Diamond-shaped Seeding of Six Peanut Cultivars[1]

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ABSTRACT

Intrarow seed spacing of peanut (*Arachis hypogaea* L.) has been studied extensively using conventional interrow widths. Modification of spatial arrangements of cultivars with different growth habits can result in optimizing yield. The objective of this study was to determine the effects of seeding in a diamond-shaped configuration on the yield, value, market grade, and plant growth of six peanut cultivars. A 3-year field study was conducted at the Tidewater Agricultural Research and Extension Center, Suffolk, Virginia, using NC 7, VA 81B, NC 9, NC-V 11, VA-C 92R and Florigiant peanut. Plots were 1.82-m wide and 3.65-m long with diamond-shaped seed configurations of 15.2 x 15.2, 30.5 x 30.5, and 45.7 x 45.7 cm. The experimental design was a randomized complete block, split-plot design with cultivars the main plot and seed configurations the split-plot with four replications. Significantly taller main stems (39.4, 30.5, and 22.9 cm) and longer cotyledonary lateral branches (50.3, 48.0, and 45.5 cm) were recorded for the 15.2 x 15.2, 30.5 x 30.5, and 45.7 x 45.7-cm diamond-shaped seed configurations, respectively. The 15.2 x 15.2-cm seed configuration resulted in higher yield, value, sound mature kernels, and total kernels and lower percentage of other kernels. The 15.2 x 15.2, 30.5 x 30.5, and 45.7 x 45.7-cm seed configurations had yields of 5935, 5497, and 4874 kg ha^{-1} and values of 4192, 3804, and 3342 \$ ha^{-1}, respectively. Sound mature kernels were 69.7, 68.2 and 67.4% and total kernels were 73.2, 72.3, and 71.8% for the 15.2 x 15.2, 30.5 x 30.5, and 45.7 x 45.7-cm seed configurations, respectively. Percentages of other kernels were 1.7, 2.0, and 2.3 for the 15.2 x 15.2, 30.5 x 30.5, and 45.7 x 45.7-cm seed configurations, respectively. Significant cultivar by seed configuration interactions were obtained for yield and value. These results indicate peanut yields can be increased by selecting cultivars which respond to diamond-shaped seed configurations or more importantly that seeding rate and configuration should be matched to the cultivar selected.

Key Words: *Arachis hypogaea*, seed configuration, diamond-shaped seeding, cultivar, spacing, planting pattern.

Traditionally, peanut growers in the Virginia-Carolina production area have used row widths of 91.4 cm with intrarow seed placement of 7.6 cm. This spacing results in a planting rate of approximately 143,458 seed ha^{-1}. Some growers prefer higher seeding rates to insure adequate plant stands and quick canopy cover for weed suppression.

Roy *et al.* (1980) reported that seeding rates between 180,000 and 300,000 plants ha^{-1} produced higher yields than did lower or higher plant populations. Mozingo and Coffelt (1984) showed that yields could be increased with a higher seeding rate for VA 81B, which has a bunch growth habit, in a twin row pattern; but obtained no significant difference between seeding rates and row pattern with Florigiant, which has a spreading growth habit. Mozingo and Steele (1989) reported higher yields with five cultivars at intrarow seed spacing of 5.1 compared to 15.2 cm in 91.4-cm rows. However, cultivars responded differently when comparing all intrarow seed spacing of 5.1, 7.6, 10.2, and 15.2 cm.

Other researchers (Cox and Reid, 1965; Buchanan and Hauser, 1980) found that increasing plant populations by decreasing row width generally increased yields. However, Mixon (1969) and Wynne *et al.* (1974) did not find significant yield increases with row spacings closer than 91.4 cm. In a 3-year study, Duke and Alexander (1964) were unable to report a significant yield increase with rows closer than the conventional 91.4 cm for cultivars with a runner growth habit. However, they reported significantly higher yields in 2 of the 3 years for a cultivar with a bunch growth habit with row spacings closer than 91.4 cm. Norden and Lipscomb (1974) also found that cultivars with a bunch growth habit produced higher yields in closer row spacings than did cultivars with a runner growth habit. Knauft *et al.* (1981) reported genotypic differences exist in the ability of peanuts to compensate for poor stands. Some genotypes did not respond to closer intrarow spacings, whereas other genotypes produced higher yields with closer intrarow spacings.

