



Pod Yield and Kernel Size Distribution of Peanut Produced Using Subsurface Drip Irrigation

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Published in Applied Engineering in Agriculture Vol. 17(2): 165-170 (American Society of Agricultural Engineers).

Article was submitted for review in June 2000; approved for publication by the Soil & Water Division of ASAE in October 2000.

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Abstract. Long-term yield data are essential to determine the economic feasibility of installing a subsurface drip irrigation (SDI) system for crop production. However, first year yields and associated economic returns are vital for system payment the first year. Vegetable and row crop production has been successful with SDI, but pod yield and kernel size distribution data on peanut (*Arachis hypogaea* L.) are limited especially during the installation year. Site 1 was established in 1997 on a Faceville sandy loam soil (fine, kaolinitic, thermic Typic Kandiodults) converted from native grass pasture. Site 2 was established in 1998 on a Tifton sandy loam soil (fine-loamy, kaolinitic, thermic Plinthic Kandiodults) following two years of cotton. These SDI systems include two lateral spacings (0.91 and 1.83 m) buried at 0.3 m soil depth. Site 1 had two emitter spacings (46 and 61 cm) and two irrigation levels. Site 2 had one emitter spacing (46 cm) and three irrigation levels. A nonirrigated (NI) control was included at each site. Irrigation water was applied daily based on estimated ET_o where irrigation level one (IL1) was $ET_o * Kc$, and IL2 and IL3 were 75 and 50% of IL1, respectively. Pod yield increased 38% with SDI (5433 kg ha⁻¹) compared to NI peanut (3937 kg ha⁻¹). When compared to the state average (3012 kg ha⁻¹), SDI showed a 81% pod yield increase. The percentage of jumbo kernels increased 39% at

Site 1 and 81% at Site 2 compared with NI. SDI peanut had lower quantity (75% less) of number one sized peanut kernels than NI. Overall, during the installation year, SDI had higher pod yields and larger kernel size than NI treatments. These yield data can be useful when projecting the economic feasibility of installing a SDI system and making the first year payment.

Keywords. *Arachis hypogaea* L., Irrigation, Subsurface drip, Pod yield, Kernel size distribution.

Subsurface drip irrigation (SDI) has the potential to provide consistently high yields with nonuniform precipitation while conserving soil, water, and energy. Other benefits include precise placement of water and chemicals, reduced water runoff, and soil erosion. SDI systems have the capability of frequently supplying water to the root zone while reducing the risk of cyclic water stress that is typical of other irrigation systems or nonirrigated production. Root deterioration can be minimized when using SDI systems (Radin et al., 1989). Subsurface drip systems are adaptable to variations of field shape making them an important consideration in the Southeast. However, SDI systems comprise less than 1% of the irrigated acreage in the United States (Adams Business Media, 1997). Various researchers have shown that SDI can increase crop yield and quality on tomato, *Lycopersicon esculentum*, (Bogle et al., 1989; Camp et al., 1989), cotton, *Gossypium hirsutum*, (Bucks et al., 1988; Henggeler, 1988), and corn, *Zea mays* (Mitchell, 1981; Mitchell and Sparks, 1982; Powell and Wright, 1993). Irrigation SDI laterals have been installed at 0.2 and 0.3 m soil depths (Bucks et al., 1981; Tollefson, 1985; Phene et al., 1987; Camp et al., 1989) on cotton, corn, fruits, and vegetables. Drip laterals have been spaced at 1, 2, and 3 m apart with yields decreasing as lateral spacing increases greater than 2 m (French et al., 1985; Lamm et al., 1992; Powell and Wright, 1993; Camp et al., 1997).

Bosch et al. (1992) using economic simulations reported that SDI would be more profitable for small areas (<30 ha) because of its lower per acre investment and lower pumping costs compared to fixed or towable center-pivot systems. SDI would also be preferred in irregularly sized fields where a full circle cannot be installed. Also, Bosch et al. (1998) showed that 1.83-m lateral spacing in corn-peanut rotations had the highest returns on sandy soils in Virginia-North Carolina region.

O'Brien et al. (1998) showed an economic comparison of SDI and center pivot systems for various field sizes and shapes. Economic simulations concluded that SDI net returns were equal to center pivot with field sizes of about 26 ha when growing continuous corn in western Kansas. As the field size decreased, SDI net returns increased. They also noted that results were sensitive to SDI life (less than 10 years), as well as changes in crop price and system components.

