

Pecan Varietal Differences in Hemipteran Kernel Damage¹

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Abstract Pecan, *Carya illinoensis* Wangenh. (K. Koch), is susceptible to feeding by leaffooted bugs (Hemiptera: Coreidae) and stink bugs (Hemiptera: Pentatomidae) from fruit set to post harvest. These hemipterans are difficult to control with insecticide sprays. We found that 33 pecan varieties had consistent and significant differences in the incidence of hemipteran kernel damage indicating that host plant resistance may help solve this problem. The rank of varieties for average incidence of damage over 4 yrs, from highest to lowest was: 'USDA 53-11-139', 'USDA 57-7-22', 'Shawnee', 'Moreland', 'USDA 40-9-266', 'USDA 49-20-112', 'Linberger', 'Cape Fear', 'Robinson', 'Shoshoni', 'USDA 64-11-17', 'USDA 55-12-17', 'Caddo', 'USDA 62-5-8', 'Sioux', 'Melrose', 'Tejas', 'Pawnee', 'Forkert', 'Kiowa', 'Owens', 'Candy', 'Gloria Grande', 'USDA 49-1-182', 'Western Schley', 'Creek', 'USDA 53-3-36', 'USDA 41-19-20', 'Maramec', 'Sumner', 'GraBohls', 'Kanza', and 'USDA 53-9-1'. Many of the more tolerant varieties have desirable kernel quality and often have good production characteristics, while many of the more susceptible varieties are also not horticulturally desirable. Adults of the southern green stinkbug, *Nezara viridula* (L.), and the leaffooted bug, *Leptoglossus phyllopus* (L.), when placed in cages on pecan nut clusters by sex, differed in their ability to cause damage to 'Cape Fear', 'Creek', 'USDA 64-11-17', 'Melrose', and 'Shoshoni'. Males of both species caused less damage than females, and *N. viridula* generally caused more damage than *L. phyllopus*.

Key Words Stink bugs, leaffooted bugs, Pentatomidae, Coreidae, host plant resistance, kernel spot, *Carya illinoensis*, *Nezara viridula*, *Leptoglossus phyllopus*

Pecan, *Carya illinoensis* Wangenh. (K. Koch), is susceptible to feeding by leaffooted bugs (Hemiptera: Coreidae) and stink bugs (Hemiptera: Pentatomidae) from fruit set to post harvest. Stink bugs are frequently found on nuts while they are in transit after harvest (Demaree 1922, Dutcher and Todd 1983). Southern green stink bug, *Nezara viridula* (L.), and leaffooted bug, *Leptoglossus phyllopus* (L.), are known to cause damage. Brown stink bug, *Euschistus servus* (Say), green stink bug, *Acrosternum hilare* (Say), dusky stink bug, *E. tristigmus* (Say), four additional stink bugs, *Oebalus pugnax* (F.), *Banasa dimidiata* (Say), *Brochymena* spp., and *Hymenarcys nervosa* (Say), and three additional leaffooted bugs, *L. oppositus* (Say), *Acantocephala* spp., and *Anasa armigera* (Say), have been found in pecan tree crowns (Dutcher and Todd 1983). Hemipterans are difficult to control with insecticide sprays because of the long period of susceptibility of the pecan to injury and the lack of

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effective sampling or trapping techniques to determine when the tree has a significant infestation. Host plant resistance may help solve this problem. Consequently, our objectives were to determine varietal susceptibility to hemipteran kernel damage and to compare the damage potential by male and female leaffooted bugs and southern green stink bugs on five pecan varieties.

