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Host Plant Resistance to Blackmargined Aphids on Pecan

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Abstract

The blackmargined aphid is a major insect pest of pecan. Host plant resistance to this insect was tested in two NPACTS (National Pecan Advanced Clone Testing System) tests in California in 1998. Number of aphids per leaf were determined 16 times at weekly intervals. 'Pawnee,' which had been shown to be resistant in Texas and Georgia, also demonstrated resistance in California. Aphid populations varied greatly, with the Lagomarsino Test averaging 4.10 aphids per leaf for the season, and the Clark Test averaging 8.52. Temporal variation in each test was great, with significant clone X date interactions. Level of host plant resistance in clones was generally unpredictable, based upon parentage. In pecan breeding programs, this makes testing of potential clone releases imperative, since predictability of performance based on pedigree has limitations.

Host plant resistance to the blackmargined aphid (*Monellia caryella* (Fitch)), yellow aphid (*Monelliopsis pecanis* Bissell), and the black pecan aphid (*Melanocallis caryaefoliae* Davis) in 'Pawnee' (7) and some other pecan clones (*Carya illinoinensis* (Wangenh.) K. Koch) has been known for some time (3, 6, 9). Host plant resistance to these insects is proving to be valuable when used in conjunction with other orchard management techniques, such as maintenance of aphid predator populations. As insecticide resistance within these aphid species becomes more apparent, host plant resistance will become even more important (2).

Of these three aphid species, the blackmargined is a major pest, and accounts for most of the damage attributable to the yellow aphid complex (yellow and blackmargined aphids) in pecan (1, 10).

In the U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS) Pecan Breeding Program, crosses are made and clones are initially selected at College Station, Texas. The best clones from this initial selection process are further tested in NPACTS (National Pecan Advanced Clone Testing System). The USDA-ARS conducts NPACTS tests in cooperation with state agricultural experiment stations, state extension services, and private individuals. Much aphid resistance data have been collected in NPACTS tests designed to determine adaptability of new breeding selections to different U.S. geographical areas. After NPACTS testing, superior clones are released as new USDA cultivars with Native American names. Here we report results from two California NPACTS test sites where clones were sys-

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tematically rated for aphid populations during the 1998 growing season.

Materials and Methods

Data were collected from two NPACTS tests established to determine adaptability of new USDA-ARS pecan clones for the Western U.S. The oldest test was established in the spring of 1977 when seedling rootstocks were planted on property owned by the Lagomarsino Trust, near Tulare, Calif. It is referred to here as the Lagomarsino NPACTS Test. These rootstocks were grafted March 1, 1978 to nine USDA advanced selections and 12 cultivars (Table 1). Tree spacing was 9.15 X 9.15 m in a square design, with three single-tree replications. The 1998 aphid data reported here were collected during the 21st leaf (year after grafting) of this test. Other performance data has been reported for this test (5).

A second test site was established near Visalia, Calif., and is referred to here as the Clark NPACTS Test. Stions (grafted trees) consisting of 7 cultivars and 17 advanced USDA selections (Table 1) grafted on VC-168 rootstocks were planted in early 1993. Tree spacing is 6.1 X 12.2 m on a rectangle design. There are two reps, and single-tree plots. Standard extension recommended orchard management practices were followed in both tests. The tests received no insecticide sprays that affected aphid populations.

Blackmargined aphid populations were monitored in the above tests 3 July through 20 Oct. 1998. Aphid populations

Table 1. Pecan clones tested in two NPACTS tests in California in 1998.

