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Effect of hydroxamic acids on feeding behaviour and performance of cereal aphids (Hemiptera: Aphididae) on wheat

ARTURO GIVOVICH and HERMANN M. NIEMEYER

Departamento de Ciencias Ecológicas, Facultad de Ciencias,
Universidad de Chile, Casilla 653, Santiago, Chile

Aphididae, electrical penetration graphs, hydroxamic acids, feeding behaviour, growth rates, wheat

Abstract. The feeding behaviour of five cereal aphid species in wheat seedlings (measured by the time taken by an aphid to penetrate the phloem and the time spent in committed phloem ingestion) and their performance (measured as mean relative growth rates) were determined as a function of hydroxamic acid concentrations in the seedlings. Lower mean relative growth rates and higher times to attain a committed phloem ingestion were associated with higher hydroxamic acid values. Duration of commited phloem ingestion was not influenced by hydroxamic acid values.

INTRODUCTION

The most prevalent cereal aphid species in Chile are *Rhopalosiphum padi* (L.), *R. maidis* (Fitch), *Metopolophium dirhodum* (Walker), *Sitobion avenae* (F.) and *Schizaphis graminum* (Rondani). These species vary in their relative importance from year to year, and in some years can cause substantial production losses (Herrera & Quiroz, 1988).

An environmentally sympathetic method to control cereal aphid populations is through intrinsic resistant factors in plants. The presence of hydroxamic acids (Hx) in wheat and their proven effects on aphids make them an ideal source of natural resistance and hence a target for breeding (Escobar & Niemeyer, 1993).

Hx show two types of deleterious effects on aphids feeding on artificial diets: they are antibiotic (Argandoña et al., 1980), even at relatively low concentrations, and feeding deterrents (Argandoña et al., 1983). Further work has demonstrated that these effects are also observed when aphid performance and behaviour are studied in Hx-containing plants (Bohidar et al., 1986; Thackray et al., 1990; Givovich & Niemeyer, 1991).

The present study evaluates the comparative effect of Hx in wheat seedlings on feeding deterrency and antibiosis towards different cereal aphid species.

MATERIAL AND METHODS

Insects

Individuals of *M. dirhodum*, *R. padi*, *R. maidis*, and *S. avenae* were collected in wheat fields near Santiago. Individuals of *S. graminum* biotype C were obtained from a previously existing colony (Zúñiga et al., 1989). All species were reared on oat seedlings (*Avena sativa* cv. Nahuén) in a room at 22°C with a 6° range, and 16L : 8D photoperiod.

Plant material

Three wheat cultivars (cvs. Millaleu, Nobo and Maitén) were selected to represent low, medium and high concentrations of Hx (0.59, 2.4 and 3.4 mmol/kg fr. wt, respectively). Seeds were obtained from the

Instituto de Investigaciones Agropecuarias (INIA). Experiments were performed with seedlings at decimal growth stage 11 (Zadoks et al., 1974).

Aphid feeding behaviour

Electrical penetration graphs (EPGs) (Tjallingii, 1990) were used to follow feeding behaviour, and to determine the time individual aphids required to attain a committed phloem ingestion (TTP) and the duration of committed phloem ingestion (CPI) on the wheat cultivars studied. Twenty individuals of each species on each wheat cultivar were studied. Recordings lasted 10 hours, during which all aphids reached the phloem and typically over 90% of them completed a phloem ingestion period. The calculation of mean TTP considered all aphid individuals, while that of mean CPI considered only those individuals that had completed a phloem ingestion period. Means were compared among cultivars by ANOVA/Duncan's test.