Methods and Materials

Damage incidence. Hemipteran kernel damage rates were determined at the Coastal Plain Experiment Station Ponder Farm in Tift Co., GA, where 33 pecan varieties are planted as four single-tree replications per variety. Not all varieties were planted in the same year in each block; therefore, the experimental design is not a true completely random design over all varieties. Varieties were planted randomly in 3 separate years with each block (year of planting) containing a new set of varieties (Worley and Mullinix 1997). Each new block contained only new varieties. Varieties planted in 1979 were 'Shawnee', 'USDA 40-9-266', 'Linberger', 'Cape Fear', 'Robinson', 'Shoshoni', 'Caddo', 'USDA 62-5-8', 'Tejas', 'Forkert', 'Kiowa', 'Owens', 'Gloria Grande', and 'GraBohls'. Varieties planted in 1981 were 'USDA 53-11-139', 'USDA 57-7-22', 'Moreland', 'USDA 49-20-112', 'Sioux', 'Melrose', 'Pawnee', 'Candy', 'USDA 64-11-17', 'USDA 55-12-17', 'USDA 49-1-182', 'Creek', 'USDA 53-3-36', 'USDA 41-19-20', 'Maramec', 'Kanza', and 'USDA 53-9-1'. Varieties planted in 1984 were 'Western Schley' and 'Sumner'.

Pecan kernels from 50 pecans per tree from the 33 varieties were examined for hemipteran kernel damage in each of 4 yrs. Pecans were selected as a sample from all the nuts on the tree that were mechanically shaken during harvest. Data were recorded as the proportion damaged of 100 kernel halves collected from 50 pecans. The distinction between nuts with two damaged halves and nuts with one damaged half could not be made as all the halves from each tree were combined into one batch.

Pecan trees naturally have irregular annual bearing and in years when all the varieties had a crop on at least one tree at the site (1989, 1991, 1993, and 1997), the data were analyzed for differences between varieties in the proportion of the sample (100 kernel halves) with hemipteran kernel damage. Most (90.2%) estimates were made on four trees per variety. If all four trees did not have a crop, then estimates were made from 50 nut samples taken from trees with a crop. Among the other estimates, 4.5% were from three trees, 4.5% were from two trees, and 0.8% were from one tree. The mean, standard deviation and 95% confidence interval for proportion damaged were calculated (Snedacor and Cochran 1967) for each variety each year. Means with 95% confidence intervals that did not overlap were deemed significantly different.

Damage potential. Damage by leaffooted bug and southern green stink bug adults to 'Cape Fear', 'Creek', 'Melrose', '64-11-17' and 'Shoshoni' pecan varieties was determined in 1991 by caging bugs on pecan nuts. At shell hardening, pecan nut clusters on trees of the 5 varieties were protected from insect damage by placing a cage over the clusters.

The cage was constructed from the outer collar of a paper cup (Sealright no. 8T5N, Fulton, NY) with the dimensions of 8.6 cm top diam, 7.4 cm bottom diam, and 5.7 cm height. Two sleeves of US Army surplus mosquito netting (9 × 9 mesh per cm²) were attached to the open top and bottom with hot glue. When folded flat, the top sleeve was 13.5 cm by 29.5 cm and the bottom sleeve was 11.7 cm by 14.8 cm. The side

seams were attached with hot glue. The cage was secured to the tree with a twist tie so that the cardboard collar protected the pecans from injury by hemipterans from outside of the cage. The bottom sleeve was tightly closed around the stem just below the nut cluster. The top of the cage also was closed with a twist tie.

Insects were collected from a pearl millet field on the Coastal Plain Experiment Station during the time of the experiment starting in the first week of September. Insects were held in plastic boxes with fresh bean pods for 3 to 5 d before placing them on the pecans at the "dough stage" of kernel maturity (Wood 1989). The treatments included: two male leaffooted bugs; two female leaffooted bugs; two male southern green stink bugs; two female southern green stink bugs; and, control with no insects. The treatments were applied to 25 nut clusters in each of the 5 varieties. Each nut cluster was thinned to 2 pecans per cluster before exposing them to the treatments so that damage estimates were based on a sample size of 50 pecans. On 'Shoshoni', two additional treatments were established where pecans were exposed to feeding by a male-female pair of either leaffooted bug or southern green stink bug. The cages were inspected each week and dead insects were replaced with live, field-collected insects. Insects remained on the nut clusters for 3 wks, then they were removed and the pecan clusters remained caged until the shucks split. The pecans were then collected and examined for hemipteran kernel damage as described by Demaree (1922). The proportion of the nuts damaged was calculated for each treatment in each variety. A 95% confidence limit was calculated (Snedecor and Cochran 1967) for each proportion. A significant difference between two means was accepted if the 95% confidence intervals did not overlap.

