Growth and Development of the Florunner Peanut Cultivar as Influenced by Population, Planting Date and Water Availability[1]

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ABSTRACT

The influence of planting date, plant population, and row pattern on peanut *(Arachis hypogaea* L.) growth and development was studied at two locations in Georgia. Twin rows were found to give faster canopy closure at high populations (212,000 plants ha^{-1}) but not at low populations (26,500 plants ha^{-1}). No yield differences due to row pattern were found. Increasing population increased competition for light which increased plant height and the percent of total dry matter partitioned to the stem. Population effect on yield was dependent on planting date and environmental conditions. When an optimum planting date (28 April 1983) was combined with adequate moisture (65 cm of water during season), increasing population from 30,000 to 240,000 plants ha^{-1} increased yield from 5290 to 6840 kg ha^{-1}. A combination of an optimum planting date and moisture-limiting conditions (33 cm) resulted in a positive yield response of 20% as population was increased from 26,000 to 208,000 plants ha^{-1}. Combining a late planting date (3 June 1983) with either adequate moisture (66 cm) or moisture-limiting conditions (35 cm) resulted in no yield response due to population. Late planting dates significantly reduced grade.

Key Words: *Arachis hypogaea* L., groundnut, moisture, drought, partitioning.

Continuing improvement in cultivars and cultural practices has caused researchers to periodically reexamine the effect of plant spacing on peanut *(Arachis hypogaea* L.) production. Population studies reported in 1981 by Knauft *et al.* (7) noted no yield differences when intra-row spacing was increased from 10.2 to 15.2 cm; however, a slight yield reduction was obtained when intra-row spacing was increased to 30.5 cm. These results were similar to those obtained by Mixon (8) with the three peanut cultivars Early Runner, Virginia Bunch 67, and Virginia Runner G26. Mixon (8) noted no yield advantage to intra-row spacings closer than 15.2 cm.

Many researchers have noted changes in shelling grades with changes in population or planting patterns. Cox and Reed (2) and Wynne *et al.* (15) noted increased in both grade and extra large kernels (ELK's) with increasing population. Mozingo and Coffelt (9) reported that row pattern also will affect ELK's. They discovered that although the cultivar Florigiant was not affected by row pattern, other cultivars had significantly higher percent fancy pods when grown in a single row pattern instead of a twin row pattern. Duke and Alexander (3) also observed that Virginia bunch-type peanut planted in conventionally spaced rows produced a greater percentage of ELK's than those planted in close row patterns.

In areas of high weed pressure, Hauser and Buchanan (5) reported yield increases of 42% and 52% as inter-row spacings were decreased from 80 cm to 40 cm and 80 cm to 20 cm, respectively. In a four-year study conducted at two locations, Hauser and Buchanan (5) noted that in fields heavily infested with sicklepod *(Cassia obtusifolia* L.), decreasing the inter-row spacing from 80 to 40 and 20 cm decreased the green weight of sicklepod by 25% and 46%, respectively. The authors also noted that Florida beggarweed *(Desmodium tortuosum* (S.W.) DC.) green weight underwent similar reductions of 27% and 42% as inter-row spacing decreased from 80 to 40 and 20 cm, respectively. Narrow rows gave complete canopy cover at an earlier date than did wide rows and therefore decreased weed competition.

High populations have also been shown to provide some insurance in those areas where the peanut rosette virus is a problem (11). In West African population studies, Tourte and Fauche (13) discovered that the percentage of rosette infected plants fell from 66% to 8% as the plant population increased from 41,500 to 332,000 plants ha^{-1} respectively. Although the percentage of infected plants decreased with increasing population, the actual number of infected plants ha^{-1} was the same (27,300 vs. 26,200). This suggests that large populations offer an insurance against losses because they leave a greater number of uninfected plants at harvest than do small populations (10).

Cultivar, cultural pratices, disease, plant populations, insect and weed pressures, along with other environmental factors, interact with each other to determine yield. Several groups now are attempting to develop growth models which they hope to use to increase our

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understanding of how different factors interact in crop production. Many of these models require information on how plant population and the environment affect canopy development, pod set, seed development, and dry weight partitioning. Such information presently is lacking. The purpose of this paper is to present data on how plant growth and development are affected by population, planting date, location, and water availability. We chose to use the Florunner cultivar in these experiments because of its predominance in production fields as well as plant growth models.

