Comparison of Peanut Yield, Quality, and Net Returns Between Nonirrigated and Irrigated Production

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ABSTRACT

Peanut yield, quality, and net return to irrigation were analyzed from commercial peanut fields in the southeastern U.S. during the 1987 through 1994 crop years. The average amount of irrigation water applied ranged from 2.51 to 28.22 cm/ha. Yields in the irrigated peanut fields averaged 569 kg/ha higher than in the nonirrigated fields. Means for farmer stock grade, jumbo shelling outturn, and seed germination also were significantly higher in the irrigated fields. Conversely, aflatoxin contamination was 140 ppb lower in the nonedible oil stock category from the irrigated fields. Yearly comparisons were made to examine significant differences in irrigation associated peanut yield and quality changes in individual crop years as well as across year comparisons for nonirrigated and irrigated practices. The net return for irrigation was examined at the quota support price, weighted average farmer stock price, and contract additional price. Average net return over total irrigation cost were $236.99, $149.22, and -$22.64 per ha, respectively.

Key Words: Aflatoxin, germination, grade, jumbos, peanut.

Approximately 195,615 ha of peanuts (*Arachis hypogaea* L.) are irrigated in the southeastern U.S. The percentage of irrigation has increased from less than 10% in the 1970s to over 49% in the 1990s (1). However, peanut yields in the southeastern region declined during the 1980s and early 1990s as compared to the decade of the 1970s. Important requirements for maximum peanut production include proper soil and climatic conditions, crop rotation, land preparation and planting conditions, fertilization, variety selection, weed and pest control, growth regulation, and adequate rainfall or irrigation (3,9,10,12,18). Each of these requirements must be managed effectively to provide maximum peanut yields (9). Changes in weather patterns (mainly higher ambient temperatures, reduced precipitation during the growing season, and more frequent drought occurrences) also have been observed over the periods of declining peanut yields (11,14). The decline in peanut yield was observed for both nonirrigated as well as irrigated peanut production (2,14).

Due to the increases in irrigated peanut hectares, declining peanut yields, and the relative high value of peanuts, research efforts have addressed irrigation management in peanuts with respect to optimal timing and amount of irrigation application. Much of this research focused on the response of peanut yield and quality to water at various stages of plant growth and development (4,6,15). The objectives of these research efforts were to maximize peanut yields by determining optimal irrigation input with little or no economic considerations. Lamb found significant differences in optimal irrigation amounts for maximizing peanut yield and profits, with peanut price also an important consideration for the optimal amount of irrigation water applied to the crop (13).

Although the above listed studies addressed potential peanut yield and quality in relatively small research plots, the effects of irrigation on peanut in commercial peanut fields are less well understood. Limited water, irrigation, and labor resources combined with competition from other crops (corn, cotton, etc.) for such resources can prevent irrigation applications for maximizing yield and quality. The objective of this research was to determine the effectiveness of irrigation on peanut yield, quality, and economic returns in commercial peanut fields in the southeastern peanut production region. Experiments were conducted during the 1987 through 1994 crop years.

Materials and Methods

The data for the analysis were gathered from a geographically diverse cross-section of the southeastern peanut-producing region based on the delivery of farmer stock peanuts. Beginning in crop year 1987, data gathering was initiated in nonirrigated and irrigated commercial peanut fields. Based on preplant interviews with cooperating farmers, historical cropping practices and field production records were obtained. Preplant tillage practices, chemical applications and incorporation methods, peanut variety, planting conditions, and similar factors were obtained at planting. After planting, weekly visits by trained field scouts provided data on plant growth and fruit development, rainfall and irrigation, maximum and minimum geocarposphere temperatures (5.08 cm depth), pest pressure, and postplant cultural practices. Fields were monitored weekly until harvest. Scouts made no recommendations to farmers. All peanut loads from each field were officially graded by the USDA-AMS-Federal State Inspection Service and marketed through commercial marketing facilities to provide yield and grade data. Samples (2268 g) were obtained at the buying point station and evaluated for shelling outturns, seed germination, and presence of aflatoxin. Means of variables were compared using a least square means procedure (LSMEAN) (16). The hypothesis formulated by the LSMEAN procedure to test mean differences is specified as:

$$\text{Ho: } LSMEAN_i = LSMEAN_j \qquad \text{[Eq. 1]}$$

$$\text{Ha: } LSMEAN_i \neq LSMEAN_j, \qquad \text{[Eq. 2]}$$

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where:

i = mean of variables from nonirrigated fields,
j = mean of variables from irrigated fields, and
$i \neq j$.