Jaaffar and Gardner (1988) reported that planting patterns that approach equidistant spacing or a square arrangement can produce greater yields than conventional rows. Gardner and Auma (1989) planted Florunner, which has a spreading growth habit, at a plant population density of 95 000 plants ha^{-1} in 35 x 30, 70 x 15, and 105 x 10-cm patterns and found that the approximately square pattern (35 x 30 cm) produced more yield, without affecting market quality, than did the more rectangular arrangements. Shear and Miller (1960) also reported that maximum yields could be expected with equidistant spacings (square arrangement). Musungayi and Gardner (1988) suggested peanut yield can be increased without affecting kernel quality by planting patterns that have a squareness approximating one. Ikeda (1992), working with soybeans [*Glycine max* (L.) Merr.], reported the highest yield with an interrow to intrarow ratio of 1:1 (squareness of one). He concluded that it is possible to increase yield with a square planting pattern and that a twin-zigzag planting pattern produced higher yields than a twin-rectangular pattern.

These results suggest that yields can be increased by altering the interrow and intrarow planting patterns. Highest yield can be expected as the planting pattern approaches a squareness of approximately one. Cultivar and growth habit also contribute to the degree of response.

Planting pattern or seeding configuration may also affect plant growth and market grade of peanuts. Main stem height and cotyledonary lateral branch length have been reported to be greater with closer spacings (Cahaner and Ashri, 1974; Knauft *et al.*, 1981; Gardner and Auma, 1989; Mozingo and Steele, 1989). Significant differences in market grade quality have been reported by some research-

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ers (Gardner and Auma, 1989; Mozingo and Coffelt, 1984; Wynne *et al.*, 1974) while others have reported no significant differences (Jaffer and Gardner, 1988; Mozingo and Steele, 1989).

The objective of this study was to determine the effects of seeding in a diamond-shaped configuration (equidistant between rows and plants in alternating rows) on the yield, value, market grade factors, and plant growth of six, large-seeded, virginia-type, peanut cultivars.

Materials and Methods

Field tests were conducted at the Tidewater Agricultural Research and Extension Center in Suffolk, Virginia, from 1986 through 1988. The soil type was a Kenansville loamy sand (loamy, siliceous, thermic Arenic Hapludults). Cultivars evaluated were NC 7, VA 81B, NC 9, NC-V 11, VA-C 92R, and Florigiant, all of which are large-seeded, virginia-type, and represent various growth habits (Table 1). Individual plots were 1.82-m wide and 3.65-m long with a 1.52-m wide planting bed raised approximately 7.6 cm. Seeding configurations on the raised planting bed consisted of horizontal rows with equidistant spacing between rows and seed within rows (Fig. 1). Seed in alternate rows were aligned midway between seed in the two adjoining horizontal rows forming a diamond-shaped seeding configuration. Within the three seed configurations used, each plant had an area of 15.2 x 15.2, 30.5 x 30.5, or 45.7 x 45.7 cm, respectively, or a squareness of one. Hereafter, seed configuration will be referred to as diamond-shaped 15.2 x 15.2, 30.5 x 30.5, or 45.7 x 45.7 cm. The experimental design was a randomized complete block, split-plot with four replications each year. Cultivars were the main plot and diamond-shaped seed configurations were the split-plot.

Seeding was accomplished using a specially constructed seed-drop device for precision spacing. This device was designed to accurately place peanut seed in a diamond-shaped configuration. The seed-drop device was constructed on a category II, 3-point hitch frame for convenience in use and transport. The overall size is 1.6-m wide by 2.5-m long and it consisted of 124 total seed cells in 13 rows spaced 15.2 cm between rows. All odd number rows have 10 cells spaced 15.2 cm apart, while even number rows have nine cells aligned midway between the cells of the odd number rows. All cells were made of 3.2-cm square metal tubing and sloped on one side for soil penetration. The sloping side is covered with flat metal and hinged for seed deposit operated by a hydraulic cylinder controlled by the tractor operator. Polyvinyl chloride (PVC) tubing (2.54-cm dia.) extends from the top of each cell to a plywood platform to allow seed placement by hand. The three different seed spacing configurations were possible by placing seed in the desired cells.