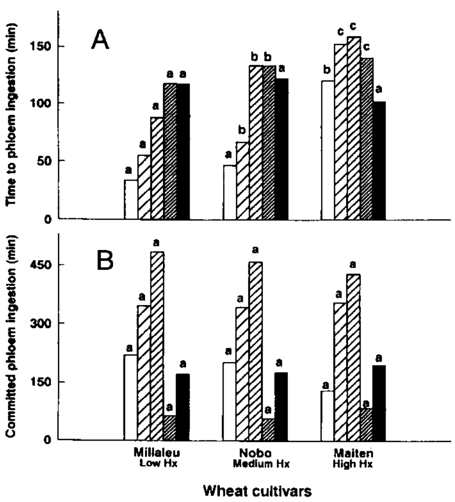
Aphid performance

Mean relative growth rates (MRGR) were employed to evaluate the performance of each aphid species on each of the tested wheat cultivars. This parameter is simple to determine (Adams & van Emden, 1972), is highly correlated with the intrinsic rate of increase of populations, and is useful in intraspecific and interspecific comparisons (r_m; Leather & Dixon, 1984; Dixon, 1985). First or second instar aphid nymphs were weighed and those with very similar weights were caged individually on the abaxial leaf surface of a test plant, and removed 96 hours later for weighing. Each species was replicated 20 times for each wheat cultivar. MRGRs were compared among wheat cultivars using ANOVA/Duncan's test.

RESULTS AND DISCUSSION

In the five species studied, the duration of committed phloem ingestion periods did not vary with the Hx levels in the wheat cultivars studied (Fig. 1B). Similar results were previously reported for *R. padi* feeding on six different wheat cultivars (Givovich & Niemeyer, 1991), and related to concentrations of DIMBOA glucoside in the phloem sap lower than the threshold for producing feeding deterrency or to a masking effect of nutrients over Hx in the sap (Givovich et al., 1994).

For each aphid species, when individuals fed on plants with higher Hx concentrations, their mean relative growth rates tended to be lower than those of aphids feeding on plants with lower Hx (Fig. 1C). This decrease was accompanied by an increase in the times



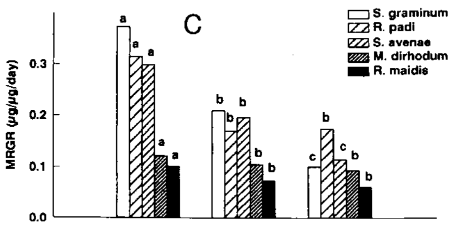


Fig. 1. Feeding behaviour and performance parameters for five different aphid species on seedlings of three wheat cultivars differing in Hx concentrations: A – time required to reach phloem; B – duration of comitted phloem ingestion; C – mean relative growth rates. Within each graph, the same letter over bars belonging to a given aphid species means that the differences are not significant (p > 0.05, ANOVA, Duncan's test).

aphids need to reach the phloem in the cases of *M. dirhodum, S. graminum, R. padi* and *S. avenae* (Fig. 1A), and suggests that behaviour during plant acceptance may be a cue for the further performance of the aphid species. These aphids, when on a wheat seedling with high Hx levels, spend more time searching for a suitable phloem vessel, with increasing frequency of probes and periods of ingestion from the xylem (Givovich & Niemeyer, 1994). Thus, not only do they feed less, but also ingest less nutrients and hence gain less weight. This interpretation is supported by the decreased honeydew production by aphids feeding on wheat seedlings containing higher concentrations of Hx (Givovich et al., 1992).

The performance of *R. maidis* appears different, since this aphid species is insensitive to Hx when searching for the phloem. It has been postulated that *R. maidis* has developed a feeding strategy to avoid Hx in the mesophyll by producing fewer cellular punctures in tissues other than sieve elements (Givovich & Niemeyer, 1994). Hence, TTP values are not influenced by Hx concentrations. The performance of *R. maidis* is lower in seedlings with higher Hx concentrations, a reflection of the toxic effects of the compound when ingested from sieve elements. A similar effect, albeit of lower magnitude, may be seen in the performance of *M. dirhodum.*

For a given wheat cultivar, the differences observed among cereal-aphid species, in relation to performance (MRGRs), may be related to different sensitivities to the antibiotic effect of Hx which, in turn, may be related to different strategies in dealing with the toxin compound (i.e. metabolization, excretion, storage) or different efficiencies in its detoxification (Pérez & Niemeyer, 1989; Lesczcynski & Dixon, 1992; Lesczcynski et al., 1992). However, it should be stated that the intrinsic behaviour of a given species in a plant may also be influenced by primary nutritional factors or by secondary metabolites other than Hx, which may inhibit or stimulate aphid feeding, or by the way a given aphid species is able to modify the metabolism of its host plant (Ryan et al., 1990).

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