Long-term crop yield and quality are two of the most important variables required when considering the economic installation of a new irrigation system, especially SDI because of its high input cost the first year. However, first year yields and associated economic returns need to be high enough to make the first year payment. If first year net returns are negative, debt is added to future years and possibly increasing the yearly payment. Peanut pod yield and quality is associated with good crop rotation, no drought stress, and good agronomic practices. Little information is available concerning pod yield and kernel size distribution of peanut using SDI. Also, there is no information describing the possible pod yield or kernel size distribution of peanut when converting nonirrigated (NI) land to SDI with good crop rotation during the

installation year. The objectives of this study were to evaluate pod yield and seed size distribution of peanuts when converting from NI to SDI during the installation year.

Materials and Methods

During the spring of 1997, a SDI system was installed at Site 1 in a native grass pasture. Soil was a Faceville sandy loam (clayey, kaolinitic, thermic, Typic Paleudault) with 0-2% slope. Drip tube laterals were installed after tillage operations of deep sub-soiling, turning with a moldboard plow, smoothing with a field conditioner, and a rotary tiller with a bedding attachment.

Thin-wall drip tube laterals (0.34 mm thick, Python by Netafim Irrigation, Inc., Fresno, Calif.; www.netafim-usa.com) were installed with a modified ripper shank at 0.3 m below the soil surface. Treatments consisted of a nonirrigated (NI) control, two irrigation water levels with two lateral spacings, two emitter spacings, and five samples per treatment (35 plots). Drip tube laterals were spaced at 0.91 and 1.83 m and emitter spacings were spaced at 0.45 and 0.61 m. Emitter flow rate was 1.51 L h^{-1} for all lateral spacings. The laterals spaced 0.91 m apart were placed directly underneath the crop row while the laterals at 1.83-m spacing were placed in alternate crop row middles. The 0.91-m lateral spacing had two emitter spacings and two irrigation water levels while the 1.83-m lateral spacing had two emitter spacings and one irrigation water level (35 plots including NI). Each irrigation strip for the 0.91-m lateral spacing was 3.6 by 67 m. The irrigation strip for the 1.83-m lateral treatment size was 5.5 by 67 m. Individual sample size for both the 0.91-m lateral spacing and NI control was 1.83 by 12.2 m.

In 1998, a SDI system was installed at Site 2 where cotton had been planted the previous two years (crop rotations before cotton are unknown due to lack of farm records). The soil was a Tifton sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudult) with 2-5% slope. Tillage equipment used prior to drip tube lateral installation consisted of a disk harrow, moldboard plow, and field conditioner to smooth the soil surface. Drip tube laterals (0.25 mm thick, Super Typhoon, Netafim Irrigation, Inc.) were installed at about 0.3 m deep using a KMC (Kelley Manufacturing Company, Tifton, Ga.; www.kelleymfg.com) ripper-spider implement with a modified ripper shank. Site 2 had three irrigation levels, two drip tube lateral spacings, and five crop rotations replicated three times in a randomized block design (90 total plots). Drip tube laterals had the same spacing and orientation as describe in Site 1. An emitter spacing of 0.45 m was used for all of Site 2. The emitter flow rate was the same as Site 1. Only three of the five crop rotations were peanut (54 plots). Individual plots for the 0.91 m lateral spacing were 5.5 m wide by 38 m long. Individual plots of the 1.83 m lateral spacing were 9.1 m wide and 38 m long. Pod yield was determined on two middle rows (1.83 by 38 m).

Peanut variety, "Georgia Green," was planted on 16 May (Site 1) and 11 May (Site 2) with a vacuum-type planter (Monosem vacuum planter, ATI. Inc., Lenexa, Kans.; www.monosemplt.com) at about 100 kg ha^{-1} on a 0.91-m row spacing. Treatments in each respective year received the same weed, insect, and disease control management applications following standard recommendations.

