# SCREENING FOR RESISTANCE IN COTTON GENOTYPES TO APHIS GOSSYPII GLOVER, THE COTTON APHID

**B. Reed, J. Gannaway, D. R. Rummel and H. G. Thorvilson**
**Texas Agricultural Experiment Station**
**Lubbock, TX**
**Department of Plant and Soil Science**
**Texas Tech University**
**Lubbock, TX**

## Abstract

Screening for resistance to *Aphis gossypii* Glover, the cotton aphid, began in hopes of developing superior-yielding cottons resistant to the aphid. It was anticipated that genotypes would range in resistance from susceptible to resistant. Original screening studies were conducted in a greenhouse to test general resistance. Sixteen cotton genotypes were tested in a completely randomized design. In general, resistance was varied, proving that genetic variability for resistance existed (*P*=.0026). Several top, bottom and middle performers were noted, and the top and bottom performers were tested against each other in choice and no-choice tests. These tests confirmed host plant resistance. The top and bottom performers currently are used as standards in ongoing screening tests. Additional screening studies were conducted in a greenhouse using a randomized block design. Six genotypes were tested per trial with two of these genotypes being the standards. Different treatments of pyrethroid-treated and infested, infested and non-infested plants without pyrethroid treatments were used in studying the effects and interactions of cotton aphid numbers with different cotton genotypes. Cotton plants were infested with cotton aphids and treatment was applied at the first true leaf stage. Aphid counts and plant health measurements were taken each week for five weeks. Thus far, ten cotton genotypes have been studied for resistance to the cotton aphid in this manner.

Throughout all screening tests, the superior cotton genotype for resistance has been *Gossypium arboreum* (*P*=.0026). This genotype displays excellent resistance to cotton aphids and does not show a great deal of damage associated with cotton aphid infestations. Another genotype, CA 3084 which is an experimental line, has consistently performed second in aphid counts and plant health studies while not being statistically different from other genotypes (*P*=.1834). CA 3084 also has shown possible, but not significant tolerance to high aphid numbers. 'Acala 1517-75', ' Paymaster HS-26' and 'Paymaster 145' have shown moderate levels of tolerance to the cotton aphid (*P*=0427). One consistently poor performer in both aphid counts and plant health has been 'Stoneville 213'.

In conclusion, the cotton genotype *Gossypium arboreum* clearly demonstrated host plant resistance to the cotton aphid. Therefore, *G. arboreum* will be entered into the Texas A&M University Cotton Improvement Program at Lubbock.

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## Introduction

The cotton aphid, *Aphis gossypii* Glover, has been a serious pest throughout the Cotton Belt. This pest not only takes vital sugars and amino acids from the growing cotton plant, but also deposits excretions known as "honeydew" onto cotton fibers. This "sticky cotton" causes major problems in textile mills, and subsequently a lower price to producers. The unique Texas High Plains area did not experience cotton aphid problems for many years. However, in the 1975 growing season, the High Plains received its first taste of what large populations of aphids could do to a cotton crop. Prior to 1975, aphid populations occurred in small, isolated "pockets" in the area. These "pockets" were ignored by producers (Rummel et al. 1995). Since the 1975 growing season, the cotton aphid has become an annual pest. Producers often have initiated insecticide treatments, whether aphid numbers warranted treatment or not.

The cotton aphid problem continued to grow throughout the 1980s. The first major evidence of a resistant aphid population first appeared in the Texas High Plains area in 1989 (Allen et al. 1990). The problem continued to increase throughout the early 1990s when the largest cotton aphid outbreaks occurred in the High Plains area. Insecticide treatments proved almost useless except at extremely high application rates. The entire area's cotton crop was affected (Rummel et al. 1995, Kidd et al. 1996, Kidd & Rummel 1997). The 1995 "sticky cotton" problem occurred on less than 200,000 bales but caused serious problems for the textile industry.