Materials and Methods

These experiments were conducted in 1983 at Plains [Greenville sandy clay loam, (clayey, kaolinitic, thermic Rhodic Paleudult) pH 6.2] and Tifton [Tifton loamy sand, (fine-loamy, siliceous, thermic Plinthic Paleudults) pH 6.2], Georgia. The Tifton treatments consisted of five planting dates (14 April, 29 April, 18 May, 2 June, or 15 June), two row patterns (single rows on 91 cm centers or twin rows 25 cm apart on 91 cm centers) and four intra-row spacings (5, 10, 20, or 40 cm for single, and 10, 20, 40, or 80 cm for each of the two twin rows). These spacings were achieved by using a high seeding rate which was thinned back to the desired intra-row spacing 20 days after planting. Twin row populations m^{-2} for 10, 20, 40, or 80 cm intra-row spacings (each of 2 rows) were equal to the single row populations m^{-2} of the 5, 10, 20, or 40 cm intra-row spacings, respectively.

The Tifton treatments were arranged in a split-split plot design (planting dates as main plots, row pattern as subplots and plant population as sub-subplots) and replicated four times. Plots at Tifton were not irrigated. Plot size for each replicated treatment was 7.2 m x 12.2 m. Yield measurements were made on the center 3.6 m x 12.2 m section of each plot. One meter was trimmed from each end one day prior to harvest.

The Plains treatments consisted of two planting dates (28 April 1983 and 3 June 1983), one row pattern (single rows on 81 cm centers) and four intra-row spacings (5, 10, 20, and 40 cm). The Plains experiment was irrigated, arranged in a split plot design (planting date as main plots and plant population as subplots) and replicated four times. Plot size for each replicated treatment was 6.4 m x 12.2 m. Yield measurements were made on the center 3.2 m x 12.2 m section of each plot. One meter was trimmed from each end prior to harvest.

The five planting dates at Tifton and the two at Plains gave us seven different environments in this experiment. Equipment restrictions at Tifton and Plains forced the use of two different inter-row distances, 91 and 81 cm respecitvely. We chose to keep the intra-row distances the same at both locations (5, 10, 20, and 40 cm). Therefore, when like intra-row spacings were compared between locations, the actual plant populations ha^{-1} were 12% higher at Plains.

Fifty days after planting, canopy coverage measurements were taken by photographing each plot, projecting the pictures onto a grid and estimating the percentage of ground covered. Harvest date, leaf area index (LAI), and dry weight of fruit and shoot parts were determined on a subsample (41 cm x 91 cm at Tifton, and 41 cm x 81 cm at Plains) of each plot. These subsamples were taken seven to twelve days prior to harvest date. Optimum harvest date and pod maturity class distribution was determined on each plot using the hull-scrape method (6, 14). Leaf area index (LAI) was calculated after measuring a sample of approximately 25% of the leaves (from the above mentioned subsample of each plot) using a Li-Cor leaf area meter[3]. Total leaf area was determined by dividing the measured leaf area of the subsample by the percentage of total leaf dry weight in the measured subsample of each plot. The calculated total leaf area was then divided by the area of ground occupied by the sample to obtain LAI values. Yield was determined on a 10.2 m section of the center two rows (or four rows in the case of the twin rows) of each plot. Samples were dried to a uniform 9% moisture, cleaned, and weighed. A 2 kg sample was retained for grade and seed size determinations. Grade was calculated as the percentage of sound mature kernels (SMK) plus sound splits. Seed size distribution was determined by using standard U.S. Federal-State Inspection Service runner seed grates with 10.3, 9.5, 8.7, 7.9, and 7.1 mm slots.

The Tifton experiment was grown under non-irrigated conditions. The 1983 season was very dry, and the Tifton experimental site was deficient in water during most of the season. The Plains location was irrigated using a lateral move system, this allowed us to maintain soil moisture (15 cm depth) at or above -20 kPa soil water pressure.