Lagomarsino Test			Clark Test		
Clone	Female parent	Male parent	Clone	Female parent	Male parent
41-19-20	San Saba Improved	Mahan	74-01-12	48-13-311[z]	Wichita
42-20-23	McCulley	Odom	75-08-09	Osage	Creek
49-23-16	Brake	Sioux	77-02-03	Cheyenne	55-17-03[y]
53-09-100	Mahan	Odom	77-09-06	Mohawk	Desirable
55-09-203	Mahan	Stuart	77-19-25	Cape Fear	Creek
56-10-06	Shoshoni	Cherokee	77-19-28	Cape Fear	Creek
56-15-03	Odom	44-12-259[x]	77-21-03	Creek	Cape Fear
61-04-09	Schley	SHG[w]	78-01-23	Cheyenne	Choctaw
64-11-17	Chickasaw	SHG	78-01-26	Cheyenne	Choctaw
Caddo	Brooks	Alley	79-02-44	Cheyenne	Cheyenne
Cape Fear	Schley	OP[v]	79-09-38	61-01-06[t]	Cheyenne
Cherokee	Schley	Evers	81-01-07	Cheyenne	Wichita
Chickasaw	Brooks	Evers	81-07-405	Wichita	Cherokee
Choctaw	Success	Mahan	82-15-02	Creek	53-09-01[u]
Creek	Mohawk	SHG	82-17-587	Wichita	OP
Kanza	Major	Shoshoni	82-17-1316	Wichita	OP
Kiowa	Mahan	Desirable	82-17-1614	Wichita	OP
Mohawk	Success	Mahan	F.W.Anderson	Govett	OP
Pawnee	Mohawk	SHG	Houma	Desirable	Curtis
Shoshoni	Odom	Evers	Maramec	Mahan	OP
Tejas	Mahan	Risien 1	Navaho	48-13-311	Wichita
			Oconee	Schley	Barton
			Salopek	Wichita	Onliwon
			Sullivan	Stuart	Nugget

[z]Selection 48-13-311 has the parentage 'Moore' X 'Schley.'
[y]Selection 55-17-3 has the parentage 'Oklahoma' X 44-12-86 ('Moore' X 'Nugget').
[x]Selection 44-12-259 has the parentage 'Moore' X 'Nugget'
[w]Starking Hardy Giant.
[v]OP=Open pollinated.
[u]Selection 53-9-1 and 53-9-100 have the parentage 'Mahan' X 'Odom.'
[t]Selection 61-1-6 has the parentage 'Barton' X 'Starking Hardy Giant.'

were determined by counting all aphids (nymphs and adults) on three large leaves on each tree. Leaf height was about 2 m., and leaves were chosen randomly around the tree perimeter. SAS analysis of variance procedures for split plot designs (4) were used to determine the influence of clones and other variables on aphid populations. Duncan's multiple range tests were used to separate seasonal means of clones and dates.

Results and Discussion

Overall, the analysis of variance tests for both the Lagomarsino and Clark Tests showed results similar to a previous study (6); in that clones, dates, and clone x date interactions were highly significant (Table 2). Aphid populations varied greatly, with the Lagomarsino Test averaging 4.10 aphids per leaf for the season, and the Clark Test averaging 8.52. The reason for this is unclear. It is interesting to note that the Lagomarsino Test was in its 21st leaf, while the younger Clark Test was in its 6th leaf. Tree crowding was therefore much greater in the Lagomarsino Test. Temporal variation among dates for aphid populations was also great in both tests. High aphid populations were evident even into October.

'Pawnee' was superior to many other clones in the Lagomarsino Test (Table 3). It was the fourth lowest clone as far as overall aphid numbers across dates, and was not statistically different from these three other resistant clones. In the two NPACTS tests at College Station, Texas (6), 'Pawnee' was superior to many other clones. Our earlier report (6) and the report by Kaakeh and Dutcher (3), show clearly that 'Pawnee' and some other clones have superior host plant resistance to the blackmargined aphid, yellow pecan aphid, and the black pecan aphid. Conversely, five clones (61-4-9, 'Tejas,' 'Choctaw,' 53-9-100, and 56-10-6) in this Lagomarsino Test had significantly higher susceptibility to aphid populations when compared to 'Pawnee.'

The clone with the lowest overall actual aphid counts in the Clark Test was 77-9-6. This clone was significantly more resistant than seven other clones. Two clones ('Navaho' (8) and 74-1-12, a sib to 'Navaho') tested here were also tested earlier in Texas. (6). These earlier test results are consistent with the results reported here, in showing that these two clones have useful levels of resistance. The most susceptible clone in the Clark Test was 77-2-3. It was statistically more susceptible than any other clone. It is a progeny of 'Cheyenne,' one of the most susceptible pecan clones known. Some other clones with 'Cheyenne' parentage were much less susceptible (Table 1).

When parentage of clones is considered (Table 1), there were two sets of sibs in the Lagomarsino Test ('Choctaw' and 'Mohawk,' and 'Creek' and 'Pawnee'). There were no significant differences for aphid infestations within either family. The most susceptible clone in this test, 61-4-9 even has a common parent ('Starking Hardy Giant') with 'Pawnee,' the most resistant clone in previous tests. In the Clark Test, there were two pairs of sibs (74-1-11 and 'Navaho,' and 78-1-23 and 78-1-26), and one family was represented by three sibs

Table 2. Analysis of variance for two aphid resistance studies in California in 1998.

