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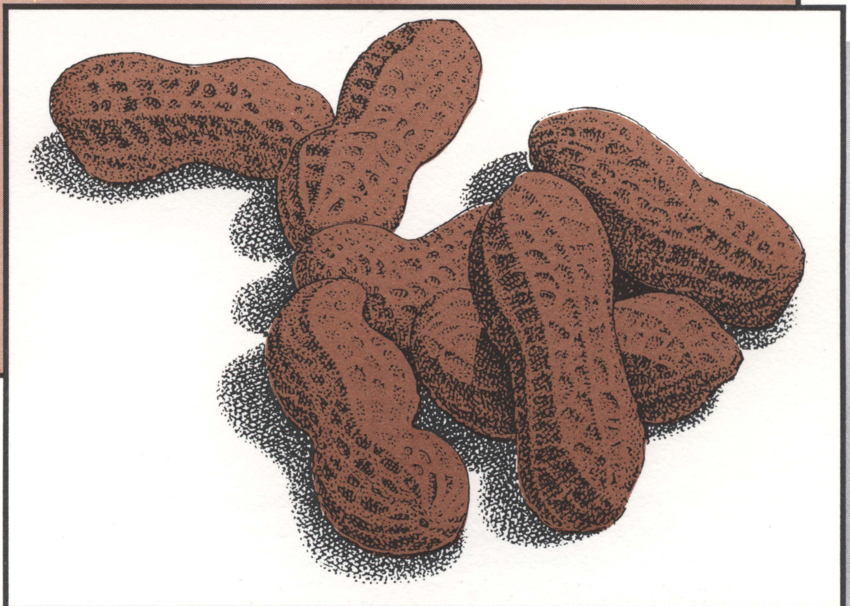

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Peanut Profits and Irrigation Yield Response in the Northern Texas High Plains, A Non-Traditional Production Area

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Summary

Investigation of surface (furrow) irrigation and timing of applications in relation to peanut yields in a non-traditional growing region, the northern Texas High Plains, indicated profitable grades and production levels of selected spanish and valencia cultivars could be attained within the area's short growing season. Irrigation rates during the growing season, which maximized profits, were nearly 26 inches for Pronto (spanish) and 23 inches for McRan (valencia). With these irrigation levels, estimated yields from multivariate water-yield response functions were 4,018 and 4,443 lb/ac, respectively. Profit-maximizing levels of seasonal irrigation were relatively insensitive to wide variations in peanut prices ($0.10 to $0.35/lb) and irrigation costs ($2 to $6/in).

Analysis of eight alternative irrigation timings (in addition to an irrigation at bloom stage) indicated an early application 21 days after planting and several mid- to late-season irrigations were significant in determining peanut yields. Moderate to heavy rainfall in September and early October would reduce yields of McRan on moderately permeable soils. Grades of Pronto were not significantly affected by the number of irrigation applications ranging from two to seven, but a moderate (four irrigations) to high (seven irrigations) number of applications were needed to assure maturity and maintain high grades of McRan.

With average rainfall, returns to management and risk were $821/ac for McRan and $673/ac for Pronto. In this case, nonquota prices would need to be about $311/ton for Pronto and $277/ton for McRan to break even with total production costs. Season-long below average monthly rainfall approaching that of the modal frequency (40 percent of average) would reduce yields about 200 lb/ac and profits by nearly $60/ac. More commonly, a monthly rainfall deficit, such as July, of 40 percent of average, would reduce Pronto yields over 90 lb/ac and McRan, over 180 lb/ac, and profits by $28 and $54/ac, respectively.

Introduction

The Texas High Plains is characterized by a relatively short frost-free season ranging from as little as 180 days in the northwest to 220 days in the south (Bonnen, 1960). The semi-arid climate of 16 to 20 inches annual rainfall requires irrigation for crops with high water requirements. Profits from irrigated crops adapted to the region have generally been declining since the mid-1970s due to high pumping costs and declining crop prices. 1989 estimates of returns to management and risk for the major irrigated crops wheat, corn, sorghum, and cotton were $20.55, $91.43, $42.81 and $9.14/ac, respectively (Texas Agricultural Extension Service 1989a and b). These narrow profit margins have renewed producer interest in alternative crops. While the region is climatically suited for producing several alternative crops, readily available markets for these crops may be limited. Also, specialized machinery and management skills may be required.

One of the more profitable crops grown in the southernmost portion of the Texas High Plains and central Texas is peanut. Estimated returns to management and risk in the High Plains range from $339/ac to $580/ac depending on the type of peanut (Texas Agricultural Extension Service, 1989a). Breakeven prices range from $326/ton for spanish peanut (used primarily for crushing) with an estimated yield of 3,500 lb/ac to $262/ton for the runner type (used for confection, roasting, and crushing) yielding 4,500 lb/ac.

Objectives

The above breakeven prices and profit levels were estimated using a high level of irrigation for peanuts. Estimates of peanut yield response to alternative levels of irrigation are needed to provide an improved economic basis for determining the maximum profit (optimum) level of irrigation. Knowledge of the most profitable timings of applications relative to physiological development and yield response is important also for efficient use of water resources. Thus, the objectives of this research were to (1) assess peanut yield response to surface (furrow) irrigation as an alternative crop in the northern Texas High Plains, and (2) evaluate the profitability of peanut production in this non-traditional short-growing-season region.