Both sites were irrigated based on replacement of crop water use for peanut described by Stansell et al. (1976). Air temperature (maximum, minimum, and average), total solar radiation, and precipitation were recorded daily at each site. Daily potential evapotranspiration (ET_o) was estimated using the modified Jensen-Haise equation adjusted for local conditions. Weekly crop coefficients, K_c , were estimated by dividing the mean of estimated archived ET_o data by the peanut water use (Stansell et al., 1976) for that time period. Daily ET_o was then multiplied by the weekly K_c to estimate the daily water replacement for peanut (ET) identified as irrigation level 1 (IL1). The other two water levels are 75% (IL2) and 50% (IL3) of IL1. Length of irrigation time for each irrigation treatment was calculated daily based on estimated daily ET to apply the desired depth of water. Irrigation events were scheduled daily except when precipitation exceeded estimated ET.

Crop maturity was determined by the hull scrape method (Williams and Drexler, 1981). Yield rows were dug with a two-row inverter and combined with a two-row combine. Yield rows at Site 1 were dug and combined on 23 September and 30 September 1997, respectively. Sample rows at Site 2 were dug and combined on 16 September and 23 September 1998, respectively. Sample weights were recorded and a 4- to 7-kg sub-sample was split from the collected plot sample and shelled to determine kernel size distribution. Pod yield was based on total sample weight adjusted to 7% moisture (wet basis). Kernel size distribution was determined using screens specified in USDA grading procedures (USDA, 1993).

Data were analyzed by standard analysis of variance procedures. Least significant difference and Duncan's new multiple range test were used to show differences among means (tested at the $P = 0.05$ level of probability) when *ANOVA F*-test showed significance.

Results

1997

Irrigation of the peanuts started about 30 days after planting. Meteorological data for 1997 showed the ambient air temperatures at or slightly below normal during the growing season. Precipitation was about normal except for July and August receiving 68 and 18% of normal, respectively (GASS, 1997). Total precipitation received from planting to harvest was 418 mm. Average irrigation amounts applied on irrigation level 1 (IL1) and 2 (IL2) were 283 and 208 mm, respectively. IL2 was about 73% of IL1 instead of the 75% projected. This result was due to software and hardware malfunctions caused by improper programming during initial setup or power outages during thunderstorms.

There was no difference of pod yield between irrigation level, lateral spacing or emitter spacing except for treatment W60IL1 (0.61-m emitter spacing and 1.83-m lateral spacing, see fig. 1). This treatment (W60IL1) had lower average pod yield than the other drip tube lateral spacings probably due to an adjacent pecan tree which competed for water in two of the five samples. Peanut leaves in this treatment showed drought stress during the day even while being irrigated. When excluding the two crop competition affected samples from the data set, there was no difference for pod yield between the 0.91-m and the 1.83-m drip tube lateral spacings. Also,

there was no difference of pod yield between irrigation levels, i.e., IL1 and IL2, in the narrow drip tube lateral spacing.

