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Interaction of Planting Date and Seeding Rate on Seedling Populations, TSW and White Mold Incidence, Leaf Spot Defoliation, and Yield of Three Peanut Cultivars in a Dryland Production System from 2014 to 2016

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Seed account for up to 20% of variable production costs for peanut (*Arachis hypogaea* L.), particularly for larger seeded cultivars such as Georgia-06G (Smith and Smith, 2013). Reducing seeding rates is one option to allow producers manage production costs. Previously, Wehtje et al. (1994) obtained similar yields with the Florunner cultivar planted at 50 to 111 pounds of seed/A when irrigated, while Hauser and Buchanan (1981) reported lower yield with a reduced compared with recommended seeding rate. Recently, Hagan et al. (2014) obtained greater yields at seeding rates of 4 and 6 compared with 2 seed per foot of row in irrigated Georgia Green, Georgia-06G, and Florida 07 peanuts. Tomato spotted wilt (TSW) has previously been shown under moderate to severe disease pressure to intensify at reduced seeding rates or fields with skips between plants (Culbreath et al. 2011; Wehtje et al. 1994). Under low disease pressure, TSW incidence was not impacted by seeding rate in a recent Alabama study (Hagan et al. 2014). In contrast to TSW, white mold intensifies with increasing seeding rates (Black et al. 2001; Hagan et al. 2015).

The objective of this project was to determine the impact of seeding rate on stand density, occurrence of tomato spotted wilt (TSW) and white mold, along with leaf spot defoliation, as well as the yield of selected commercial runner peanut cultivars in a dryland production system at the Wiregrass Research and Extension Center in Headland, AL.

Production Methods: The study area at the Wiregrass Research and Extension Center, which is maintained in a peanut-cotton rotation, was turned with a moldboard plow and worked to seed bed condition with a disk harrow. Rows were laid off with a KMC strip till unit with rolling baskets. The peanut varieties 'Georgia-06G', 'Georgia-09B', and 'Georgia-12Y' were planted at 3, 4, 6, and 8 seed per foot of row using conventional tillage practices in a Dothan fine sandy loam (OM<1%) soil at the Wiregrass Research and Extension Center on April 25 and May 30, 2014; April 24 and May 26. 2015; and April 21 and May 23, 2016. Leaf spot, thrips, and weed control along with fertility recommendations of the Alabama Cooperative Extension System were followed. The study area was not irrigated. A factorial design arranged in a split-split plot had planting date as whole plots, peanut cultivar as the split plot, and seeding rates as the split-split plot treatment. Whole plots were randomized in four complete blocks. Individual split-split plots, which consisted of four 30-foot rows spaced 3-feet apart, were randomized within each

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whole plot. Stand counts, which are displayed as the number of seedlings per row foot, were recorded for the first and second planting dates on May 13 and June 13, 2014; May 11 and June 12, 2015; and May 6 and June 7, respectively. For the first planting in all study years, Georgia-06G and Georgia-09B were inverted September 22, 2014; September 9, 2015; and September 18, 2016 with Georgia-12Y being inverted on September 29, 2014; September 18, 2015; and September 16, 2016. For the second planting, all varieties were dug on October 22, 2014; October 8, 2015; and October 6, 2016.

Insect and Disease Assessment: Final tomato spotted wilt (TSW) and white mold incidence are expressed as the number of hits (one hit was defined a < 1 foot of consecutive symptomatic plants per row) for each disease per 60 foot of row. Incidence of TSW was assessed for the first and second planting dates on September 5 and October 21, 2014; August 31 and October 5, 2015; and September 1 and October 5, 2016, respectively while white mold incidence was determined immediately after plot inversion for the first planting of Georgia-06G and Georgia-09B on September 22, 2014; September 9, 2015; and September 6, 2016 with the later maturing Georgia-12Y being dug on October 2, 2014; September 18, 2015; and September 16, 2016. For the second planting, all varieties were inverted on October 22, 2014; October 8, 2015; and October 6, 2016. Early and late leaf spot were rated together on September 5 and October 21, 2014; August 31 and October 5, 2015; and September 1 and October 5, 2016 for the first and second planting, respectively, using the 1-10 Florida peanut leaf spot scoring system where 1 = no disease, 2 = very few leaf spots, 3 = few leaf spots in lower and upper canopy, 4 = some leaf spotting and ≤ 10% defoliation, 5 = leaf spots noticeable and ≤ 25% defoliation, 6 = leaf spots numerous and ≤ 50% defoliation, 7 = leaf spots very numerous and ≤ 75% defoliation, 8 = numerous leaf spots on few remaining leaves and ≤ 90% defoliation, 9 = very few remaining leaves covered with leaf spots and ≤ 95% defoliation, and 10 = plants defoliated or dead. Defoliation values were calculated using the formula [% Defoliation = 100/(1+e(-(leaf spot scoring system -6.0672)/0.7975)]. Yields of all varieties in all study years are reported at 7% moisture. Significance of interactions was evaluated using PROC GLIMMIX procedure in SAS with ddfm=satterwait option with year, planting date, variety, and seeding rate as fixed effects and replication-planting date-variety (year) as random effects (SAS Institute, Inc. 2016). Statistical analyses for stand density, leaf spot defoliation, along with TSW and white mold incidence, and yield were done on rank transformations for non-normal data. Data were back transformed for presentation. Means were separated using Fisher's least significant difference (LSD) test ($P \leq 0.05$).

