *Salix* sp. In Italy and Europe it can be regarded as an endangered species, due to spontaneous hybridization with cultivated *P. deltoides* and *P.* × *euramericana* and to the gradual reduction of natural populations as a result of man's activities (BISOFFI *et al.* 1987; CAGELLI & LEFÈVRE 1995). This paper reports the results of laboratory tests carried out in a 5-year period (1989 –1993) to evaluate the susceptibility of 244 *P. nigra* genotypes collected in 205 different sites throughout Italy (BISOFFI *et al.* 1987) to *Ph. passerinii*. The purity of the genotypes has been assessed in nursery and in adult plants on the basis of morphological traits and the presence of insect indicators, such as *Pemphigus* spp. and *Thecabius affinis*, which are able to infest exclusively *P. nigra*. The biological response of each genotype to *Ph. passerinii* has been related to geographic and climatic parameters of its area of origin with a view to orientating the breeding goals of the Istituto di Sperimentazione per la Pioppicoltura in Casale Monferrato.

MATERIALS AND METHODS

Cuttings of about 250 *P. nigra* genotypes originally collected in a survey that covered the entire Italian territory were planted and grown in stool beds located in the western part of the Po Valley (Casale Monferrato,

AL), the central part of the Po Valley (Bigarello, MN) and Southern Italy (Battipaglia, SA). The individual sites of origin were 205, 86% of them being located at an altitude of 0 to 500 m and the remaining 14% 500 to 850 m.

244 genotypes – 54% coming from Northern Italy (latitude >44 °N), 24% from Central Italy (lat. 41–44 °N) and 22% from the Southern Italy (lat. <41 °N) – had a satisfactory growth and were subjected to a laboratory evaluation of their resistance to *Ph. passerinii* according to the methodology set up by ARRU (1974) and improved by LAPIETRA and ALLEGRO (1990).

The test consists in the artificial inoculation of 2 groups of 4 dormant cuttings per genotype and in the evaluation of the surviving insects and of the progeny produced 28 days after inoculation. The inoculation is performed by putting 4 cuttings to be tested in tight contact with an infested cutting of the clone I–214, coming from a massal aphid rearing. During the bioassay the cuttings are kept in plastic jars with water in the bottom, at a temperature of 20–22 °C and a relative humidity of about 70%.

The intensity of the biological response is evaluated by visual inspection by attributing to each bundle of cuttings a score on a 0 to 4 scale (ψ); each value of the scale corresponds to the $\log_5$ of the lower limit of 5 classes of infestation expressed as mean number of aphids per cutting (table 1).

Table 1 Laboratory evaluation scale of *Populus nigra* sensibility to *Phloeomyzus passerinii*

Class limits number of aphids/ cutting	Infestation value (Ψ) $\log_5$ of lower class limit
1–4	0*
5–24	1
25–124	2
125–624	3
>624	4

* Value assigned also to cuttings with no aphids

It has been demonstrated that the results of this test are generally highly correlated with the behavior of the genotypes in field conditions, at least at the extremes of the sensibility scale (LAPIETRA & ALLEGRO 1986). Actually, laboratory conditions can be considered very severe for the cuttings, on account of the high inoculation pressure and of the favourable climatic conditions for the aphid development. Observations carried out in poplar plantations during a long period of time in coincidence with natural infestations of the pest showed that poplar clones which are scarcely or non infested in the laboratory ($\psi \leq 2.00$) are always resistant in the field. Clones that are severely infested in the laboratory ($\psi > 3.00$) are generally susceptible in the field, but with some remarkable exceptions. On the contrary the field behavior of clones which fall in an intermediate area ($2.00 < \psi \leq 3.00$) is not predictable (LAPIETRA & ALLEGRO 1986).

As it was impossible to test simultaneously all the genotypes (laboratory capacity allows to test about 120 genotypes, with 2 replications of 4 cuttings per genotype, per year), a reference poplar clone (I–214), whose behavior towards the aphid is well known, was always present. When the response of I–214 did not fall in its normal limits ($3.50 < \psi \leq 3.75$), the test was considered not reliable and repeated.

In order to assess the influence of the environment where the cuttings were grown on the expression of susceptibility in the lab test, 39 genotypes were simultaneously tested using cuttings coming from the 3 different cultivation sites cited above and the data subjected to ANOVA.

Finally, a correlation analysis was performed in order to detect possible relationships between susceptibility and sex, latitude, longitude, elevation of the site of origin and a xero-thermic index based on a classification of Italian bioclimatic areas according to TOMASELLI *et al.* (1973).

RESULTS AND DISCUSSION

The test carried out simultaneously with the cuttings of 39 different genotypes grown in 3 different localities showed no influence of the cultivation environment on the expression of susceptibility ($P = 0.33$), whilst the differences among genotypes were highly significant ($P < 0.0001$). Following this evidence, only the assays carried out on the material coming from the Bigarello stool beds were considered in the correlation analysis, as the cuttings always proved to be in better health condition with respect to Casale Monferrato and Battipaglia.