These aphid problems have initiated many studies involving cotton aphid control. Planting dates, plant nutrient availability, plant density, light intensity, beneficial arthropod populations, temperature, and pyrethroid sprays all have been studied for their effects on cotton aphids (Heathersbee et al. 1994, Leser et al. 1992, Kidd et al. 1996, Rummel & Kidd 1997, Slosser et al. 1989, Auclair 1966). All of these studies dealt mainly with methods of control and biology of the cotton aphid. However, one major tool for control of the cotton aphid has been overlooked. Host plant resistance is of vital importance in the control of any insect or plant disease in troubled areas (Metcalf et al. 1994). A few phenotypic properties have been identified as being "unfriendly to aphids" such as smooth leaf characteristics (Allen et al. 1992, Weathersbee and Hardee 1994, Rummel et al. 1995). Also, melon enzymatic studies have shown cotton aphid population differences (Owusu et al. 1996). However, no genotype of cotton has been identified with consistent resistance to the cotton aphid.

Several studies dealing with the biology of the cotton aphid are of some importance. A temperature of 72 degrees F. has beneficial effects on cotton aphid reproduction (Auclair 1966). High plant nitrogen levels and ample available water also have beneficial effects on aphid populations (Allen et al. 1992). Pyrethroid sprays also benefit cotton aphid populations by killing beneficials and slightly changing the cotton plants' physiology (Kidd & Rummel 1997).

Some of the previous research indicates that host plant resistance to the cotton aphid exists. In this study, we have attempted to identify host plant resistance to the cotton aphid in cotton genotypes.

## Materials and Methods

A wide array of cotton genotypes was used in this study. Among genotypes tested were obsolete varieties, current local varieties, current varieties grown across the Cotton Belt, foreign varieties, and several other accessions.

We gave cotton aphids the best environmental conditions possible for optimum plant pressure. A greenhouse served as the initial screening site for aphid resistance. The greenhouse temperature was kept at 72 degrees F. year-round. This was accomplished with a gas heater in the winter and a greenhouse evaporative cooling system in the summer. The plant growth medium consisted of a 50/50 mix of a commercial potting mix and soil. As the growth medium was being prepared, 400 mg of 45-0-0 slow-release urea per replication was added. The medium was then poured into 6-inch pots, and each pot contained one plant. The plants were irrigated with a Rainbirdä automatic watering system. The plants received an estimated two tenths of an inch of water every two days from emergence to completion of the test.

The aphids also were reared year round in the greenhouse. These aphids were kept separate in a predator exclusion cage. The cage was made of a wooden frame and fine Lumiteä screen. The Lumiteä allowed 100% light penetration to the plants and aphids, and thus did not change any behavioral patterns. The cotton aphids were "fed" Paymaster HS-26, a cotton variety known to support cotton aphids. The food plants were periodically replaced to keep an ample population of cotton aphids available.

### Original Test

The original screening test was very broad in hopes of finding any useable type of resistance. A broad range of sixteen cotton genotypes was evaluated for resistance to the cotton aphid in the spring of 1997. These sixteen genotypes were arranged in a completely randomized design (CRD), consisting of three replications of three plants per replication. All plants in this test were infested with cotton aphids at the first true leaf growth stage and counted for five weeks. Statistics were done by utilizing ANOVA tables and LSD means. The acceptable level of error was determined to be $P$=.05. The genotypes tested consisted of twelve commercial cultivars, as follows:

1. Half & Half
2. Paymaster HS-26
3. Paymaster 145
4. Acala 1517-75
5. Acala SJ-2
6. Acala Maxxa
7. Lankart 57
8. Stoneville 213
9. Gregg 65
10. Pima S-7
11. Northern Star 5
12. Tamcot Sphinx

three experimental lines, as follows:

13. CA 3093
14. CA 3084
15. Covey Red

and one diploid species, as follows:

16. *Gossypium arboreum*

### Screening Tests

Two separate screening tests were conducted in the greenhouse. Using *G. arboreum* and Stoneville213 as our standards, we tested Paymaster HS-26, Acala 1517-75, 'Tamcot Sphinx,' and CA 3084 in the first test during the spring of 1998. *G. arboreum* and Stoneville 213 again were used as standards to test the genotypes 'Lankart 57,' Paymaster 145, 'Coker 312', and 'Half & Half' in the second test during the summer of 1998.