Results and Discussion

Damage incidence. The overall amount of hemipteran kernel damage was significantly different among the 4 yrs of the experiment. Mean (\pm SD) proportion of the samples with hemipteran kernel damage across all varieties was, 0.073 ± 0.005 for 1989, 0.058 ± 0.004 for 1991, 0.019 ± 0.003 for 1993, and 0.016 ± 0.002 for 1997. Damage was uniform across the orchard each year. Total amount of damage was not significantly different among rows or columns of trees in the orchard. Variety differences were significant in many comparisons (Table 1). In 1989, all varieties had some damage. Varieties were sorted by damage incidence into five groups with some overlap between groups. 'USDA 53-11-139' had the highest damage incidence of all varieties. 'USDA 57-7-22' and 'USDA 40-9-266' had the second highest damage level. 'Cape Fear', 'Shoshoni', 'Robinson', 'USDA 62-5-8', and 'USDA 49-20-112' had the third highest damage level though 'Cape Fear' and 'USDA 40-9-266' were not different. A fourth and lower level of damage was found in 'Linberger', 'Shawnee', 'USDA 55-12-17', 'Moreland', 'Sioux', 'Melrose', 'Tejas', 'Pawnee', 'Caddo', 'Owens', 'Kiowa', 'USDA 64-11-17', and 'GraBohls'. Within the fourth group, 'Linberger', 'Shawnee', and 'USDA 55-12-17' were not different from 'Robinson', 'Shoshoni', 'USDA 62-5-8', and 'USDA 49-20-112' in the third group. Varieties in a fifth group, 'Forkert', 'Candy', 'Creek', 'Gloria Grande', 'Mareamec', 'Summer', 'USDA 49-1-182', 'W. Schley', 'USDA 53-3-36', 'USDA 41-19-20', 'Kanza', and 'USDA 53-9-1' had very low damage levels that were significantly different from 'Linberger', 'Shawnee', 'USDA 55-12-17', and 'Moreland'. A comparison of group four to group five indicated that 'Sioux', 'Melrose', 'Tejas', 'Pawnee', 'Caddo', 'Owens', 'Kiowa', 'USDA 64-11-17', and 'GraBohls' had similar damage incidence to 'Forkert', 'Candy', 'Creek', 'Gloria