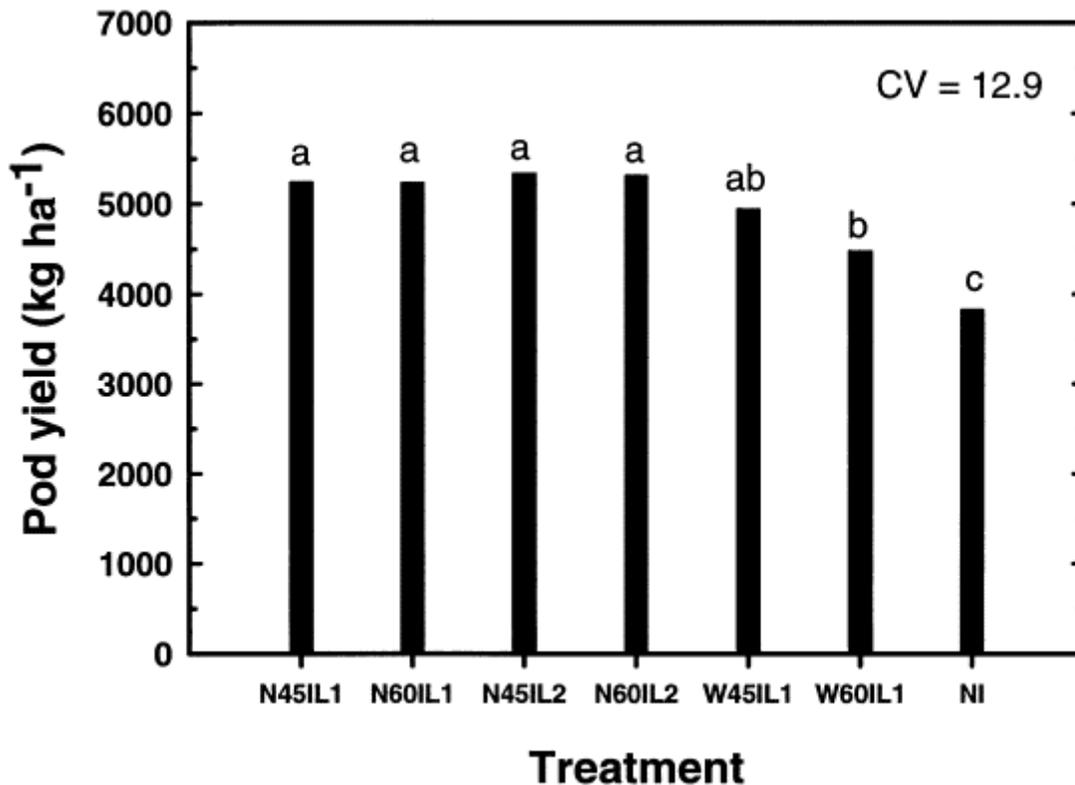


Figure 1. Pod yield vs. irrigation treatment for Site 1 (1997). Treatments are as follows, N (narrow) and W (wide) = lateral spacing of 0.91 and 1.83 m, respectively. Emitter spacings are 45 and 60 cm. Irrigation levels are IL1 (100%), IL2 (75%), and NI = nonirrigated. Treatments followed by the same letter are not significantly different at the $P = 0.05$ level based on Duncan's new multiple range test.

All drip-irrigated treatments (excluding the two samples discussed above) had 36% higher pod yield (5215 kg ha^{-1}) compared with the nonirrigated (NI) treatment (3827 kg ha^{-1}). NI treatment plots had lower yields probably due to drought during July and August. Drought during pod filling can reduce yield and quality from shriveled and aborted seeds (Pallas et al., 1979).

Average pod moisture content of drip-irrigated peanut at harvest was 19.2% moisture (w.b.). Average pod moisture for the NI peanut was 14.8% moisture (w.b.). During harvest, the drip irrigated vines and leaves were wilted but still green while the NI peanut vines were black and brittle. A precipitation event stopped harvest for a couple of days to allow the soil and crop to dry. Data were not collected to determine the quantity of vine mass between irrigated and NI treatments or digging loss during harvest. However, it was noted that during the growing season peanut leaves in the NI treatment would wilt in the afternoon during the July and August drought while the irrigated peanuts did not. Average soil temperature in the NI pod zone (0 to 5 cm)

during this drought period was 2.5 °C warmer than the drip irrigated treatments (data not shown).

There was no difference for the percentage of jumbos or number one peanut kernels among irrigation water level, lateral spacing, or emitter spacing. Drip irrigated peanuts had a higher percentage of jumbo kernels (10.7%) compared with NI peanut (7.7%). Additionally, NI peanut had a higher percentage of number one kernels (14.4%) when compared with the average drip irrigated peanut (10.7%) (table 1).

Table 1. Kernel size distribution, sound mature kernel (SMK), and other kernel (OK) for emitter spacing, lateral spacing, irrigation water level (IL), and nonirrigated (NI) treatments for Site 1 (1997).

Treatment	Shelled Kernel Parameters			Total	Total
	Jumbo (%)	Medium (%)	Ones (%)	SMK ^[a] (%)	OK ^[a] (%)
Emitter spacing (m) ^[b]					
0.45	10.8a ^[c]	38.7a	11.0a	69.9a	7.5a
0.61	11.0a	37.1a	10.3a	69.4a	7.7a
cv.	10.3	5.4	10.8	1.0	7.4
Lateral spacing (m)					
0.91	10.9a	37.9a	10.6a	69.6a	7.6a
1.83	10.4a	34.1b	11.5a	68.6a	8.0a
cv.	11.9	7.3	10.7	1.3	8.5
Irrigation level (% of ET)					
IL1 (100%)	10.8a	36.1a	11.2a	69.7a	7.8a
IL2 (75%)	10.6a	37.6a	10.3a	69.6a	7.5a
NI	7.7b	35.6b	14.4b	70.2b	7.1a
cv.	15.6	7.0	14.9	1.4	8.9
^[a] SMK = sound mature kernels; OK = other kernels.					
^[b] 1 m = 3.28 ft.					
^[c] Within columns, means followed by the same letter are not significantly different at the LSD 0.05 probability level.					

