Planting Date Effect upon Leaf spot Disease and Pod Yield across Years and Peanut Genotypes

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ABSTRACT

During 2012, 2015, and 2018 a set of 18 peanut (*Arachis hypogaea* L.) genotypes (some common and some different) were used to evaluate the effect of planting dates (April, May, and June) on leaf spot disease and pod yield. Within each year, the same genotypes were grown during the three planting dates at the Gibbs Farm near the University of Georgia, Coastal Plain Experiment Station, Tifton, GA using a randomized complete block design with five replications without fungicides or insecticides but with irrigation. Each year, significant differences ($P \leq 0.05$) were found among the genotypes within each of these three planting dates for leaf spot disease ratings (0-9 scale) and pod yields. 'Georganic' in 2012 and 2015; and GA 132705, 'Georgia-19HP', and 'Georgia-14N' in 2018 had among the lowest leaf spot ratings. 'Georgia-12Y' had the highest average pod yield for each year of the three years. Each year during this study, the April planting date had the lowest, and the June planting date had the highest leaf spot disease ratings. Percent coefficient of variation (CV) was consistently lower at the June planting date which suggest the least variability among the peanut genotypes. In the overall average of genotypes, the April planting date resulted in the highest pod yield and the June planting date had the lowest average pod yield. In summary, April planting dates resulted in the highest pod yields, and the lowest leaf spot ratings across each of the three years.

Key Words: *Arachis hypogaea* L., groundnut, general field resistance, cultivars, breeding lines.

Early leaf spot caused by *Passalora arachidicola* (Hori) U. Braun syn.*Cercospora arachidicola* (Hori) and late leaf spot caused by *Nothopassalora personata* (Berk. & M.A. Curtis) U. Braun, C. Nakash., Videira & Crous syn. *Cercosporidicum personatum* (Berk. & Curt.) Deighton, are major endemic foliar diseases in southeastern U.S. peanut (*Arachis hypogaea* L.) production. Fungicides are routinely used to control these two leaf spot diseases each year. Such foliar fungicides are very effective but are also costly with estimates over $40 million for cost of control for leaf spot in Georgia alone in 2017 (Little, 2019).

Development of general leaf spot field resistant cultivars to reduce production costs and increase yield would be highly desirable. Planting dates coupled with cultivar resistance have been shown to affect leaf spot intensity and severity in peanut production (Jordan *et al*., 2019). These authors found that later plantings increased late leaf spot severity in two years (2015 and 2016), and pod yields were higher for 'Georgia-12Y' (Branch, 2013) compared to 'Georgia-06G' (Branch, 2007).

Earlier, Branch and Culbreath (2008, 2013) found high levels of leaf spot resistance and high yields in later-maturing cultivars: 'Georganic' (Holbrook and Culbreath, 2008), 'Georgia-01R' (Branch, 2002), 'Georgia-05E' (Branch, 2006), 'Georgia-10T' (Branch and Culbreath, 2011), and Georgia-12Y (GA 072531). The objective of this study was to evaluate peanut genotypes at three planting dates in each of three years to assess the effect of planting date on pod yield and leaf spot disease pressure.

Materials and Methods

During 2012, 2015, and 2018, a set of 18 peanut genotypes (some common and some different across years) were used to evaluate the effect of planting date on leaf spot severity and pod yield. Within each year, the same set of 18 peanut genotypes were included for each of the three planting dates at the Gibbs Farm near the University of Georgia, Coastal Plain Experiment Station, Tifton, GA.

Randomized complete block field design with five replications was used each year without fungicides or insecticides but with irrigation. These trials were conducted on a Tifton loamy sand soil type (fine-loamy, siliceous, thermic Plinthic Kandidult). Plots consisted of two-rows, 6.1m long x 1.8 m wide (0.8 m within row and 1.0 m between rows on adjacent plots).

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Table 1. Combined early and late leaf spot ratings averaged across three planting dates and 18 peanut genotypes when grown under irrigation without insecticides and fungicides at Tifton, Georgia, 2012.