The screening tests were conducted in a randomized block design (RBD). Three tables held six genotypes of cotton with each table representing one replication. Each genotype was evaluated by three treatments per replication. Pyrethroid-infested, infested, and non-infested treatments were studied. Two plants of each genotype underwent one each of the three treatments. This gave a total of 36 plants per table and 108 plants per test.

Pyrethroid-infested plants were infested with three to seven cotton aphids at the first true leaf growth stage and treated with a pyrethroid (Ammoä). These plants then were treated again ten days later with the pyrethroid. The infested treatment plants were infested at the same time and with the same number of cotton aphids as the pyrethroid-infested. The non-infested plants acted as a control treatment. These plants were kept aphid free. The soils of the control plants were treated with a systemic insecticide (Payloadä) prior to planting. In addition, the control plants were removed from their location on the table as needed and treated with an aphicide (Bidrinä). After treatment, the plants were returned to their positions on the table. All treatments were

present on each table and their actual sites on the tables were randomly selected.

Weekly counts of aphids began one week after infestation and continued for five weeks. The entire plant was counted, and different life stages of the cotton aphid were recorded. At the end of the five-week period, aphid numbers were compared statistically between cotton genotypes for each count and across the counting season using ANOVA and LSD.

During the five-week period, genotypes were compared for plant development and general health. Data on plant height, number of leaves, and the number of squares and bolls were taken during the five-week period. After five weeks, a destructive test was conducted on all plants of all treatments and genotypes. Data on leaf surface area, number of leaves, plant height, and plant weight were taken. Pyrethroid-infested, infested, and control plants of all six genotypes were tested for statistical differences between genotypes and treatments again using ANOVA and LSD.

**Choice and No-Choice Trials**

After screening tests were completed, choice and no-choice tests began. The top performers from each screening test were tested against the bottom performer one at a time. In the no-choice tests, the superior-performing genotypes were planted alone in a predator exclusion cage. They were infested and counted using the same procedure as the pyrethroid-infested treatment from the screening tests. Choice tests were conducted at the same time as the no-choice tests. In a choice cage, one superior-performing genotype was planted with a inferior-performing genotype. This test also matched the procedures of the pyrethroid-infested treatment from the screening tests. Throughout the summer months *G. arboreum*, CA 3084, Paymaster HS-26, Acala 1517-75, and Paymaster 145 were all tested against Stoneville 213 in this manner.

## Results and Discussion

**Original Test**

The results of this test were based solely on cotton aphid numbers per plant (Table 1). No plant health or control data were taken. The results only confirmed our hypothesis of varying host plant resistance. The results represented are mean aphid numbers during the five weeks.

*Gossypium arboreum*, a diploid species, had fewer cotton aphids present. Stoneville 213 had the largest number of cotton aphids surviving. With the detection of varying levels of resistance, we initiated our screening tests. Stoneville 213 and *G. arboreum* are used as our standards by which to test other genotypes.

**Screening Test 1**

*G. arboreum* again proved to be resistant to the aphids, having fewer total aphids per plant starting the third check week and throughout the remainder of the test ($P$=.0047), (Figures 1&2). *G. arboreum* also was superior in the number of winged ($P$=.0026), and young ($P$=.0006), while the number of adult aphids was not statistically different ($P$=.0690), at the end of five weeks (Figures 3&4). No other genotypes were statistically different in any aphid numbers.

Paymaster HS-26 and Acala 1517-75 were superior performers in plant height ($P$=.0427), (Figure 7). No other plant health test proved to be significant. However, *G. arboreum* did have the least amount of variation between pyrethroid-infested, infested, and control treatments ($P$=.1748) (Figure not shown). While not significant, Paymaster HS-26 and Acala 1517-75 also were leaders in number of leaves ($P$=.0635), plant weight ($P$=.0806), and leaf surface area ($P$=.5946). The genotype CA 3084 performed well in fruit production, but not at a significant level ($P$=.4293), (Figures 6-10).