1998

Water application through the drip system was initiated about 30 days after planting depending on rainfall patterns. Mean air temperatures were about 107% of normal and precipitation was 22% of normal during June (normal = 25.7 °C and 125 mm, respectively; GASS, 1997) while the rest of the growing season had about average monthly temperatures and rainfall (GASS, 1997). Total rainfall measured onsite April through September was 850 mm that was about 50 mm less than estimated ET_o . With ET_o nearly equal to precipitation, it implies the crop would not need large amounts of irrigation, however, precipitation events were associated with strong tropical storms that accumulated $> 25 \text{ mm d}^{-1}$ on 11 occasions and $> 50 \text{ mm d}^{-1}$ on six occasions with one event accumulating 140 mm d^{-1} . Precipitation received between these storms was not equal to estimated crop water use, thus, irrigation water was needed and applied. Total water applied to IL1 was 243 mm while IL2 and IL3 received 183 and 117 mm, respectively. The SDI system functioned quite well the first year without major problems. Irrigation treatments IL2 and IL3 received 75 and 48% of the water applied to IL1 indicating that program algorithms and controls functioned properly during the irrigation season.

There was no difference between pod yield and kernel size distribution for irrigation water level or drip tube spacing. However, there were differences between these yield parameters when comparing SDI with NI (table 2). Pod yield for SDI averaged 5680 kg ha^{-1} while NI plots averaged 4048 kg ha^{-1} (fig. 2). Kernel size distribution for SDI had higher percentage of jumbo kernels (20.3%) than the NI treatment (11.2%). Additionally, SDI had lower percentage of medium and number one kernels (39.5 and 5.7%) compared to the NI plots (44.7 and 8.1%).

Table 2. Kernel size distribution, sound mature kernel (SMK), and other kernel (OK) for lateral spacing, irrigation water level (IL), and nonirrigated (NI) treatments for Site 2 (1998)

Treatment	Shelled Kernel Parameters			Total	Total
	Jumbo (%)	Medium (%)	Ones (%)	SMK ^[a] (%)	OK ^[a] (%)
Lateral spacing (m) ^[b]					
0.91	20.3a ^[c]	39.6a	5.8a	72.3a	4.3a
1.83	20.2a	39.5a	5.9a	72.3a	4.3a
cv.	14.3	5.7	14.5	1.0	10.8
Irrigation level (% of ET_o)					
IL1 (100%)	20.9a	39.9a	5.8a	72.6a	4.2a
IL2 (75%)	19.7a	39.9a	6.0a	72.1a	4.5a
IL3 (50%)	20.2a	38.9a	5.8a	72.2a	4.2a
NI	11.2b	44.7b	8.1b	68.8b	7.6b
^[a] SMK = sound mature kernels; OK = other kernels.					
^[b] 1 m = 3.28 ft.					
^[c] Within columns, means followed by the same letter are not significantly different at the LSD					

0.05 probability level.