Review of Literature

Newman (1979) and Bausch et al. (1971) found that early season plant water stress delayed blooming as well as maturity, reduced vegetative growth, and resulted in lower yields. Newman indicated stress at the bloom stage at Stephenville, Texas, where the frost-free period is nearly 240 days, could delay maturity 15 percent which could be critical for some late maturing spanish and runner varieties. Hiler et al. (1970) reported frequent, light water applications were superior to infrequent, heavy applications. In further studies in 1975, when seasonal rainfall was only 35 percent of normal, Newman and Roberson (1976) found that frequent irrigations on a 4-day interval caused plant leaf yellowing as a result of excessive moisture. Average yields of 7 varieties were reduced more than 20 percent compared with the highest yielding irrigation interval of 8 days. Others have found that water stress was more critical during pod set and pod formation in contrast to stress at earlier stages of physiological development (Stansell and Pallas, 1985; An, 1978; Reddi and Reddy, 1977). Furthermore, excessive late season irrigations or rainfall, especially on heavier soils, can decrease yields (Mantell and Goldin, 1964). Peg attachments may be weakened and disease incidence may increase, resulting in higher harvesting losses through detached pods. However, if soil moisture conditions are extremely dry at harvest, the digging procedure may be more difficult (Newman, 1979).

While much of the previous research was located in areas having sufficient growing season for peanut maturity, little is known regarding attainable peanut yields and the yield response to irrigation outside traditional peanut production areas, where a relatively short growing season may influence seed quality and yields.

Methods and Procedures

The research was conducted at a farm site near the Texas Agricultural Experiment Station North Plains Research Field, Etter, Texas, on a Dalhart fine sandy loam soil (Alfisol, Aridic Haplustalf). This soil is characterized by a fine sandy loam layer from 0 to 9 inches in depth, a sandy clay of 52 inches depth, sandy clay loam to varying depths of around 6 to 7 feet, and a highly calcareous layer below. Soil permeability is moderate and available water capacity high. The soil typically has a pH ranging from 7.5 to 8.0.

Peanut irrigation research was conducted at the farm site for 4 years, 1983-1986. A randomized complete block experimental design was used to evaluate four alternative irrigation levels each year. Two peanut types, spanish and valencia, consisting of two single 40-in rows each were evaluated in two adjacent subplots in each irrigation plot. Relatively early maturing cultivars were evaluated including 'Pronto', a spanish type, and 'McRan', a valencia type. Three replications were evaluated for each of 16 irrigation treatments of each cultivar. Irrigation plots were 13 1/3 ft wide and ranged from 200 to 300 ft in length over the years. Main plots were separated by two rows of unirrigated cotton to prevent interaction of irrigation applications. Cultivar subplots were located 80 ft from the beginning of the furrow run and were 6 2/3 ft wide (two 40-in rows) by 30 ft to 36 ft in length over the years.

Planting dates were about May 20 and the seeding rate was 80 lb/ac. Prior to planting, plots were uniformly irrigated after incorporating 0.75 lb/ac trifluralin [2, 6-dinitro-N, N-dipropyl-4-(trifluoromethyl) benzamine]. Nitrogen (N) and phosphorous (P) fertilizer applications varied by year and plot location. Adequate rates were applied to prevent N and P from limiting production based on soil nutrient analysis.

Insects such as thrips were controlled as needed. No diseases were encountered, but plots were moved each year to a new location that had no history of peanut production. The preceding crop was either irrigated or dryland wheat at each location.

Irrigation treatments consisted of alternative timings and amounts on graded furrows. In 1983, two to five seasonal irrigations were applied whereas in following years five to seven irrigations were evaluated. All irrigation treatments received an irrigation at early bloom (about 42 days after planting) while other applications were varied at days after planting of 21, 56, 63, 70, 77, 84, 98, and 112. Net water applications for the growing season (excluding preplant irrigation) ranged from a low of 8 inches to a high of 29 inches. Net water application amounts were determined as the difference between gross applications measured with in-line water meters and plot runoff measured by H-flumes equipped with stage recorders. Deep percolation losses were inconsequential due to the short irrigation run and nominal net amounts measured relative to the soil water holding capacity.

Cultivar yields were obtained from 13-ft sections of the rows nearest the middle of the main irrigation plot. Plants were undercut with a blade in early October and hand-harvested. Yield samples were threshed and oven-dried. Yields were expressed as 12 percent seed moisture. Grades for irrigation treatments and cultivars were determined from composite samples of the three replications.

Yield response to varying levels of seasonal irrigation amounts, timings of application, and seasonal precipitation was analyzed by ordinary least squares (SAS, 1985). Forty-eight yield observations of each cultivar (3 replications x 16 treatments) were used in the analysis. Significant differences between grades were assessed by Duncan's multiple range test.

Results

The following discussion presents (1) two peanut water-yield response functions for Pronto and McRan, (2) water-yield response functions relating significant irrigation applications, other than at bloom, (3) quality impacts of irrigation applications on grades, and (4) economic implications regarding both the maximum profit levels of irrigation with varying water costs and peanut prices and the potential profitability of producing each of the cultivars in the northern Texas High Plains.

Water-yield Response Function, Pronto Cultivar

Yields of Pronto were significantly related to seasonal irrigation levels and rainfall variables. The following relationship explained 84 percent of the variation (R^2=0.843) in yields:

$$(1)\ YP = \underset{(-1.87)}{\underset{[348.1]}{-649.84}} + \underset{(2.32)}{\underset{[3.01]}{6.994}}\ I^2 - \underset{(-1.85)}{\underset{[0.10]}{0.1855}}\ I^3 + \underset{(2.13)}{\underset{[3.99]}{8.5036}}\ (I{*}JUN)$$

$$+ \underset{(4.04)}{\underset{[171.0]}{690.15}}\ JAS - \underset{(-2.76)}{\underset{[15.20]}{41.937}}\ (JAS)^2$$

$R^2 = 0.843$ F = 44.94 n=48

where Y_P = in-shell yield of Pronto peanut (lb/ac),
I = seasonal irrigation (in),
JUN = June precipitation (in),
I*JUN=Interaction of seasonal irrigation x June precipitation (in), and JAS = total July + August + September precipitation (in).