After planting, the soil was compacted with a water-filled roller to insure adequate soil to seed contact for good seed germination. Approximately two weeks after planting any missing or extremely weak plants were replanted to insure stands of approximately 100%. Excellent stands were obtained for all treatments. Standard peanut agronomic production practices as recommended by the Virginia Cooperative Extension Service were used. Modifications were made in application of landplaster and pesticides to adjust for solid bed seeding versus conventional row seeding.

Main stem height and cotyledonary (n + 1) lateral branch length measurements were taken each year approximately 1 August. Four plants were measured in each replication.

Before harvest plants from both ends of each plot (three rows for the 15.2 x 15.2, two rows for the 30.5 x 30.5, and one row for the 45.7 x 45.7-cm seed configurations, respectively) were removed and discarded to eliminate increased yields from border effect (Shear and Miller, 1960). Plants were machine dug using a solid digger blade the width of the plot and hand shaken using pitchforks. After field drying, peanut pods were harvested from each plot with a small stationary picker, artificially dried, weighed, and yields adjusted to a standard peanut moisture content of 7%.

Samples from each replication were graded each year according to USDA procedures for peanut marketing. Grade factors included percentages of fancy pods (nonshelled fruit that rode a 13.5-mm roller spacing on the presizer), extra large kernels (seed that rode an 8.5- x 25.4-mm slotted screen), sound mature kernels (seed that rode a 6.0- x 25.4-mm slotted screen), other kernels (seed that fell through a 6.0- x 25.4-mm slotted screen), and total kernels (all seed in the shelled sample including sound mature kernels, sound splits, other kernels, and damaged kernels). Market value ($ ha^{-1}) was determined according to the USDA peanut price support schedules for each year of the test. Analyses of variance were performed for each year and the average across years using Duncan's New Multiple Range Test.

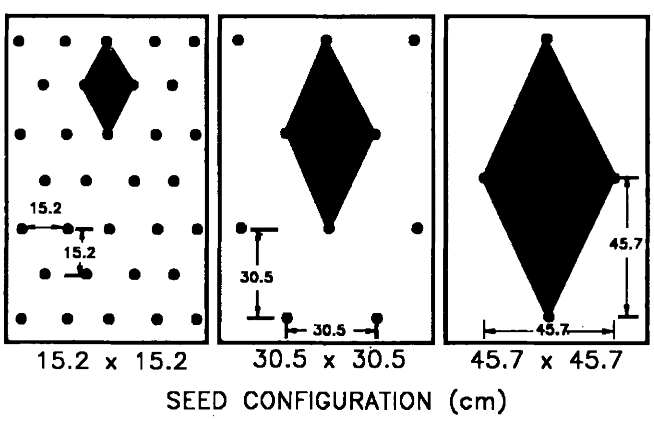

Fig. 1. Drawing of the three configurations with shaded area depicting the diamond shape seen in the field.

Table 1. Growth habit of six, large-seeded, virginia-type, peanut cultivars used in diamond-shaped seed configuration studies 1986-1988.

Cultivar	Growth habit
VA 81B	bunch (erect plant)
NC 7	intermediate
Florigiant	runner (spreading plant)
NC 9	runner (spreading plant)
NC-V 11	runner (spreading plant)
VA-C 92R	runner (spreading plant)

Results and Discussion

Mean squares from the analysis of variance for the 3-year averages of the characteristics measured are reported (Table 2). Due to environmental conditions all characteristics analyzed differed (0.01 probability level) among years. Since cultivars were known to differ (Mozingo *et al.*, 1987; Mozingo, 1990; Mozingo *et al.*, 1993), significant differences (0.01 probability level) among cultivars were found for all characteristics as expected. Highly significant differences (0.01 probability level) for diamond-shaped seed configurations were obtained for all characteristics except extra large kernel (ELK) percentage, which was significant at 0.05 probability level, and fancy pod percentage, which was not significant. Highly significant cultivar by seed spacing interactions were obtained for yield and value. Year by seed configuration interactions were significant for plant growth and some of the market grade factors, but were not significant for yield or value which were of primary concern in this study.

