Influence of Planter Type and Seeding Rate on Yield and Disease Incidence in Peanut[1]

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ABSTRACT

Variability of peanut (*Arachis hypogaea* L.) seedling spacing, and yield were compared for a conventional and a vacuum-type planter in field studies conducted in 1991 and 1992. Vacuum-type planters have an improved seed metering system and are considered to be more precise. This added precision may serve to compensate for lower than normal seeding rates. Seeding rates evaluated decreased in a step-wise manner from the normal range of 123 to 101 kg/ha, to a minimum of 34 kg/ha. Spacing between individual seedlings was measured after emergence. The occurrence of tomato spotted wilt (TSWV) and southern stem rot were also determined. In 1991 and across all seeding rates, variability in seedling spacing (i.e. standard deviation) was identical between the two planters. In 1992, at 3 of the five seeding rates (34, 56, and 101 kg/ha) standard deviation was less with the vacuum planter. In both years yield and disease occurrence was influenced only by seeding rate, and was independent of planter type. TSWV was inversely related to seeding rate, the opposite relationship occurred with southern stem rot. Maximum yield was achieved with a seeding rate of 101 kg/ha.

Key Words: Planter efficiency, vacuum planters, Southern stem rot, *Sclerotium rolfsii*, tomato spotted wilt virus , TSWV.

An important factor in achieving optimum performance is plant population and placement. In theory, planting on a equally-spaced grid pattern should be most efficient. However, the need for vehicular traffic necessitates some type of row arrangement.Peanut is commonly planted in rows spaced 0.9 m rows apart, at seeding rates of 100-125 kg/ha, or approximately 32,500 plants/ha. This row spacing is based on a historical precedent dating back to when draft animals were used. Modification of a row-type arrangement so as to more closely approach an equally spaced arrangement has generally resulted in improved crop performance. The performance of peanuts planted in two narrowly-spaced rows, commonly termed 'twin row', in lieu of the traditional single row has been evaluated (7,8). The twin row pattern allows for greater spacing between individual plants, which in turn resulted in greater leaf area indices, canopy light interception and crop growth rate (8). Yield was also improved (7,8).

Since these nonconventional planting arrangements have been demonstrated to be beneficial, it seems reasonable that a more uniform plant spacing within a single row pattern should likewise be beneficial. The uniformity of plant spacing for sorghum (13) and corn (9) were correlated with yield. Generally, greater uniformity was associated with improved yield. No comparable studies dealing with peanut have been published.

The incidence of at least two peanut diseases are, to some extent, governed by plant population and perhaps plant arrangement. Southern stem rot is caused by the fungus (*Sclerotium rolfsii* Sacc). This fungus produces soilborne sclerotia but no airborne spores (12). The crop canopy can serve to create and maintain a humid sub-canopy environment that can serve to enhance disease occurrence and severity (3). Thus, a dense moisture-retaining canopy which is commonly associated with a relatively high plant popula-

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tion can exacerbate this disease. In contrast, the occurrence of tomato spotted wilt virus (TSWV) can be increased by a relatively low plant population (2). This virus is vectored by several species of air-born thrips, which are preferentially attracted to plants surrounded by exposed ground, as opposed to canopy-covered sites (10). Thus, any cultural practice that would shorten the period between planting and canopy closure should decrease the incidence of TSWV. These cultural practices would include relatively high seeding rates. While the severity of both of these diseases have been linked to plant population, it is unknown whether their incidence can be manipulated by variability in plant spacing within a common plant population.

Planters are designed to uniformly place seeds into an opened furrow at a predetermined spacing. Seed metering is achieved through two basic machine designs. The first design is based upon a rotating plate. The outer rim of this plate contains equally spaced and sized cells. Seeds from the hopper enter into these cells, and subsequently dropped into a chute that directs them into the opened furrow. Seed selection is based upon the closeness in volume between that of the cell and that of the seed. Thus, the ability to singulate seeds is a function of seed size and shape. The second design utilizes a hollow, vacuum-containing plate. This plate contains equally spaced pockets, and each pocket has a center perforation which serves as a suction port. Seed metering is more precise since the suction port can hold only a single seed. Planters that utilize vacuum metering are considered to be more technologically advanced, and should result in greater uniformity of plant spacing (1).