	Leaf Spot Rating (0-9 Scale)			
Peanut Genotype	April 20	May 11	June 1	Mean
FloRun '107'	6.8 a*	8.6 a	9.0 a	8.1 a
Georgia-13M	6.0 ab	8.2 abc	8.6 abc	7.6 ab
Florida-EP '113'	5.4 bc	8.4 ab	9.0 a	7.6 ab
Georgia Greener	5.0 cd	8.4 ab	8.4 a-d	7.3 bc
Georgia-06G	4.6 c-f	8.4 ab	8.6 abc	7.2 bcd
Florida-07	4.2 d-g	8.2 abc	8.8 ab	7.1 b-e
GA 072514	4.6 e-f	7.4 b-e	8.8 ab	6.9 c-f
Georgia-10T	4.8 cde	8.0 a-d	8.0 c-f	6.9 c-f
'Georgia-14N	4.0 efg	7.2 cde	9.0 a	6.7 c-g
Georgia-07W	4.6 c-f	7.2 cde	8.2 b-e	6.7 d-h
GA 072515	3.8 fgh	7.2 cde	8.8 ab	6.6 e-h
TUFRunner '727'	4.2 d-g	7.4 b-e	7.6 ef	6.4 fgh
Tifguard	4.2 d-g	7.0 de	7.8 def	6.3 ghi
GA 082546	3.4 gh	7.8 a-d	7.6 ef	6.3 ghi
Georgia-12Y	4.4 def	6.6 ef	7.4 f	6.1 hi
GA 082524	3.8 fgh	5.8 fg	7.8 def	5.8 ij
GA 072523	3.0 h	5.4 g	7.8 def	5.4 jk
Georganic	3.4 gh	5.8 fg	6.2 g	5.1 k
Mean	4.5 C	7.4 B	8.2 A	6.7
%CV	17.3	12.7	7.4	7.0

*Means within columns followed by the same lower case letter or overall mean within the row followed by the same upper case letter are not significantly different at $P \leq 0.05$.

The three planting dates were April 20, May 11, and June 1 in 2012; April 14, May 11, and June 1 in 2015; and April 12, May 11, and June 1 in 2018. Consistent production practices included conventional tillage, fertilization, and irrigation as recommended by the Georgia Cooperative Extension Service, but excluded all pesticides, except for seed treatment and herbicides as needed to maintain weed control throughout the growing season. These field tests were in a three-year rotation following corn (*Zea ma*ys L.) and cotton (*Gossypium hirsutum* L.).

Leaf spot ratings among all genotypes were recorded on an individual plot basis within a few days prior to actual digging during each growing season. Both early and late leaf spot were prevalent and evaluated together on a 0-9 visual canopy rating scale, where 0 = no visible leaf spot (immune) and 9 = dead and defoliated plants (very highly susceptible). The 0-9 leaf spot rating scale used in this study is most similar to the 1-9 scale of Pittman (1995), except for the addition of the 0 = immune rating.

Multiple harvest dates were used within each planting date test during each of the three years. In general, highly susceptible genotypes (8-9 rating) were harvested based on plant defoliation due to leaf spot disease severity; while the more resistant entries were dug near optimum maturity based on the hull-scrape determination from adjacent border plants (Williams and Drexler, 1981). After harvest, peanut pods from individual whole plots were dried with forced warm air to approximately 6% moisture. Entire plot pod samples were then hand-cleaned over a screen table before weighing for yield determinations.

Data from each test and year was statistically analyzed separately by analysis of variance (ANOVA). Waller-Duncan's T-test (k-ratio=100) was used for mean separation at $P \leq 0.05$ in SAS (SAS, Cary, NC).

Results

Significant differences among genotypes were found both within each planting date and between each planting date for leaf spot ratings during 2012 (Table 1). Georganic had the lowest leaf spot rating (highest resistance) averaged across the three planting dates; however, it was not significantly different from GA 072523, GA 082524, GA 082546, and GA 072515 in the 20 April 2012 planting date. Likewise, Georganic was not significantly different from GA 072523 and GA 082524 in the 11 May 2012 planting date. There was a consistent and significant increase in leaf spot pressure (higher ratings) from April to May to June ranging from 4.5 to 7.4 to 8.2, respectively.

Conversely in 2012, pod yields decreased incrementally from April to May to June from 6160 to 3745 to 2927 kg/ha, respectively (Table 2). On average, the later June planting date resulted in the lowest pod yields and the highest leaf spot ratings. Georgia-12Y resulted in the highest pod yield across the three planting dates, but it was not significantly different from GA 072523, GA 072515, and TUFRunner '727'. However, Georgia-12Y did have a significantly higher yield than all other genotypes during April and June planting dates, except it was not significantly different than Georgia-06G in the April planting.