[3]Name of a company or product does not simply approval by the University of Georgia to the exclusion of others which are suitable.

Results and Discussion

Moisture distribution (rainfall + irrigation) for each location is shown in Fig. 1. Tifton rainfall at Julian dates 156 and 212 (7 and 12.5 cm of rain, respectively) occurred over a period of four to six hours. The Tifton soil is subject to crusting and wheel traffic compaction both of which severely limit infiltration. Because of this, probably only a maximum of 5 cm from each of these two rainfalls was effectively obtained by the soil and canopy. By subtracting 9.5 cm from the rainfall record leaves a calculated total effective rainfalls of 36, 33, 36, 35, and 35 cm for the Tifton planting dates 14 April, 29 April, 18 May, 2 June and 15 June, 1983, respectively. Total moisture received during the period from planting to harvest for the Plains plantings of 28 April and 3 June, 1983 were 65 and 66 cm, respectively. Although these two sites differed in soil type, air temperature, and moisture, the major difference between these two locations during this experiment was attributed to water availability. Significant differences between row patterns (twin or single) were noted in our 50 days after planting (DAP) canopy measurements. All other measured traits exhibited nonsignificant row pattern effects and nonsignificant interaction of row pattern with other sources of variation. Therefore, effect of row pattern was not included in analyses for traits other than canopy closure, this doubled the number of reps for each population.

Data taken on all parameters other than canopy coverage were not statistically different (among similar populations and row patterns) for the first 3 planting dates)14 April, 29 April, and 18 May, 1983) at Tifton. For ease of discussion we chose to present data from the 29 April planting to represent this group. Likewise data, other than canopy closure from the Tifton 2 June and 15 June plantings were not statistically different among similar populations and row patterns. We therefore chose to simplify our discussion by using the 2 June data to represent this late planting-date group. Because canopy closure could not be treated in a similar manner, canopy closure data from all 7 environments will be discussed separately.

Canopy Development

The most pronounced increase in coverage due to row pattern was observed in the Tifton 14 April planting 5 cm single or 10 cm twin intra-row spacings (Table 1). Fifty days after planting (DAP), 28% of the ground was covered in the single row plots whereas twin row coverage was 50% with the same population. Thus, twin rows resulted in a 79% increase in ground coverage over single rows. The effect of twin rows was not nearly as pronounced at lower populations. At the 14 April planting date and 40 cm intra-row spacing, the single rows covered 9% of the ground compared to 12% by the twin row pattern

