Plant Growth Response of Two Runner Peanut Cultivars to Reduced Seeding Rate[1]

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ABSTRACT

The ability of peanut plants to adjust to wide plant-to-plant spacing and the use of more precise mechanical planters have not been thoroughly exploited to reduce seeding rates. The magnitude of plant growth adjustment of two runner peanut cultivars to reduced seeding rate was studied in 1992 and 1993. A precision vacuum planter was used to plant the cultivars GK-7 and Southern Runner (SR) in single rows per bed at 8, 12, and 22 seed/m^2. Total plant dry matter weight (TDM), leaf area (LA), and main stem height, nodes, and branches were measured six times during each season. Vegetative growth adjustment to reduced seeding rate was detected as early as 52 d after planting (DAP) in 1992 and 42 DAP in 1993. Plants fully adjusted to reduced seeding rate when they began forming pods at 70 DAP in 1992 and 75 DAP in 1993. By this stage, individual plants in the 8 seed/m^2 treatment accumulated 2 to 2.7 times as much total dry matter (TDM) as plants in the 22 seed/m^2, and all seeding treatments within each cultivar accumulated equivalent amounts of TDM on a unit ground area basis. The 8 seed/m^2 treatment produced significantly greater TDM/m^2 and leaf area index (LAI) than the 22 seed/m^2 treatment by the end of both seasons (132 DAP in 1992 and 152 DAP in 1993). The partitioning of dry weight to pods and leaves was also greatest for the 8 seed/m^2 seeding treatment. By the end of the season, the 8 seed/m^2 seeding treatment produced as much as 30% more pod dry weight (PDW) per m^2 than the 22 seed/m^2 treatment. Plants in the 8 seed/m^2 seeding were significantly shorter but produced more main stem nodes and branches than the 22 seed/m^2 seeding. Under the conditions of this study, plants of these runner cultivars showed the capacity to grow larger and compensate fully for reduced seeding rate before any measurable pod production began. Pod production, therefore, was not reduced and in some situations increased by reducing the seeding rate to as low as 8 seed/m^2.

Key Words: *Arachis hypogaea*, leaf area index, partitioning, plant density, yield.

Irrigated peanut (*Arachis hypogaea* L.) has traditionally been planted at high rates to minimize erratic stands. Precision planters that place seed more uniformly in depth and spacing than conventional planters reduce the risk of erratic spacing. Due to high peanut seed costs, an opportunity exists to increase net return by exploiting the ability of peanut plants to adjust to wide spacing and the use of more precise mechanical planters to reduce seeding rates.

Peanut plants readily adjust to wide plant-to-plant spacing by growing larger. However, the degree of adjustment depends on the environment and the growth habit and earliness of the cultivar. Cahaner and Ashri (1974) studied the response of virginia-type peanut cultivars to plant density and found that increasing plant density from 7.6 to 15.2 plants/m^2 increased vegetative growth without affecting pod yield and the growth of cotyledonary branches. Bell *et al.* (1991) found that the optimum plant population for pod yield and dry matter production in Australia was 6.5 to 7.5 plants/m^2 for two virginia-type peanut cultivars with decumbent growth habit and described as late (cv. Early Bunch) and very late (cv. Mani Pintar) maturing, compared with >22.5 plants/m^2 for the spanish-type cv. Chico which they

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described as very early maturing with erect growth habit. The optimum plant population for McCubbin, a spanish-type cultivar with erect growing habit and described as early maturing, was 9.5 to 10.5 plants/m^2. These results suggest that seeding rates can be reduced when the cultivar used and growing conditions favor vegetative growth. Reducing seeding rate may not be practical when conditions are not ideal for vegetative growth and rapid ground cover (Bell and Wright, 1998; Giayetto *et al.*,1998).

Seeding rate studies in the past did not thoroughly evaluate plant growth adjustment as affected by seeding rate or plant density. Furthermore, most of the previous seeding rate or plant population studies were planted by hand and thinned to a desired stand and, therefore, may not reflect current mechanized peanut planting practices. The objective of this study was to determine the magnitude of plant growth adjustment of two runner peanut cultivars, GK-7 and Southern Runner, when the seeding rate (planted with a precision planter) is reduced below the traditional rate of 17 to 21 seed/m^2.