Data on the cost of irrigating peanuts were available in most crop enterprise budgets and related publications for various types of irrigation systems. Irrigation costs were divided into two categories: fixed and variable costs. Variable costs included labor, fuel, operating interest, and repairs were estimated at $6.32/ha/cm of water applied. Fixed costs for irrigation equipment, land preparation, pipe, and power units were estimated at $172.84/ha (8).

The peanut prices used to examine the economic return of irrigation were separated into three categories: quota support price, contract additional price, and the average price of farmer stock peanuts in the Southeast during each respective year (17). Further, the net return to irrigation was provided over variable and total costs. Appropriate adjustments to the calculated value per hectare were based on farmer stock grade as determined by the official Federal-State Inspection Service grade sheet. The following function was specified to analyze the net return for irrigation within a particular year:

$$R = \Sigma_i \Sigma_j \; [(P_j Y_j - P_i Y_i) - rX_j - Fx_j] n_{ij}^{-1} \qquad \text{[Eq. 3]}$$

where:

R is the per hectare return to irrigation in peanuts,
i denotes nonirrigated peanut fields,
j denotes irrigated peanut fields,
n denotes the number of fields in the survey in a given year (n = i + j),
P is peanut price [P = f (market price, farmer stock grade)],
Y is peanut yield,
r is variable cost of applying irrigation water,
X is the amount of irrigation water applied, and
FX is the fixed cost associated with irrigation investment.

To estimate the net returns to irrigation over the survey period, the following function was specified:

$$R = \Sigma_i \Sigma_j \Sigma_k \; \{[(P_{jk} Y_{jk} - P_{ik} Y_{ik}) - rX_{jk} - Fx_{jk}] N_{ijk}^{-1}\} \qquad \text{[Eq. 4]}$$

where:

k denotes crop year,
N denotes the total number of fields in the survey (N = ik + jk), and
all other variables are previously defined.

Results and Discussion

Peanut Yield and Quality. Nonirrigated and irrigated peanut yield and quality means, standard deviations, and ranges are summarized in Table 1. Over the 1987 through 1994 period, significant ($P < 0.05$) differences in irrigated peanut yield and quality were obtained. Irrigated peanut yields averaged 569 kg/ha higher than nonirrigated yields. The irrigation-associated increases in farmer stock grade, jumbos, and germination also were significant ($P = 0.05$) at 2.3, 2.0, and 6.0%, respectively. Aflatoxin in the nonedible oil stock category was significantly ($P = 0.05$) reduced by approximately 140 ppb in the irrigated fields. It should be noted that aflatoxin measurement in the oil stock category was comprised of nonedible peanuts, and this category typically contains higher levels of aflatoxin than edible peanuts. The variation associated with all treatments used were reduced in the irrigated peanuts (Table 1).

Table 1. Nonirrigated and irrigated means, number of observations, standard deviations, and ranges for peanut yield, grade, jumbos, germination, and aflatoxin in the Southeast, 1987-1994.

Variable	Unit	Nonirrigated[a]	Irrigated
Yield	kg/ha	2964 a	3533 b
	N	539	415
	SD	1002	830
	RANGE	0-6028	311-5674
Farmer stock grade	%	71.0 a	73.3 b
	N	352	276
	SD	5.5	4.1
	RANGE	52-80	56-81
Jumbos	%	15.2 a	17.2 b
	N	249	200
	SD	7.3	7.2
	RANGE	1.2-38.2	2.8-39.6
Germination	%	75.7 a	81.7 b
	N	249	200
	SD	15.8	10.7
	RANGE	22.0-96.0	26.0-95.0
Aflatoxin	PPB:OS	180.2 a	40.4 b
	N	249	200
	SD	807.9	273.3
	RANGE	0-6200.0	0-3700.0

[a]Means followed by the same letter are not significantly different at P = 0.05 within rows.

Irrigated peanut yields were significantly higher than the nonirrigated yields in 5 of the 8 yr in the survey (Table 2). The 3 yr in which the means were not significantly different (1989, 1991, 1994) had limited amounts of supplemental water supplied through irrigation due to more consistent rainfall during the growing season (Table 3). Yields in the irrigated fields were significantly different ($P = 0.05$) in only 2 of the 8 yr as compared to 4 of 8 yr in the nonirrigated fields, thus indicating a stabilizing effect of irrigation (Table 2).

In crop years 1988 and 1989 samples were not obtained for aflatoxin evaluation. Contamination of peanut in drought years is evidenced by crop years 1990 and 1993 (Table 4). Although the irrigated fields had significantly lower aflatoxin levels in the crop years 1990 and 1993, contamination levels in the oil stock category were

Table 2. Nonirrigated and irrigated peanut yield means and number of observations, 1987-1994.