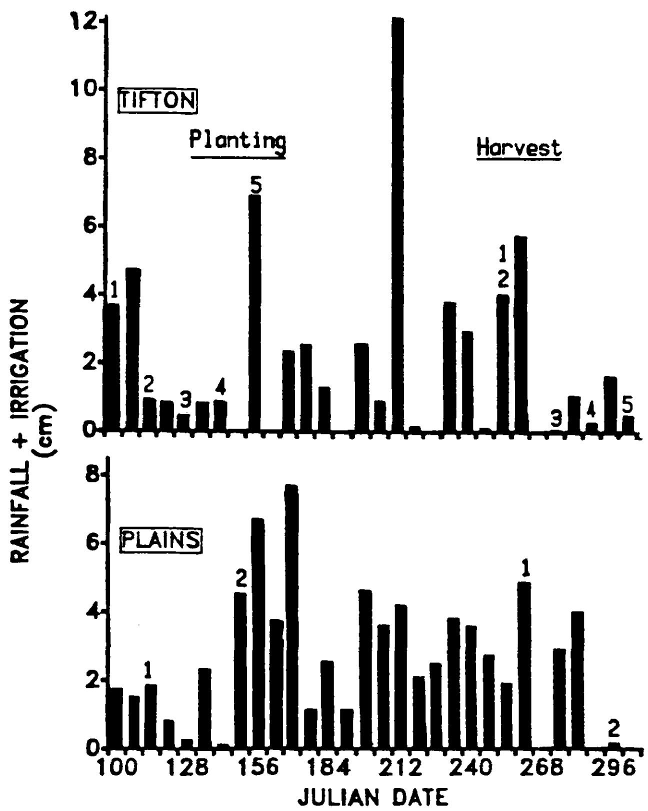

Fig. 1. Rainfall + irrigation during the 1983 season for Tifton and Plains. Tifton planting dates of 14 April, 29 April, 18 May, 2 June, and 15 June are indicated by numbers 1, 2, 3, 4 and 5 respectively on the left hand side of the Tifton section of the figure. Tifton harvest dates of 15 September, 15 September, 4 October, 27 October, and 10 November for planting dates 1-5 are indicated by the numbers 1-5 on the right hand side of the figure. Plains planting dates of 28 April and 3 June are indicated by numbers 1 and 2 respectively on the left hand side of the Plains section of the figure. Plains harvest dates of 16 September and 17 October for planting dates 1-2 are indicated by the numbers 1 and 2 on the right hand side of the figure.

Table 1. Canopy coverage at 50 DAP as influenced by location, planting date, row pattern and intra-row spacing.

Intra-row spacing S	T	Tifton 14 April S	T	29 April S	T	18 May S	T	2 June S	T	15 June S	T	Plains 28 April S	3 June S
— cm —		%	%	%	%	%	%	%	%	%	%	%	%
5	(10)	28	50	71	73	78	87	60	73	85	89	35	78
10	(20)	26	40	67	73	76	79	62	68	76	89	30	76
20	(40)	17	20	64	70	66	62	57	63	73	76	21	74
40	(80)	9	12	46	50	46	55	57	53	62	58	17	70
SE		3	4	4	5	4	4	3	4	4	4	3	4

Planting date.

Designates row pattern of single (S) or twin (T) rows. Twin row spacings shown in ( ) represent the intra-row spacing for each of the two twin rows. The population m-2 is equal for the single and twin row patterns shown on the same horizontal line.

Percent of ground covered by leaves at 50 DAP.

The shape of the growing area for each plant may have been responsible for this population by row pattern interaction. The theoretical growing area per plant for the 5 cm intra-row single and twin row patterns (2 rows x 10 cm intra-row), which have a 91 cm inter-row spacing, would be 5 cm x 91 cm and 10 cm x 45.5 cm, respectively. The 40 cm intra-row single and twin row patterns (2 rows x 80 cm intra-row) would have theoretical growing areas of 40 cm x 91 cm and 80 cm x 45.5 cm, respectively. Those patterns with the most uniform (closest to a square) shape would be expected to exhibit the most efficient canopy coverage rates due to less leaf overlap. Because the theoretical shape for the 40 cm intra-row single and its equivalent twin pattern (40 x 91 and 80 x 45 cm, respectively) is nearly the same, their coverage rates should, also, be equal. Therefore at low populations row pattern will not have as great an effect on canopy development as at high populations.

As population was increased from intra-row spacings of one plant every 40 cm to one plant every 5 cm, ground cover increased from 9% to 28% (14 April single row data, Table 1). This 211% increase in percent of ground covered, as population was increased 700%, probably was due to a greater leaf overlap at the 5 cm spacing and is a good illustration of a runner peanut plant's ability to compensate for growing area.

Fifty days after planting, the percent canopy coverage in the Tifton 29 April planting averaged 62% over all populations (Table 1). The Plains 24 April planting, however, averaged only 26%. This difference probably was due to the slightly (3-5C) cooler soils early in the season at Plains (data not shown). However, the canopy closure values of the late planting date at Plains (3 June) were higher (averaging 74%) than those values measured for the late planting at Tifton 2 June (averaging 59%). This was most likely due to greater water availability at Plains.

LAI measurements taken 7-12 days prior to harvest demonstrate the ability of the runner growth habit to compensate for growing area (Table 2). No significant differences in LAI due to population or planting date were noted at either location. The drought conditions during the entire growing season at Tifton (approximately 36 cm of rain for each planting date) resulted in LAI's of around 2.5. Similar planting dates at Plains (which averaged 66 cm of moisture) had LAI's of approximately 5.1 (Table 3). The plants responded to limited moisture by limiting leaf growth. This would conserve the moisture needed for growth and the moisture lost through transpiration from the additional leaf area.