Materials and Methods

The study was conducted in a commercial field in Texas as described previously (Tewolde *et al.*, 2002). Seed of GK-7 and Southern Runner (SR) were planted in single rows per bed at 8, 12, and 22 seed/m^2 on 12 May 1992 and on 19 May 1993. The design was a randomized complete block (four replications in 1992 and six replications in 1993) with a split plot arrangement of treatments. Cultivars were planted to main plots and seeding rates to subplots. Each subplot consisted of 18 beds spaced at 0.91 m with a length of 9.1 m. A line-source sprinkler irrigation system was used to impose a gradient of irrigation. Irrigation was applied at 53, 62, 78, 93, 109, and 120 d after planting (DAP) in 1992 and at 64, 78, 89, 103, 124, and 146 DAP in 1993. The gradient of total water applied to each subplot ranged from none at the driest end to as high as 760 mm in 1992 and 699 mm in 1993 at the wettest end. Total rainfall amounts received during the growing seasons were 261 mm in 1992 and 338 mm in 1993.

Plant samples were taken from three replications six times during each growing season to determine plant growth. On the first two sampling dates, one sample was taken from each subplot at 37 and 52 DAP in 1992 and at 42 and 55 DAP in 1993 before imposing differential irrigation. The remaining four samples were taken after imposing differential irrigations at 70, 90, 111, and 132 DAP in 1992 and 75, 96, 117, and 152 DAP in 1993. On each of these sampling dates, five samples were taken from each subplot at 1.8, 5.5, 9.1, 12.8, and 14.6 m from the irrigation line on the downwind side of the system and 1.8, 3.7, 5.5, 7.3, and 11.0 m distances on the upwind side. These sampling distances were chosen so that applied water would be equivalent to the corresponding positions on the other side of the line. All plants were sampled from two 30.48-cm rows (0.557 m^2) on the first two sampling dates and from one 30.48-cm row (0.278 m^2) on the other four sampling dates. Plants were kept at 4 C until processed.

Data taken from each plant sample included number of main stem nodes, number of main stem branches with at least three fully expanded leaves, main stem height, and the length of one of the cotyledonary branches. After taking a small representative branch for specific leaf area (SLA) determination, each sample was partitioned into leaves, stems, and fruits (pods), placed in forced air driers at 80 C for 3 to 5 d and weighed. All leaflets from the SLA subsample were separated from the branch and the area measured with a CI-251 area meter (CID Inc., Moscow, ID). Specific leaf area was determined as the area of the leaflets divided by their dry weight. Leaf area (LA) was determined by multiplying SLA by total leaf dry weight.

Evaluation of plant growth adjustment of the cultivars to reduced seeding rate was based on data from irrigation levels that were not limiting to yield (Tewolde *et al.*, 2002) under the conditions of this study. Therefore, all data from irrigation treatments that received $\geq$ 500 mm irrigation were pooled and subjected to analysis of variance. Data points in all figures are means across three irrigation levels, two cultivars, and three replications.

Results and Discussion

Data on plant growth response to seeding rate are presented as averages of the two cultivars and the three highest irrigation levels that did not reduce yield (Tewolde *et al.*, 2002). Interactions between cultivars and seeding rates rarely occurred. The response of the 12 seed/m^2 seeding was usually intermediate between the 8 and 22 seed/m^2 rates and, therefore, is discussed minimally.

Nodes. Plants produced as many as 30 main stem nodes in 1992 and 28 main stem nodes in 1993 (Fig. 1). Decreasing planting density from 22 to 8 seed/m^2 increased the number of main stem nodes by up to two in 1992 and three in 1993. The main stem node advantage of the low density planting was detected at almost all growth stages in both cultivars in 1992 and in GK-7 in 1993. However, differences were statistically significant only prior to the early fruit formation stage (52, 70, 90 DAP in 1992 and 42, 55, 75 DAP in 1993). The season-end node number was larger in 1992 ($\approx$30) than in 1993 ($\approx$28) although the 1992 season was shorter by 20 d. Plant development may have been slowed by higher midseason vapor pressure deficit and relatively less frequent irrigation in 1993 than in 1992 (Tewolde *et al.*, 2002).