Table 1. Hemipteran kernel damage at harvest in 33 pecan cultivars over 4 years

Variety	Mean proportion of the kernels damaged \pm 95% confidence interval in each year and overall years				
	1989	1991	1993	1997	Overall years
'USDA 53-11-139'	0.42 \pm 0.048	0.030 \pm 0.017	0.022 \pm 0.014	0.30 \pm 0.045	0.19 \pm 0.039
'USDA 57-7-22'	0.25 \pm 0.042	0.27 \pm 0.044	0.013 \pm 0.011	0.050 \pm 0.021	0.15 \pm 0.035
'Shawnee'	0.070 \pm 0.025	0.18 \pm 0.038	0.10 \pm 0.029	0.040 \pm 0.019	0.098 \pm 0.029
'Moreland'	0.060 \pm 0.023	0.18 \pm 0.038	0.018 \pm 0.013	0.040 \pm 0.019	0.075 \pm 0.026
'USDA 40-9-266'	0.23 \pm 0.041	0 \pm 0	0.048 \pm 0.021	0.010 \pm 0.0098	0.072 \pm 0.025
'USDA 49-20-112'	0.10 \pm 0.029	0.16 \pm 0.036	0.012 \pm 0.011	0.020 \pm 0.014	0.073 \pm 0.025
'Linberger'	0.080 \pm 0.027	0.14 \pm 0.034	0.0050 \pm 0.0069	0.040 \pm 0.019	0.066 \pm 0.024
'Cape Fear'	0.16 \pm 0.036	0.040 \pm 0.019	0.015 \pm 0.012	0.025 \pm 0.015	0.060 \pm 0.023
'Robinson'	0.11 \pm 0.031	0.10 \pm 0.029	0 \pm 0	0.013 \pm 0.011	0.056 \pm 0.022
'Shoshoni'	0.12 \pm 0.032	0 \pm 0	0.043 \pm 0.020	0.030 \pm 0.017	0.048 \pm 0.021
'USDA 64-11-17'	0.040 \pm 0.019	0 \pm 0	0.088 \pm 0.028	0.030 \pm 0.017	0.039 \pm 0.019
'USDA 55-12-17'	0.070 \pm 0.025	0.070 \pm 0.025	0.003 \pm 0.0054	0.010 \pm 0.0098	0.039 \pm 0.019
'Caddo'	0.040 \pm 0.019	0.080 \pm 0.027	0.003 \pm 0.0054	0.020 \pm 0.014	0.036 \pm 0.018
'USDA 62-5-8'	0.11 \pm 0.031	0 \pm 0	0.018 \pm 0.013	0.005 \pm 0.0069	0.033 \pm 0.018
'Stoux'	0.050 \pm 0.021	0.040 \pm 0.0192	0.015 \pm 0.012	0.010 \pm 0.0098	0.029 \pm 0.016

'Melrose'	0.060 ± 0.023	0.040 ± 0.0192	0.010 ± 0.0098	0.005 ± 0.0069	0.029 ± 0.016
'Tejas'	0.060 ± 0.023	0 ± 0	0.016 ± 0.012	0.010 ± 0.0097	0.022 ± 0.014
'Pawnee'	0.050 ± 0.021	0.020 ± 0.014	0.050 ± 0.021	0.020 ± 0.014	0.024 ± 0.015
'Forkert'	0.030 ± 0.017	0.030 ± 0.017	0.0075 ± 0.0085	0.020 ± 0.014	0.022 ± 0.014
'Kiowa'	0.040 ± 0.019	0.030 ± 0.017	0.009 ± 0.0093	0.005 ± 0.0069	0.021 ± 0.014
'Owens'	0.040 ± 0.019	0.010 ± 0.0097	0.050 ± 0.021	0.010 ± 0.0098	0.016 ± 0.012
'Candy'	0.030 ± 0.017	0.010 ± 0.0098	0.018 ± 0.013	0.010 ± 0.0097	0.017 ± 0.013
'Gloria Grande'	0.020 ± 0.014	0.010 ± 0.0097	0.008 ± 0.0087	0.020 ± 0.014	0.015 ± 0.011
'USDA 49-1-182'	0.010 ± 0.0097	0.010 ± 0.0098	0.0025 ± 0.0049	0.040 ± 0.019	0.016 ± 0.012
'W. Schley'	0.010 ± 0.0097	0.040 ± 0.019	0.0075 ± 0.0085	0 ± 0	0.014 ± 0.012
'Creek'	0.020 ± 0.014	0.020 ± 0.014	0.015 ± 0.012	0 ± 0	0.014 ± 0.011
'USDA 53-3-36'	0.010 ± 0.0098	0.030 ± 0.017	0.0020 ± 0.0044	0.010 ± 0.0098	0.013 ± 0.011
'USDA 41-19-20'	0.010 ± 0.0097	0.040 ± 0.019	0 ± 0	0 ± 0	0.012 ± 0.011
'Maramec'	0.020 ± 0.014	0.020 ± 0.014	0.0025 ± 0.0049	0.0050 ± 0.0069	0.012 ± 0.011
'Summer'	0.020 ± 0.014	0.020 ± 0.014	0.0020 ± 0.0044	0.0030 ± 0.0054	0.011 ± 0.010
'GraBohls'	0.040 ± 0.019	0 ± 0	0.0025 ± 0.0049	0 ± 0	0.011 ± 0.010
'Kanza'	0.010 ± 0.0098	0 ± 0	0.010 ± 0.0098	0.010 ± 0.0098	0.0075 ± 0.0085
'USDA 53-9-1'	0.010 ± 0.0098	0.020 ± 0.014	0 ± 0	0 ± 0	0.0075 ± 0.0085