Dry Weight Partitioning

Separating plant dry weight into leaf, stem, and pod tissue allowed us to calculate partitioning values. At Plains and Tifton, planting date was not a significant factor in partitioning. Population was a significant factor in dry weight partitioning at Plains (both planting dates) and at Tifton (29 April planting date). Increases in population significantly increased the percent of total dry matter partitioned to stem tissue, decreased the percent of total dry matter partitioned to pod tissue (includes pegs, immature, and mature pods) while the percent of total dry matter partitioned to the leaf remained the same. Increasing the population from intra-row spacings of one plant every 40 cm to one plant every 5 cm increased the percent of total dry matter partitioned to the stem from 28 (Plains, 28 April), 31 (Plains, 3 June), and 27% (Tifton, 29 April) to 32, 37, and 34%, respectively.

Table 2. Dry weight distribution and leaf area index as influenced by location planting date and intra-row spacing.

Intra-row spacing	Plains								Tifton							
	28 April Planting				3 June Planting				29 April Planting				2 June Planting			
	Dry Wt. Distribution				Dry Wt. Distribution				Dry Wt. Distribution				Dry Wt. Distribution			
	Leaf	Stem	Pod	LAI	Leaf	Stem	Pod	LAI	Leaf	Stem	Pod	LAI	Leaf	Stem	Pod	LAI
— cm —	%	%	%		%	%	%		%	%	%		%	%	%	
5	31	32	37	4.9	29	37	34	4.9	19	34	47	2.3	21	40	39	2.4
10	33	30	37	5.8	30	35	40	4.5	22	33	45	2.6	23	37	41	2.7
20	33	28	39	5.7	32	32	37	4.5	24	30	46	2.4	20	37	43	2.3
40	30	28	42	4.3	28	31	41	4.4	21	27	52	2.6	21	35	44	2.4
SE	2	1	2	1.0	2	2	1	0.7	2	1	2	0.3	5	3	4	0.4

Includes pegs, immature pods and mature pods.

Table 3. Yield and grade as influenced by location, planting date and intra-row spacing.

Intra-row spacing	Tifton				Plains			
	29 April		2 June		28 April		3 June	
	Yield	Grade	Yield	Grade	Yield	Grade	Yield	Grade
— cm —	kgha-1	%	kgha-1	%	kgha-1	%	kgha-1	%
5	4150	82	3450	75	6840	77	5370	69
10	3910	82	3470	74	6440	78	5810	70
20	3890	81	3844	76	6180	78	5650	72
40	3580	80	3390	76	5290	76	5430	73
SE	207	1	250	2	210	2	260	2
Average	3880	81	3535	75	6190	77	5560	71

Planting Date.
Grade was calculated as % sound mature kernels + % sound splits.

Increases in the percent of dry matter in the stem were offset by decreases in pod dry matter percentages. As the population increased from an intra-row spacing of 40 to one of 5 cm, the percent of dry weight partitioned to the pod decreased from 42 (Plains, 28 April), 41 (Plains, 2 June), and 52% (Tifton, 29 April) to 37, 34, and 47%, respectively (Table 2). Main stem heights also increased as population increased from 40 cm intra-row spacings to 5 cm spacings. When averaged over both planting dates at Plains, increasing the population by 700% (40 cm spacings to 5 cm spacings) resulted in main stem heights increasing by 88% (33 cm to 62 cm, data not shown), percent of total dry weight partitioned to stem tissue increasing by 17% (29.5 to 34.5%), LAI increasing by 13% (4.35 to 4.9), percent of total dry weight in pod tissue decreasing by 14% (41.5 to 35.5%), while the percent of dry weight in leaves stayed the same (Table 2). The plants responded to increased plant to plant competiton (due to higher populations), by placing a greater percentage of the plants total dry weight into the stem. Increased partitioning to the stem allows the plant to grow taller and more effectively compete for light.

Our results are similar to those obtained by Suzuki and Furukawa (12), who noted that increasing the population of the cultivars Southern Cross (Spanish bunch type), Chibahandachi (Virginia bunch) and Chiba 43 (Virginia runner) from 38,000 plants ha^{-1} to 174,000 plants ha^{-1} increased the percent of total dry weight (shoot + pod) partitioned to the shoot from 30, 22, and 27% to 41, 34, and 33% respectively. Suzuki and Furukawa (12), also noted that as population increased, stems grew longer and thinner with less branching, root dry weight (per unit area) increased, and the percent of flowers becoming pegs increased.