The *P. nigra* population tested showed a large variability in its behavior towards *Ph. passerinii*, with mean infestation values (ψ) ranging from 0.00 to 4.00. Genotypes displaying high sensibility ($3.00 < \psi \leq 4.00$) were the most frequent (57.0%); a few genotypes were highly resistant ($0.00 < \psi \leq 1.00$) and resistant ($1.00 < \psi \leq 2.00$) (11.5% and 6.1%, respectively). The genotypes falling in the middle sensibility area ($2.00 < \psi \leq 3.00$) were 25.4%. According to a latitudinal transect of Italian peninsula, it is evident that susceptible genotypes are found more frequently in Northern than in Southern areas (fig. 1), and that resistant and highly resistant genotypes are a relevant proportion in Central and Southern areas. The χ^2 test shows significant differ-

Table 2 Percent distribution of *Populus nigra* genotypes in the different classes of susceptibility to *Phloeomyzus passerinii* according to their geographic origin

Geographic origin	Latitude °N	Log_5 aphid number/cutting				Number of genotypes
		0.00–1.00	1.01–2.00	2.01–3.00	3.01–4.00	
Northern Italy	>44°	2.26	5.26	19.55	72.93	133
Central Italy	44°–41°	6.90	6.90	32.75	53.45	58
Southern Italy	<41°	39.62	7.55	32.08	20.75	53
Total		11.48	6.15	25.41	56.96	244

$\chi^2 = 70.13$; d. f. = 6; P<0.001

Table 3 Pairwise correlation coefficients (*r*) between the variables associated to 244 *Populus nigra* genotypes susceptible to *Phloeomyzus passerinii*, sex, latitude, longitude, elevation and xero-thermic index of the site origin

Variable	Sex	Latitude N	Longitude E	Xero-thermic index	Altitude
Susceptibility	0.05	0.49***	-0.48***	0.46***	0.04
Sex	–	0.08	-0.06	0.12	-0.02
Latitude N	–	–	-0.77***	0.83***	0.13
Longitude E	–	–	–	-0.60***	-0.25*
Xero-thermic index	–	–	–	–	0.19

* *r* value significant for P<0.05; *** *r* value significant for P<0.001

ences of susceptibility according to the geographic area of origin (table 2).

Also the correlation analysis showed a clear relationship between susceptibility of the genotypes and their geographic origin, with susceptibility increasing with latitude. Obviously, as Italy runs in direction northwest-southeast, longitude appeared to be related to latitude and, indirectly, with the level of susceptibility. In the same way also the xero-thermic index of TOMASELLI *et al.* (1973) can be considered indirectly related to the resistance level, as it is strictly dependent upon climatic factors such as temperatures and rainfalls in the vegetative period, which vary with the latitude. No significant relationship emerged between resistance and sex, nor between resistance and the elevation of the site of origin (table 3). Therefore, latitude is the only predictive variable (x) that can reasonably be considered in a linear regression model, where sensibility to *Ph. passerinii* is the dependent variable (y). The calculated regression is: $y = -7.29 + 0.23 \cdot x$ ($F_{1,242} = 75.78$; $P < 0.001$; $r^2 = 0.24$; standard error of the regression coefficient = 0.0268).

CONCLUSIONS

In *P. nigra* the degree of susceptibility to *Ph. passerinii* in a lab test is independent of the growing conditions of the plant. Such evidence suggests a genetic basis for the mechanism, probably consisting in preformed chemical or physical barriers to infection.

The clear relationship between susceptibility and latitude, with increasing frequencies of resistant genotypes proceeding from the humid and cold environment of the Po Valley to the warmer and drier areas of Central and Southern Italy, confirms the results of a previous study by ARRU and LAPIETRA (1979), that demonstrated higher resistance levels in southern provenances of *P. deltoides* with respect to northern provenances of the USA. As the woolly poplar aphid prefers high air humidity and little sunlight, heavy attacks are very unlikely in Central and Southern Italy; therefore the resistance character is probably based on genetic factors which evolved in xeric habitats along with mechanisms that are not influenced by the pest selective pressure, maybe as an adaptation to high sun

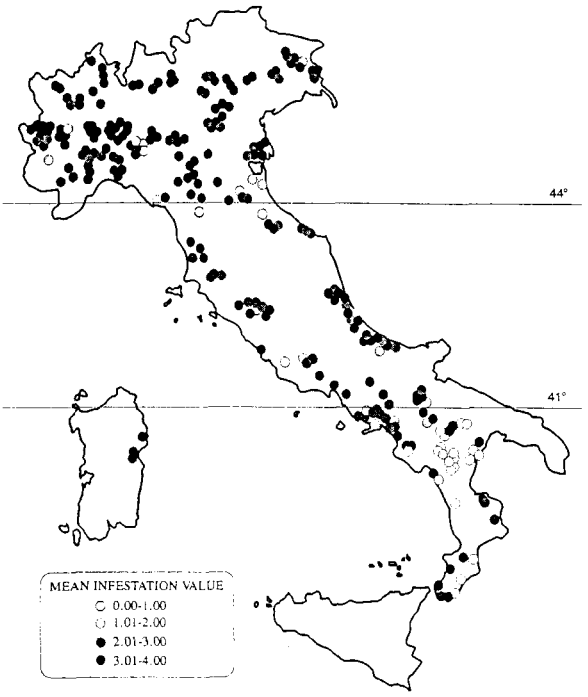

Figure 1 Distribution in Italy and susceptibility to *Phloeomyzus passerinii* of 244 *Populus nigra* genotypes tested in the laboratory

radiation or to heavy water stress. Although the *P. nigra* genotypes tested are not easily ascribable to the different sub-species present in Italy, characters typically selected in xeric habitats are evident in many southern genotypes, such as the abundant pubescence of the green shoots. Moreover it should be noted that the northern *P. nigra* genotypes did not develop specific mechanisms of resistance to *Ph. passerinii*, although environmental conditions are favourable to pest attacks, probably on account of the smaller incidence of attacks in the natural *P. nigra* stands, usually mixed and genetically diversified, in comparison with the monoclonal plantations of Euroamerican poplars, where the high plant density creates a particularly humid microclimate, much appreciated by the aphid.

The genetic control of resistance to *Ph. passerinii* and the high variability in the Italian *P. nigra* population suggest possible remarkable gains from a breeding strategy aimed at the production of resistant Euroamerican hybrids.

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