Brackets include standard error of the estimates and the parentheses contain the T-values of the coefficients. All regression coefficients were significant at the 4 percent level of significance or less except I^3, which was significant at the 7 percent level. The F-value was significant at $P = 0.0001$. Forty-eight observations were used (n).

Figure 1 and Table 1 indicate estimated yields (total physical product or TPP) of Pronto for seasonal irrigation levels (excluding preplant irrigation) ranging from I=0 to 30 inches. TPP was based on monthly average rainfall for a 26-year record at the North Plains Research Field, Etter, Texas. June rainfall (JUN variable) averaged 2.61 in and July + August + September rainfall (JAS variable) averaged 5.96 in.

Stages of economic production are also indicated in Figure 1. Stage I of economic production indicates the range of irrigation over which average physical product (APP) increases to a maximum. Profits are not yet maximized over this stage since APP increases as water increases. In Stage II, however, APP decreases as water increases and, at some point within Stage II, the incremental value of added product (MPP multiplied by price) becomes less than the added cost of irrigation. Thus, Stage II, ranging from where APP is maximum to maximum TPP (MPP=0), is the economically rational range of irrigation assuming profit maximization. Beyond this point in Stage III, yields decrease with additional water (Heady, 1950).

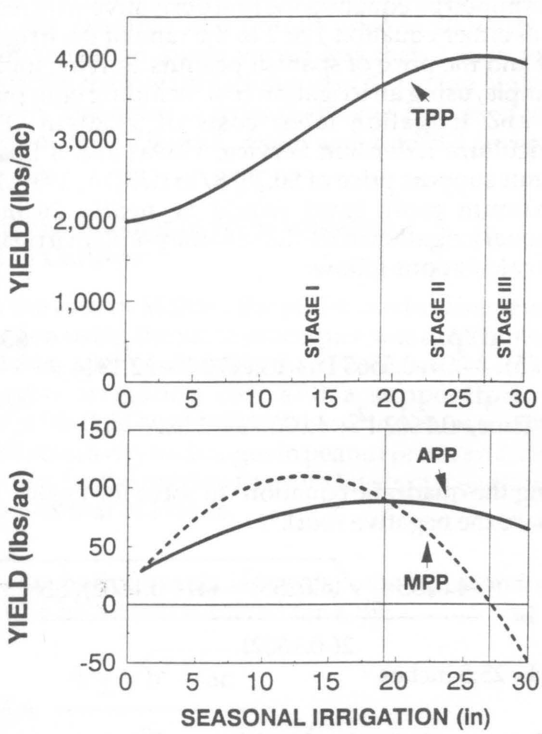

Figure 1. Pronto water-yield response function (TPP), average physical product (APP), and marginal physical product (MPP).

Table 1. Comparison of Pronto and McRan estimated yields at selected irrigation levels, average rainfall.

Seasonal irrg. level	McRan	Pronto	% McRan over Pronto
	Average Rainfall[1]		
	lb/ac		
0	2786	1974	41%
1	2795	2003	40%
2	2820	2045	38%
3	2861	2098	36%
4	2915	2163	35%
5	2981	2236	33%
6	3058	2319	32%
7	3143	2408	31%
8	3236	2504	29%
9	3335	2605	28%
10	3438	2710	27%
11	3543	2817	26%
12	3650	2927	25%
13	3756	3037	24%
14	3859	3146	23%
15	3960	3254	22%
16	4055	3359	21%
17	4143	3461	20%
18	4223	3557	19%
19	4293	3648	18%
20	4352	3731	17%
21	4397	3806	16%
22	4428	3872	14%
23	4443	3927	13%
24	4441	3970	12%
25	4418	4001	10%
26	4376	4018	9%
27	4310	4020	7%
28	4221	4006	5%
29	4106	3975	3%
30	3965	3925	1%

[1]Estimated from equations 1 and 3.

For Pronto, APP was maximum at approximately 19 inches and TPP was maximum at approximately 27 inches. Producers irrigating with less than 19 inches, in Stage I, would increase average productivity with increased water applications. If more than 27 inches of water is applied, yields would be expected to decrease as in Stage III; reducing crop income while unnecessarily increasing the cost of irrigation.

Equation 1 can be simplified to a less complex function, which may be more useful in practice, when rainfall amounts are substituted for the precipitation variables. Thus, using rainfall quantities characteristic of the northern Texas High Plains as given above, the equation becomes:

$$(2)\ Y_P = 1{,}973.78 + 22.1944\ I + 6.9936\ I^2 - 0.1855\ I^3$$

where Y_P = in-shell yield of Pronto (lb/ac) and I = seasonal irrigation (in). The influence of rainfall on yield is now included in the intercept term.