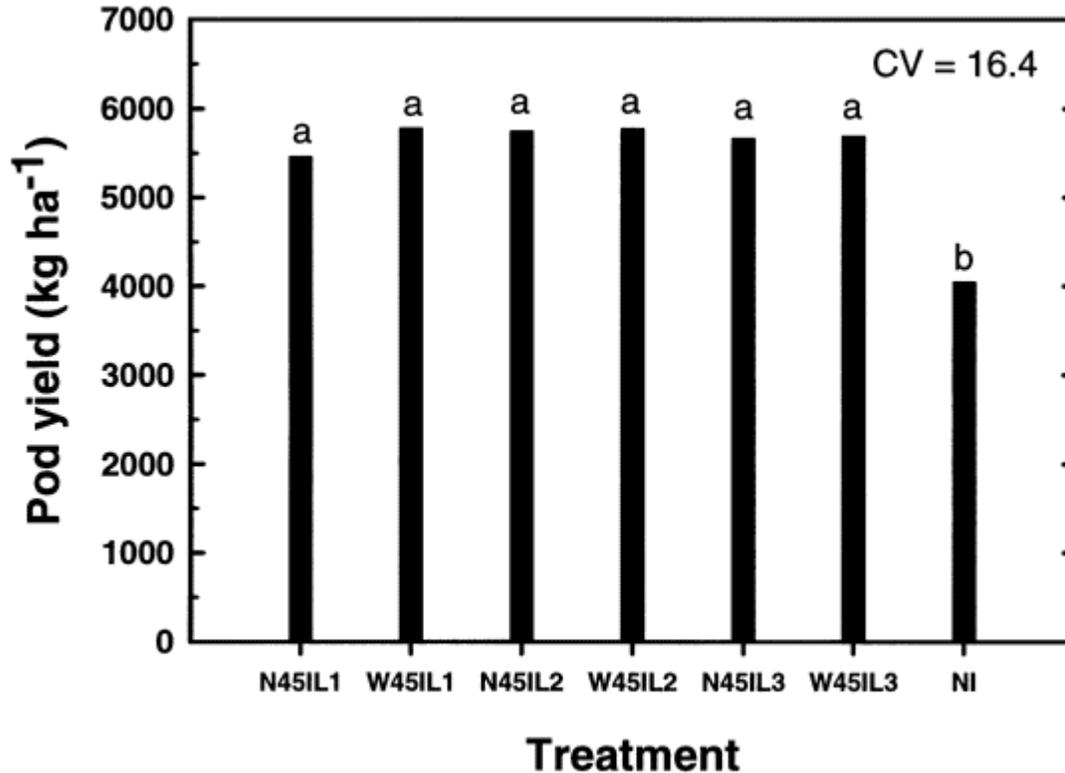


Figure 2. Pod yield vs. irrigation treatment for Site 2 (1998). Treatments are as follows, N (narrow) and W (wide) = lateral spacing of 0.91 and 1.83 m, respectively. The emitter spacing was 45 cm for all treatments. Irrigation levels were IL1 (100%), IL2 (75%), IL3 (50%), and NI = nonirrigated. Treatments followed by the same letter are not significantly different at the $P = 0.05$ level based on Duncan's new multiple range test.

Discussion

Crop yield and quality are two major economic variables used to determine the feasibility of installing a new irrigation system. Collected data from these two sites indicate that SDI increased pod yield about 38% when compared to NI peanut. When compared to the state average pod yield of 3012 kg ha⁻¹ SDI showed a 74% yield increase. Lamb et al. (1997) showed that the average nonirrigated pod yield over an eight-year period was 2963 kg ha⁻¹. In this same report, Lamb et al. (1997) showed that the average irrigated pod yield was 3533 kg ha⁻¹. Therefore using the state average (GASS, 1997) for comparison is applicable. A comparison of the irrigated pod yield shows that SDI had a 54% increase, however, long-term SDI yield data are not available to determine consistency over time. Pod yields on the NI treatment were higher than the state average can be explained by a good crop rotation. Peanut pod yield typically increases as the length of time between peanut crop increases. Also peanut pod yield is higher following a grass crop.

There was no difference of jumbo kernels between drip tube lateral spacing or emitter spacing (Site 1 only). SDI increased the quantity of jumbo kernels an average of 60% for both sites when compared to NI. Site 2 had a maximum of 80% more jumbo kernels with SDI than with NI. Lamb et al. (1997) showed that nonirrigated peanut had an average 15.2% jumbo kernels while irrigated areas had 17.2%. Drip irrigated treatments had consistently higher percentage of jumbo kernels than nonirrigated treatments. However, only in 1998 were the SDI jumbo kernels higher than the average described by Lamb et al. (1997).

At Site 1 (1997) there were more mediums in the narrow lateral spacing than the wide lateral spacing. However, at Site 2 (1998) there was no difference for quantity of medium kernels between lateral spacings. Since the medium kernel percentage did not always increase when using SDI, it is still unknown if wider drip tube spacings affects kernel size distribution for this size kernel.

Conclusions

There was no difference in pod yield or kernel size distribution between irrigation water level, lateral spacing, or emitter spacing. Irrigated peanut pod yield had an average 38% increase over NI peanut with good crop rotation. Also, SDI kernels had more jumbo kernels (60%) and less number ones (75%) than NI peanut. More research is required to confirm the proper water requirements needed for best pod yield and kernel distribution using an SDI system. Also, more data are required to determine proper crop rotations for best long-term yield values and crop quality for SDI systems. When converting cropland to subsurface drip irrigation regime in the Southeast, land operators can expect higher pod yield and larger kernel size than with nonirrigated land. These yield data can be useful when projecting the economic feasibility of installing a SDI system and making the first year payment.

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