The superiority of *G. arboreum* in supporting fewer aphids indicates a true form of resistance. The cotton aphids survive and reproduce on *G. arboreum*, ruling out the possibility of antibiosis as the form of resistance. Therefore, the results indicate a harsh form of non-preference. The performance of Paymaster HS-26 and Acala 1517-75 indicate a mild form of tolerance.

In the choice and no-choice tests, *G. arboreum*, CA 3084, Paymaster HS-26, and Acala 1517-75 all were tested against Stoneville 213. Again *G. arboreum* proved to be superior ($P$<.0001) (Figures not shown). Not only did *G. arboreum* have fewer numbers of aphids in the choice cage, but also in the no-choice cage. In fact, the numbers of aphids on *G. arboreum* in the no-choice cage was lower than in the choice cage. The higher aphid numbers may be accounted for by aphid movement back from Stoneville 213 in the choice cage. The numbers of aphids on CA 3084 ($P$=.1258), Paymaster HS-26 ($P$=.5245), and Acala 1517-75 ($P$=.6423) were not significantly different (Figures not shown).

**Screening Test 2**

Early in the test, problems arose. The seed used to plant Stoneville 213 was old and did not germinate well. As a result, the Stoneville 213 plants were 10-14 days younger than the rest of the test plants and could not support the same high number of aphids. This skewed the results of the aphid number test and none of the aphid number data was significant, despite a large gap held by *G. arboreum* and Stoneville 213 ($P$=.0683) over all other genotypes, (Figures 11-15). However, *G. arboreum* was far superior in number of leaves ($P$<.0001), plant height ($P$<.0001), and number of squares or bolls ($P$<.0001), (Figures 16-18). Paymaster 145 shared superiority with *G. arboreum* in plant weight ($P$<.0001), and leaf area ($P$=.0288), (Figures 19-20).

These results indicated that *G. arboreum* held superiority in plant health studies due to lower aphid numbers from non-preference, while Paymaster 145 displayed a moderate form of tolerance. In choice and no-choice tests, Paymaster 145 was not significantly different in aphid numbers from Stoneville 213 (*P*=.7982). *G. arboreum* was not tested again in the choice and no-choice tests.

## Conclusions

The cotton genotype *Gossypium arboreum* clearly demonstrated host plant resistance to the cotton aphid. Therefore, *G. arboreum* will be entered into the Texas A&M University Cotton Improvement Program at Lubbock, but this genotype offers challenges to a breeding program. *G. arboreum* is a diploid cotton and contains few agronomic properties desirable to cotton production. However, the aphid resistant trait alone has enough economic possibilities to receive interest in improvement toward production.

Several other genotypes showed possible mild to moderate forms of tolerance. These genotypes were Paymaster 145, Paymaster HS-26, Acala 1517-75, and CA 3084. The possible presence of a tolerance trait may be useful in producing high yields of cotton under high cotton aphid numbers early in the growing season. For this reason, the tolerance trait deserves some attention. However, if the same problem of high cotton aphid numbers occurs late in the season, which is more likely, the problem with "sticky cotton" faced by producers and the textile mills has not been solved.

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Table 1. Results of original test.

| Cotton genotypes | aphids |
|---|---|
| 1. *Gossypium arboreum* | 85.59 f |
| 2. Tamcot Sphinx | 96.49 ef |
| 3. Covey Red | 122.62 def |
| 4. Northern Star 5 | 128.01 cdef |
| 5. CA 3084 | 150.54 bcdef |
| 6. Pima S-7 | 160.29 bcdef |
| 7. Paymaster 145 | 170.73 bcdef |
| 8. CA 3093 | 193.27 bcdef |
| 9. Paymaster HS-26 | 202.25 bcdef |
| 10. Acala SJ-2 | 203.85 bcdef |
| 11. Acala Maxxa | 209.42 bcde |
| 12. Gregg 65 | 219.13 bcd |
| 13. Lankart 57 | 238.19 bcd |
| 14. Half & Half | 246.44 bc |
| 15. Acala 1517-75 | 276.88 ab |
| 16. Stoneville 213 | 373.39 a |