Water-yield Response Function, McRan Cultivar

Irrigation and rainfall also explained much of the yield variation for the McRan cultivar. The following function explained 83 percent of the variation (R^2=0.830) in yields:

$$(3)\ Y_M = \underset{\substack{[429.2]\\(-4.55)}}{-1{,}954.91} + \underset{\substack{[3.7]\\(2.50)}}{9.28\ I^2} - \underset{\substack{[0.12]\\(-2.09)}}{0.26\ I^3} - \underset{\substack{[0.007]\\(-3.10)}}{0.02\ (I{*}Jun)^2}$$

$$+\underset{\substack{[204.9]\\(6.01)}}{1{,}231.57\ JAS} - \underset{\substack{[17.9]\\(-4.09)}}{73.18\ (JAS)^2}$$

$R^2 = 0.830$ F = 44.94 n=48

where Y_M = in-shell yield of McRan (lb/ac) and other variables are the same as above for equation 1.

In the case of McRan, Stage II (Figure 2), begins with about 18 inches seasonal irrigation; only an inch less than Pronto. However, the end of Stage II where TPP is maximum is significantly lower at 23.5 inches compared with about 27 inches for Pronto. Estimated yields of McRan were higher than Pronto for equal irrigation quantities up to 30 inches seasonal irrigation. Thus, McRan was estimated to be superior to Pronto in irrigation water-use efficiency (yield per unit seasonal irrigation water) at irrigation levels up to 30 inches with average rainfall conditions. The effects of rainfall deficits are discussed later. Table 1 compares the estimated yields derived from equations 1 for Pronto and 3 for McRan with equivalent irrigation levels.

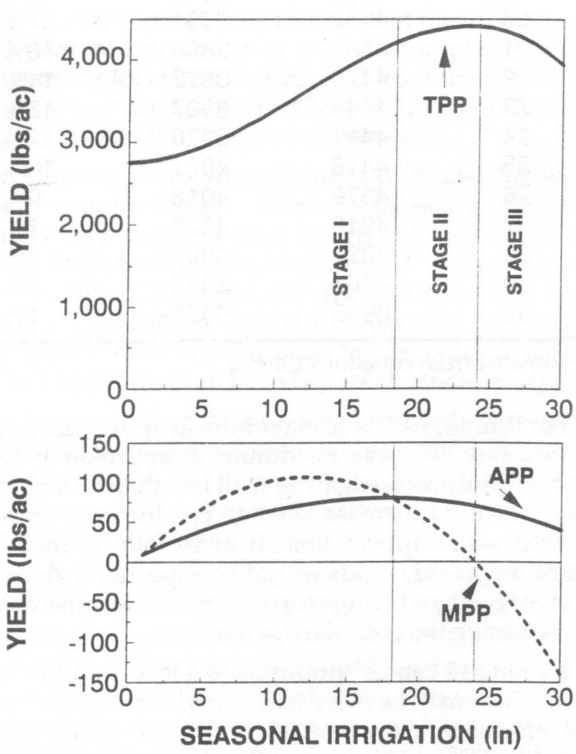

Figure 2. McRan water-yield response function (TPP), average physical product (APP), and marginal physical product (MPP).

Peanut producers with limited seasonal irrigation water supplies, as is typical of many areas in the southern High Plains, need to consider the superior water-use efficiency of McRan if a market exists for this type peanut and production costs and cultivar prices are similar. Non-traditional production areas such as the northern Texas High Plains where water supplies are generally adequate may want to consider both cultivars for production.

Equation 3 also can be simplified by substituting rainfall quantities (given above) for the precipitation variables to become:

$$(4)\ Y_M = 2{,}785.78 + 9.144\ I^2 - 0.26\ I^3$$

where Y_M = in shell yield of McRan (lb/ac), I = seasonal irrigation (in), and rainfall impacts on yield are now included in the intercept term.

Profit Maximizing Level of Irrigation for Pronto

The quantity of seasonal irrigation water which maximizes profits, holding all other inputs constant, can be determined by equating the first derivative with respect to I of either equation 1 or 2 to the ratio of the irrigation cost and the price of spanish peanuts. Solving for I, for example, using an irrigation cost including both pumping and irrigation labor costs of \$3.80/in (Texas Agriculture Extension Service, 1989a) and a Spanish peanut support price of \$0.2878/lb (USDA, 1989a), the maximum profit level would be nearly 26 inches seasonal irrigation in addition to the preplant irrigation. The calculations follow:

$$(5)\ \frac{dYp}{dI} = -0.5565\ I^2 + 13.9872\ I + 22.1944 = \frac{\$3.80}{\$0.2878}$$

Thus, $-0.1602\ I^2 + 4.0255\ I + 2.5875 = 0$

Using the quadratic equation[1] to solve for I gives (ignore the negative root):

$$I = \frac{-4.0255 \pm \sqrt{(4.0255)^2 - (4)(-0.1602)(2.5875)}}{2(-0.1602)}$$

I= 25.8 inches

Optimum irrigation levels vary with irrigation cost and peanut price. Table 2 gives optimum irrigation levels for various irrigation costs ranging from \$2 to

Table 2. Maximum profit levels of seasonal irrigation with varying peanut prices and irrigation costs, Pronto and McRan.

