Economic Returns of Irrigated and Non-Irrigated Peanut Based Cropping Systems

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ABSTRACT

Proper crop rotation is essential to maintaining high peanut yield and quality. However, the economic considerations of sustainable cropping systems must incorporate commodity prices, production costs, and yield responses of the crops within the cropping system. Research was conducted at the USDA/ARS National Peanut Research Laboratory's Multi-crop Irrigation Research Farm in Shellman, Georgia to determine the average net returns of irrigated and non-irrigated cropping systems consisting of peanut (*Arachis hypogea* L.), cotton (*Gossypium hirsutum* L.), and corn (*Zea mays* L.). Five replicated cropping systems provided data on yield responses from irrigated and non-irrigated rotation sequences defined as: continuous peanuts (PPP), cotton/peanuts/cotton (CPC), corn/peanuts/corn (MPM), cotton/cotton/peanuts (CCP), and cotton/corn/peanuts (CMP). The peanut yield in the PPP rotation was 3300 kg/ha in the non-irrigated treatment. Non-irrigated yields in CPC and MPM rotation sequences were 3940 and 3890 kg/ha, respectively and yields in CCP and CMP rotation sequences were 4770 and 4710 kg/ha, respectively. The peanut yield in the PPP rotation was 4080 kg/ha in the irrigated treatment. Irrigated yields in CPC and MPM rotation sequences were 5280 and 5230 kg/ha, respectively and yields in CCP and CMP rotation sequences were 5940 and 6010 kg/ha, respectively. The economic returns of the cropping systems were analyzed for 3 different price level combinations. Production costs (variable and fixed) were obtained from partial budgets. Returns were defined as the 3 year average net returns of each cropping system and were calculated for each price level combination which resulted in 57 comparable average net returns for the irrigated and non-irrigated treatments. Net returns were influenced by rotation sequence, price, and irrigation.

Key Words: Crop rotation sequence, corn, cotton, net returns, irrigation.

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The farm gate value of corn, cotton, and peanut in Georgia was 63.4, 374.0, and 388.5 million dollars, respectively in crop year (CY) 2001. Total hectarage devoted to these crops in 2001 totaled 107,325, 603,450, and 208,575 with irrigated hectare accounting for 85,050, 247,050, and 101,250 in corn, cotton, and peanut, respectively (Anon., 1999; USDA, 2004). Thus, non-irrigated hectare comprised 22,275 (21%), 356,400 (59%), and 107,325 (51%) of the states hectare in corn, cotton and peanuts. Further, the majority of each crop is produced in reporting districts in Georgia (Districts 7 and 8) and they are commonly grown in crop rotation sequences together.

The Farm Security and Rural Investment Act of 2002 replaced the quota poundage system for peanuts with a new marketing loan program for peanuts. Under the 2002 farm bill, peanut, cotton, and corn (and other commodities) were assigned base hectare and production yields based on historic production. Once the base was assigned to a farm, the producer on the farm would be eligible for government payments that were based on the assigned historical base and not determined by current production. The Direct (Decoupled) Payment is a guaranteed payment to producers that is not based on current commodity prices. However, the Counter Cyclical Payment is designed to change counter to current commodity prices to stabilize farm incomes. When commodity prices are high the counter cyclical payment is reduced or eliminated and when commodity prices are low the counter cyclical payment is increased but not to exceed a pre-determined rate. Separating the direct payment and counter cyclical payment from current production mandates that planting decisions be made independent of crop base and instead based on current commodity prices. A government loan rate was also established for each commodity, which established a minimum price that producers could expect when commodities are placed in the government loan program. Crop base is not required for producers to participate in the government loan.