Branches. Reducing the seeding rate from 22 to 8 seed/m^2 increased number of branches with at least three fully expanded leaves (Fig. 1). Plants in the 8 seed/m^2 treatment produced significantly more branches per plant than plants in the 22 seed/m^2 treatment at 52, 70, and 90 DAP in 1992. In 1993, plants in the 8 seed/m^2 treatment produced significantly more branches per plant than plants in the 22 seed/m^2 treatment at all growth stages. The length of cotyledonary branches was the same regardless of the seeding rate (data not shown). Our results agree with the findings of Cahaner and Ashri (1974) but not with those of Mozingo and Steele (1989) who found increased cotyledonary branch length with increasing plant density.

Plant Height. Increasing the seeding rate increased main stem height by 10 to 15 cm. Plants in the 22 seed/m^2 treatment were significantly ($P \leq 0.05$) taller than the 8 seed/m^2 treatment at all growth stages in both seasons except at 90 and 111 DAP in 1992 (Fig. 1). Since the number of main stem nodes increased with decreasing seeding rate, the increased main stem height in the 22

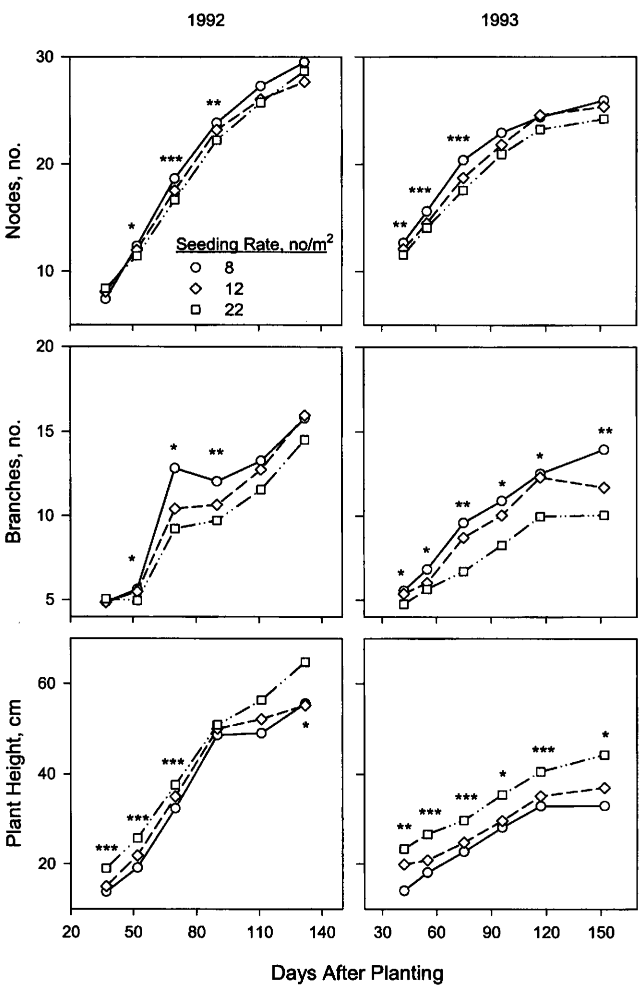

Fig. 1. Seeding rate effect on main stem nodes, height, and branches during the growing season of peanut in Frio County, TX. *,,*** = significant at P ≤ 0.05, 0.01, 0.001, respectively.**