Irrigation cost ($/in)	Peanut Price ($/lb) 0.10	0.15	0.20	0.25	0.30	0.35
			inches			
Pronto:						
$2	25.2	25.7	25.9	26.0	26.1	26.2
$3	24.5	25.2	25.6	25.8	25.9	26.0
$4	23.7	24.7	25.2	25.5	25.7	25.8
$5	22.9	24.2	24.8	25.2	25.4	25.6
$6	21.9	23.7	24.5	24.9	25.2	25.4
McRan:						
$2	22.3	22.7	22.9	23.0	23.1	23.2
$3	21.7	22.3	22.6	22.8	22.9	23.0
$4	21.0	21.9	22.3	22.6	22.7	22.8
$5	20.3	21.5	22.0	22.3	22.5	22.7
$6	19.5	21.0	21.7	22.1	22.3	22.5

$6/in and peanut prices ranging from $0.10 to $0.35/lb. The results indicated optimum irrigation levels were relatively insensitive to changes in peanut price or cost of irrigation although relatively larger changes in optimum irrigation levels were indicated as irrigation costs varied at a low price of peanut than at a higher price. For example, at a peanut price of $0.30/lb, optimum irrigation levels varied less than 1 inch when comparing the low irrigation cost of $2/in to a high cost of $6/in. The range of irrigation levels increased to 1.4 inches at $0.20/lb and, even wider to 3.3 inches at $0.10/lb.

Profit Maximizing Level of Irrigation, McRan Cultivar

In the case of McRan, the profit maximizing level of irrigation using the same procedure was determined to be 22.8 in, which is 3 in less than Pronto at 25.8 in, with the same irrigation cost and a support price of $0.3054/lb (USDA, 1989b). Table 2 indicates a similar lack of sensitivity to changes in peanut prices and irrigation costs for the maximum profit levels of irrigation for McRan as that of Pronto.

[1]The quadratic formula is based on the equation form y= aX2 + bX +c and is solved for X by:

$$X = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Yield Responses to Alternative Timings of Irrigations

Alternative timings of irrigations were also evaluated with respect to yield response. Over the years of research, but not necessarily every year, irrigations were applied at time intervals following planting of 21 days, 42 days, 56 days, 63 days, 70 days, 77 days, 84 days, 98 days, and 112 days.

Day 42 represents the initial bloom stage of physiological development. This stage of development was presumed to be a critical water requirement period (Newman, 1979). Thus, all treatments were irrigated at day 42.

Table 3a indicates the seasonal irrigation treatments, days-after-planting of each application, and net water applied by furrow irrigation after adjusting for runoff. Irrigation applications of Pronto peanut were statistically significant at the 11 percent level or higher for days 21, 70, 77, 84, 98, and 112. The following functional relationship explained 88 percent of the yield variation:

$$(5)\ Y_P = \underset{\substack{[220.8]\\(0.86)}}{190.82} + \underset{\substack{[31.3]\\(3.49)}}{109.18}\ D21R + \underset{\substack{[46.8]\\(1.61)}}{75.53}\ D70R + \underset{\substack{[72.6]\\(2.87)}}{208.34}\ D77R + \underset{\substack{[36.2]\\(2.65)}}{95.92}\ D84R$$

$$+ \underset{\substack{[29.6]\\(4.97)}}{147.09}\ D98R + \underset{\substack{[261.6]\\(1.95)}}{509.01}\ (D112R + HARVR) - \underset{\substack{[35.9]\\(-1.68)}}{60.50}\ (D112R + HARVR)^2$$

$R^2 = 0.877 \quad F = 40.787$

where Y_P = in-shell yield of Pronto (lb/ac),

D21R = irrigation quantity applied at 21 days plus accumulated rainfall 21 days after planting (in),

D70R = irrigation quantity applied at 70 days plus accumulated rainfall 64 to 70 days after planting (in),

D77R = irrigation quantity applied at 77 days plus accumulated rainfall 71 to 77 days after planting (in),

D84R = irrigation quantity applied at 84 days plus accumulated rainfall 78 to 84 days after planting (in),

D98 = irrigation quantity applied at 98 days plus accumulated rainfall 85 to 98 days after planting (in),

and (D112R + HARVR) = irrigation quantity applied at 112 days plus accumulated rainfall 99 to 112 days after planting and to harvest (about 30 days later) (in).

Standard errors of the regression coefficients are in brackets and T-values are in parentheses. The first irrigation after planting (day 21) and five of the seven mid- to late-season irrigations (days 70, 77, 84, 98 and 112) were significant in explaining yield variations. Insignificant application times were days 56, and 63.

Note that these results do not mitigate the importance of irrigating at bloom (42 days) if soil moisture and plant conditions warrant. The obvious absence of day 42 irrigation as a significant application time in equation 5 above is explained by the commonality of this irrigation in all treatments and years (Table 3a).

High levels of irrigation around day 112 (in early September) combined with high rainfall to harvest in early October can reduce yields as is indicated by the negative quadratic relationship of these two additive variables. Negative impacts of this relationship would be expected to be lessened on highly permeable sandy soils.

Table 3a. Seasonal irrigation treatments by year, timing of irrigations, and net amount of application.

Irrigation Treatment	Year	Applications - Days after Planting (Net applied)[1] 21	42	56	63	70	77	84	98	112	Total
		(inches)									
P + 2	1983	---	4.0	---	---	4.0	---	---	---	---	8.0
P + 3	1983	---	4.0	4.0	---	---	---	4.0	---	---	12.0
P + 4	1983	---	4.0	---	---	4.0	---	4.0	4.0	---	16.0
P + 5	1983	---	4.0	4.0	---	4.0	---	4.0	4.0	---	20.0
	1984	3.5	4.0	3.6	---	---	3.9	---	3.9	---	18.9
	1985	1.9	3.3	3.7	---	---	4.5	4.2	---	---	17.6
	1985	1.9	3.3	3.7	---	---	4.4	---	5.1	---	18.4
	1986	4.0	2.7	3.1	---	3.8	---	3.0	---	---	22.5
	1986	4.0	2.7	3.1	---	3.3	---	---	3.3	---	22.3
P + 6	1984	3.5	4.0	3.6	---	---	3.9	3.3	---	3.7	22.0
	1985	1.9	3.3	3.7	3.7	---	4.3	3.4	---	---	20.3
	1986	4.0	2.7	3.1	2.8	4.2	---	3.4	---	---	26.1
P + 7	1984	3.5	4.0	3.6	---	3.5	3.1	3.3	3.4	---	24.4
	1984	3.5	4.0	3.6	---	3.5	3.1	3.3	---	3.7	24.7
	1985	1.9	3.3	3.7	3.7	---	4.7	3.4	5.1	---	25.8
	1986	4.0	2.7	3.1	2.9	3.2	---	3.2	4.0	---	29.0
Average of years[2]	-	3.13	3.50	3.60	3.28	3.71	3.99	3.5	4.1	3.7	20.5