Plant Growth

Measurements of plant growth revealed differences among diamond-shaped seed configurations. Significantly taller main stems and longer cotyledonary lateral branches were obtained with closer seed configurations (Fig. 2). These results agreed with data obtained for virginia-type cultivars

Table 2. Mean squares from analyses of variance for plant growth, market grade factors, yield, and value.

Source	df	Main Stem Height	Lateral Branch Length	Market grade factors† FP	ELK	OK	SMK	TK	Yield	Value
									—x 10-3—	
Years (Y)	2	716.0**	773.2**	1 789.8**	1 310.3**	55.8**	208.7**	82.6**	1 472**	616**
Reps within Y	9	49.8**	34.8*	33.8	21.5	0.6	3.0	2.4	177	54
Cultivars (C)	5	137.9**	199.4**	1 911.8**	2 090.5**	4.1**	138.8**	113.0**	1 760**	570**
Y X C	10	5.8	3.8	69.1	44.0*	1.4**	7.2	2.8	496	142
Error A	45	12.9	13.0	36.8	20.0	0.5	9.7	4.3	266	83
Seed Configuration (SC)	2	1 965.2**	158.8**	17.0	62.4*	5.9**	95.2**	40.4**	18 288**	5 253**
Y X SC	4	31.5**	37.3**	99.0**	286.6**	1.0*	10.8	7.7**	183	27
C X SC	10	3.3	18.5**	84.8**	37.6*	0.5	3.6	1.9	647**	189**
Y X C X SC	20	2.0	3.0	37.0	35.5*	0.8**	8.4*	3.3*	170	61
Error B	108	2.4	5.3	24.3	17.9	0.3	4.6	1.9	172	51

*, **Indicate 0.05 and 0.01 significance level, respectively.

†FP, ELK, OK, SMK, and TK represent fancy pods, extra large kernels, other kernels, sound mature kernels, and total kernels, respectively.

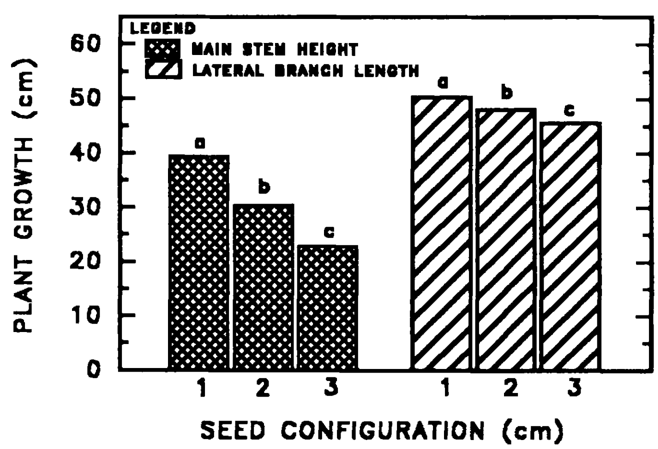

Fig. 2. Effect of seed configuration (1=15.2 x 15.2 cm, 2=30.5 x 30.5 cm, 3=45.7 x 45.7 cm) on plant growth. The same letter above bars within a group indicates that differences are not significant (P=0.05) according to Duncan's Multiple Range Test.

by other researchers (Duke and Alexander, 1964; Knauft *et al.*, 1981; Mozingo and Steele, 1989). The diamond-shaped seeding configuration showed that an increase in plant populations caused the plant to grow taller and produce a longer lateral branch. Although significant differences were obtained with diamond-shaped seeding for lateral branch length, the differences among seed configurations were less than for main stem height.

Year by seed configuration interactions were significant for main stem height and lateral branch length. Main stems were taller with each decrease in seed space configuration each year; however, the interaction was created by the magnitude of difference between years. The 1988 growing season produced much more vigorous plants than were produced in 1986 or 1987. The difference between the 15.2 x 15.2 and the 45.7 x 45.7-cm seed configuration was twice as much in 1988 as in 1986 or 1987; thus, the significant interaction for main stem height.