Results

Seedling populations differed by year, planting date, and variety along with planting date, variety, and seeding rate (Table 1). Differences in seedling populations across year and planting date were reported for Georgia-06G but not Georgia-09B and Georgia-12Y, which had similarly high seedling counts for the April and May plantings in 2014, 2015, and 2016 (Table 2). For Georgia-06G, similarly greater seedling populations were observed for the April and May in 2014 compared with the May 2015 as well as both plantings in 2016 with the May 2015 and April 2016 plantings having similarly lower counts. Georgia-06G had seedling counts similar to those obtained for the other two varieties only in 2014

Table 1. *F*-values from generalized linear mixed model analysis for effects of planting date, variety, and seeding rate on seedling populations, TSW and white mold incidence, leaf spot defoliation, and yield

Source	Seedling population	Leaf spot	TSW [z]	White mold	Yield
Year	49.41*** [y]	1.49	43.74***	86.01***	814.99***
Planting date	63.43***	107.11***	3.36	26.96***	102.37***
Year x Planting date	64.45***	33.68***	6.26**	49.17***	2.79
Variety	165.30***	49.14***	22.32***	72.48***	0.57
Year × Variety	26.62***	6.63***	6.62***	21.99***	0.41
Planting date × Variety	23.24***	1.70	0.76	7.98***	6.16**
Year × Planting date × Variety	25.90***	10.65***	4.76**	11.47***	5.15***
Seeding rate	1719.74***	4.76**	3.58*	4.45**	0.21
Year × Seeding rate	9.20***	1.20	1.07	2.69*	0.75
Planting date × Seeding rate	6.35***	2.84*	0.08	0.96	4.71**
Year × Planting date × Seeding rate	4.79***	0.68	0.69	1.60	0.29
Variety × Seeding rate	4.37***	0.46	1.76	2.03	0.27
Year × Variety × Seeding rate	0.87	0.67	0.55	1.55	1.17
Planting date × Variety × Seeding rate	2.31***	0.64	1.35	1.49	0.25
Year × Planting date × Variety × Seeding rate	1.59	0.46	1.77	1.04	1.19

[z] TSW = tomato spotted wilt.

[y] Significance at the 0.05, 0.01, and 0.001 levels is indicated by *, **, or ***, respectively.

Table 2. Interaction of year and planting date on seedling populations of three commercial runner peanut varieties in a dryland production system in 2014, 2015, and 2016.

Variety	2014		2015		2016	
	April [z]	May	April	May	April	May
Georgia-06G [y]	3.29 a-d [x]	3.18 b-e	3.45 a-d	2.36 f	2.82 ef	2.98 de
Georgia-09B	3.54 abc	3.25 a-e	3.68 ab	3.45 a-d	3.29 a-e	3.38 a-d
Georgia-12Y	3.52 abc	3.50 abc	3.69 a	3.58 abc	3.13 cde	3.24 a-e

[z] Planting dates were April 25 and May 30, 2014; April 24 and May 26. 2015; and April 21 and May 23, 2016.

[y] Peanut seedling populations expressed as the number of seedlings per foot of row.

[x] Means followed by the same letter are not significantly different according to Fisher's least significant difference (LSD) test ($P \leq 0.05$).