Varieties are listed from greatest to least damage overall years. Means for variety within each year and overall years were deemed significantly different if there was no overlap between the 95% confidence intervals.

Grande', 'Maramec', and 'Summer'. 'USDA 49-1-182', 'Western Schley', 'USDA 53-3-36', 'USDA 41-19-20', 'Kanza', and 'USDA 53-9-1' had lower damage incidence than all varieties in the fourth group. The variety ranking based on overall proportion damage in the 4 yrs from highest to lowest was: 'USDA 53-11-139', 'USDA 57-7-22', 'Shawnee', 'Moreland', 'USDA 40-9-266', 'USDA 49-20-112', 'Linberger', 'Cape Fear', 'Robinson', 'Shoshoni', 'USDA 64-11-17', 'USDA 55-12-17', 'Caddo', 'USDA 62-5-8', 'Sioux', 'Melrose', 'Tejas', 'Pawnee', 'Forkert', 'Kiowa', 'Owens', 'Candy', 'Gloria Grande', 'USDA 49-1-182', 'Western Schley', 'Creek', 'USDA 53-3-36', 'USDA 41-19-20', 'Maramec', 'Summer', 'GraBohls', 'Kanza', and 'USDA 53-9-1'.

Damage potential. The study with caged bugs on pecan nuts in the field indicated significant differences in the ability of male and female leaffooted bugs and southern green stink bugs to damage kernels (Table 2). On 'Cape Fear', male leaffooted bug

Table 2. The amount of hemipteran kernel damage in pecans of five varieties exposed to pairs of hemipterans of the indicated sex and species

Variety	Treatment	Proportion damaged ± 95% confidence interval
'Melrose'	control	0.04 ± 0.5
	male <i>L. phyllopus</i>	0.10 ± 0.08
	male <i>N. viridula</i>	0.44 ± 0.14
	female <i>L. phyllopus</i>	0.26 ± 0.12
	female <i>N. viridula</i>	0.13 ± 0.09
'USDA 64-11-17'	control	0.076 ± 0.073
	male <i>L. phyllopus</i>	0.14 ± 0.096
	male <i>N. viridula</i>	0.00 ± 0.00
	female <i>L. phyllopus</i>	0.30 ± 0.12
	female <i>N. viridula</i>	0.85 ± 0.10
'Cape Fear'	control	0.00 ± 0.00
	male <i>L. phyllopus</i>	0.14 ± 0.09
	male <i>N. viridula</i>	0.64 ± 0.13
	female <i>L. phyllopus</i>	0.88 ± 0.09
	female <i>N. viridula</i>	0.96 ± 0.05
'Creek'	control	0.04 ± 0.05
	male <i>L. phyllopus</i>	0.12 ± 0.09
	male <i>N. viridula</i>	0.30 ± 0.13
	female <i>L. phyllopus</i>	0.36 ± 0.13
	female <i>N. viridula</i>	0.65 ± 0.13
'Shoshoni'	control	0.06 ± 0.06
	male <i>L. phyllopus</i>	0.22 ± 0.11
	male <i>N. viridula</i>	0.50 ± 0.14
	female <i>L. phyllopus</i>	0.26 ± 0.12
	female <i>N. viridula</i>	0.54 ± 0.14
	m-f pair <i>L. phyllopus</i>	0.70 ± 0.13
	m-f pair <i>N. viridula</i>	1.00 ± 0.00