Significant genotypic differences were also found within and between planting dates for leaf spot ratings during 2015 (Table 3). Georganic again had the lowest leaf spot rating averaged across the three planting dates, but it was not different from GA 132705, GA 132706, and GA 132708. In 2015, similar to 2012, there was a significant and consistent increase in leaf spot from April to May to June with June having the highest leaf spot rating averaged over the same 18 peanut

Table 2. Pod yield averaged across three planting dates and 18 peanut genotypes when grown under irrigation without insecticides and fungicides at Tifton, Georgia, 2012.

	Pod Yield (kg/ha)			
Peanut Genotype	April 20	May 11	June 1	Mean
Georgia-12Y	7204 a*	4651 a-d	4691 a	5515 a
GA 072523	6616 bc	5401 a	3601 b	5206 ab
GA 072515	6587 cd	5180 ab	3296 b-e	5021 abc
TUFRunner '727'	6602 cd	5039 abc	3381 bc	5008 abc
GA 072514	6309 cd	4346 a-e	3319 bcd	4658 bcd
Georgia-10T	5399 fg	5070 abc	3077 b-g	4515 cde
Tifguard	6112 cde	3519 d-g	3483 b	4371 def
Georgia-06G	6982 ab	3522 d-g	2457 g	4320 def
Georgia-07W	6078 cde	4186 b-f	2578 efg	4281 def
Georgia-14N	6224 cd	3874 c-g	2535 fg	4212 def
Georgia-13M	6191 cd	3572 d-g	2647 d-g	4136 d-g
Florida-07	6553 cd	3431 efg	2402 h	4129 d-g
Georgia Greener	6435 cd	3131 fgh	2652 c-g	4073 efg
Georganic	5589 efg	3001 fgh	3232 b-f	3941 fgh
GA 082524	5024 g	3013 fgh	2741 c-g	3593 gh
FloRun '107'	6182 cd	2841 ghi	1706 hi	3576 gh
GA 082546	5030 g	1698 i	3570 b	3432 hi
Florida-EP '113'	5765 def	1938 hi	1308 i	3004 i
Mean	6160 A	3745 B	2927 C	4278
%CV	7.7	26.1	20.8	11.3

*Means within columns followed by the same lower case letter or overall mean within the row followed by the same upper case letter are not significantly different at P≤0.05.

genotypes compared to May and April planting dates. In 2015, GA 072523 had significantly higher overall leaf spot rating than Georganic compared to 2012 (Table 1).

Also in 2015, pod yields were similar to 2012 in that the June planting date resulted in the lowest pod yields followed by May; whereas, April had the highest pod yields averaged over the same 18 different genotypes (Table 4). Geogia-12Y had the highest overall pod yield, but it was not significantly different from several other genotypes during April, May, and June planting dates, including Georgia-06G in the April planting. Even though Georganic exhibited better leaf spot resistance based upon ratings, its pod yield was among the lowest of the 18 genotypes across the three planting dates.

Similar to 2012 and 2015, significant genotypic differences were again found within and between planting dates for leaf spot ratings during 2018 (Table 5). GA 132705 had the lowest leaf spot rating averaged across planting dates, but it was not different from several other genotypes in April and May. However in the highest leaf spot pressure June planting, it did have a significantly lower leaf spot rating compared to all other genotypes.

Table 3. Combined early and late leaf spot ratings averaged across three planting dates and 18 peanut genotypes when grown under irrigation without insecticides and fungicides at Tifton, Georgia, 2015.

	Leaf Spot Rating (0-9 Scale)			
Peanut Genotype	April 14	May 11	June 1	Mean
TUFRunner '511'	7.0 a*	8.6 a	9.0 a	8.2 a
Georgia-18RU	6.2 a	8.2 ab	8.6 ab	7.7 a
GA 122544	4.6 bc	8.0 ab	8.0 bcd	6.9 b
GA 122715	4.8 b	7.2 cd	8.2 bc	6.7 b
Georgia-06G	4.2 bcd	7.6 bc	7.8 cd	6.5 bc
Tifguard	4.0 b-e	6.6 de	7.4 de	6.0 cd
Georgia-14N	3.8 c-f	6.0 e-h	7.8 cd	5.9 de
Georgia-12Y	3.4 d-g	6.0 e-h	7.6 cde	5.7 de
GA 132711	3.2 e-h	6.4 ef	7.0 ef	5.5 de
GA 132712	3.4 d-g	6.2 efg	7.0 ef	5.5 de
GA 132707	2.6 g-j	6.2 efg	7.4 de	5.4 def
GA 132703	3.6 def	5.8 f-i	6.6 f	5.3 ef
GA 072523	3.2 e-h	5.6 g-j	7.0 ef	5.3 ef
GA 132704	2.4 hij	6.0 e-h	7.4 de	5.3 ef
GA 132708	3.0 f-i	5.2 ijk	6.4 fg	4.9 fg
GA 132706	2.6 g-j	5.4 h-k	6.6 f	4.9 fg
GA 132705	2.2 ij	4.8 k	5.8 g	4.3 g
Georganic	2.0 j	5.0 jk	5.8 g	4.3 g
Mean	3.7 C	6.4 B	7.3 A	5.8
%CV	20.4	10.4	8.9	9.2

*Means within columns followed by the same lower case letter or overall mean within the row followed by the same upper case letter are not significantly different at P≤0.05.

