Peanut Yield Decline in the Southeast and Economically Feasible Solutions

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ABSTRACT

Peanut (*Arachis hypogaea* L.) yields in the Southeast declined 368 kg/ha during the 1980's and 596 kg/ha in the late 1980's when compared to the 1974-1979 period. The peanut yield decline was correlated with significant meteorological and policy changes in the Southeast during each time period. Meteorological changes were statistically estimated to decrease peanut yield by 137 kg/ha and 194 kg/ha in the 1980's and late 1980's, respectively. The effect on peanut yields from changes in agricultural policy and management decisions was estimated at -166 kg/ha and -225 kg/ha during the respective time periods. Field data gathered during crop years 1987-1990 reflected the meteorological and policy changes during the late 1980's in both non-irrigated and irrigated peanut fields. EXNUT, an expert systems model for peanut irrigation and pest management, was evaluated in 1987, 1988, 1989, and 1990 against expert farmers in the Southeast and increased peanut yields by 204 kg/ha. Evaluation of EXNUT demonstrated one example of how expert system technology can offer economically feasible solutions to the peanut yield decline in the Southeast.

Key Words: *Arachis hypogaea* L., peanut yield decline, EXNUT, expert systems, economically feasible solutions, crop rotation, crop insurance, management

Peanut yields in the Southeast declined 11.5% during the 1980's as compared to the 1974-1979 period[2]. The yield decline was even more dramatic during the latter half of the 1980's at 14.6%. The decline in peanut yields has been observed for both non-irrigated as well as irrigated peanut production (1). Analyzing the factors which have contributed to the yield decline is complex due to the interactions and simultaneity of the factors required for successful peanut production. Important requirements for peanut production in the Southeast 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 (2, 6, 7, 9, 12). Each of these requirements must be effectively managed to provide maximum peanut yields (6). Undoubtedly, production management and peanut yields have been affected by meteorological and policy changes in the Southeast during the 1980's. Meteorological changes include hotter, drier weather during the 1980's (8). Policy changes include those which have encouraged shorter crop rotations and poorer management practices (10).

It is the purpose of this paper to evaluate the effects of policy changes and the hotter, drier weather on the yield decline and to investigate the potential impact of certain management strategies, such as EXNUT, to reverse this trend.

Materials and Methods

County, State, and Regional

Data for this analysis were first gathered and analyzed on a county and state basis. The county analysis applies only to counties with 2,025 planted peanut hectares or greater in 1989 which represents approximately 90 percent of the total planted peanuts in the Southeast. The data include yield and number of hectares of peanuts and other crops of significance from 1974-1989. Also gathered was climatological data for various weather stations in Alabama, Florida, and Georgia. These data include total rainfall during the growing season (April through September) and monthly rainfall and average 1.5 meter ambient maximum temperature during July and August. An average of the data from at least two local weather stations was used for each county.

The data was analyzed statistically using an ordinary least squares (OLS) regression (11). The equation was specified such that the appropriate lag was placed on each variable. For example, the planted hectares of corn, grain sorghum, and other non-legume crops were given a one year lag because they traditionally have preceded peanuts. To normalize the data, the ratio of legume hectares planted in each county (mainly peanuts and soybeans) to non-legume hectares (mainly corn, grain, sorghum, and cotton) was obtained. The ratio of insured peanut hectares to total peanut hectares in each county was also used in the regression. Thus, the model was specified as:

$$PY = R_1\ R_2\ TR\ JR\ AR\ JT\ AT,$$

where:

PY = peanut yield per harvested hectare,

R_1 = ratio of legume hectares (current year) to non-legume hectares (previous year) for each county,

R_2 = ratio of insured peanut hectares to total peanut hectares for each county,

TR = total rainfall from April to September,

JR = July rainfall,

AR = August rainfall,

JT = July 1.5 meters ambient average maximum temperature, and,

AT = August 1.5 meters ambient average maximum temperature.