Important requirements for peanut production include proper soil and climatic conditions, crop rotation, land preparation and planting conditions, fertilization, variety selection, weed and pest control, and adequate rainfall or irrigation (Davidson *et al.*, 1990; Lamb *et al.*, 1997; Smith *et al.*, 2003; Wright *et al.*, 1986). Each of these requirements must be effectively managed to provide maximum peanut yields (Lamb *et al.*, 1997). However, maximum crop yields does not equal maximum economic return and while sound agronomic production practices must be followed, the elements of production costs, and crop price must be equally considered along with yield to determine cropping systems profitability. Lamb *et al.*, 1997 reported that due to the relative high value of peanuts compared to other crops and the significant capital investment of irrigation, irrigated peanuts were often grown under shorter rotation sequences than non-irrigated peanuts. The study was conducted under the now terminated supply management system where the value of quota peanuts was higher than both corn and cotton. In another study, Lamb *et al.*, 1997 illustrated the impact of price on profitability in peanut production. Returns over total cost to irrigated production in the Southeast based on the quota support price ($610), weighted average price ($460), and contract additional price ($300), were positive in 6 yrs, 4 yrs, and only 1 yr of an 8 yr study period, respectively (Lamb *et al.*, 1997). The impact of peanut and other crop prices was illustrated in a North Carolina study when peanuts valued at the contract additional (export) price were not profitable because of the high production cost (Jordan *et al.*, 2002).

The objective of this manuscript is to compare the economic profitability (defined as average net return per hectare) for five irrigated and non-irrigated cropping systems valued at different commodity price scenarios.

Materials and Methods

Experiments were conducted during the 2001–2003 crop years at the USDA-ARS Multi-crop Irrigation Research Farm in Shellman, GA (84°36′W, 30°44′N). The soil type is a Greenville fine sandy loam (fine, kaolinitic, thermic Rhodic Kandiudults) with 0–2% slope. Conventional tillage practices were followed for all crops. Prior crops on the location consisted of non-irrigated corn (1998), wheat/milo (1999), and soybeans (2000). Conventional tillage practices were followed on all treatments consisting of disking (twice), subsoiling (once), moldboard plowing (once), field cultivating (once), rototill to establish seedbeds and planting. Disease control in peanut included chlorothalonil for the first two sprays, tebuconazole for the next four applications, and chlorothalonil on the final application. Each plot consisted of 18 rows established on 0.91 m spacing. Corn (*Zea mays* L.) and cotton (*Gossypium hirsutum* L.) were planted in single rows using a Monosem 8822 single row vacuum planter while peanuts were planted in twin rows 0.18 m apart on a 0.91 m bed spacing using a Monosem 8812 twin row vacuum planter. Corn variety was Dekalb 686 planted at 6.5 seeds/m and cotton variety was Deltapine DP 458 BG/RR planted at approximately 10.5 seeds/m. Peanut variety was Georgia Green planted at 23 seeds/m. Planting dates in each of the crop years for corn, cotton, and peanuts were:

	2001	2002	2003
Corn	April 13th	March 25th	March 22nd
Cotton	May 25th	May 10th	May 9th
Peanuts	May 24th	May 9th	May 6th

Irrigation scheduling (timing and amount) in peanut was managed by the Irrigator Pro expert system (Davidson *et al.*, 1990; Davidson *et al.*, 1991, Lamb *et al.*, 1993). Irrigation scheduling for corn and cotton was managed based on the recommended water curves and application amounts schedules in the University of Georgia crop production guides for cotton and corn (Anon., 1990; Anon., 2001).

Five cropping sequences including peanut, cotton, and corn were addressed consisting of:

Rotation	Identifier	2001	2002	2003
Continuous peanut	(PPP)	Peanut	Peanut	Peanut
Cotton, Peanut, Cotton	(CPC)	Cotton	Peanut	Cotton
Corn, Peanut, Corn	(MPM)	Corn	Peanut	Corn
Cotton, Corn, Peanut	(CMP)	Cotton	Corn	Peanut
Cotton, Cotton, Peanut	(CCP)	Cotton	Cotton	Peanut

A randomized block design was used to compare sprinkler irrigation with a non-irrigated control during the 2001–003 crop years with three replications of each rotation sequence.