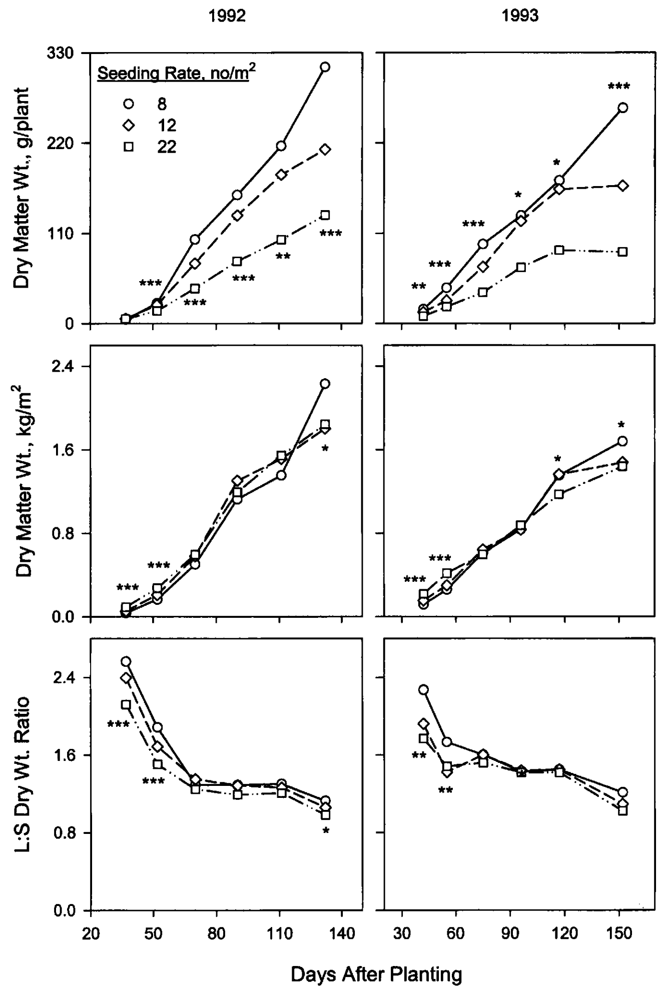

Fig. 2. Seeding rate effect on total plant dry weight and leaf-to-stem (L:S) dry weight ratio during the growing season of peanut in Frio County, TX. *,,*** = significant at P ≤ 0.05, 0.01, 0.001, respectively.**

seed/m² treatment should be due to greater internode length. Increased plant height is the most consistently reported response of peanut plants to high plant population (Knauft *et al.*, 1981; Kvien and Bergmark, 1987; Mozingo and Steele, 1989).

Dry Matter and Leaf Area. Individual plant growth was the greatest adjustment plants made to reduced seeding rate. Plants showed measurable size (growth) adjustment to reduced seeding rate as early as 52 DAP in 1992 and 42 DAP in 1993. Individual plants in the 8 seed/m² treatment accumulated significantly more total dry matter (TDM, Fig. 2) and leaf area (LA, Fig. 3) than plants in the 22 seed/m² treatment at 52 DAP in 1992 and 42 and 55 DAP in 1993. Plants in the 8 seed/m² treatment were larger by as much as twofold than plants in the 22 seed/m² treatment at 52 DAP in 1992 and 55 DAP in 1993. On a unit ground area basis, however, the 22 seed/m² treatment produced significantly greater TDM and LA than the 8 seed/m² seeding during the same period. Plants in the low seeding rate treatment had, therefore, not fully compensated during the earliest two measurements.

Plants in the low seeding treatments continued to adjust to low plant population by growing at a faster rate throughout both growing seasons. At 70 DAP in 1992 and 75 DAP in 1993, all seeding treatments within each cultivar accumulated equivalent amounts of TDM on a unit ground area basis. At this stage, individual plants in the 8 seed/m² treatment accumulated 2 to 2.7 times as much TDM as plants in the 22 seed/m². This compensation occurred by the time plants began forming measurable amounts of pods at 70 DAP in 1992 and 75 DAP in 1993.

By the end of the season, plants in the 8 seed/m² seeding produced 2.4 to 3.1 times as much TDM and LA/plant as plants in the 22 seed/m² seeding. On a unit ground area basis, the 8 seed/m² treatment produced significantly greater TDM and LA than the 22 seed/m² treatment at 132 DAP in 1992 and 152 DAP in 1993.