Field Data

Beginning in crop year (CY) 1987, data was gathered from 44 non-irrigated and irrigated commercial peanut fields in the Southeast. In CYs 1988, 1989, and 1990 the number of fields were 53, 63, and 51, respectively. Based on pre-plant interviews with farmers, historical cropping practices and field production records were obtained. Pre-plant tillage practices, chemical applications and incorporation methods, variety, planting conditions, and other factors were obtained at planting. After planting, weekly visits by field scouts provided data on plant growth, rainfall and/or irrigation, fruit initiation date, average geocarposphere maximum and minimum soil temperature, pest pressure, and post plant cultural practices. Fields in the survey, which were geographically selected to represent average growing conditions and management practices in the Southeast, were monitored weekly until harvest. Scouts made no recommendations to farmers. All loads from each field were graded and marketed through commercial marketing facilities to provide field yield and grade data. Samples were obtained at farmer marketing and evaluated for shelling outturns, germination, and aflatoxin level.

During CYs 1980-1984, an extensive data base was collected to develop an expert system, EXNUT, for managing peanut irrigation and pests (3). EXNUT was developed in 1985 and revised in 1986. Beginning in 1987, EXNUT was evaluated and validated in controlled irrigation experiments in the Southeast. The evaluations were conducted across a variety of soil types, rotation histories, and meteorological and field conditions against the irrigation and pest management strategies of expert farmers in the Southeast. Expert farmers were those identified by county agents and long-term yield records as having the best irrigation and pest control practices in the Southeast (4). Individual comparisons were conducted varying only the irrigation and pests management strategies as recommended by EXNUT and the expert farmer. Soil types, rotation histories, field conditions and other production parameters were held constant. Field scouts and the cooperating farmers monitored the fields as required by EXNUT, entered the field data into the expert system, and followed the recommendations of EXNUT. The number of fields during CYs 1987, 1988, 1989 and 1990 were 8, 11, 7, and 6, respectively. Pre-plant, planting time, and after planting data were gathered as previously mentioned.

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[2]Crop year 1974 is the initial year due to the acceptance of the Florunner variety over the traditional Spanish variety.

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Results

County, State and Regional

The means of the regression variables for the 1974-1979, 1980-1989, and 1986-1989 periods are presented in Table 1. Significant decreases in peanut yield were observed during each period. Significant policy and meteorological changes occurred during the decade of the 1980's. Peanut and soybean hectares exceeded non-legume hectares and continued to increase throughout the 1980's. The percentages of peanuts protected by federal crop insurance also significantly increased during the 1980's.

Table 1. Means for peanut yield, R1, R2, TR, JR, AR, JT, and AT in the Southeast for the 1974-1979, 1980-1989, and 1986-1989 periods.

Variable	Period 1974-1979	1980s	1986-1989
Peanut yield (kg/ha)	3413.73 A[1]	3045.93 B	2817.88 C
R1 (legume ratio)	0.8155 A	1.3394 B	1.5160 C
R2 (insurance ratio)	0.0756 A	0.4176 B	0.5401 C
TR (total rainfall)	74.3689 A	62.9615 B	58.7383 C
JR (July rainfall)	15.5618 A	13.1509 B	12.6482 B
AR (August rainfall)	11.9258 A	11.6385 A	10.3142 B
JT (July max. temp.)	32.4552 A	33.3850 B	33.5309 B
AT (August max. temp.)	32.2739 A	32.8651 B	33.2614 B

[1]Means for each variable followed by the same letter are not significantly different at the p = .05 as determined by Duncan.

Weather patterns during the 1980's and the late 1980's were also significantly different from the 1970's (Table 1). Total rainfall during the growing season decreased during the 1980's When compared to the 1974-1979 period, July rainfall was 2.4 cm less in the 1980's and 2.9 cm less in the 1986-1989 period. The same trends were observed for August rainfall in the Southeast, although the differences in the means were less. Average ambient temperatures (1.5m) were higher during July and August for the 1980's and the 1986-1989 period (Table 1).

The parameter estimates from the OLS regression are presented in Table 2. All parameter estimates were significant ($P<.01$) and were used to estimate the effect each variable had on the declining peanut yields in the Southeast. Using the 1974-1979 period as a base period, differences in the means in Table 1 were obtained for each variable. The mean differences were multiplied by the respective parameter estimate to estimate the peanut yield effect of each variable for the 1980's and 1986-1989 periods. All of the variables had negative effects on peanut yield except for total rainfall during the growing season (Table 2).