Net returns per hectare and cropping systems returns were calculated for non-irrigated and irrigated production. Three price levels for corn, cotton, and peanut were defined as low, medium, and high. The Farm Security and Rural Investment Act of 2002 established a loan price for corn, cotton, and peanut which provided a minimum price for each commodity even in periods of depressed commodity prices. Thus, the loan rate prices define the low prices for corn ($1.98/bu), cotton ($0.52/lb), and peanuts ($355.98/M). The

Table 1. Rainfall and irrigation for peanuts, corn, and cotton during the 2001–2003 crop years at the Shellman Multi-crop Irrigation Research Farm.

Crop Year	Peanut		Corn		Cotton	
	Rainfall	Irrigation	Rainfall	Irrigation	Rainfall	Irrigation
	mm					
2001	528	183	404	289	546	256
2002	439	188	338	378	442	282
2003	706	89	599	191	708	114

high price was defined as the higher of the average annual market price received by farmers during the 1990–003 period or the target price defined by The Farm Security and Rural Investment Act of 2002 for corn ($2.63/bu), cotton ($0.724/lb), and peanuts ($495.00/M). The medium price is defined as the simple average of the low and high price for each respective crop. Total production cost (variable and fixed cost) for corn, cotton, and peanut used to determine net returns were $665/ha, $1381/ha, and $1008/ha for non-irrigated and $1196/ha, $1801/ha, and $1421/ha for irrigated production cost, respectively (Smith *et al.*, 2003).

Results and Discussion

Rainfall and irrigation applied during the 2001–003 growing seasons for peanut, corn, and cotton are provided in Table 1. The regions 20 yr average rainfall during the growing season is approximately 566 mm per year. Rainfall on peanut during the 2001–003 growing seasons totaled 528, 439, and 706 mm, respectively indicating that the 2001 rainfall was near normal with respect to the average rainfall while 2002 received substantially less rainfall and 2003 received higher rainfall amounts during the growing season. Total irrigation amount applied each year for peanut, corn, and cotton is also contained in Table 1. Irrigation amounts were approximately the same in 2001 and 2002 at 183 and 188 mm/ha, respectively. In 2003, the amount of irrigation applied was 89 mm/ha.

Differences in yield for peanut, corn, and cotton were affected by irrigation and crop rotation. Irrigated peanut yield in the PPP rotation was significantly increased in CY 2001 and 2002. However, due to excessive digging losses caused primarily by *Sclerotium rolfsi* and *Rhizoctonia solani* in the irrigated peanuts, the non-irrigated yield was higher in 2003 in the continuous rotation (Table 2).

Irrigated corn yield in the MPM rotation sequence was higher than non-irrigated corn yield in CY 2001 and 2003. Peanut yield during CY 2002 was also significantly increased by irrigation compared to non-irrigated. Irrigated cotton yield in the CPC rotation sequence was higher than non-irrigated cotton yield in CY 2001 however no significant differences resulted in 2003. Peanut yield during CY 2002 was also significantly increased by irrigation compared to non-irrigated in the CPC rotation sequence. In CY 2002, irrigated peanut yield following corn and cotton were significantly higher than the irrigated peanut yield following peanuts. Non-irrigated yields following corn and cotton were numerically higher than those following peanut, however, the means did not separate statistically (Table 2).

The cropping systems with 2 years out of peanut production are represented by CMP and CCP.

Table 2. Irrigated and non-irrigated Peanut (P), Cotton (C), and Corn (M) yield during crop years 2001–2003 for five different cropping systems at the USDA/ARS Shellman Irrigation Research Farm.

