AN INDEX OF ACCEPTABILITY TO GREEN PEACH APHIDS[1] FOR *SOLANUM* GERMPLASM AND FOR A SUSPECTED NON-HOST PLANT[2]

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Abstract

An electronic system that recorded feeding activity was used in replicated trials conducted to evaluate 25 *Solanum* cultivars and 1 *Pelargonium* (geranium) cultivar for acceptability to the green peach aphid, *Myzus persicae* (Sulzer). The number of probes and the time spent in probing were found to be indicators of relative acceptability; the number of feedings and the time spent in feeding were not. Although tests as brief as 15 min were useful in screening *Solanum* germplasm for resistance to the green peach aphid, 30 min tests were deemed more reliable. An index of acceptability was prepared by using the potato variety Katahdin as a standard for comparison.

Resumen

Un sistema electrónico que registraba la actividad de ingestión fue utilizado en pruebas repetidas para evaluar 25 cultivares *Solanum* y un cultivar Pelargonium (geranio) por aceptabilidad del áfido *Myzus persicae* (Sulzer). Se consideró que el número de pruebas y el tiempo empleado en los ensayos eran indicadores de la aceptabilidad relativa; no así el número de ingestiones ni el tiempo empleado en alimentarse. A pesar de que pruebas tan rápidas como de 15 minutos fueron útiles para tamizar germplasma de *Solanum* para resistencia al áfido *Myzus persicae*, se consideró más seguras las pruebas que requieren 30 minutos. Se preparó un índice de aceptabilidad utilizando papas de la variedad Katahdin como comparación.

Introduction

Sams et al. (4) used excised leaflets to evaluate resistance to the green peach aphid, *Myzus persicae* (Sulzer), in *Solanum* germplasm and obtained

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high correlations with field counts. Shanks and Chase (5) used a DC electrical system to record the probing and feeding behavior of the strawberry aphid, *Chaetosiphon fragaefolii* (Cockerell), on host and non-host plants. They found generally less probing time on a non-host than on a preferred host plant but reported that probing behavior could not be predicted on the basis of the susceptibility or resistance of a plant. Adams and Wade (1) used an AC electronic system converted to DC at the recorder to divide acceptability of *Solanum* germplasm to *M. persicae* into 5 categories based on probing frequency and the appearance of the waveform produced.

The following study was made with an AC electrical system and recorder to determine the relative significance of three components (non-probing, probing, salivation-ingestion) of green peach aphid feeding activity as indicators of acceptability of plants. The resulting waveforms were used to construct a non-subjective index for evaluating *Solanum* germplasm.

Methods and Materials

Twenty-five *Solanum* cultivars and 1 *Pelargonium* (geranium) cultivar, a suspected non-host for the green peach aphid were selected for testing. Sixty tests, including 2 tests of each of 3 *Solanum* cultivars and the geranium, were conducted over a 57-day period. The geranium plants were cuttings grown in commercial potting mix. *Solanum* test plants and green peach aphid colonies were maintained according to methods previously described (3). Aphids were mature in 9-10 days and were used in tests when 12-14 days old.

Feeding behavior of individual aphids was evaluated by using an electronic system as described by Brown and Holbrook (2) that records waveforms reflecting an aphid's probing and feeding activity on heat-sensitive paper tape at a chart drive speed of 1 mm/sec (2,3). Two such systems were operated simultaneously, one recording the behavior of an aphid on a test plant and the other recording the behavior of an aphid on a potato plant of the Katahdin variety and of the same age (6-12 wk). The Katahdin variety was selected as the control because it had been used as the rearing host for the aphid. Five replications were made during each test, each with a different aphid.

An aphid was prepared for testing as previously described (2,3). Then after a ca 30-min starvation period, the aphid was attached to the monitoring system by clamping the distal end of its tether wire in an alligator clip on a shielded wire lead. The test plant was connected to the system by placing a second shielded wire lead in the potting mix near the plant roots. The aphid was placed on the underside of a terminal leaflet near the leaflet tip, the recorder was immediately activated, and all non-probing, probing and

feeding activities were monitored for 45 min. The aphid was then removed and discarded. Examples of the waveforms recorded by the electronic monitoring system have been published previously (2,3). When a wired green peach aphid is moving or standing on a dry leaf surface, it produces a flat line at the baseline set on the chart. When the proboscis and stylets contact the plant surface and salivation begins, several sharp, high spikes are recorded. If the aphid then moves to another site, the waveform returns to baseline and remains flat until the next contact of the mouthparts. When probing continues, a series of spikes of intermediate height is produced as the stylets pass through the layers of plant tissue, usually intercellularly. The aphid may withdraw the stylets during this portion of the probe or may continue probing until the stylets reach the phloem bundles. The extended feeding (salivation-ingestion) begins. The salivation-ingestion phase is often preceded by a ca 5-sec drop in the waveform to near the baseline, but the activity is recorded as a fairly flat waveform at some height above the baseline and is distinct from other probing behavior.

For the present, 4 variables were selected for consideration: (1) number of probes; (2) total time (sec) spent probing; (3) number of periods of salivation-ingestion exceeding 60 sec (it is not uncommon for aphids to make brief contact with cells and ingest from them before continuing on to the phloem); (4) total time (sec) spent in salivation-ingestion.