	Lagomarsino Test			Clark Test		
Source	df	SS	Probability[z]	df	SS	Probability[z]
Block	2	28	NS	1	305	0.03
Clone	20	1558	0.00	23	5659	0.00
Block X Clone	40	541		23	1230	
Date	15	12055	0.00	15	5236	0.00
Clone X Date	300	4298	0.00	345	2603	0.00
Block X Clone X Date	630	3355		360	1883	

[z]Probability of a greater F value for differences due to chance alone.

Table 3. Mean number of blackmargined aphids per compound leaf for different pecan clones on indicated dates in the Lagomarsino NPACTS Test at Tulare, Calif. in 1998. Duncan's multiple range test ($p < .05$) separation is presented for clone means across dates and for dates.

Clone	3 July	10 July	17 July	24 July	31 July	7 Aug.	14 Aug.	21 Aug.	28 Aug.	4 Sept.	11 Sept.	18 Sept.	25 Sept.	2 Oct.	9 Oct.	16 Oct.	Mean
41-19-0020	3.56	1.78	1.22	0.11	0.56	1.22	1.00	1.00	0.44	2.33	3.67	7.56	8.44	10.78	11.22	10.67	**4.10 c-f**
42-20-0023	5.56	4.00	2.33	1.33	3.56	8.89	1.89	1.22	0.67	1.56	1.78	3.00	5.22	5.11	5.44	8.00	**3.72 ef**
49-23-0016	4.89	1.78	2.33	1.78	1.33	3.22	1.56	1.56	1.00	0.44	2.11	3.89	4.89	6.56	7.78	9.89	**3.44 e-g**
53-09-0100	14.11	4.00	2.78	1.11	2.44	2.89	1.67	1.67	1.00	1.00	1.44	7.33	8.56	11.78	14.44	11.89	**5.51 a-d**
55-09-0203	6.11	2.11	1.44	0.22	0.78	1.00	1.00	1.11	0.89	5.22	3.00	2.78	5.78	9.00	9.67	12.11	**3.89 d-f**
56-10-0006	5.44	3.00	0.22	0.44	1.44	2.89	1.67	1.44	0.78	0.78	3.78	4.67	9.67	9.67	20.78	21.22	**5.49 a-d**
56-15-0003	5.00	3.89	1.67	0.33	1.33	1.78	1.44	1.56	0.56	1.33	2.22	3.44	5.67	7.44	7.78	8.33	**3.36 e-g**
61-04-0009	4.67	1.67	1.56	1.11	2.22	2.33	1.33	1.56	0.89	1.11	4.00	9.78	13.6	17.56	26.00	15.11	**6.53 a**
64-11-0017	4.11	2.56	0.33	0.11	1.22	3.00	1.78	1.56	0.44	0.33	3.67	6.33	8.33	10.11	12.44	14.11	**4.40 c-f**
Caddo	7.56	5.78	1.67	0.22	0.44	0.56	0.67	0.78	0.33	1.33	1.33	2.33	4.33	4.89	7.44	9.00	**3.04 fg**
Cape Fear	5.00	2.00	0.89	0.00	0.56	1.00	1.89	1.22	0.11	1.00	1.89	4.00	5.33	6.11	6.56	7.33	**2.81 fg**
Cherokee	4.78	1.67	1.33	0.56	1.78	4.00	2.67	1.89	1.22	2.44	2.22	1.67	4.11	6.22	6.56	7.00	**3.13 fg**
Chickasaw	9.89	2.22	1.11	0.89	1.11	2.22	2.33	2.00	2.11	2.00	1.44	0.56	2.22	4.44	4.56	5.33	**2.78 fg**
Choctaw	5.44	3.44	1.56	0.11	1.33	2.11	2.44	3.33	3.78	5.89	5.56	4.33	8.00	13.00	15.56	17.00	**5.81 a-c**
Creek	8.00	1.56	1.11	0.11	1.00	0.56	1.22	1.56	0.89	0.78	3.00	4.44	7.56	10.56	14.11	16.89	**4.58 b-e**
Kanza	10.22	4.56	2.00	0.44	1.67	1.89	1.67	1.56	0.78	1.44	4.33	8.78	8.78	9.22	9.56	12.33	**4.95 a-e**
Kiowa	2.67	1.56	0.89	0.00	0.11	0.44	0.44	0.56	0.33	0.56	1.44	1.56	4.00	4.22	4.44	5.78	**1.81 g**
Mohawk	9.22	3.00	1.22	0.56	1.89	3.11	2.22	2.00	0.67	2.00	3.33	4.67	5.89	7.89	9.67	10.78	**4.26 c-f**
Pawnee	4.33	1.11	0.56	0.11	1.00	0.78	0.78	1.22	0.44	0.78	4.22	3.78	7.78	8.22	8.56	8.78	**3.28 e-g**
Shoshoni	4.00	2.22	0.89	0.56	1.33	3.33	1.78	1.67	0.56	1.67	2.00	2.33	4.22	5.67	6.44	7.56	**2.89 fg**
Tejas	4.11	2.00	0.67	0.56	1.11	3.00	2.00	2.22	1.67	8.22	6.11	7.22	11.33	12.4	18.44	18.78	**6.24 ab**
Mean	6.13c	2.66ef	1.32hi	0.51j	1.34h-j	2.39e-g	1.59g-i	1.56g-i	0.93l-j	2.01f-h	2.98e	4.50d	6.85c	8.61b	10.83a	11.33a	**4.10**