Crop year	Yield[a]			
	Nonirrigated		Irrigated	
	n_i	kg/ha	n_j	kg/ha
1987	21	2834 a,A	19	3533 a,B
1988	28	3051 ab,A	25	3610 a,B
1989	40	3639 c,A	34	3776 a,A
1990	26	1706 d,A	25	2966 b,B
1991	60	3288 b,A	43	3606 a,A
1992	95	3355 bc,A	73	3815 a,B
1993	137	2245 e,A	99	3184 b,B
1994	132	3549 bc,A	97	3629 a,A

[a]Means followed by the same lower-case letter are not significantly different at P = 0.05 within columns and means followed by the same upper-case letter are not significantly different at P = 0.05 within rows.

Table 3. Average irrigated application amount (cm), variable cost for irrigation ($/ha), and total cost for irrigation ($/ha), 1987-1994.

Crop year	Avg irrigation amount	Costs for irrigation	
		Variable	Total
	cm	$/ha	$/ha
1987	28.24	178.48	351.32
1988	13.86	87.60	260.44
1989	7.86	49.68	222.52
1990	26.04	164.57	337.41
1991	7.71	48.73	221.57
1992	13.12	82.92	255.76
1993	26.37	166.66	339.50
1994	2.51	15.86	188.70

Table 4. Nonirrigated and irrigated aflatoxin level means in ppb in the oil stock category and number of observations, 1987-1994.

Crop year	Aflatoxin level[a]			
	Nonirrigated		Irrigated	
	n_i	ppb	n_j	ppb
1987	14	4.9 a,A	12	2.8 a,A
1988	0	NA	0	NA
1989	0	NA	0	NA
1990	17	811.0 b,A	15	144.9 b,B
1991	41	20.6 a,A	28	4.7 a,A
1992	44	8.1 a,A	32	12.6 a,A
1993	72	511.2 c,A	60	109.4 b,B
1994	61	4.3 a,A	53	3.7 a,A

[a]Means followed by the same lower-case letter are not significantly different at P = 0.05 within columns and means followed by the same upper-case letter are not significantly different at P = 0.05 within rows.

still significantly higher (P = 0.05) in the irrigated fields when compared to other years. This indicates that, while supplemental irrigation is effective in reducing aflatoxin levels in drought years, lack of capacity to adequately irrigate peanuts can contribute to aflatoxin levels in oil stock. However, the data and previous studies indicate that proper irrigation management will eliminate aflatoxin in peanut during drought years (5,7).

Farmer stock grade was significantly higher (P = 0.05) 4 of the 8 yr in the irrigated fields (Table 5). The effects of the crop years 1990 and 1993 droughts were evident as jumbo outturn were significantly reduced (P = 0.05) in the nonirrigated fields (Table 6). In crop years 1990 and 1993 significant differences (P = 0.05) were found for seed germination (Table 7). In these years, germination in the nonirrigated fields were well below acceptable levels (54.8 and 71.4%, respectively). Careful selection of seed lots during drought years is vitally important to maintaining seed quality for the next crop year.

Table 5. Nonirrigated and irrigated farmer stock grade (smk+ss) means and number of observations, 1987-1994.

Crop year	Farmer stock grade[a]			
	Nonirrigated		Irrigated	
	n_i	%	n_j	%
1987	16	65.3 a,A	14	70.5 ab,B
1988	19	70.5 b,A	15	74.3 cdB
1989	40	76.1 c,A	34	75.6 de,A
1990	18	66.7 a,A	17	69.6 a,B
1991	49	71.0 b,A	31	72.8 bc,A
1992	59	70.9 b,A	43	72.5 bc,A
1993	79	69.5 b,A	62	72.6 bc,B
1994	72	77.9 c,A	60	77.7 e,A

[a]Means followed by the same lower-case letter are not significantly different at P = 0.05 within columns and means followed by the same upper-case letter are not significantly different at P = 0.05 within rows.

Table 6. Nonirrigated and irrigated jumbo outturn means and number of observations, 1987-1994.

Crop year	Jumbo outturn[a]			
	Nonirrigated		Irrigated	
	n_i	%	n_j	%
1987	14	10.5 a,A	12	13.4 a,A
1988	0	NA	0	NA
1989	0	NA	0	NA
1990	17	13.1 ab,A	15	20.7 c,B
1991	41	11.7 a,A	28	13.7 a,A
1992	44	16.9 bc,A	32	18.4 bc,A
1993	72	12.3 a,A	60	15.5 ab,B
1994	61	19.1 c,A	53	19.1 c,A

[a]Means followed by the same lower-case letter are not significantly different at P = 0.05 within columns and means followed by the same upper-case letter are not significantly different at P = 0.05 within rows.