Table 4. Pod yield averaged across three planting dates and 18 peanut genotypes when grown under irrigation without insecticides and fungicides at Tifton, Georgia, 2015.

	Pod Yield (kg/ha)			
Peanut Genotype	April 14	May 11	June 1	Mean
Georgia-12Y	6844 a*	5804 ab	4119 ab	5588 a
GA 132712	5972 bcd	6103 a	4330 ab	5468 ab
GA 132705	5906 cd	5949 a	4423 a	5426 ab
GA 072523	6046 bcd	5990 a	3964 abc	5333 ab
Tifguard	6620 ab	5866 a	3477 cde	5321 ab
GA 132704	5995 bcd	5904 a	3908 a-d	5280 abc
GA 132703	5541 de	6041 a	4126 ab	5236 abc
GA 132706	5466 de	5952 a	4274 ab	5232 abc
GA 122544	6595 abc	5734 ab	3300 def	5209 abc
Georgia-06G	7020 a	5906 a	2703 fg	5209 abc
GA 132711	5688 d	5820 ab	4023 abc	5177 a-d
GA 132708	5759 d	5413 abc	4045 ab	5072 a-d
Georgia-18RU	6856 a	5372 abc	2612 g	4946 bcd
GA 132707	5867 d	4699 cd	3721 bcd	4762 cde
GA 122715	5770 d	5217 abc	3027 efg	4671 de
Georgia-14N	4873 e	4932 bc	2920 efg	4242 ef
Georganic	4157 f	3939 d	3725 bcd	3940 f
TUFRunner '511'	3980 f	3814 d	1071 h	2955 g
Mean	5830 A	5472 B	3542 C	4948
%CV	10.3	13.3	14.9	9.0

*Means within columns followed by the same lower case letter or overall mean within the row followed by the same upper case letter are not significantly different at P≤0.05.

Table 5. Combined early and late leaf spot ratings averaged across three planting dates and 18 peanut genotypes when grown under irrigation without insecticides and fungicides at Tifton, Georgia, 2018.

	Leaf Spot Rating (0-9 Scale)			
Peanut Genotype	April 12	May 11	June 1	Mean
GA 152537	5.2 a*	7.0 a	8.4 a	6.9 a
TUFRunner '297'	5.0 a	6.0 b	8.4 a	6.5 ab
GA 122706	3.6 bc	6.0 b	7.4 bc	5.7 bc
GA 142728	3.8 b	5.4 bc	7.8 ab	5.7 bc
Georgia-06G	3.2 bcd	5.4 bc	7.4 bc	5.3 bcd
Georgia Greener	2.8 de	5.0 c	7.4 bc	5.1 bcd
FloRun '331'	3.2 bcd	5.0 c	6.4 de	4.9 c-f
GA 10T-3-2	2.6 def	4.8 cd	6.6 de	4.7 c-g
GA 10T-3-1	2.2 efg	5.0 c	6.4 de	4.5 c-g
GA 152545	2.6 def	3.8 ef	7.0 cd	4.5 d-g
Georgia-12Y	2.6 def	4.0 de	6.0 ef	4.2 d-h
Tifguard	3.0 cd	3.6 ef	5.6 fg	4.1 e-h
GA 132712	2.0 fgh	4.0 de	5.4 fg	3.8 fgh
TifNV-High O/L	1.8 gh	3.8 ef	5.4 fg	3.7 gh
AU-NPL 17	2.2 efg	3.6 ef	5.2 g	3.7 gh
Georgia-14N	1.6 gh	3.0 f	5.2 g	3.3 h
Georgia-19HP	1.4 h	3.0 f	5.4 fg	3.3 h
GA 132705	1.6 gh	3.2 ef	4.4 h	3.1 h
Mean	2.8 C	4.5 B	6.4 A	4.6
% CV	24.4	16.6	8.8	37.0

*Means within columns followed by the same lower case letter or overall mean within the row followed by the same upper case letter are not significantly different at P≤0.05.