Vigorous plant growth in 1988 resulted in significant differences among all seed configurations for lateral branch length. No significant differences were obtained in 1987, and only the 45.7 x 45.7-cm seed configuration was significantly different in 1986; thus, the significant year by seed configuration interaction for lateral branch length.

Market Grade Factors

Highly significant differences (0.01 probability level) were obtained for seed configuration main effects for other kernels (OK), sound mature kernels (SMK) and total kernels (TK). Percentages of SMK and TK increased and percentage of OK decreased with closer seed configurations (Table 3). These results may be explained by the fact that at closer seed configurations, 15.2 x 15.2 versus 30.5 x 30.5 versus 45.7 x 45.7 cm, pods are set and mature more uniformly. This results in higher SMK and TK percentages and lower OK percentage (less immature kernels). Gardner and Auma (1989) reported a higher SMK percentage with planting patterns of 35 x 30 cm versus 70 x 15 cm versus 105 x 10 cm. Shear and Miller (1960) reported a higher shelling percentage (total kernels) with a square planting pattern of 15.2 cm than with a 30.5-cm pattern, while the 22.9-cm square pattern was intermediate.

Significant differences were not obtained for fancy pod percentage. The ELK percentage was significant at the 0.05 probability level and these differences, although significant, were very small. The large year by seed configuration interaction for ELK may have contributed to the main effect significance (Table 2). Higher percentages of ELK were obtained for closer seed configuration each year except 1986 when the 15.2 x 15.2-cm seed configuration was significantly lower than either the 30.5 x 30.5 or 45.7 x 45.7-cm seed configuration. In 1986, the rainfall for September was approximately 1.5 cm, which is well below the normal of 10.7 cm and extremely low for the final stages of pod filling. Overhead irrigation was not available in 1986 but was used in 1987 and 1988 to supplement rainfall so that total water for the growing season was normal in 1987 and 1988.

Table 3. Effects of seed configurations on market grade factors.

Seed Configuration (cm)	FP	ELK	OK	SMK	TK
	(%)				
15.2 x 15.2	81.4a†	44.0ab	1.7c	69.7a	73.2a
30.5 x 30.5	81.6a	44.8a	2.0b	68.2b	72.3b
45.7 x 45.7	80.6a	43.0b	2.3a	67.4c	71.8c

†Means followed by the same letter within a grade character column are not significantly different (P=0.05) according to Duncan's Multiple Range Test.

With the extremely high plant population density in the 15.2 x 15.2-cm seed configuration coupled with the low rainfall in 1986, the kernels did not reach full size and created a low percentage of ELK for this seed configuration compared to other years. Mozingo *et al.* (1991) reported ELK percentage continued to increase with each delay in harvest beginning on 12 September, although percentage of fancy pods did not change significantly. This indicates that pod size had reached a maximum by early September, while kernel size continued to increase. Therefore, in 1986, with a shortage of rainfall and the high plant population density of the 15.2 x 15.2-cm seed configuration, peanut plants in this configuration were not able to produce a high percentage of mature kernels which would grade ELK.

Yield and Value

Seed configurations had a highly significant effect (0.01 probability level) on yield and value. Closer seed configurations had higher yields and values than did more distant seed configurations (Fig. 3). Yield decreased 5.7% and value 9.3% with an increase in seed configuration from the 15.2 x 15.2 to the 30.5 x 30.5-cm spacing; however, yield decreased by 12.9% and value by 12.1% when the seed configuration was increased from the 30.5 x 30.5 to the 45.7 x 45.7-cm spacing.