Table 7. Nonirrigated and irrigated seed germination means and number of observations, 1987-1994.

Crop year	Germination[a]			
	Nonirrigated		Irrigated	
	n_i	%	n_j	%
1987	14	88.8 a,A	12	91.7 a,A
1988	0	NA	0	NA
1989	0	NA	0	NA
1990	17	54.8b,A	15	75.8 b,B
1991	41	80.9 a,A	28	85.0 a,A
1992	44	82.8 a,A	32	85.3 a,A
1993	72	71.4 c,A	60	76.8 b,B
1994	61	80.4 a,A	53	84.7 a,A

[a]Means followed by the same lower-case letter are not significantly different at P = 0.05 within columns and means followed by the same upper-case letter are not significantly different at P = 0.05 within rows.

Economic Feasibility of Peanut Irrigation. Although increases in peanut yield and quality from irrigation are of prime importance, investment and application cost, peanut quality mandates, risk reduction, and the increase in gross revenue from irrigation will dictate future investment in irrigation resources. Table 3 contains the average amount of supplemental irrigation applied by crop year and the variable and total cost of applying the irrigation water. The yearly average irrigation application amounts ranged from 2.51 to 28.24 cm, with variable cost ranging from $15.86 to $178.48/ha. Total cost ranged from $188.70 to $351.32/ha.

The economic returns to irrigation over variable and total costs were analyzed over three separate peanut prices for each crop year: (a) quota support price, (b) average price received by farmers, and (c) contract additional peanut price. Table 8 contains the data for economic returns at the quota support price. Return over variable cost averaged $351.09/ha over 8 yr while return over total cost averaged $178.25/ha. Only 2 yr received negative returns over total cost to irrigation at the quota support price.

Table 8. Increased gross revenue and net return to irrigation over variable and total cost in peanuts at the quota support price in the southeastern U.S., 1987-1994.

Crop year	Increased gross revenue	Net return to irrigation	
		Over variable cost	Over total cost
	$/ha	------- $/ha -------	
1987	584.04	405.56	232.72
1988	464.18	376.58	203.74
1989	82.88	33.20	-139.64
1990	948.72	784.15	611.31
1991	268.25	219.52	46.68
1992	382.26	299.34	126.50
1993	780.39	613.73	440.89
1994	92.49	76.63	-96.21

The average price received by farmers reflects a weighted average price of quota and additional marketings each year (17). Return to irrigation over variable and total cost averaged $263.33 and $90.49/ha at the weighted average price, respectively (Table 9). At the weighted average selling price 3 of 8 yr reflected negative returns to irrigation over total cost.

At the contract additional peanut price, the net returns to irrigation over variable cost averaged $97.75/ha. Conversely, the average net return over total cost was negative at -$75.09/ha. The returns over total costs were negative 7 of 8 yr (over 87%).

Table 9. Increased gross revenue and net return to irrigation over variable and total cost in peanuts at the average farmer stock price in the southeastern U.S., 1987- 1994.

Crop year	Increased gross revenue	Net return to irrigation	
		Over variable cost	Over total cost
	$/ha	------- $/ha -------	
1987	444.31	265.83	92.99
1988	344.93	257.33	84.49
1989	83.10	33.42	139.42
1990	860.67	696.10	523.26
1991	189.35	140.62	-32.22
1992	298.69	215.77	42.93
1993	630.99	464.33	291.49
1994	49.12	33.26	-139.58

Table 10. Increased gross revenue and net return to irrigation over variable and total cost in peanuts at the contract additional price in the southeastern U.S., 1987-1994.

Crop year	Increased gross revenue	Net return to irrigation	
		Over variable cost	Over total cost
	$/ha	-------- $/ha --------	
1987	271.09	92.61	-80.23
1988	207.37	119.77	-53.07
1989	40.07	-9.61	-182.45
1990	437.76	273.19	100.35
1991	105.22	56.49	-116.35
1992	161.36	78.44	-94.40
1993	319.43	152.77	-20.07
1994	34.20	18.34	-154.50

Summary

The data indicate significant increases in peanut yield, quality, and value associated with irrigated peanut production. However, net return over variable and total costs depended on the price received for peanuts. Analysis of investment in irrigation cannot be limited to the returns associated with only one crop which would comprise the rotation sequence of a particular field. The yield differences and prices associated for all crops as well as expectations on future changes in yields, prices, and production cost must be incorporated. Changes in the peanut title of the new farm bill mandate a constant quota support price of $672.22/mt through the year 2002. However, other crop prices and production cost are not constant and must be considered when making investment decisions.

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