A greater leaf area associated with high planting density is commonly believed to be an advantage over low planting density. Weeds are presumably suppressed by high plant population. However, a greater fraction of this leaf area is concentrated in the planting row. Leaves

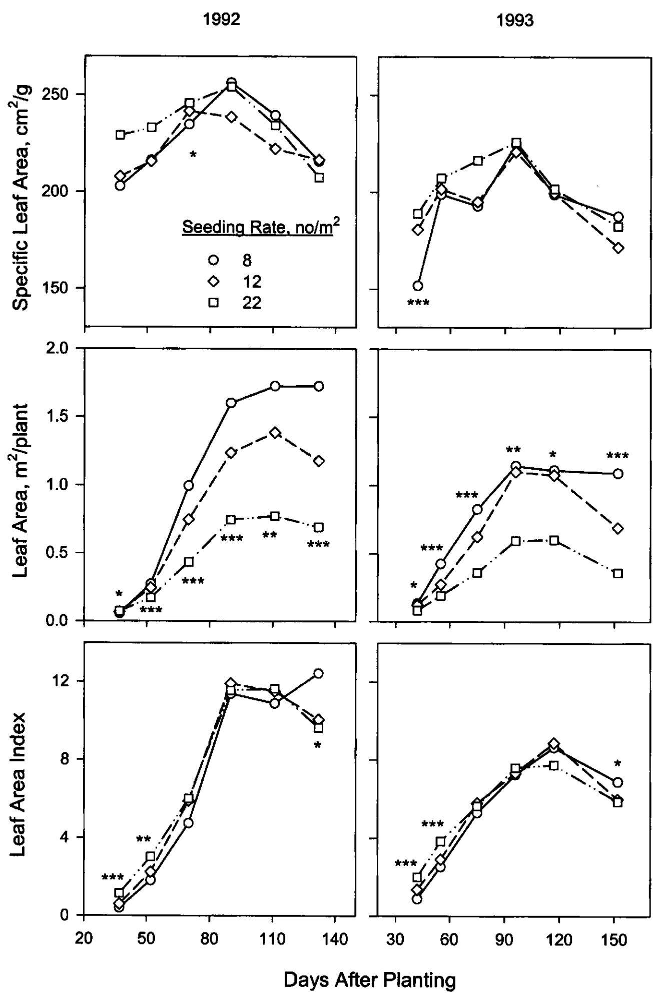

Fig. 3. Seeding rate effect on leaf area development during the growing season of peanut in Frio County, TX. *,,*** = significant at P ≤ 0.05, 0.01, 0.001, respectively.**

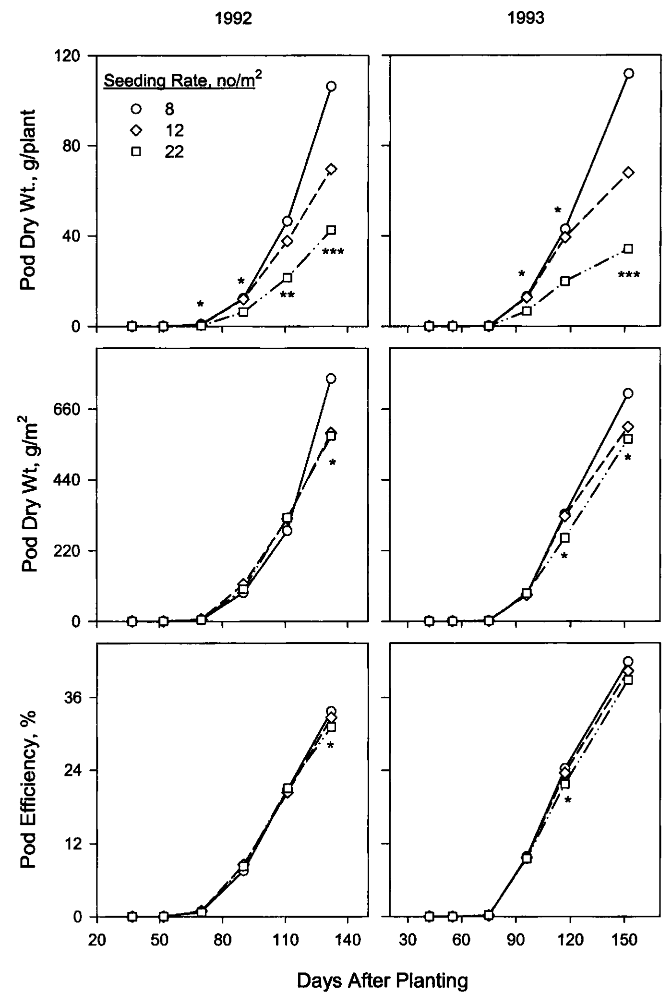

Fig. 4. Seeding rate effect on pod dry weight and pod efficiency during the growing season of peanut in Frio County, TX. *,,*** = significant at P ≤ 0.05, 0.01, 0.001, respectively.**

are not evenly spread across the rows and, therefore, the weed suppressing differences between the high and low seeding densities may not be as great as their differences in leaf area. Furthermore, herbicides are used in virtually all irrigated peanut production. The differences in LAI between the low and high densities disappeared fairly early in the season, and it may not be necessary to plant at high densities in order to suppress weeds.