(77-19-25, 77-19-38, and 77-21-3). There were no significant differences between sibs for aphid infestations within the first two pairs, but one of the three sibs (77-19-38) had significantly fewer aphids than the other two. Besides full sibs, there was much commonality of parentage across clones in both tests. No parent was identifiable as an outstanding source of strong resistance or susceptibility, not even 'Mohawk' or 'Starking Hardy Giant,' the parents of the highly resistant 'Pawnee.'

Perhaps this lack of parent to progeny association is a function of the high heterozygosity of pecan, which leads to large phenotypic differences. In pecan breeding programs, this makes clonal testing imperative, since predictability of performance

Table 4. Mean number of blackmargined aphids per compound leaf for different pecan clones in the Clark NPACTS Test at Visalia, Calif. in 1998. Duncan's multiple range test (p <. 05) separation is given for clone means across dates and for dates.

Clone	7 July	14 July	21 July	28 July	4 Aug.	11 Aug.	18 Aug.	25 Aug.	1 Sept.	8 Sept.	15 Sept.	22 Sept.	29 Sept.	6 Oct.	13 Oct.	20 Oct.	Means
74-01-0012	2.00	4.83	7.33	8.00	11.00	9.50	8.50	8.00	7.50	8.50	6.00	4.83	6.83	8.67	8.83	7.83	**7.39 b-e**
75-08-0009	1.67	2.00	5.00	4.17	6.00	5.17	6.17	5.67	5.17	6.33	5.50	4.33	8.83	10.00	10.17	8.67	**5.93 e**
77-02-0003	0.83	6.17	12.83	21.50	22.33	21.50	21.50	19.00	18.67	19.83	20.00	17.00	18.17	18.50	17.83	17.17	**17.05 a**
77-09-0006	0.83	3.00	3.67	4.67	6.00	5.50	5.17	3.33	3.50	5.17	5.50	5.83	7.67	8.83	9.33	9.50	**5.47 e**
77-19-0025	2.17	3.83	10.50	14.50	15.83	15.33	15.17	12.67	11.00	11.67	9.33	9.83	10.00	11.67	12.50	17.50	**11.47 b**
77-19-0028	1.83	1.50	5.17	6.33	8.83	8.00	9.67	5.67	5.00	6.00	4.00	4.33	6.33	8.33	8.33	9.50	**6.18 e**
77-21-0003	2.50	4.17	6.67	12.83	14.00	13.00	13.83	12.33	10.83	11.83	10.83	10.33	11.50	13.33	14.50	14.17	**11.04 b-d**
78-01-0023	3.00	6.17	7.50	10.33	11.67	11.67	10.83	7.83	7.33	6.83	7.00	8.50	13.00	13.83	13.00	12.83	**9.46 b-e**
78-01-0026	4.17	8.67	8.33	8.50	10.00	8.17	7.00	6.67	5.17	6.17	5.83	6.50	7.50	9.50	10.50	11.33	**7.75 b-e**
79-02-0044	4.83	6.17	6.33	8.17	10.50	9.17	9.33	7.83	5.67	7.83	7.17	7.33	11.33	13.50	12.67	12.50	**8.77 b-e**
79-09-0038	2.00	1.67	7.17	16.17	18.00	17.00	15.83	14.33	10.00	11.00	10.17	10.00	10.33	11.00	12.50	14.00	**11.32 bc**
81-01-0007	1.67	4.00	4.67	7.33	8.17	7.33	7.17	5.67	4.83	6.50	5.17	6.17	8.83	10.17	11.00	10.67	**6.83 de**
81-07-0405	5.33	1.67	4.33	6.67	8.17	8.17	7.17	4.83	5.33	7.00	4.33	4.17	9.50	9.33	10.50	15.00	**6.97 c-e**
82-15-0002	1.00	1.17	2.33	3.67	5.83	5.17	3.00	3.00	6.33	6.33	5.17	6.17	10.83	11.17	11.67	11.17	**5.88 e**
82-17-0587	1.33	3.50	4.17	5.00	7.00	6.50	5.17	5.50	5.33	7.50	5.50	6.83	9.17	10.50	10.50	11.33	**6.55 e**
82-17-1316	2.67	5.83	11.50	13.33	15.17	13.83	15.00	12.17	10.50	11.00	8.50	9.67	11.17	12.83	12.33	11.17	**11.04 b-d**
82-17-1614	0.67	1.50	3.83	6.33	8.33	7.67	7.67	7.67	6.50	7.83	4.33	5.83	7.50	8.33	7.17	7.33	**6.16 e**
FWAnder	1.83	2.83	9.83	14.83	14.33	13.17	13.50	12.67	10.67	11.67	11.17	10.00	12.17	13.50	13.83	13.83	**11.24 b-d**