Analyses of variance and Duncan's multiple range tests (1.0%) were performed on each of the 4 variables with data from both test and control plants.

Results and Discussion

Comparison of Variables – Fifty-seven of the 60 averages (5 replicates/test) for mean number of probes per test were similar including all 30 of the Katahdin controls. None of these averages differed from all others, but those for the 2 trials with the geranium (11.0 and 12.2) and for Russet Burbank I (9.6) were significantly greater than at least 51 other averages.

In the case of the mean total probing time per test, 56 of the 60 averages were similar again including all Katahdin controls. The averages for the 2 tests with geranium (734.4 sec and 1233.0 sec) differed significantly from each other and both were significantly lower than all other averages. The average for Russet Burbank I (1722.0 sec) was similar to 28 other averages including 10 Katahdin controls.

The mean number of probes per test and the mean total seconds of probing were significantly correlated (−0.90).

Fifty-nine of the 60 averages for the mean number of feeding periods per test were similar. The single variant was the average for Pungo (3.75); it

was similar to only 2 other averages. Therefore, Pungo was apparently an acceptable food source for the green peach aphid.

No significant differences among plants were found when the mean total times (sec) spent feeding were compared.

In sum, in replicated trials of 45-min duration, the 2 most important indicators of acceptability were the mean number of probes and the mean total probing time. The means for number and duration of feedings were both too variable to permit their use in evaluating acceptability because a green peach aphid allowed free access to a plant will eventually ingest fluids whether the plant is preferred or not preferred. This is in agreement with observations (1) that plant preference is shown by this aphid soon after probing is initiated. The homogeneity of the data for the Katahdin controls in regard to all 4 variables indicated that this cultivar could be utilized as a standard for comparison; it also indicated that tests separated in time could be compared.

Index of Susceptibility – The data for mean number of probes and mean total probing time (Table 1, 45 min tests) obtained in the comparisons could therefore be used to prepare an "acceptability index" in which the Katahdin controls of each test were used as a standard. The following formula was set up:

$$\frac{(NPT/NPC) + (TPC/TPT)}{2}$$

where NPT=mean number of probes on the test plant,
NPC=mean number of probes on the control plant,
TPC=mean total time (sec) of probing on the control plant, and
TPT=mean total time (sec) of probing on the test plant.

The smaller the resulting value, the more acceptable was the test plant as a food source to the insect.

The mean acceptability index for the 30 test plants for the 45-min tests was 1.244 (±0.486 sd). The only test plant that differed significantly from this value at the 5% (2.216, + 2sd) was geranium II (3.155), but the index number for the other geranium was very close to the 5% level at 2.214.

The tests on which the index of acceptability were based were 45 min long so the green peach aphids would have adequate time to produce feeding (salivation-ingestion) patterns and subsequent data on number of feeding periods and time spent feeding. Since these patterns had proved to be unimportant, the acceptability index was worked out on the basis of the results of the first 30-min and the first 15-min of the original 45-min tests.

At 30 min, the correlation coefficient between mean number of probes and mean total probe time was still significant (−0.86). Moreover, the acceptability values for the 45- and the 30-min tests were also highly

TABLE 1. — *Probing behavior of the green peach aphid and acceptability index for plants.*