Cropping System	CY 2001		CY 2002		CY 2003	
	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated
	kg/ha					
PPP	3210 a	5160 b	3210 a	4080 b	4310 a	3400 b
MPM	100 a	210 b	3670 a	5280 b	150 a	210 b
CPC	660 a	1200 b	3550 a	5010 b	1000 a	1060 a
CMP	580 a	1270 b	20 a	190 b	5060 a	5650 b
CCP	690 a	1220 b	350 a	1290 b	5060 a	5820 b

Within rows for specific crop years, irrigated and non-irrigated means followed by the same letter are not significantly different (P=0.05) as determined by Duncan.

Significant yield increases in the irrigated cotton (2001), corn (2002), and peanuts (2003) resulted when compared to the respective non-irrigated yields. The same results were observed in the CCP cropping system (Table 2). Significant peanut yield increases associated with crop rotation resulted when comparing the peanut yield in 2003 from the CMP and CCP rotations to the PPP rotation in both the irrigated and non-irrigated treatments (Table 2).

For each cropping system, the 3 yr average net return per hectare was calculated for the low, medium, and high commodity price combinations utilizing the crop yield data in Table 2. This resulted in 57 comparable average net returns for the non-irrigated and irrigated systems. For comparisons, the average net returns were ranked in ascending order. The average net returns in the non-irrigated had a spread of \$514/ha across all cropping systems and price combinations with the lowest non-irrigated net return recorded in the MPM rotation sequence at low prices at −\$64/ha and the highest being the CMP at \$450/ha for the high price combinations, respectively (Table 3). The significant differences for the non-irrigated means, as determined by Fisher's Protected LSD test at $P<0.05$, for each rotation sequence by commodity price combination are contained in Table 3.

The average net returns in the irrigated treatments had a larger spread than the non-irrigated at \$996/ha. The lowest irrigated net return recorded was the PPP rotation sequence at low prices at −\$149/ha and the highest was the CMP at \$847/ha for the high price combinations, respectively. The significant differences for the irrigated means, as determined by Fisher's Protected LSD test at $P<0.05$, for each rotation sequence by commodity price combination are contained in table 4.

Although not widely utilized, farmers can utilize futures markets to minimize price risk in corn and cotton. However, futures markets do not exist in peanuts and farmers thus have very limited ability to hedge price fluctuations. Since futures markets are not commonly utilized and are absent in peanut markets, farmers are basically price takers and have little control over the price received for their crops. This necessitates the need for good rotation sequences and proper irrigation management. Comparison of the non-irrigated MPM and CPC rotations revealed that no significant differences resulted in the average net returns when tested across all price combinations ($P<0.05$). Significant differences in the average net returns did not result in the irrigated comparison for the MPM and CPC rotations either ($P<0.05$). In the MPM rotation, the average net return was \$109/ha higher in irrigated treatment compared to non-irrigated across all price combinations ($P<0.05$). In the CPC rotation, the irrigated average net returns were increased by \$119/ha compared to the non-irrigated ($P<0.05$).

In the CMP rotation, irrigation increased the average net return by \$183/ha over the non-irrigated average net return ($P<0.05$). Average net returns in the irrigated CCP rotation were \$284/ha higher than the non-irrigated returns ($P<0.05$). Within the non-irrigated treatment, no differences resulted when comparing average net return of the CMP rotation versus the CCP rotation. Similar results were found for the same irrigated comparison. Although not statistically different, negative average net returns to irrigation resulted in the PPP rotation as the irrigated returns were \$82/ha less than the non-irrigated returns.

In the non-irrigated treatments pooled across all prices, no significant differences in average net returns resulted between the PPP, MPM, CPC, CMP, and CCP cropping systems. In the irrigated treatments across all price combinations, the average net return in MPM and CPC cropping systems were \$143/ha and \$185/ha higher than the return in the PPP cropping system, respectively ($P<0.05$). In the irrigated treatments across all price combinations, the average net return in CMP and CCP cropping systems were \$321/ha and \$385/ha higher than the return in the PPP cropping system, respectively ($P<0.05$). The average net return in the CMP and CCP cropping systems were significantly higher than the MPM and CPC. Thus, under irrigated production, it is to the producer's benefit to have at least a 2 year rotation out of peanuts when returns are pooled across commodity prices.