In our studies we noted significant location effects on dry matter partitioned to the pod. At Tifton 48% (29 April) and 42% (2 June) of the total dry weight was pods, compared to the Plains values of 39% (28 April) and 38% (3 June), respectively. Water availability probably was the major factor in the partitioning differences between locations, and also the reason for no significant differences between planting dates within the Tifton location. As mentioned earlier, total water applied (rainfall + irrigation) during the period from planting to harvest for each planting date and location were 65, 66, 33, and 35 cm for the Plains plantings of 28 April and 3 June and the Tifton plantings of 29 April, and 2 June, respectively. In a manner similar to many plants, the peanut's reaction to water stress was to partition a greater percentage of dry matter to the seed, thereby enhancing the survivability of the species.

Yield and Grade

Population effect on yield and grade was dependent on planting date and location. Increasing the population, from intra-row spacings of one plant every 40 cm to one plant every 5 cm, significantly increased yield from 3580, and 5290 kg ha^{-1} to 4150, and 6840 kg ha^{-1} at Tifton 29 April, and Plains 28 April, respectively (Table 3). However, no yield differences due to population were noted for the 2 June Tifton planting date or for the 3 June planting at Plains. Late planting date often is cited as a yield limiting factor. In this experiment, the effect of late planting date on yield and grade probably overshadowed the effect of plant population. Population differences (within planting dates) had no effect on grade at either location.

Location had significant effects on both yield and grade. Yields of similar planting dates (averaged over all populations) were higher at Plains [6190 kg ha^{-1} (28 April) and 5560 kg ha^{-1} (2 June)]. We believe most of this yield difference can be attributed to differences in the amount of moisture received at each location (averaging in the amount of moisture received at each location (averaging 66 cm at Plains and 36 cm at Tifton). Grades, however, were higher at Tifton [81% (29 April) and 75% (2 June)] than at Plains [77% (28 April) and

Table 4. Pod maturity class distribution 7-12 days prior to digging as influenced by location, planting date and intra-row spacing.

	Plains												Tifton											
	28 April planting 133 DAP						3 June planting 130 DAP						29 April planting 130 DAP						2 June planting 139 DAP					
Intra-row	Pod Class						Pod Class						Pod Class						Pod Class					
spacing	7	6	5	4	3	1-2	7	6	5	4	3	1-2	7	6	5	4	3	1-2	7	6	5	4	3	1-2
— cm —	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
5	20	11	4	12	5	47	8	14	15	9	7	47	8	13	10	11	2	56	6	10	16	34	10	24
10	16	9	8	18	4	46	10	13	12	13	11	42	9	12	12	14	2	51	4	12	18	32	10	24
20	14	5	10	17	4	50	10	12	13	13	11	41	10	12	12	19	3	46	6	11	19	29	12	23
40	11	7	11	14	4	54	10	13	13	7	18	30	11	8	8	19	2	52	3	10	24	29	10	24
SE	4	3	2	4	2	5	4	7	5	9	3	9	2	4	3	4	2	8	3	6	4	6	2	7

28 April sample taken 7 days prior to digging (DPD); 3 June taken 9 DPD; 29 April taken 10 DPD; 2 June taken 12 DPI
Williams and Drexler (1981) (7 = most mature).

Table 5. Seed size distribution as influenced by location, planting date and intra-row spacing.

	Plains										Tifton									
	28 April planting					3 June planting					29 April planting					2 June planting				
Intra-row	screen slot width (mm)					screen slot width (mm)					screen slot width (mm)					screen slot width (mm)				
spacing	9.5	8.7	7.9	7.1	<7.1	9.5	8.7	7.9	7.1	<7.1	9.5	8.7	7.9	7.1	<7.1	9.5	8.7	7.9	7.1	<7.1
— cm —	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
5	6	22	38	25	9	5	22	36	27	10	4	20	41	28	7	2	14	35	32	17
10	4	18	38	30	10	4	19	41	27	9	3	16	42	31	8	2	14	36	31	17
20	3	16	38	32	12	3	17	38	32	10	3	16	40	33	8	3	16	39	29	13
40	2	12	33	35	16	4	18	35	33	10	2	14	39	36	9	2	13	36	34	15
SE	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1	2	2	3	2

71% (2 June)] (Table 3). Both locations showed significant decreases in grade with the later planting dates. This difference in grade was attributed to differences in pod set and maturity. Data will be presented in the next section of this paper to support this conclusion.