Numbers given in: mean number of aphids per plant for five weeks. LSD=122.19, ANOVA *P=.0058*

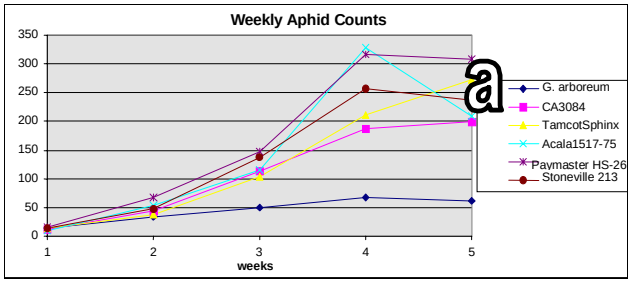


Figure 1. Summary of the weekly aphid counts for screening test 1, given in total number of aphids per plant. ANOVA (*P*=.0047), LSD=60.337

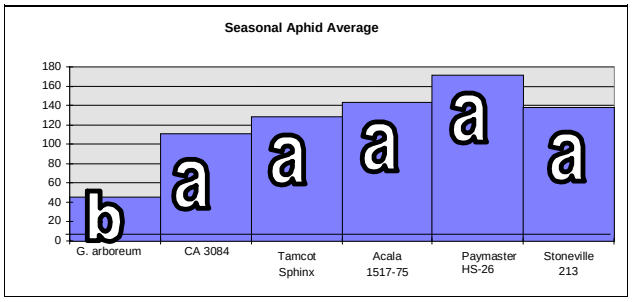


Figure 2. Seasonal aphid average per plant for screening test 1. Total number of mean aphids per genotype across all five weeks. ANOVA (*P=.0047),* LSD=60.337

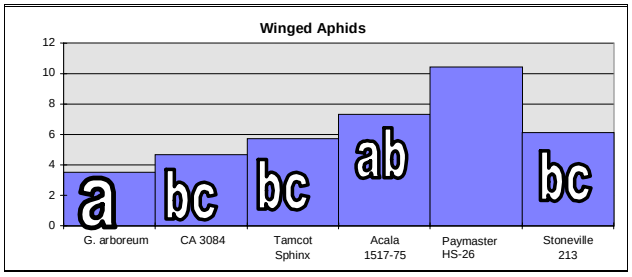


Figure 3. Seasonal number of winged aphids for screening test 1. Total mean no. of winged aphids per genotype for the entire five weeks. ANOVA (*P*=.0026), LSD=3.2073

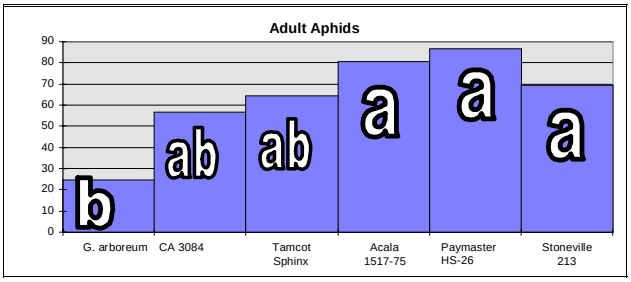


Figure 4. Seasonal number of adult aphids for screening test 1. Total mean no. of aphids per genotype for the entire five weeks. ANOVA (*P*=.0690), LSD=41.725