Breakeven Yield Analysis

Breakeven yields (defined as cost of production divided by price) were estimated for non-irrigated and irrigated peanuts, cotton, and corn at low, medium, and high prices (Table 5). For the non-irrigated peanuts in the PPP cropping system, the breakeven yield of peanuts was reached in only the 3rd year of the rotation where timely rainfall was received during the growing season. The non-irrigated MPM and CPC actual yields were approximately the same as the breakeven peanut yield at low prices (difference = 20 and 101 kg/ha). The non-irrigated breakeven peanut yield at low prices was exceeded in both the CMP and CCP rotation. All non-irrigated breakeven peanut yields were exceeded at the medium and high peanut prices (Table 5). For the irrigated peanuts in the PPP cropping system, the breakeven yield of peanuts was reached only in the 1st year of the rotation at low prices.

Table 3. Average net returns for 5 non-irrigated cropping systems and low, medium, and high commodity prices.

Rank	Average Net Returns	Cropping System	Price Combinations: Maize	Peanut	Cotton	Significant Differences[1]
1	−63.58	MPM	Low	Low		a
2	−33.58	CPC		Low	Low	ab
3	−3.41	CMP	Low	Low	Low	a–c
4	3.46	CCP		Low	Low	a–d
5	23.20	PPP		Low		a–e
6	30.10	MPM	Low	Medium		a–f
7	43.39	CMP	Low	Low	Medium	a–g
8	47.62	CMP	Medium	Low	Low	a–h
9	57.03	CPC		Medium	Low	a–i
10	90.17	CMP	Low	Low	High	a–j
11	90.76	CPC		Low	Medium	a–k
12	94.42	CMP	Medium	Medium	Low	a–k
13	96.22	CCP		Low	Medium	a–l
14	97.11	MPM	Medium	Low		a–l
15	98.64	CMP	High	Low	Low	a–l
16	123.80	MPM	Low	High		a–l
17	125.68	CMP	Low	Low	Medium	a–m
18	132.69	CCP		Medium	Low	b–m
19	141.19	CMP	Medium	Low	High	b–n
20	145.44	CMP	High	Low	Medium	b–n
21	145.44	CMP	High	High	Medium	b–n
22	147.62	CPC		High	Low	b–n
23	172.45	CMP	Low	Medium	Medium	c–o
24	176.70	CMP	Medium	Medium	Low	c–o
25	181.37	CPC		Medium	Medium	c–o
26	188.98	CCP		Low	High	c–o
27	190.81	MPM	Medium	Medium		d–o
28	192.22	CMP	High	Low	High	d–o
29	215.10	CPC		Low	High	e–p
30	219.25	CMP	Low	Medium	High	f–p
31	223.50	CMP	Medium	Medium	Medium	g–p
32	225.45	CCP		Medium	Medium	g–p
33	227.73	CMP	High	Medium	Low	g–p
34	247.87	PPP		Medium		h–p
35	254.76	CMP	Low	High	Low	i–q
36	257.82	MPM	High	Low		j–q
37	261.95	CCP		High	Low	j–r
38	270.28	CMP	Medium	Medium	High	j–r
39	271.96	CPC		High	Medium	j–r
40	274.53	CMP	High	Medium	Medium	j–r
41	284.51	MPM	Medium	High		k–r
42	301.56	CMP	Low	High	Medium	k–r
43	305.71	CPC		Low	High	l–r
44	305.79	CMP	Medium	High	Low	l–r
45	318.24	CCP		Medium	High	m–r
46	321.33	CMP	High	Low	High	n–r
47	348.36	CMP	Low	High	High	n–r
48	351.52	MPM	High	Medium		n–r
49	352.59	CMP	Medium	High	Medium	n–r
50	354.71	CCP	Low	High	Medium	o–r
51	356.81	CMP	High	High	Low	o–r
52	396.30	CPC		High	High	p–r
53	398.37	PPP		High		p–r
54	399.39	CMP	Medium	High	High	p–r
55	445.22	MPM	High	High		q–r
56	447.50	CCP		High	High	r
57	450.39	CMP	High	High	High	r

[1]Means followed by the same letter are not significantly different as determined by Fisher's Protected LSD test at $P<0.05$. Note: M=Corn (maize); C=Cotton; P=Peanut.