Regardless of the planting date and variety, seedling populations increased with each successive rise in seeding rate (Table 3). For both the April and May plantings, greater seedling populations were noted for Georgia-09B and Georgia-12Y at all seeding rates when compared with Georgia-06G. With few exceptions, seedling counts for the former two varieties were similar across both planting dates and seeding rates. With Georgia-06G, greater seedling populations were seen at the April- than May-planting for all seeding rates except at 3 seed per foot where similarly low counts were recorded for both plantings.

Table 3. Interaction of planting date, variety, and seeding rate on peanut seedling populations over three study years.

Seeding rate seed/row ft	April [z]			May		
	Georgia-06G [y]	Georgia-09B	Georgia-12Y	Georgia-06G	Georgia-09B	Georgia-12Y
3	2.20 ij [x]	2.47 gh	2.50 g	1.97 j	2.30 hi	2.53 g
4	2.83 f	3.10 e	3.10 e	2.43 g	2.83 f	2.97 ef
6	3.50 d	3.73 c	3.77 c	3.17 e	3.83 c	3.80 c
8	4.30 b	4.70 a	4.43 ab	3.73 c	4.53 ab	4.47 ab

[z] Planting dates were April 25 and May 30, 2014; April 24 and May 26. 2015; and April 21 and May 23, 2016.
[y] Peanut seedling populations expressed as the number of seedlings per foot of row.
[x] Means followed by the same letter are not significantly different according to Fisher's least significant difference (LSD) test ($P \leq 0.05$).

Overall, TSW incidence over the three study years was low (Table 4). Disease incidence varied by study year, planting date, and variety (Table 1) with higher TSW indices being recorded at both planting dates for Georgia-09B and Georgia-06G in 2016 than in the preceding two study years, while Georgia-12Y had similarly low TSW levels over the three-year study period (Table 4). Generally, TSW incidence in Georgia-06G and Georgia-09B matched that observed in Georgia-12Y in 2014 and 2015.

Seeding rate significantly impacted TSW incidence (Table 1). Disease incidence was greater at the 3 than 4 and 8 seed per foot seeding rates and intermediate at the 6 seed per foot seed rate (Fig. 1).

Figure 1. TSW incidence as impacted by seeding rate. Bars topped with the same letter are not significantly different according to Fisher's LSD ($P \leq 0.05$).

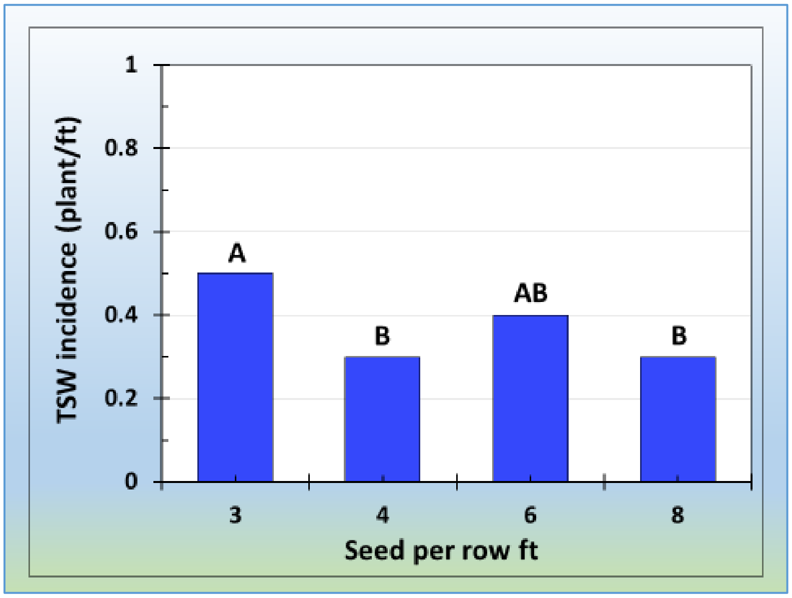


Table 4. Impact of year and planting date on TSW incidence in three peanut varieties over three study years.