Means of the proportion damaged with overlapping 95% confidence intervals were deemed not significantly different.

caused significantly less damage than male southern green stink bug. Females of both species caused significantly more damage than males. Female leaffooted bug damage was not significantly different from female southern green stink bug damage. On 'Creek', male leaffooted bug caused less damage than female leaffooted bug and female southern green stink bug. Male southern green stink bug caused less damage than female southern green stink bug and the same amount of damage as male and female leaffooted bug. Female southern green stink bug caused the greatest amount of damage to 'Creek' pecans. On 'Melrose', male southern green stink bug caused more damage than male leaffooted bug or female southern green stink bug and female leaffooted bug caused the same amount of damage as male leaffooted bug, male southern green stink bug and female southern green stink bug. On 'USDA 64-11-17', female southern green stink bug caused the highest amount of damage, and male southern green stink bug did not cause damage. Leaffooted bug males and females caused the same amount of damage though the damage level caused by males was not distinguishable from the control and the damage level caused by females was slightly higher than the damage level in the control. On 'Shoshoni', male leaffooted bug caused significantly less damage than male southern green stink bug. Female leaffooted bug caused significantly less damage than female southern green stink bug. Male and female southern green stink bug caused similar amounts of damage. Male-female pairs of southern green stink bug caused significantly more damage than male-male or female-female pairs of both species as well as male-female pairs of leaffooted bug.

Some significant differences were found between varieties within the treatments. Male leaffooted bug caused low damage levels that were not different between varieties and only significantly greater than the control in 'Cape Fear'. Male southern green stink bug damage was higher in 'Cape Fear' than in 'USDA 64-11-17', 'Creek' or 'Shoshoni' and was lower in 'USDA 64-11-17' than in all other varieties. Damage by southern green stink bug males was the same in 'Creek', 'Melrose', and 'Shoshoni'. Female leaffooted bug damage was higher in 'Cape Fear' than in 'Creek', 'Melrose', 'USDA 64-11-17' or 'Shoshoni'. 'Creek', 'Melrose', 'USDA 64-11-17' or 'Shoshoni' had the same amount of damage when exposed to feeding by female leaffooted bug. Female southern green stink bug damage was significantly higher in 'Cape Fear' and 'USDA 64-11-17' than in 'Creek' and 'Shoshoni'. 'Melrose' had the least amount of damage. Among the types of insects compared in the cage study, male leaffooted bug and female southern green stink bug appear to have the least and highest damage potential, respectively, with male southern green stink bug and female leaffooted bug having an equal and intermediate damage potential.

Favored characteristics of pecan varieties in the southeastern U.S. include high and consistent production, early ripening, high proportion kernel (kernel weight/total nut weight), and resistance to pecan scab fungus, *Cladosporium caryigenum* (Ellis & Langl.). Although none of the varieties tested was resistant to hemipteran kernel damage, varieties with consistently light damage also have the favored horticultural characteristics ('USDA 62-5-8' through 'USDA 53-9-1'). 'Pawnee' is also resistant to all three pecan aphid species (Kaakeh and Dutcher 1994, Thompson and Grauke 1998). 'Gloria Grande' and 'Candy' have excellent scab resistance (Worley and Mullinix 1997).

Further research is needed to determine the damage potential of other hemipteran species commonly found in the pecan orchards. The mechanism leading to the sig-

nificant differences in hemipteran damage between varieties will require more detailed observations and experiments.

Many of the more tolerant varieties have desirable kernel quality and often have good production characteristics, while many of the more susceptible varieties are also not horticulturally desirable. These results demonstrate the importance of the variety and hemipteran species in the incidence of hemipteran kernel damage.

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