Table 4. Average net returns for 5 irrigated cropping systems and low, medium, and high commodity prices.

Rank	Average Net Returns	Cropping System	Price Combinations			Significant Differences[1]
			Maize	Peanut	Cotton	
1	−149.62	PPP		Low		a
2	−93.63	MPM	Low	Low		ab
3	−29.97	CPC		Low	Low	a–c
4	32.57	CMP	Low	Low	Low	b–d
5	41.32	MPM	Low	Medium		b–d
6	97.98	CPC		Medium	Low	c–e
7	127.60	CMP	Low	Medium	Low	c–f
8	139.14	CMP	Low	Low	Medium	c–g
9	148.36	PPP		Medium		d–h
10	158.44	CMP	Medium	Low	Low	d–h
11	173.32	CCP	Low	Low	Low	d–i
12	176.26	MPM	Low	High		d–i
13	176.90	CMP	Low	Low	Medium	d–i
14	180.31	MPM	Medium	Low	Low	d–j
15	222.61	CMP	Low	Low	High	e–j
16	225.68	CPC		High	Low	e–j
17	253.48	CMP	Medium	Low	Medium	e–k
18	267.09	CPC		Medium	Medium	e–l
19	271.91	CMP	Low	Medium	Medium	e–m
20	284.31	CMP	High	Low	Low	f–n
21	302.75	CMP	Medium	Medium	Low	f–o
22	308.26	CPC		Low	High	g–o
23	315.23	MPM	Medium	Medium		g–p
24	319.82	CMP	Low	High	Low	h–p
25	321.87	CCP	Low	Medium	Low	h–p
26	348.49	CMP	Medium	Low	High	i–q
27	361.63	CCP		Low	Medium	j–r
28	366.92	CMP	Low	Medium	High	j–s
29	372.23	PPP		High		j–s
30	379.32	CMP	High	Low	Medium	j–t
31	395.04	CPC		High	Medium	j–t
32	397.78	CMP	Medium	Medium	Medium	j–t
33	416.22	CMP	Low	High	Medium	k–u
34	428.62	CMP	High	Medium	Low	k–u
35	436.21	CPC		Medium	High	l–u
36	447.08	CMP	Medium	High	Low	m–v
37	450.17	MPM	Medium	High		n–v
38	454.22	MPM	High	Low		n–v
39	470.43	CCP		High	Low	o–v
40	474.36	CMP	High	Low	High	o–w
41	492.79	CMP	Medium	Medium	High	p–w
42	510.16	CCP		Medium	Medium	q–x
43	511.23	CMP	Low	High	High	q–x
44	523.63	CMP	High	Medium	Medium	q–x
45	542.09	CMP	Medium	High	Medium	r–x
46	549.92	CCP		Low	High	s–y
47	564.15	CPC		High	High	t–y
48	572.93	CMP	High	High	Low	t–z
49	589.14	MPM	High	Medium		u–z
50	618.66	CMP	High	Medium	High	u–z
51	618.69	CMP	High	High	Medium	u–z
52	637.10	CMP	Medium	High	High	u–z
53	658.72	CCP		High	Medium	u–z
54	698.48	CCP		Medium	High	x–z
55	724.08	MPM	High	High		y–z
56	762.97	CMP	High	High	High	y–z
57	847.03	CCP		High	High	z

[1]Means followed by the same letter are not significantly different as determined by Fisher's Protected LSD test at $P<0.05$.
Note: M=Corn (maize); C=Cotton; P=Peanut.