Variety	TSW Incidence (# hits/ 30 ft row)					
	2014 [z]		2015		2016	
	April	May	April	May	April	May
Georgia-06G	0.3 de [y]	0.1 ef	0.1 ef	0.1 ef	1.0 b	0.8 bc
Georgia-09B	0.2 ef	0.3 def	0.1 ef	0.5 cd	1.6 a	0.7 bc
Georgia-12Y	0.1 ef	0.0 f	0.0 f	0.0 f	0.1 ef	0.2 def

[z] Planting dates were April 25 and May 30, 2014; April 24 and May 26. 2015; and April 21 and May 23, 2016.
[y] Means followed the same letter are not significantly difference according to Fishers least significant difference test (LSD) test ($P \leq 0.05$).

While overall leaf spot pressure was low, defoliation varied by study year, planting date, and variety and by planting date and seeding rate (Table 1). With the exception of Georgia-09B and Georgia-12Y in 2015, leaf spot-incited defoliation was greater for May- than April-planted peanuts (Table 5). Except for the April 2014 planting, Georgia-06G and Georgia-12Y had lower defoliation levels compared with Georgia-09B. Similar or lower leaf spot defoliation levels were recorded for Georgia-12Y than Georgia-06G except at the May 2016 planting date, when the latter variety suffered less premature defoliation.

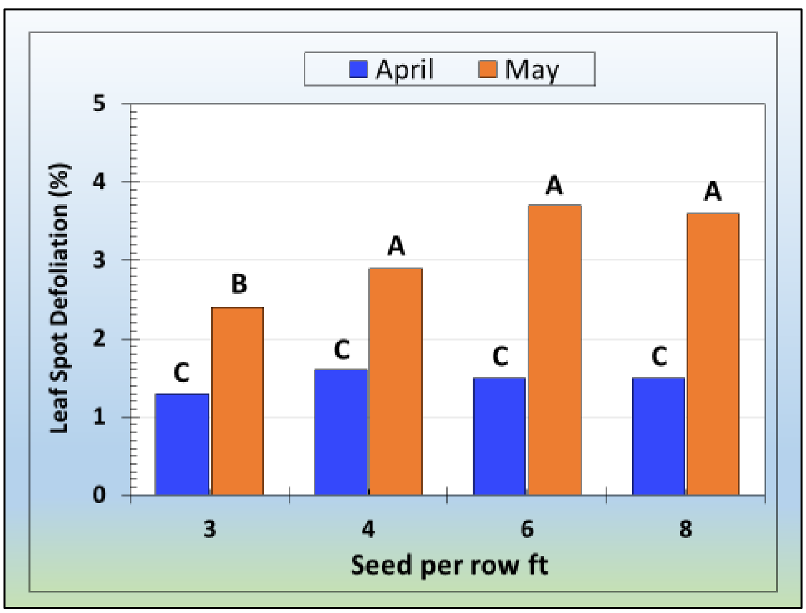
Table 5. Leaf spot defoliation on three peanut varieties as influenced by an interaction with year and planting date.

Variety	% Defoliation					
	2014		2015		2016	
	April[z]	May	April	May	April	May
Georgia-06G	0.7 i[y]	4.1 bc	1.3 f	1.8 f	0.9 gh	2.4 cd
Georgia-09B	0.7 i	4.7 ab	5.0 a	3.4 de	1.6 e	5.5 a
Georgia-12Y	0.9 hi	1.7 e	1.2 fg	1.7 fg	0.8 hi	3.4 b

[z] Planting dates were April 25 and May 30, 2014; April 24 and May 26. 2015; and April 21 and May 23, 2016.
[y] Means followed the same letter are not significantly difference according to Fishers least significant difference test (LSD) test (*P*≤0.05).

Leaf spot defoliation levels were similarly lower at all seeding rates at the April than May planting dates (Fig. 2). For the May planting, similarly greater leaf spot-incited defoliation was noted at the three higher than the 3 seed per foot seeding rate.

Figure 2. Leaf spot defoliation as influenced by planting date and seeding rate. Bars topped with the same letter are not significantly different according to Fisher's LSD (*P*≤0.05).



White mold incidence differed by year, planting date, and variety along with year and seeding rate (Table 1). Planting date impacted white mold indices in 2015 and 2016 but not 2014 when similar disease ratings were taken for the three peanut varieties at both planting dates (Table 5). In 2015, white mold incidence was greater at the April than May plantings for Georgia-06G, Georgia-09B, and Georgia-12Y with the former two varieties having similarly greater disease ratings for both plantings than the latter variety. While Georgia-06G and Georgia-12Y had similar disease indices at both planting dates in 2016, greater ratings were recorded for the May than April planting of Georgia-09B. In 2014 and 2015 but not 2016, Georgia-12Y suffered less white mold damage at each planting date than Georgia-06G and Georgia-09B with the former having lower disease ratings at the May 2016 planting date.