Cultivar Control	45-Min Test			30-Min Test			15-Min Test		
	Number of Probes	Total Probe Time (Sec)	Accept-ability Index	Number of Probes	Total Probe Time (Sec)	Accept-ability Index	Number of Probes	Total Probe Time (Sec)	Accept-ability Index
Pungo	4.6	2366.8	1.138	3.2	1580.4	0.976	2.4	766.4	0.812
Katahdin	3.6	2362.0		3.2	1505.4		3.0	631.8	
Plymouth	5.4	2268.2	0.858	4.0	1383.0	0.819	4.0	483.0	1.292
Katahdin	6.6	2038.2		5.6	1276.6		3.0	604.0	
Norchip I	5.2	2059.0	1.548	3.2	1491.4	1.169	2.4	720.4	1.165
Katahdin	2.8	2549.4		2.6	1651.2		2.0	813.4	
Norland	3.2	2524.2	1.087	2.6	1672.4	1.012	2.4	792.4	0.975
Katahdin	2.8	2602.4		2.6	1713.4		2.6	813.4	
Mohawk	5.8	2186.6	1.058	4.6	1445.8	1.214	4.2	569.0	1.254
Katahdin	5.2	2185.6		3.4	1555.4		3.2	680.6	
Monona	3.6	2409.4	0.826	3.6	1493.8	1.075	2.8	677.4	1.080
Katahdin	5.2	2310.6		3.2	1530.8		2.8	786.0	
Lenape	3.2	2535.4	1.045	3.0	1663.2	1.099	2.6	791.2	0.969
Katahdin	2.8	2402.0		2.4	1576.6		2.4	676.6	
Saco	6.6	2137.6	1.414	4.8	1363.4	1.453	3.4	681.2	1.230
Katahdin	3.8	2332.4		2.8	1624.8		2.6	785.4	
Cariboo	3.0	2477.8	1.098	3.0	1577.2	1.155	2.6	704.8	1.148
Katahdin	2.6	2577.2		2.4	1671.6		2.2	785.8	
Cascade	3.4	2368.2	0.968	3.0	1530.4	1.096	2.6	656.4	1.151
Katahdin	3.6	2349.2		2.6	1587.6		2.2	735.2	
Green Mountain I	6.2	2188.8	1.598	3.6	1460.8	1.325	2.2	728.6	1.046
Katahdin	3.0	2473.2		2.4	1680.6		2.2	796.0	
Peconic	4.0	2283.2	0.928	3.6	1512.2	0.900	3.2	672.6	0.974
Katahdin	4.6	2252.8		4.2	1425.6		3.0	592.8	
Belleisle	5.0	2138.4	1.046	4.2	1374.8	1.017	3.2	571.0	1.103
Katahdin	4.8	2246.2		4.4	1484.4		3.2	688.4	
Russet Burbank I	9.6	1722.0	1.525	6.2	1136.2	1.308	4.4	566.2	1.062
Katahdin	5.6	2300.6		4.8	1505.4		4.4	646.8	
Superior	6.4	2242.4	0.879	5.6	1429.6	0.765	4.2	621.4	0.831
Katahdin	7.6	2052.2		7.6	1133.2		5.0	511.0	
Cobbler	5.4	2292.0	1.685	5.2	1425.6	1.770	4.2	590.2	1.736
Katahdin	2.4	2565.8		2.2	1677.4		2.0	809.6	
Sebago	3.4	2407.8	1.125	3.2	1605.6	1.112	3.0	722.2	1.173
Katahdin	2.8	2492.0		2.6	1593.6		2.4	792.0	
S. brachycarpum	7.4	1997.2	1.682	5.6	1312.4	1.890	4.8	587.6	1.705
Katahdin	3.4	2371.6		2.2	1619.0		2.2	721.6	
47156	3.2	2450.2	1.018	2.8	1624.2	0.941	2.8	767.2	0.988
Katahdin	3.2	2536.4		3.2	1636.0		2.8	748.8	
Kennebec	5.2	2225.2	1.340	4.0	1514.6	1.347	3.6	652.2	1.253
Katahdin	3.2	2347.4		2.4	1556.0		2.4	656.0	
Wy 1122	5.2	2316.8	0.961	3.2	1598.6	0.923	3.2	746.6	0.961
Katahdin	5.8	2375.8		3.8	1606.2		3.4	731.6	
Houma	3.2	2456.4	0.791	2.8	1590.0	1.016	2.2	770.6	0.881
Katahdin	5.0	2312.6		2.8	1641.0		2.8	751.6	
Geranium I	11.0	1233.0	2.214	8.2	881.6	2.274*	4.6	503.0	1.537
Katahdin	4.4	2377.6		3.0	1600.4		2.8	720.0	
Wauseon	4.0	2319.6	0.861	3.4	1493.4	0.750	2.6	694.8	0.760
Katahdin	4.8	2059.2		4.6	1135.6		3.6	554.6	
Abnaki	3.5	2372.4	0.915	2.8	1575.6	0.798	2.6	731.6	0.857
Katahdin	4.2	2364.2		4.2	1464.2		3.2	659.0	
Russet Burbank II	3.0	1969.8	1.238	2.8	1217.0	1.292	2.2	431.8	1.346
Katahdin	2.4	2416.0		2.2	1594.8		2.2	730.4	
Green Mountain II	6.0	1990.0	1.305	4.2	1305.8	1.102	3.0	576.6	0.856
Katahdin	4.0	2205.6		3.6	1354.6		3.4	478.4	
Norchip II	3.8	2322.8	1.509	3.2	1567.0	0.984	3.0	693.0	1.038
Katahdin	3.6	2469.4		3.4	1608.8		3.0	746.2	
Geranium II	12.2	918.0	3.155*	8.4	531.4	3.072*	4.4	248.6	2.424*
Katahdin	3.4	2498.0		2.8	1671.0		2.6	784.4	
S. kurtzianum	3.6	2295.2	0.940	2.8	1483.8	0.889	2.6	617.6	0.977
Katahdin	4.2	2347.0		3.8	1545.0		3.2	704.4	
$\bar{x}$	4.612	2270.783	1.244	3.697	1484.457	1.218	3.020	674.357	1.153
s	1.950	284.080	0.486	1.383	204.110	0.486	0.753	109.242	0.340

* $\geq$ 2 s from $\bar{x}$

correlated (0.96). In addition, in the 30-min tests, the values for both geranium trials differed significantly from all others (>2sd). At 15 min, the correlation coefficient between mean number of probes and mean total probe time had dropped to −0.66, and the correlation coefficient between the 45-min index and the 15-min index was 0.84. However, the significantly different plants were the same ones indicated by the 45-min acceptability index.

It would thus appear that five 15-min tests of a plant might be sufficient to determine whether it is significantly different in acceptability to the green peach aphid from a Katahdin control. Nevertheless, results would probably be more precise with five 30-min tests.

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