Table 5. Breakeven yields for irrigated and non-irrigated peanut, cotton, and corn.

	Peanut		Cotton		Corn	
Price Level	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated
			kg/ha			
Low	3570	4590	880	1240	150	270
Medium	2940	3840	730	1040	110	190
High	2530	3300	630	890	80	150

Non-irrigated cotton yields exceeded breakeven cotton yields at low and medium prices only 20% of the time and 60% of the time at high prices. Irrigated cotton yields exceeded breakeven yields at low prices 80% of the time while breakeven yields and medium and high prices were exceeded 100% of the time. Non-irrigated corn yields never exceeded breakeven corn yields at low prices and exceeded breakevens at medium and high prices 33% and 66% of the time, respectively. Irrigated corn yields did not exceed the breakeven yields at low prices but exceeded the breakeven at medium and high prices 100% of the time.

Irrigation improves the probability that a producer will achieve their breakeven yields (including the fixed and variable costs for irrigation). Across all cropping systems at low commodity prices, the non-irrigated breakeven yields were realized 33% of the time while the irrigated breakeven yields were realized 53% of the time. At medium prices the non-irrigated breakeven yields were obtained 53% of the time and 93% for irrigated. At high prices the breakeven non-irrigated yields were obtained 80% of the time compared with 100% for the irrigated treatments.

Summary and Conclusions

Irrigation, crop rotation, and commodity prices are important factors in comparing the profitability of different peanut based cropping systems. Producers generally have very limited control over commodity prices and can be considered price takers and the price received a function of aggregate supply and demand for the commodity. Proper irrigation management and crop rotations are essential to sustaining cropping systems returns especially in periods of depressed crop prices.

Literature Cited

Anon. 1996. 1995 Irrigation survey reflects steady growth. Irrigation J. 49:24–9.

Anon. 1990. Univ. of Georgia. Growing Corn in Georgia. Tech. Bull. 547:22–28.

Anon. 2001. Univ. of Georgia. Georgia Cotton Production Guide. CSS-03-01:53–54.

Davidson, J.I., Jr., C.L. Butts, S. Parker, and C.A. Jones. 1990. EXNUT: An expert system for peanut production. ASAE Paper No. 90–7557. Amer. Soc. Agric. Eng., St. Joseph, MI.

Davidson, J.I., Jr., P.D. Blankenship, R.J. Henning, W.R. Guerke, R.D. Smith, and R.J. Cole. 1991. Geocarposphere temperature as it related to Florunner peanut production and irrigation patterns and soil temperature. Peanut Sci. 18:79–85.

Jordan, D.L., J.E. Bailey, J.S. Barnes, C.R. Bogle, S.G. Bullen, A.B. Brown, K.L. Edmisten, E.J. Dunphy, and P.D. Johnson. 2002. Yield and economic return of ten peanut-based cropping systems. Agr. J. 94:1289–1294.

Lamb, M.C., J.I. Davidson, Jr., and C.L. Butts. 1993. Peanut Yield Decline in the southeast and economically feasible solutions. Peanut Sci. 20:36–40.

Lamb, M.C., J.I. Davidson, Jr., J.W. Childre, and N.R. Martin, Jr. 1997. Comparison of peanut yield, quality, and net returns between non-irrigated and irrigated production. Peanut Sci. 245:97–101.

Smith, N.B., W.D. Shurley, W. Given, and C. Lacy. 2003. South Georgia Crop Enterprise Cost Analysis 2003. Univ. of Georgia Cooperative Extension Ser. Pub. 94-010-S:3–24.

USDA, National Agricultural Statistics Service, Agricultural Statistics. 2004. U.S Gov't. Print. Ofc. Washington, DC.

Wright, F.S., D.M. Porter, N.L. Powell, and B.B. Ross. 1986. Irrigation and tillage effects on peanut yield in Virginia. Peanut Sci. 13:89–92.