[1]Irrigation amounts are net furrow applications adjusted for runoff. Applications occurred within 2 to 3 days of that indicated depending on rainfall events.

[2]Excludes equivalent multiple treatment application amounts in any one year, except where different amounts were applied within the year in which case all treatments within the year were averaged.

In the case of McRan, the following relationship, which explained nearly 85 percent of the yield variation, was developed:

$$(6)\quad Y_M = -931.61 + 172.91\ D21R + 167.10\ D70R + 495.11\ D77R$$
$$[343.6]\quad [20.7]\quad [61.0]\quad [58.4]$$
$$(-2.71)\quad (8.35)\quad (2.74)\quad (8.49)$$

$$+ 253.58\ D84R + 246.21\ D98R - 3.25\ (D84RxD98R)^2 - 20.41\ (HARVR)^2$$
$$[72.9]\quad [70.6]\quad [1.05]\quad [6.93]$$
$$(3.48)\quad (3.49)\quad (-3.09)\quad (-2.95)$$

$R^2 = 0.846 \quad F = 31.399$

where Y_M = in-shell yield of McRan (lb/ac),

D21R = irrigation quantity applied at 21 days plus accumulated rainfall to 21 days after planting (in),

D70R = irrigation quantity applied at 63 days plus accumulated rainfall 64 to 70 days after planting (in),

D77R = irrigation quantity applied at 77 days plus accumulated rainfall 71 to 77 days after planting (in),

D84R = irrigation quantity applied at 84 days plus accumulated rainfall 78 to 84 days after planting (in),

D98R = irrigation quantity applied at 98 days plus accumulated rainfall 85 to 98 days after planting (in),

and HARVR = rainfall from 112 days after planting to harvest (about 30 days) (in).

Significant irrigation applications included days 21, 70, 77, 84, and 98. All coefficients were significant at the 10 percent level of probability. Again, these results do not reduce the importance of a bloom irrigation at day 42 if conditions dictate. Insignificant applications were days 56, 63, and 112.

Similarly, a reduction in McRan yield, as with Pronto, would be expected to occur if rainfall is high during September and early October. The significance of the first seasonal irrigation at day 21 is again emphasized.

Limitations

The results of this relatively short 4-year investigation were limited by the quantity and distribution of rainfall, by the limited number and levels of alternative irrigations, by the timing of rainfall events relative to irrigation applications, and, in certain cases, to a limited number of observations such as with D63 and D112. Although, on average, rainfall was near normal (90 percent), monthly and seasonal amounts were poorly distributed. In 1983 and 1984, the driest growing seasons, seasonal rainfall was 38 percent and 60 percent of the 26-year average rainfall, respectively, while 1985 and 1986 were characterized by one-month extremely wet periods resulting, respectively, in 118 percent and 133 percent of seasonal average rainfall. With respect to monthly distributions, both June and July were below average for the study period with 63 percent and 52 percent of average, respectively. August rainfall was 110 percent and September, 139 percent of average for the 4 years.

Furthermore, D21 yield response was fully evaluated in all years for only one irrigation treatment, preplant + 5 additional irrigations (P+5). In other years and irrigation treatments, the D21 irrigation was either included or excluded. However, low P+5 Pronto yield in 1983 when June rainfall was below normal resulted in a low seasonal water-use efficiency (including seasonal rainfall) of 80 lb/in compared with significantly higher efficiencies when the months of June also were extremely dry in 1984 and 1986, and when June was wet in 1985. Water-use efficiencies for all treatments ranged from 106 to 118 lb/in during these years; further indicating the importance of the D21 application. This early season irrigation was also observed to advance blooming date somewhat and may have advanced maturity, particularly when June rainfall was low.

Quality Considerations of Irrigation Treatments

The preceding analysis of maximum profit levels of irrigation and the yield responses to irrigation amounts and timings of application did not consider potential quality or grade impacts of alternative irrigation levels on each of the two cultivars. Some selected and extraordinary climatic events during the 4-year period also may have affected the grade levels in the short growing season. For example, a record month-early frost occurred on Sept. 21, 1983, defoliating much of the leaf area prior to harvest. Yields of plant samples defoliated by frost in the highest irrigation treatment (P+5) were graded and a 4 to 5 percent decrease occurred in the percent sound mature kernels (SMK) and sound splits (SS) compared with selected undefoliated plants (data not shown). Another exceptional climatic event, uncharacteristic of the northern Texas High Plains, occurred in 1985 when harvest was delayed by more than 8 in of rainfall in September and early October (Table 3b). Grades (%SMK + SS) of McRan were lower for all irrigation treatments than Pronto, indicating some field losses during harvest of mature peanut that would have increased the overall grade (data not shown).