Field Results

The average yields for the non-irrigated and irrigated peanut fields in the CYs 1987, 1988, 1989, and 1990 surveys are presented in Table 3. On the average, irrigation significantly increased peanut yields in 3 of the 4 years. In 1989, no differences were found between non-irrigated and irrigated peanut yields. The surveys were taken across a variety of rotation sequences and soil types. The average

Table 2. Parameter estimates from OLS regression and estimated effects of R1, R2, TR, JR, AR, JT, and AT on peanut yield (kg/ha).

Variable	Parameter estimate	Estimated effect on peanut yield (kg/ha) 1980's	1986-1989
Intercept	8426.715	------	------
R1	-83.528	-43.760	-58.843
R2	-357.645	-122.315	-166.126
TR	-4.614	53.879	72.120
JR	18.746	-45.195	-54.620
AR	20.666	-5.937	-33.306
JT	-117.271	-109.038	-126.149
AT	-52.388	-30.974	-51.736

All parameter estimates were significant at the 0.01 level.

Example calculation for R1 (1980's)

Peanut yield effect (1980-89) = (R1 80-89 - R1 74-79) * R1 parameter estimate

Peanut yield effect (1980-89) = (1.3394 - 0.8155) * -83.528

Peanut yield effect (1980-89) = -43.760

Table 3. Mean yields (kg/ha) from non-irrigated and irrigated peanut fields from surveys and from EXNUT managed fields during crop years 1987, 1988, 1989, and 1990.

Crop year	Non-irrigated yields	n	Irrigated yields	n	EXNUT yields	n	Expert Farmer yields	n
1987	2809	23	3449	21	3906	8	3852	8
1988	3060	29	3587	24	4347	11	4301	11
1989	3651	37	3598	26	4406	7	4080	7
1990	1608	28	2892	23	4057	6	3654	6
Average	2782	28	3382	22	4179	8	3975	8

rotations for the peanut fields in the survey were 1.72 and 1.63 years out of peanuts for non-irrigated and irrigated peanuts, respectively. Because of greater capital investment for irrigation, shorter rotation sequences for peanuts are normally practiced on irrigated fields.

The data was sorted according to the number of years between peanut crops to determine if differences in peanut yields in the survey were related to rotation length and suitability. Figures 1 and 2 provide the non-irrigated and irrigated rotations and the average yields associated with the number of years out of peanuts or soybeans. Due to the effects on both non-irrigated and irrigated peanut yields from the extreme drought in CY 1990, discussion of peanut yield as affected by rotation will apply only to CYs 1987, 1988, and 1989. Non-irrigated and irrigated peanut yields were affected differently by the length of rotation out of peanuts or soybeans. For non-irrigated fields, peanut yields increased 309 and 709 kg/ha for one and two years of rotation compared to peanuts following peanuts or soybeans. Three years of rotation provided only a 79 kg/ha increase in peanut yield over the two year rotation. For the irrigated fields in the survey, one year of rotation out of peanuts or soybeans provided only a 219 kg/ha increase in yield. However, the average increase in irrigated peanut yields for the two and

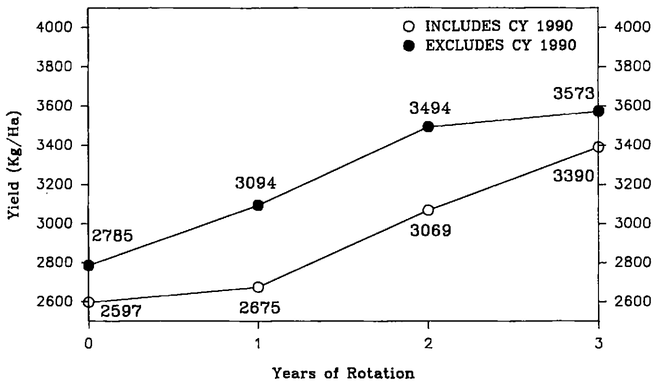

Fig. 1. Non-irrigated peanut yields vs years of rotation.

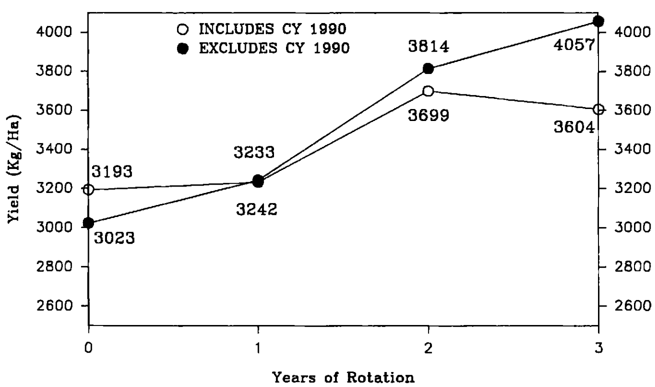

Fig. 2. Irrigated peanut yields vs years of rotation.

three year rotations were 791 and 1034 kg/ha.