Planters with rotating-disk metering have been standard for peanut production for many years. Yet few studies on their performance in terms of plant spacing uniformity have been published. Chhinnan *et al.* (4) evaluated the accuracy of seed spacing in peanut utilizing a planter equipped with rotating plate metering. Experimental variables included planting speed, seed size, and seed level within the hopper. Higher planting speeds resulted in more skips, a wider average spacing, and more overall variability in seed spacing. Smaller seed resulted in more multiple drops, fewer skips, more seed placement errors and lower average spacings. The frequency of skips increased and the average spacing increased as the seed level in the hopper dropped. In recent years planters with vacuum metering have begun to be marketed to peanut producers. Proponents contend that the greater precision of vacuum metering will permit a reduction in seeding rate, and thus a cost savings to the grower. Comparisons of crop performance as a function of planter type are limited. Wilkins *et al.* (14) evaluated plant spacing uniformity and yield in two cultivars of green peas (*Pisum sativa*) as achieved with conventional and vacuum planters. The vacuum planter produced a slightly more uniform plant spacing than the conventional planter. For both planters, the deviation from the theoretical perfect spacing was fairly high. Yield was greater with the vacuum planter in only one of two years, and in only one cultivar.

The objective of this study was to compare the uniformity of peanut seedling spacing, and yield at normal and progressively lower seeding rates when planted by a contentional and a vacuum planter. The intent was to determine whether any added precision from the vacuum planter could allow for a reduction in seeding rate. In addition, the occurrence of TSWV and Southern stem rot was also determined.

Materials and Methods

Experiments were conducted in 1991 and 1992 at the Wiregrass Experiment Station of Auburn University located at Headland, Alabama. The soil was a Dothan loamy sand (Plinthic paleudults) with <1% organic matter. Peanut seed of the cultivar Florunner, which passed through a 9.5 mm screen, and was retained by a 6.4 mm screen, was used. These two screen sizes correspond to the 16/64- and 24/64- inch screens as used by the peanut seed industry (5). Seed lots sized accordingly averaged 1850 seed/kg, and would be considered 'large ' or 'select'. Germination was 70% in 1991, and 91% in 1992.

Five seeding rates were used: 123, 101, 78, 56, and 34 kg/ha. These rates correspond to 18.9, 15.2, 11.9, 8.4 and 5.1 seeds/m of row, respectively. And assuming perfectly uniform spacing, the distance between individual seedlings would be 5.3, 6.6, 8.4, 11.9, and 19.8 cm, respectively.

The other experimental variable was planter type. The conventional rotary-plate metering system planter was a Model 7100 Max-emerge manufactured by John Deere[6]. The vacuum-plate metering system planter was a Model 7300 Max-emerge manufactured by John Deere. Planters were adjusted according to the manufacture's recommendations so as to achieve the aforementioned seeding rates. Both were operated at 6 km/h, which was within the manufacturers' recommendations for adequate performance.

A split-plot design with eight replications was used. Seeding rates were randomly assigned to whole plots within each of the eight replicate blocks. Planter type was randomly assigned to subplots within each whole plot. Individual plots were 6.2 m long and consisted of 4 rows, spaced 92 cm apart. Cultural practices were in accordance with the Alabama Cooperative Extension Services recommendations. Plots were maintained weed free by weekly hand hoeing.

Immediately after emergence, the spacing between each of 20 consecutive seedlings was measured in the second row of each of each plot. These measurements were used to prepare density estimates of plant spacing, and in turn visual interpretation of planter performance (14). These data were also used to calculate a standard deviation (sd) of seedling spacing, which were compared within a common seeding rate between planters with an F-test (p=0.05). Total number of plants per plot infected with TSWV was determined prior to harvest. Plants identified as infected with TSWV were generally stunted; additional symptoms included leaf chlorosis, mottling, necrosis, line patterns and distortion as described by Gudauskas (6). Number of Southern stem rot infection loci per plot was determined after peanut inversion according to Rodriguez-Cabana *et al.* (11). A loci was defined as $\leq$30 cm of consecutive southern stem rot-damaged plants in a row. Peanuts were harvested with conventional equipment. Harvested nuts were dried to 14% moisture, weighed, and extrapolated to a kilogram per hectare basis. Disease and yield data were subjected to analysis of variance. Regression effects of seeding rate were evaluated. All tests of main and interaction effects were made using the 0.05 level of significance.

Results and Discussion

Seedling spacing: In 1991, within individual seeding rates, no differences in the standard deviation of seeding spacing were detected between the two planter types (Table 1). In fact, when pooled across seeding rates, the standard deviation for the two planter types were numerically identical. In 1992, standard deviation between planter type was significant different at the 34, 56 and 101 kg/ha seeding rates; in each case the vacuum planter provided a lower standard deviation. And with data pooled over all seeding rates, the standard deviation of seedling spacing for the vacuum and the conventional planter were 8.2 and 9.8, respectively; the difference was significantly different. Wilkins also noted a slight and inconsistent increase in the precision of seed spacing with a vacuum planter relative to that provided by a conventional planter (14).

Table 1. Comparison of variation in seedling spacing and the occurrence of TSWV as influenced by seeding rate and planter.