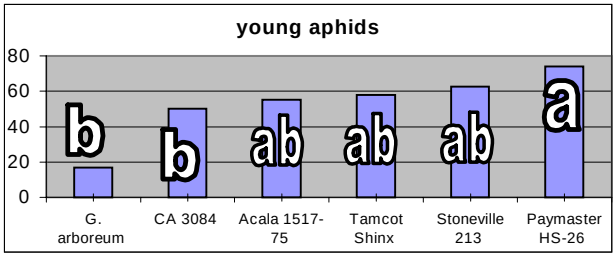


Figure 5. Number of young aphids for screening test 1. Seasonal mean of young aphids for all five weeks. ANOVA (*P*=.0006), LSD=23.226

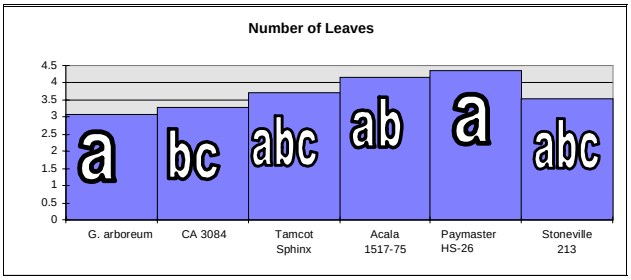


Figure 6. Number of leaves for test 1. Taken in a destructive test after five weeks. ANOVA (*P*=.1081), LSD= 1.006

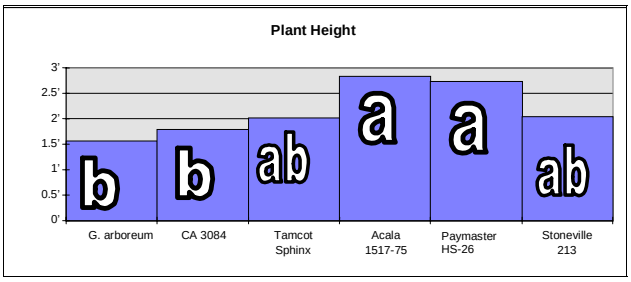


Figure 7. Plant Height for screening test 1. Taken in a destructive test after five weeks. ANOVA (*P*=.0427), LSD=0.9048

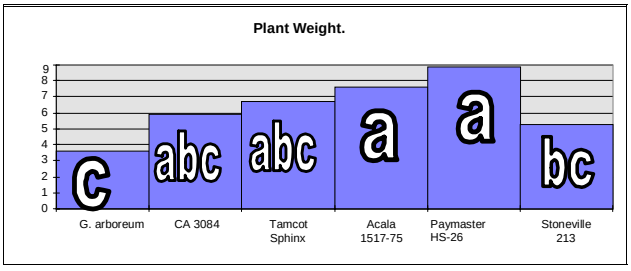


Figure 8. Plant wet weight for screening test 1. Taken in a destructive test after five weeks. Given in ounces. ANOVA (*P*=.0806), LSD=3.5695

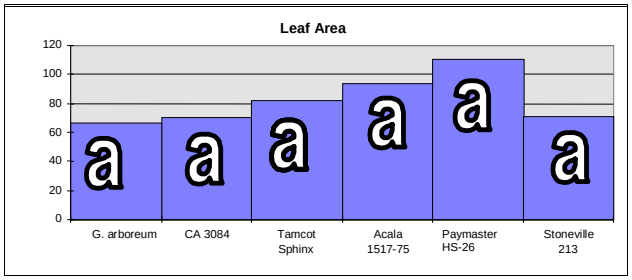


Figure 9. Leaf surface area for screening test 1. Taken in a destructive test after five weeks. Given in $cm^2$. ANOVA (*P*=.0806), LSD=3.5695

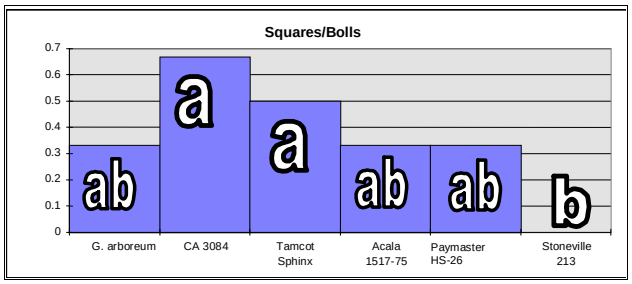


Figure 10. Number of squares or bolls for screening test 1. Mean number of squares per plant for the five week period. ANOVA (*P*=.4293), LSD=.4364