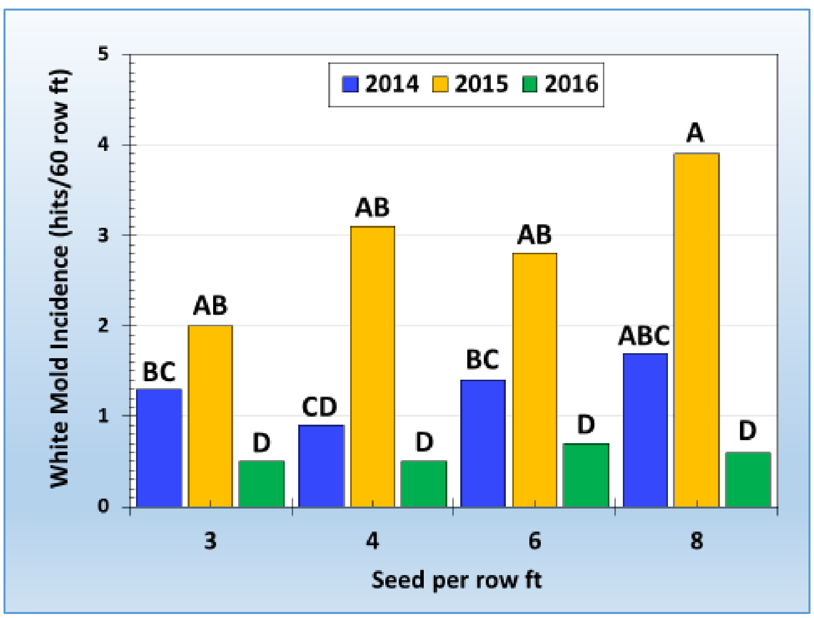
Table 5. White mold incidence on three peanut varieties as influenced by year and planting date.

Variety	2014		2015		2016	
	April [z]	May	April	May	April	May
Georgia-06G	1.5 b [y]	2.0 b	4.6 a	1.7 b	0.4 cd	0.5 cd
Georgia-09B	2.0 b	1.6 b	7.9 a	2.4 b	0.5 cd	1.5 b
Georgia-12Y	0.3 d	0.6 cd	0.8 c	0.3 d	0.2 d	0.3 d

[z] Planting dates were April 25 and May 30, 2014; April 24 and May 26. 2015; and April 21 and May 23, 2016.
[y] Means followed the same letter are not significantly difference according to Fishers least significant difference test (LSD) test (*P*≤0.05).

In each of the study years, white mold incidence was similar across all seeding rates (Fig. 3). With exception of the 4 seed/ft seeding rate, lower white mold indices were recorded in 2016 compared with the previous two years. At each seeding rate in 2014 and 2015, white mold incidence was similar except for the 4 seed/ft seeding rate.

Figure 3. White mold incidence as impacted by year and seeding rate. Bars topped with the same letter are not significantly different according to Fisher's LSD (*P*≤0.05).



Yield differed by year, planting date, and variety as well as by planting date and seeding rate (Table 1). For both the April and May plantings, greater yields were recorded in 2016, while the lowest yields for each planting date were obtained in 2014 (Table 6). In 2014 and 2015, yields for Georgia-06G, Georgia-09B, and Georgia-12Y were greater for the April than the May plantings but similar for the former two varieties at both planting dates in 2016. In contrast, Georgia-12Y produced greater yield in 2016 when planted in April compared with May. At each planting date in 2014 and 2015, similar yields were noted for all three varieties. In 2016, the April planting of Georgia-12Y had greater yield than Georgia-06G but not Georgia-09B but had lower yield at the May planting date than both of the latter varieties.