These results agree with those of Shear and Miller (1960) whereby higher yields were recorded with closer spacing in a square arrangement. Other researchers (Gardner and Auma, 1989; Jaaffer and Gardner, 1988) have concluded

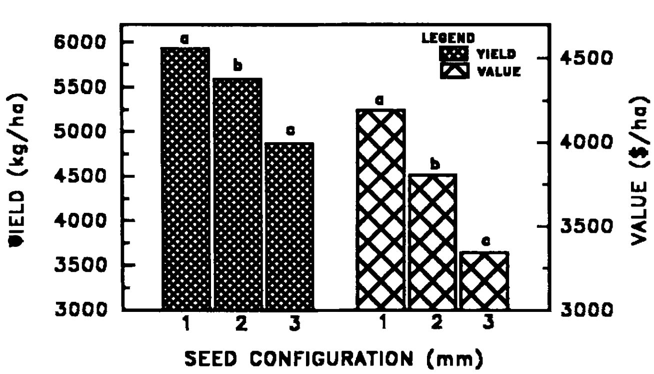

Fig. 3. Effect of seed configuration (1=15.2 x 15.2 cm, 2=30.5 x 30.5 cm, 3=45.7 x 45.7 cm) on yield and value. The same letter above bars within a group indicates that differences are not significant (P=0.05) according to Duncan's Multiple Range Test.

that planting in approximately square patterns should produce higher yields than in conventional rows. Although the seed configuration was considered diamond-shaped in our study, each plant had a squareness of one. These results indicate that even within equidistant spacing (squareness of one), yields can be increased with closer seed configurations (15.2 x 15.2 > 30.5 x 30.5 > 45.7 x 45.7).

Highly significant cultivar by seed configuration interactions were obtained for yield and value. Since the growth habit and yield potential of the cultivars studied varied, these interactions were not totally unexpected. These interactions can be explained by the fact that the bunch type cultivar, VA 81B, responded more positively to the closer seed configuration (15.2 x 15.2 cm) when compared to the intermediate seed configuration (30.5 x 30.5 cm) or the more distant seed configuration (45.7 x 45.7 cm), than did some of the runner growth type cultivars, particularly Florigiant (Fig. 4). Florigiant has vigorous vine growth and yielded well at the 45.7 x 45.7-cm seed configuration; whereas, VA 81B, with its erect bunch growth habit did not perform well in comparison. Differences in yield potential also exist among the cultivars. VA-C 92R has outstanding yield potential (Mozingo *et al.*, 1993) and produced higher yields at all seed configurations than other cultivars, except VA 81B at the 15.2 x 15.2-cm seed configuration.

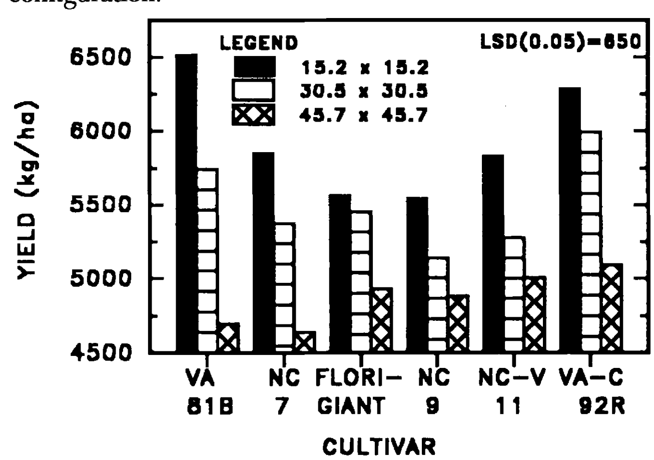

Fig. 4. Effect of cultivar and seed configuration on yield.

Conclusions

Based on previous research and the findings of this study, maximum yield of peanut cultivars should be obtained with planting patterns or seed configurations which approach squareness or have an interrow to intrarow spacing ratio of 1:1. Within seed configurations, cultivars also responded differently for yield and value, with bunch type cultivars responding more positively to closer seed configurations (higher plant density) and runner growth type performing better than bunch at more distant seed configurations. Market grade factors were variable, with SMK and TK percentages being higher and OK percentage lower at closer seed configurations (higher plant density). As a practical application, peanut producers should be able to increase yield, value, and market grade factors by modifying their present seed configuration without increasing seed requirements. This could be accomplished by planting three equidistant rows (22.9-cm interrow spacing) using

22.9-cm intrarow spacing, which would require the same quantity of seed as is presently being seeded in 91.4-cm interrow spacings with 7.6-cm intrarow seeding.

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