Although our studies found no significant yield differences between single and twin row patterns, Hauser and Buchanan (4) noted yield increases of 12-15% when twin rows were compared to single rows. These studies were conducted with varying levels of weed control. Our population studies were conducted in weed-free environments decreasing the likelihood of finding significant yield differences due to row pattern or population. Hauser and Buchanan (4) also noted that no yield differences occurred in their experimental site which was subject to drought. Buchanan and Hauser's (1) studies concerning beggarweed and sicklepod interactions with peanut found that the effect of row spacing on yield generally was less where weeds were present for the shortest period of time.

Row pattern did not significantly affect yield or grade in our studies. However, population and planting date were significant variables for both yield and grade. From the Plains data, we noted that increasing population from 30,000 plants ha^{-1} to 240,000 plants ha^{-1} (40 cm to 5 cm intra-rows) significantly increased yield by 29% at the 28 April planting date (Table 3). In addition, yield of the 28 April planting date, 240,000 plants ha^{-1} population, was 27% greater than the same population planted on 3 June (Table 3). No yield differences due to planting date were noted at the 30,000 plant ha^{-1} population. The conclusion is that at the 240,000 plant ha^{-1} population, planting date became the most limiting factor. However, at the 30,000 plant ha^{-1} treatment, population was more limiting than planting date.

Pod Maturity Class Distribution

Pod maturity distributions near harvest time reflect pod set and maturation throughout the season. While all samples for these studies were not taken the same number of days after planting, they all were taken at approximately the same stage of crop development (7-12 days prior to digging), Table 4. Classes 1-2 (white mesocarp) included pegs as well as very immature pods which are not machine harvestable. The Tifton planting date of 29 April was significantly higher in its percentage of pods in classes 1-2 (average 51%) than the later 3 June planting date (average 24%).

The high percentage of class 1 and 2 pods in the early planting date at Tifton was offset by declines in classes 3 and 4. Pod percentages in class 3-4 averaged 15% and 41% for Tifton planting dates of 29 April and 2 June, respectively (Table 4). Pods in classes 3 and 4 are immature but still machine harvestable, and therefore will lower the grade. The higher percentages of immature pods (classes 3 and 4) in the later Tifton plantings are part of the reason for the lower grades at the 2 June planting date (when compared to the earlier 29 April planting date). Increases in class 3 pods due to late planting date also were found in the Plains data (Table 4). The lower grades of the 3 June planting date at Plains (when compared to the Plains 28 April planting) were most likely due to the increase in class 3 pods.

Seed Size Distribution

Seed size distribution was not affected by row pattern, planting date, or location; however, significant increases in the percent of large kernels (screen widths of 7.9 mm or larger) at all planting dates were noticed as population increased (Table 5). When averaged over both locations and all planting dates, the percent of large kernels increased from 52 to 62% as the population increased from an intra-row spacing of one plant every 40 cm to one plant every 5 cm. These results are consistent to those of Cox and Reed (2) and Wynne *et al.* (15). Both reported increases in grade and ELK's as population increased. Because the first pods formed on a plant generally are the largest, and because each plant sets less fruit at high populations, it would seem appropriate that higher populations would increase the percentage of large kernels.

Summary

Our study found significant interactions for various combinations of population, row pattern, water availability, planting date, and location. Significant interactions were dependent on trait and sampling time.

Twin rows were found to give faster canopy closure at high populations (212,000 plants ha^{-1}, Tifton 40 cm intra-row spacing). However, no yield differences due to row pattern were found. Increasing population increased plant to plant competition for light which increased plant height and the percent of dry matter partitioned to the stem. Population effect on yield was dependent on environmental conditions.

Acknowledgments

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