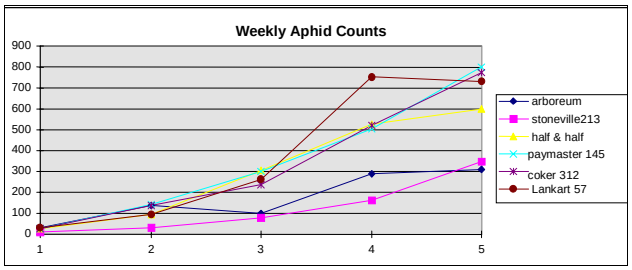


Figure 11. Summary of the weekly aphid counts for screening test 2, given in total number of aphids per plant. ANOVA (*P*=.0683), LSD=197.47

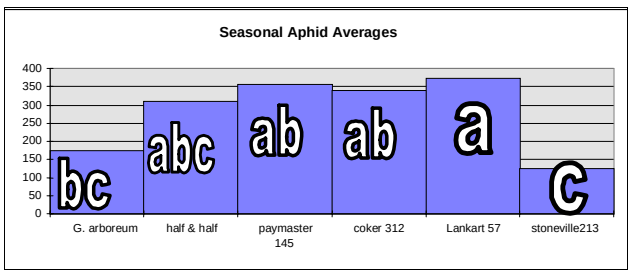


Figure 12. Seasonal aphid average per plant for screening test 2. Total number of mean aphids per genotype across all five weeks. ANOVA (*P*=.0683), LSD=197.47

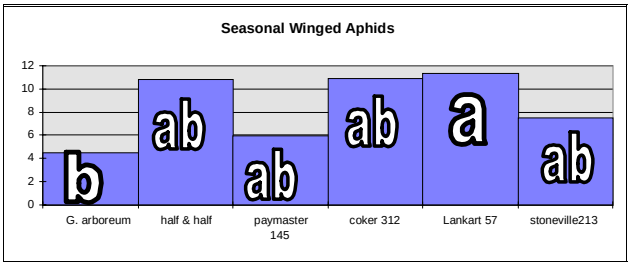


Figure 13. Seasonal number of winged aphids for screening test 2. Total mean no. of winged aphids per genotype for the entire five weeks. ANOVA (*P*=.1835), LSD=6.6638

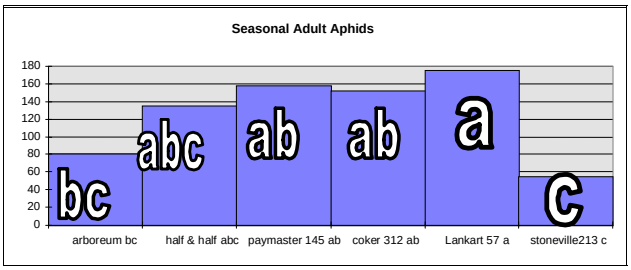


Figure 14. Seasonal number of adult aphids for screening test 2. Total mean no. of aphids per genotype for the entire five weeks. ANOVA (*P*=.0814), LSD=93.336

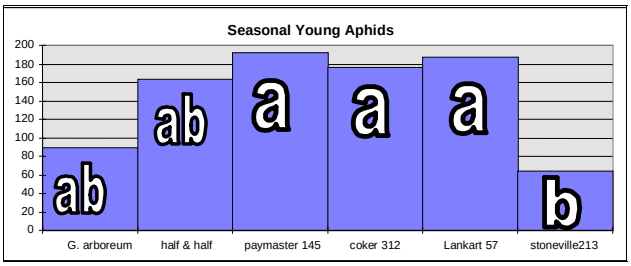


Figure 15. Number of young aphids for screening test 2. Seasonal mean of young aphids for all five weeks. ANOVA (*P*=.0704), LSD=104.62