Pod Production. Plants had measurable amounts of pods 70 DAP in 1992 and 75 DAP in 1993 and continued to produce pods throughout the seasons at different rates depending on the seeding rate (Fig. 4). The 8 seed/m² seeding treatment produced significantly greater pod dry weight (PDW) per plant than the 22 seed/m² seeding treatment 70 DAP in 1992 and 96 DAP in 1993. Unlike TDM and LAI, PDW on a unit ground area basis was never greater for the 22 than the 8 seed/m² seeding at any time during either season. By the time pods began forming, plants had fully compensated for low seeding rate with respect to TDM and LA. Individual plants in the low seeding rate treatment accumulated PDW at a greater rate than the high seeding rate. At the last sample date (132 DAP in 1992 and 152 DAP in 1993), the 8 seed/m² seeding treatment produced as much as 30% more PDW/m² than the 22 seed/m² treatment.

Our results show that these runner peanut cultivars grow larger and produce more pods to compensate for reduced seeding rate. As a result, pod yield was not reduced when the seeding rate was reduced from 22 to 8 seed/m² (Tewolde *et al.*, 2002). In some situations, reducing the seeding rate may benefit pod yield, because diseases such as southern blight, can be less severe with lower plant density (Black *et al.*, 2001).

Dry Matter Partitioning. Reduced seeding rate altered dry weight partitioning to different plant parts. The strongest response was the partitioning of greater dry weight to leaves than to stems early in the season before fruiting. Plants in the 8 seed/m² treatment had significantly greater leaf-to-stem (L:S) dry weight ratio than the plants in the 22 seed/m² treatment in the first two measurements in both years (Fig. 2). Differences among the seeding treatments were small and statistically insignificant in the remaining four measurements. The SLA in the high seeding rate also was greater than in the low seeding rate treatment during the first two or three measurements suggesting that leaves were thinner due to the high seeding rate (Fig. 3). High seeding rate in these runner cultivars apparently induces stem extension, mainly internode elongation, at least during the early stages. This effect requires plants to divert more assimilates to stems than to leaves.

Partitioning of dry weight to pods also was greater with the 8 seed/m^2 seeding rate than with the 22 seed/m^2 seeding rate (Fig. 4). The ratio of pod dry weight to that of the total dry weight (pod efficiency) was significantly greater for the 8 than the 22 seed/m^2 seeding treatment at 132 DAP in 1992 and 117 in 1993.

Our results are similar to those of Kvien and Bergmark (1987) who found that increases in plant population increased dry weight partitioning to stems and decreased partitioning to reproductive parts on plants sampled 7 to 12 d prior to harvest. Bell *et al.* (1991) found harvest index to be cultivar dependent. They found harvest index to increase with increasing plant density in two spanish cultivars which they described as very early maturing (Chico) and early maturing (McCubbin). They did not, however, find any harvest index response to plant density in two virginia-type peanut cultivars described as late (Early Bunch) and very late (Mani Pintar) maturing.

Conclusions

We evaluated the magnitude of plant growth adjustment of two runner peanut cultivars, GK-7 and Southern Runner, to reduced seeding rate when planted with precision planters. Individual plants accumulated as much as 2.4 to 3.1 total dry matter and were significantly larger when planted at 8 than at 22 seed/m^2. This adjustment for lower seeding rate and therefore wider plant-to-plant spacing occurred before plants formed any measurable amounts of pods. As a result, total pod production/m^2 was not affected and sometimes increased by reducing the seeding rate from 22 to as low as 8 seed/m^2. Our results demonstrate that runner cultivars such as GK-7 and Southern Runner are capable of growing larger and compensating for reduced seeding as low as 8 seed/m^2 when grown under conditions similar to this study.

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