Regarding irrigation effects on grades (%SMK + SS), no significant impacts of irrigation treatments over the study period were found for Pronto (Table 4). However, in the case of McRan, the lowest irrigation treatment (P+2) graded significantly lower than P+4, P+6, and P+7 treatments. Also, McRan grades averaged significantly lower than Pronto over all irrigation treatments.

Profitability of Pronto versus McRan Peanut Production

The previous analysis of optimum irrigation levels with varying irrigation costs and peanut prices is useful in determining maximum profit application levels. No impacts on profits were evaluated with respect to cultivar grade differentials, however, and no estimate of profits per acre was made. A reassessment of the optimal irrigation level was required due to the impacts on price of the grades and grade differentials by cultivar.

The average grade for 1983-86 of all P+5, P+6, and P+7 treatments for Pronto was about 73 percent SMK +SS and 4 percent other kernels (OK). McRan graded about 70 percent SMK + SS and 4 percent OK. 1989 CCC support prices based on these grades were $646.10/ton for Pronto and $644.63/ton for McRan (USDA, 1989a and b). The optimum irrigation levels (using an irrigation fuel and labor cost of $3.80/in and the respective peanut prices) were 25.9 in for Pronto and 23.0 in for McRan. Yield estimates from Table 1 with these irrigation levels (rounded to the nearest inch) were 4,018 lb/ac for Pronto and 4,443 lb/ac for McRan. Enterprise

Table 3b. Monthly rainfall, net seasonal irrigation applied, total water, and treatment average yields by year and irrigation treatment.

Irrigation Treatment	Year	Rainfall Received June	July	Aug.	Sept.	Net Seasonal Irrigation Applied[1]	Total Seasonal Water	Yield[2] Pronto	McRan
		(inches)						lb/ac	
P + 2	1983	1.60	1.30	0.15	0.20	8.00	11.25	797	232
P + 3	1983	1.60	1.30	0.15	0.20	12.00	15.25	951	600
P + 4	1983	1.60	1.30	0.15	0.20	16.00	19.25	2,042	1,668
P + 5	1983	1.60	1.30	0.15	0.20	20.00	23.25	1,854	1,067
	1984	0.95	1.70	1.90	0.60	18.90	24.05	2,849	2,999
	1985	2.90	0.35	0.75	6.14	17.60	27.74	2,950	2,761
	1985	2.90	0.35	0.75	6.14	18.40	28.54	3,283	3,034
	1986	1.15	0.95	7.32	1.95	22.50	33.87	3,629	3,238
	1986	1.15	0.95	7.32	1.95	22.30	33.67	3,579	3,463
P + 6	1984	0.95	1.70	1.90	0.60	22.00	27.15	2,988	3,233
	1985	2.90	0.35	0.75	6.14	20.30	30.44	2,960	2,303
	1986	1.15	0.95	7.32	1.95	26.10	37.47	3,296	3,575
P + 7	1984	0.95	1.70	1.90	0.60	24.40	29.55	2,990	3,259
	1984	0.95	1.70	1.90	0.60	24.70	29.85	3,220	3,516
	1985	2.90	0.35	0.75	6.14	25.80	35.94	3,650	2,375
	1986	1.15	0.95	7.32	1.95	29.00	40.37	3,871	3,440

[1]Refer to Table 3a for irrigation amounts and timing of applications.

[2]Treatment average of three replications.

Table 4. Treatment means of peanut grades by cultivar.

Irrigation[1]	Pronto %SMK + %SS[2]	Pronto % OK	McRan %SMK + %SS[2]	McRan %OK
P + 2	73 a	4	63 b	7
P + 3	70 a	4	65 ab	7
P + 4	71 a	5	70 a	7
P + 5	73 a	4	68.5 ab	4
P + 6	72 a	4	70.5 a	3.5
P + 7	73 a	4	70.5 a	3.5
Cultivar Avg.[3]	72 a	4.2	67.9 b	5.3

[1]Refer to Table 3a for irrigation amounts and timings of applications.

[2]Means followed by the same letter in each column are not significantly different at the 5 percent level by Duncan's multiple range test.

[3]Means followed by the same letter are not significantly different at the 5 percent level by Duncan's multiple range test in this row.

budgets are given in Table 5 for each type of peanut using a furrow application efficiency of 65 percent for these two levels of irrigation on a sandy loam soil (Musick et al., 1987). The preplant irrigation quantity used was a net 6 in application. (Sprinkler situations might require a higher cost per unit water applied but could reduce total water applied due to the ability to control both application amounts and depth of application, particularly in the amount and depth of preirrigation requirements.)

The budgets were based on typical peanut cultural practices in the Texas High Plains area and surface (furrow) irrigation. Production costs were estimated to be $483/ac and $477/ac including harvesting, hauling, and drying expenses for Pronto and McRan, respectively. The higher estimated yield for McRan resulted in higher gross income and higher returns to management and risk of $821/ac compared with $673/ac for Pronto using 1989 USDA support prices.

Considering all costs except a charge for management, the breakeven price was $311/ton for Pronto and $277/ton for McRan. Thus, nonquota market prices would need to be substantially higher than the 1989 CCC loan rate of $149.75/ton for nonquota production to be profitable in the absence of established quotas and production history.

Assessment of Production and Profit Risks

The previous discussion pointed out the potential of yield reductions associated with late-season irrigations and excessive rainfall in September on moderately permeable soils. Using equation 5 with respect to late season irrigation and/or rainfall to harvest, Pronto

Table 5. Estimated profits of peanut production for the northern Texas High Plains by cultivar, furrow irrigated.