		Vacuum planter		Convential planter	
	Seeding Rate	Standard Deviation (sd) of seedling spacing	TSWV	Standard Deviation (sd) of seedling spacing	TSWV
	(kg/ha)	(cm)	(loci/ plot)	(cm)	(loci/ plot)
1991:					
	34	23.7	6.6	25.1	5.4
	56	15.5	3.8	16.5	3.7
	78	10.6	2.6	9.3	3.9
	101	8.9	3.3	9.7	1.5
	123	8.3	2.5	7.9	2.6
pooled sd		12.3	—	12.3	—
mean		—	3.8	—	3.3
Regression effect		—	Quad.	—	Linear
1992:					
	34	12.9	5.6	16.5*	6.5
	56	8.8	6.3	10.1*	4.3
	78	6.4	4.1	7.0	3.3
	101	5.3	3.6	6.1*	3.8
	123	4.7	3.1	4.9	3.9
pooled sd		8.2	—	9.8*	—
mean		—	4.6	—	4.4
Regression effect		—	Linear	—	Quad.

*indicates that standard deviation of seedling spacing was significantly different between the two planters according to a F-test ($p<0.05$).

Examination of the density estimates reveals some interesting trends (Fig. 1); in the interest of space, only the density profiles from 123, 78 and 34 kg/ha seeding rates are shown. As mentioned previously, the theoretical perfect spacing between individual seedlings for these seeding rates is 5.3, 7.8 and 19.8 cm, respectively. This target spacing was reasonably achieved by both planter types in both years at the two higher seeding rates. For both planters, seedlings spaced further apart than the target spacing was the most common source of variation. This could be attributed to missed drops and/or seeds that failed to emerge. The ability of either planter types to consistently achieve the relatively wide spacing (19.8 cm) of the lowest seeding rate (34 kg/ha) was limited. For both planters only a very small proportion of the seedlings were at the desired spacing. Deviation both above and below the desired spacing was equally common; with some seedlings spaced up to 60 cm apart.

Inspection of the data reveals that regardless of the planter type, variation in seedling spacing increased as seeding rate decreased. The authors' observed that at normal seeding rates (i.e. ≥ 101 kg/ha) seeds are placed sufficiently close together so that they work cooperatively in opening (an event commonly termed 'cracking') the soil, allowing emergence. This mutually-beneficial behavior becomes limited as the seed spacing increases, and the number of seeds failing to emerge increases.

Southern stem rot Number of Southern stem rot loci was influenced by both year and seeding rate; neither the interaction of these two variable nor planter type were significant. When pooled over all other variables, Southern stem rot infestation averaged 3.6 and 8.3 loci/plot for 1991 and 1992, respectively (data not shown). Since the seeding rate effect was independent of year, means were pooled across years for regression analysis and for presentation (Table 2). Number of loci increased from 5.0/plot at 34 kg/ha, to 6.7/plot at 123 kg/ha. A linear relationship could not be rejected with a lack of fit test, indicating that the relationship between Southern stem rot and seeding rate could be described as a linear relationship. This relationship was independent of planter type. Additional plant foliage and moisture-retaining canopy resulting from a higher seeding rate, probably served to enhance this disease (3).

TSWV A significant three-way interaction was detected between year, seeding rate and planter with respect to the occurrence of TSWV. (Table 1). TSWV generally declined with increasing seeding rate; the opposite to what was observed with Southern stem rot. The observation that a sparse stand can increase the incidence of TSWV has been made by others (1,10). Averaged across both years and planters, the number of TSWV-infected plants decreased from a maximum of 6.0/plot at 34 kg/ha to a minimum of 3.0/plot at 123 kg/ha. However, the exact nature of the response was dependent upon the year and planter. Consequently, data are presented on an individual year and planter basis, and the highest level polynomial effects required so that no significant lack of fit remained are identified under the appropriate column of means. Within individual seeding rates, $LSD_{(0.05)}$ comparisons revealed no significant differences in TSWV between planter type.

Yield: Yield was influenced only by the seeding rate. Consequently, data has been pooled over both years and planter type for presentation (Table 2). A straight line relationship proved to be inadequate in describing the relationship between yield and seeding rate. However, adding a quadratic term to the linear model significantly improved the model so that no significant lack of fit remained. As seeding rate increased from 34 to 101 kg/ha, Yield progressively increased from only 4300 kg/ha to a maximum of 4893 kg/ha. A further increase in seeding rate to 123 kg/ha was slightly detrimental to yield. Within each individual seeding rate, no yield benefit, neither in statistical differences nor in simple numerical trends, could be detected so as to indicate that one planter type offered an advantage over the other.

Although a vacuum planter possesses a more technologically advanced seed metering system, confounding factors such as seed viability and the seed's ability to survive and emerge renders insignificant any additional precision relative to that offered by the conventional planter. These data emphasize the importance of seeding rate in achieving maximum peanut yield.