Houma	2.33	3.17	12.17	13.83	9.67	9.00	8.33	6.33	7.33	8.00	5.83	7.00	8.50	9.67	7.83	7.83	**7.93 b-e**
Maramec	2.00	3.33	6.50	6.00	7.50	6.33	5.83	4.50	3.17	4.17	3.50	3.50	7.50	8.83	9.33	11.00	**5.81 e**
Navaho	1.50	2.67	3.33	4.33	5.83	5.50	4.50	6.67	6.00	7.50	8.50	9.33	10.50	11.17	10.83	11.50	**6.85 de**
Oconee	2.17	2.17	8.50	13.17	13.67	13.00	12.17	11.33	11.17	12.67	14.17	12.17	13.00	14.00	14.83	15.00	**11.45 b**
Salopek	1.17	3.67	4.33	11.33	13.67	12.33	11.83	11.00	8.17	7.67	6.83	7.17	8.83	11.50	12.50	11.50	**8.97 b-e**
Sullivan	2.17	1.00	5.00	6.67	7.33	6.83	5.67	5.50	4.33	7.17	8.67	9.33	9.83	10.67	10.83	12.17	**7.07 b-e**
Means	2.15j	3.53i	6.71h	9.45de	10.78bc	9.95cd	9.58d	8.34fg	7.48gh	8.59ef	7.62f-h	7.76fg	9.95cd	11.20ab	11.39ab	11.85a	**8.52**

based on pedigree has limitations. That pecan is clonally propagated is an advantage, since genetic value of each clone can be determined in performance tests such as these, and genetic variability is nonexistent within cultivars in orchard situations.

The highly significant clone x date interactions reported here are somewhat a function of differential leaf damage on different clones as the season progresses. Certain clones are preferred over other clones, and are more heavily infested early in the season. Later in the season, these clones are less preferred due to incurred feeding damage. This leaf damage, as far as suitability for further aphid feeding has been shown by Wood, et al. (11). This complex temporal-host plant resistance relationship is typical in pecan where aphid populations vary by clone and date, and justifies multiple rating dates during the season to determine clonal host plant resistance. As determined earlier (6), two or three well-timed rating dates should be used.

Until recently, host plant resistance to aphids in pecan was too often dismissed as being of little value. These ideas were usually based upon inconsistent results obtained by single rating dates and aphid populations which change within and among seasons. The clonal differences shown here, and in other tests, are encouraging to pecan breeders, since it is obvious that host plant resistance to these insects is effective enough to serve as a valuable form of control, especially in concert with other management strategies. Previous studies on aphid resistance in pecan (3), show that, to some degree, if a clone is resistant to one of the three major species of aphids, it should have some resistance to the other two. From a breeding standpoint, this is encouraging, since independence of genetic resistance would greatly complicate breeding efforts. Host plant resistance should continue to become more important in future insect control strategies since is so environmentally and economically desirable.

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Addendum

Through an oversight Alvan Gaus was omitted from the author list of "Performance of 'Gala' Apple on 18 Dwarf Rootstocks: Five-year Summary of the 1994 NC-140 Dwarf Rootstock Trial" Journal American Pomological Society 54(2):92-107.