Item	Pronto	McRan
	$/ac	
Yield, lb/ac	4,018	4,443
Income	$1,298.02	$1,435.15
Expenses:		
Herbicide	8.00	8.00
Nitrogen fertilizer, 40#/ac	4.40	4.40
Phosphorous fert., 80#/ac	16.80	16.80
Apply fert.	4.20	4.20
Seed + inoculant	45.25	45.25
Insecticide + appli., one	5.00	5.00
Fungicide + appli., three	30.00	30.00
Hoeing	11.00	11.00
Tractor fuel, lube	12.87	12.87
Tractor labor	15.51	15.51
Irrig. fuel, and labor[1]	187.08	169.54
Interest, 11%	16.31	15.83
Digging	10.00	10.00
Harvest and haul, $33/ton	66.30	73.31
Drying, $25/ton	50.23	55.54
Total variable costs	482.95	477.25
Returns over variable costs:	815.07	957.90
Fixed Costs:		
Machinery	40.11	40.11
Irrigation facilities	61.77	57.14
Land	40.00	40.00
Returns to mgm't and risk:	673.19	820.65
Breakeven price/ton	$311.02	$276.61

[1]Irrigation includes 6 in net applied for preirrigation.

Source: Texas Agricultural Extension Service, 1989a.

yields would begin declining with a total of 4.72 in or more rainfall after mid-August based on a 3.7 in irrigation in early September (D112). The 26-year rainfall history at the North Plains Research Field, Etter, Texas, indicates this quantity was exceeded by rainfall 5 times or 19 percent of the time. In the case of McRan, equation 6 indicates rainfall during the month prior to harvest would reduce yields by 20 lb/ac multiplied by the square of the amount received. The highest frequency of rainfall over the past 26 years was only about 0.5 in, reducing yields 5 lb/ac; but on average, 1.6 in was received for a 51 lb/ac reduction.

Severe shortfalls in seasonal rainfall are expected to reduce yields. In the Texas High Plains, the highest frequency of rainfall quantities are less than the average monthly rainfall. The monthly modal rainfall or highest frequency was approximately 40 percent of the average for the months of June, July, and August and slightly less, 30 percent, for September. Continually dry seasons such as this are rare, though, occurring only 1 time during the past 26 years. If these conditions persisted, yields would be reduced nearly 200 lb/ac for each cultivar. Profits from McRan would be reduced by $57/ac and Pronto by $59/ac. More common occurrences are dry monthly periods, such as July or August, in which approximately 20 percent of the time 40 percent or less of the monthly percent average rainfall was received over the past 26 years. Figures 3 and 4 depict the yield impacts of a July deficit. Pronto yields, Figure 3, were reduced 95 lb/ac but McRan yields, Figure 4, were reduced 183 lb/ac with 40 percent of average July rainfall. In this case, Pronto profits would be reduced $28/ac and McRan, $54/ac.

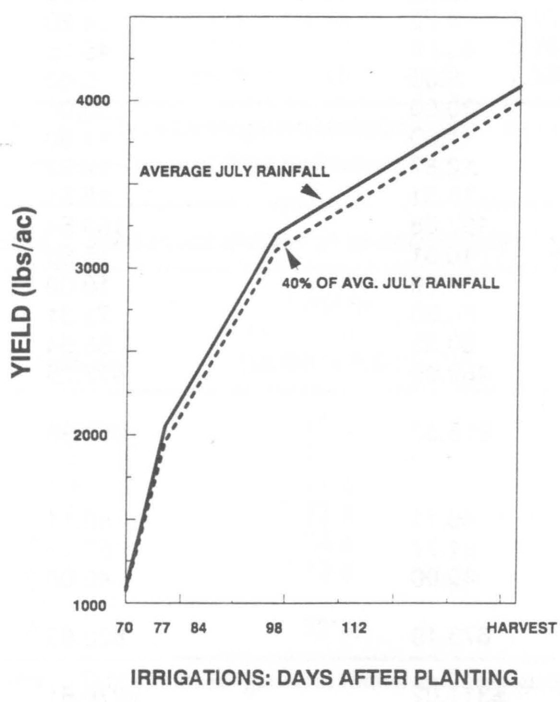

Figure 3. Pronto yields with average and 40 percent of average July rainfall.

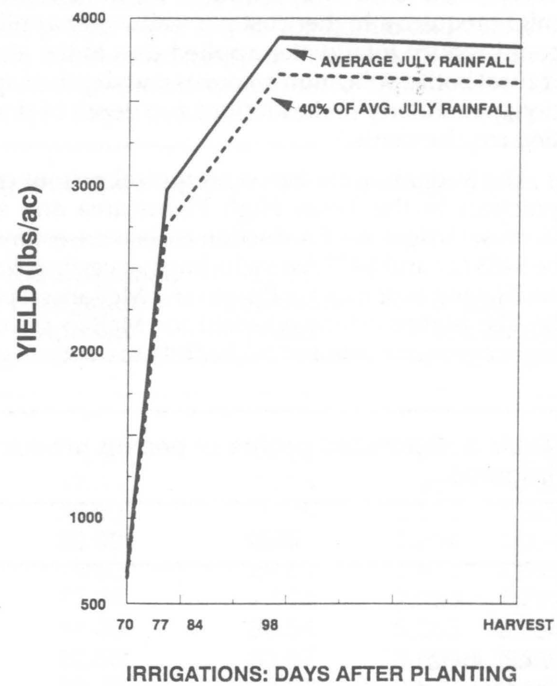

Figure 4. McRan yields with average and 40 percent of average July rainfall.

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