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Table 2. Effect of seeding rate on the occurrence of Southern stem rot and yield as averaged over both planters (conventional and vacuum) and year (1991 and 1992).

Seeding rate	Southern stem rot	Yield
(kg/ha)	(loci/plot)	(kg/ha)
34	5.0	4,300
56	6.1	4,633
78	6.0	4,754
101	6.1	4,893
123	6.7	4,794
Regression effect	Linear	Quad.

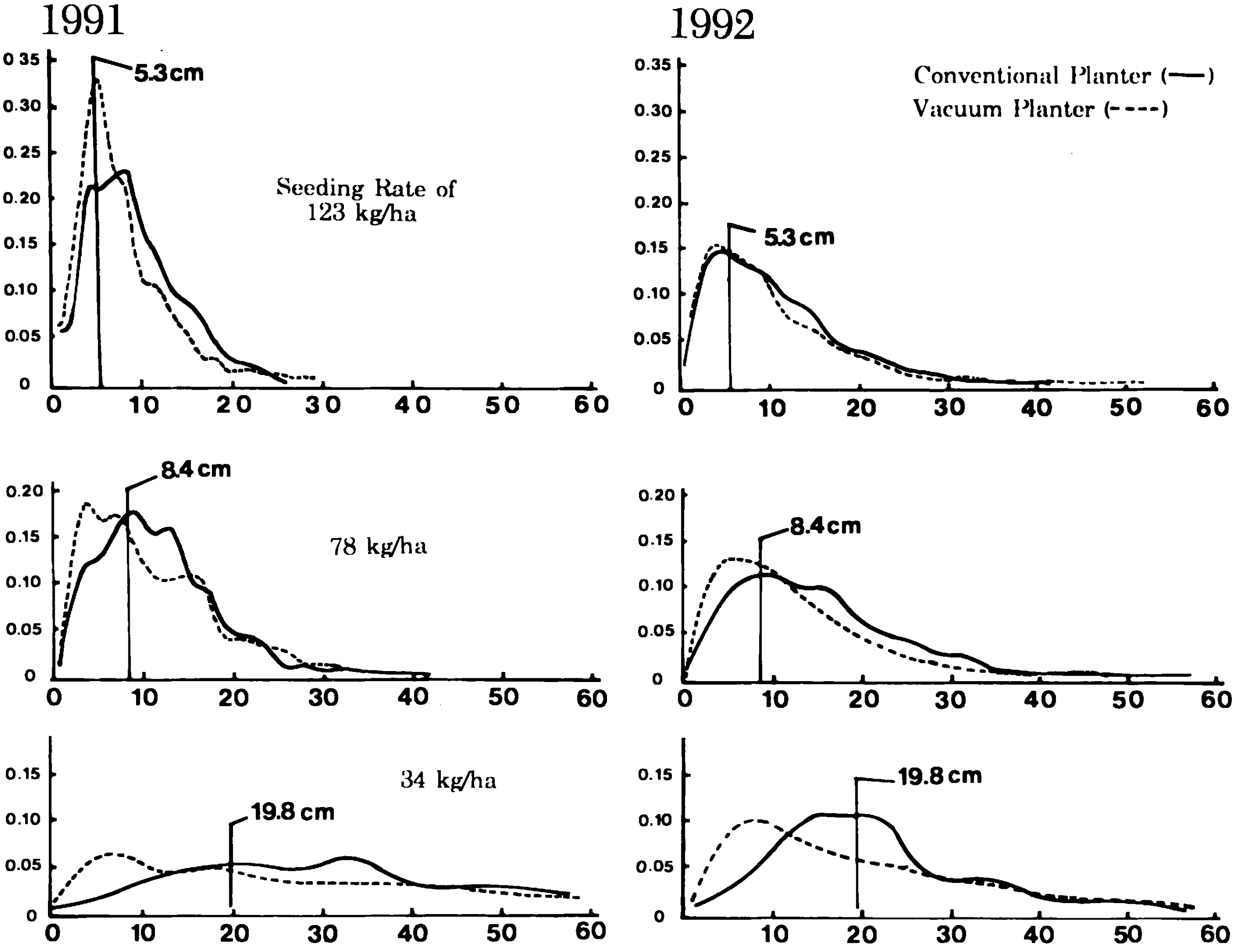

Fig. 1. Relative frequency of spacing between seedlings as influenced by the type of planter. 'X' axis is distance (cm) between seedling, 'Y' is density. The density function f(X) is a unitless measure which may be used to determine the proportion of X values which fall within the interval (a,b) by integrating f(X) over the interval (a,b). The theoretical perfect spacing between seedlings would be 5.3, 8.4 and 19.8 cm for the seeding rates of 123, 78, and 34 kg/ha, respectively.