Table 6. Pod yield averaged across three planting dates and 18 peanut genotypes when grown under irrigation without insecticides and fungicides at Tifton, Georgia, 2018.

	Pod Yield (kg/ha)			
Peanut Genotype	April 12	May 11	June 1	Mean
Georgia-12Y	5528 a*	5214 ab	4337 ab	5027 a
GA 152545	5407 ab	5240 ab	4033 abc	4893 a
AU-NPL 17	5021 a-d	5305 ab	4293 ab	4873 a
Georgia-19HP	4814 b-f	5223 ab	4510 a	4849 ab
GA 10T-3-2	5192 abc	4699 bc	4314 ab	4735 ab
FloRun '331'	4928 a-e	5075 ab	4112 abc	4705 ab
GA 10T-3-1	5001 a-d	4790 abc	4182 abc	4658 abc
Georgia Greener	5574 a	5139 ab	3209 def	4641 abc
Georgia-06G	5336 abc	5180 ab	3104 efg	4540 abc
GA 132712	4318 ef	5053 ab	4027 abc	4466 a-d
GA 142728	5442 ab	5431 a	2505 g	4459 a-d
TifNV-High O/L	4733 c-f	4706 bc	3589 cde	4343 a-d
GA 122706	5210 abc	4908 abc	2815 fg	4311 a-d
Tifguard	4394 def	4699 bc	3832 bcd	4308 a-d
GA 132705	4145 fg	4839 abc	3898 abc	4293 a-d
TUFRunner '297'	5592 a	5029 ab	1125 h	3916 bcd
GA 152537	5309 abc	4297 cd	1570 h	3725 cd
Georgia-14N	3517 g	3909 d	3233 def	3552 d
Mean	4970 A	4930 A	3483 B	4460
% CV	10.9	9.8	15.6	23.9

*Means within columns followed by the same lower case letter or overall mean within the row followed by the same upper case letter are not significantly different at P≤0.05.

April pod yields in 2018 were lower than in 2012 and 2015. This resulted in the April and May planting dates not being significantly different. However, June planting date was again the significantly lowest compared to April and May in pod yield averaged over the same genotypes (Table 6). Georgia-12Y again had the highest pod yield, but it was not significantly different from several other genotypes during April, May, and June. 'Georgia-19HP' (Branch and Brenneman, 2020) had the highest pod yield in the June planting date, but it was not significantly different from several other genotypes including Georgia-12Y and GA 132705.

Discussion

Results from this three-year field study clearly shows the effect of planting date on leaf spot disease and pod yield across different peanut genotypes. April planting date consistently resulted in significantly less leaf spot pressure compared to May and June. However, it should be noted that these field tests were in a good crop rotation following corn and cotton during this planting date study. The trend was similar to that reported by Jordan *et al*., 2019) where shorter rotations, every other year cotton and peanut, were used.

Geogia-12Y did not have the lowest leaf spot ratings, but it did have the highest pod yield during each of the three years. The high yield performance and stability of Georgia-12Y could be attributed not only to its leaf spot resistance but also to its white mold resistance (Standish *et al*., 2019). These results further demonstrate that high leaf spot resistance may not solely be associated with high yield performance among peanut genotypes.

In summary, the overall pod yields decreased across the three planting dates with April planting dates having significantly highest pod yields, May intermediate, and June planting dates having the lowest average pod yields. These results also confirm and expand upon the findings of an earlier report (Jordan *et al*., 2019) in which April planting dates decrease severity of late leaf spot for two peanut cultivars, Georgia-06G and Georgia-12Y. However with early April planting dates, peanut genotypes in the southeast U.S. also need to have *Tomato spotted wilt virus* (TSWV) resistance, since early planting dates results in greater TSWV pressure (Brown *et al*., 2005). Georgia-12Y has a good combined general field resistance to all three

of these major peanut diseases (leaf spot, white mold, and TSWV).

These results also have implications for field characterization of leaf spot resistance. Maximum disease potential with later planting dates would likely reduce the likelihood of escapes that could occur with early planting dates. Ideally, evaluation of genotypes with multiple planting dates should ensure the most accurate characterization of effect on leaf spot epidemics. However, various factors may limit the number of planting dates that can be used, especially for trials comparing larger numbers of genotypes for initial screenings or for mapping populations. If only one planting date is feasible, later plantings such as June plantings utilized in this study should increase the potential for leaf spot epidemic development and likely increase the ability to identify more resistant and/or tolerant genotypes.

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