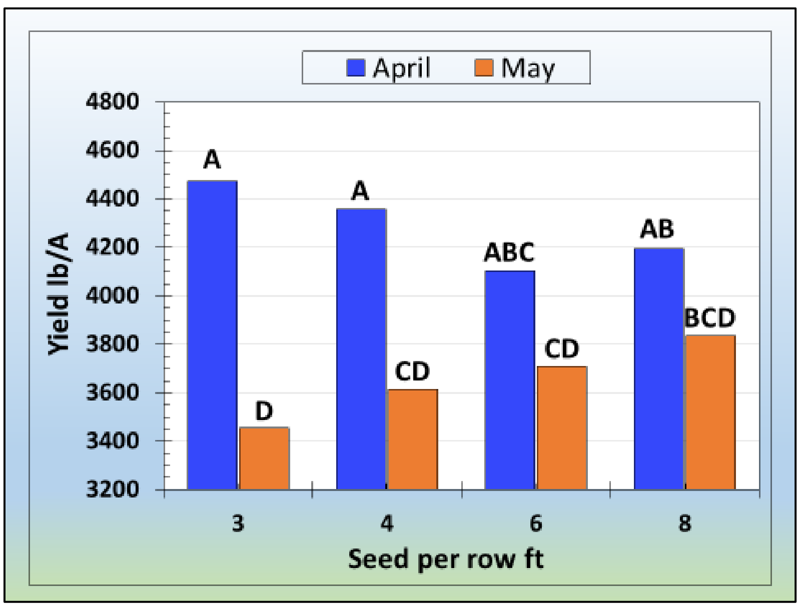
Table 6. Yield of three peanut varieties as influenced by an interaction with year and planting date.

Variety	2014		2015		2016	
	April [z]	May	April	May	April	May
Georgia-06G	3054 e [y]	2122 g	3737 d	2897 e	5741 b	5755 b
Georgia-09B	2912 e	2538 g	3713 d	2882 e	5913 ab	5803 b
Georgia-12Y	3112 e	2089 g	3695 d	3027 e	6331 a	5070 c

[z] Planting dates were April 25 and May 30, 2014; April 24 and May 26. 2015; and April 21 and May 23, 2016.
[y] Means followed the same letter are not significantly difference according to Fishers least significant difference test (LSD) test ($P \leq 0.05$).

Greater yields were recorded for the April than May planting at the two lower but not two higher seeding rates (Fig. 3). At both the April and May planting date, yields were similar across seeding rates.

Figure 3. Yield as influenced by planting date and seeding rate. Bars topped with the same letter are not significantly different according to Fisher's LSD ($P \leq 0.05$).



Summary: Planting date but not seeding rate had the greatest impact on yield of peanut. Yields were greater in two of three study years for the April than May-planted peanuts, regardless of the variety. With a few exceptions in 2016, similar yields were also obtained with Georgia-06G, Georgia-09B, and Georgia-12Y. The absence of a yield response to increasing seeding rates in a dryland production system was a bit of a surprise. The lack of a variety × seeding rate

interaction showed that the absence of a seeding rate response was consistent across all varieties. Seeding rate had a limited impact in a previous Alabama study on the yield of commercial peanut varieties in an irrigated production system.

Despite consistently low TSW, leaf spot, and white mold pressure, planting date, variety, and seeding rate alone or in combination significantly impacted disease activity. While TSW incidence was often similar across planting dates along with varieties, greater indices for this disease were seen in the April than May planting of Georgia-09B in 2016. Previously, incidence of this disease was usually greater in April than May-planted peanuts. The elevated level of TSW recorded at the lowest seeding rate is also consistent with the results of previous field studies. Leaf spot defoliation, which was greater in two of three years the May than April planted Georgia-06G, Georgia-09B and Georgia-12Y, also intensified slightly but significantly with rising seeding rates in the May but not the April-planted peanuts. When noticeable white mold development was seen in 2015, disease incidence was greater in April than May-planted Georgia-06G, Georgia-09B, and to a lesser extent Georgia-12Y varieties. Overall, white mold incidence was lower in Georgia-12Y than the other two varieties. Despite a significant year × seeding rate interaction, white mold did not intensify with rising seeding rates in any study year, which is contrary to results of previous studies in irrigated peanut.

Study results suggest that growers have some flexibility with seeding rates in dryland production settings. Even under drier conditions in 2014 and 2015, yield was similar across all seeding rates for all three peanut varieties. None of the varieties screened has a significant yield advantage. The reduction in disease damage sometime noted in Georgia-12Y did not result in a significant yield gain nor did the slightly higher levels of TSW, leaf spot, and white mold depress the yield of Georgia-09B. The impact of planting date and seeding rate on disease activity in peanut did not result in any differences in yield.

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