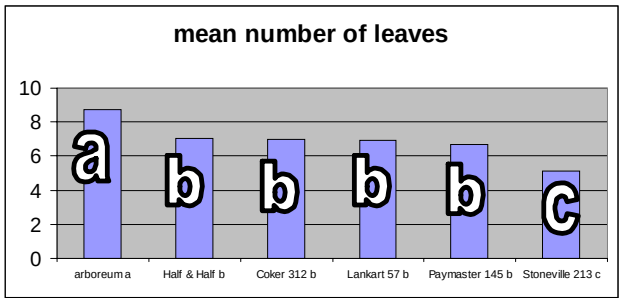


Figure 16. Number of leafs for test 2. Taken in a destructive test after five weeks. ANOVA (*P*<.0001), LSD=1.954

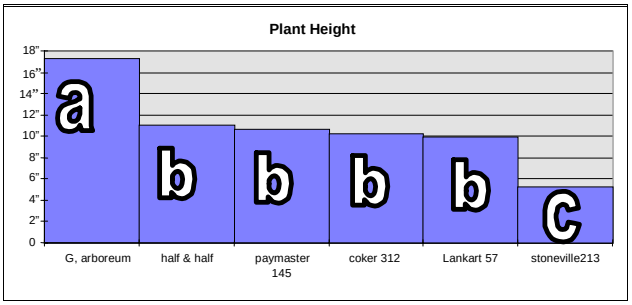


Figure 17. Plant Height for screening test 2. Taken in a destructive test after five weeks. ANOVA (*P*<.0001), LSD=2.1826

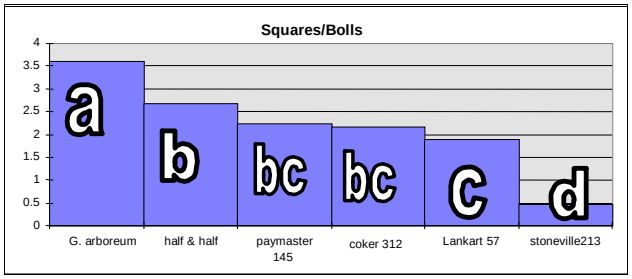


Figure 18. Number of squares or bolls for screening test 2. Mean number of squares per plant for the five week period. ANOVA (*P*<.0001), LSD=.7882

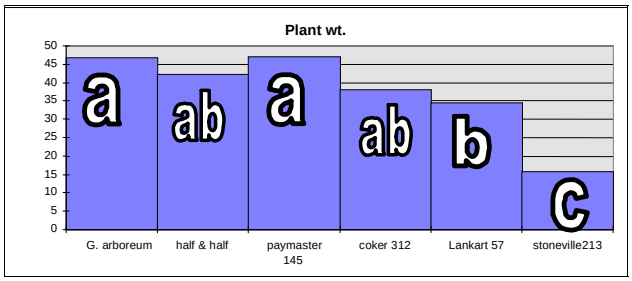


Figure 19. Plant wet weight for screening test 2. Taken in a destructive test after five weeks. Given in ounces. ANOVA (*P*<.0001), LSD=11.026

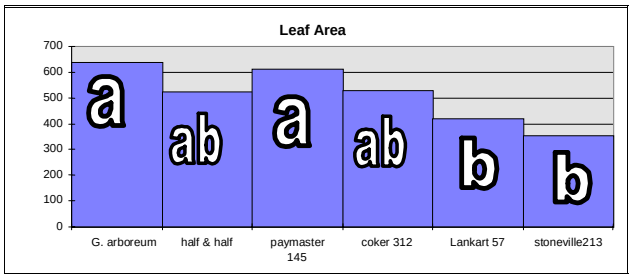


Figure 20. Leaf surface area for screening test 2. Taken in a destructive test after five weeks. Given in $cm^2$. ANOVA (*P*=.0288), LSD=186.99