The average yields for the peanut fields managed by EXNUT and the expert farmers during the CYs 1987, 1988, 1989, and 1990 are presented in Table 3. EXNUT increased peanut yields over the expert farmers by 54, 46, 326, and 40 kg/ha during each successive crop year, respectively. Compared to the irrigated fields in the survey, EXNUT yields were 457, 760, 808, and 1165 kg/ha higher during each successive crop year, respectively.

Discussion

The results indicate that significant policy and meteorological changes occurred in the Southeast during the 1980's. These changes were greater during the 1986-1989 period. Further, the results indicate that declining peanut yields in the Southeast were associated with most of these changes. R1 and R2 represent some of the policy changes in Southeast agriculture during the decade of the 1980's. R1 and R2 are management variables and are affected by the management decisions of individual farming operations. Thus, for this analysis the estimated effects of R1 and R2 are summed for an estimate of changing management decisions during the 1980's. The effect of changing management decisions on peanut yields were -166.075 kg/ha and -224.97 kg/ha during the 1980's and the 1986-1989 periods, respectively. Rising production cost, depressed market prices for alternative crops, government set aside programs, and crop insurance guarantees for peanuts which are potentially greater than variable production costs have resulted in shifts away from corn and grain sorghum for increased hectares in peanut (quota and non-quota) and fallow land. The cause and effect relationships between crop insurance and peanut yield are unclear and are difficult to separate except on an individual field basis. Harvest requirements of crop insurance for peanut impose a 280 kg/ha reduction in yield if a field is not harvested. As a result, harvested acres on fields with marginal yields are probably increased. Such relationships need to be developed to provide more effective crop insurance programs.

The remaining variables (TR, JR, AR, JT, and AT) represent changes in weather patterns between the periods. The effect of these variables from Table 2 were summed to estimate the effect of meteorological changes in the Southeast as related to peanut yields. For the 1980's and 1986-1989 periods, the data suggested that peanut yield decreases of 137.3 kg/ha and 193.7 kg/ha could be attributed to changes in weather patterns.

The field data supports the policy and meteorological changes in the county and state data during the late 1980's. Changes in crop hectares affected both and length and suitability of peanut rotations in the survey. Of the row crops in the survey, corn/grain sorghum as an immediate prior crop to peanuts provided the highest peanut yield. Planted hectares in corn in the Southeast decreased from 972 thousand hectares in 1974 to 243 thousand hectares in 1989. Decreases in other rotatable crops with peanuts followed similar patterns, thus suggesting that changes in traditional rotation sequences have varied. A survey of Georgia county extension agents showed that in 1978 approximately 83 percent of Georgia planted peanuts followed corn or grain sorghum (7). By 1985, only 58 percent of the peanuts planted in Georgia followed corn or grain sorghum (9). This trend is supported by the survey data. The crops immediately preceding peanuts in the survey and the percentage of the total for the data set were corn/grain sorghum (42.79%), fallow (21.93), cotton (15.93%), and peanuts/soybeans (9.45%). The remainder (10.55% was comprised of tobacco, pasture, and various produce crops. The result of such shifts in traditional cropping patterns is a decrease in length and suitability of peanut rotations (1, 5).

Aggregate data and field level data indicate that declining peanut yields are associated with some of the policy and meteorological changes which have occurred in the Southeast during the 1980's. Such changes must be met with economically feasible management strategies which allow peanut producers to address various situations. EXNUT is an example of an economically feasible management tool for peanut production. One of the key concepts in EXNUT is use of geocarposphere (GCS) temperature (5 cm soil temperature) to manage pests and irrigation. Significant relationships of GCS temperature and water during the fruiting period to peanut yield, quality, and pest have been published (3). Davidson *et al.* (3) reported that during the fruiting period, maximum GCS temperature should be maintained in the range of 26.6-28.3 C. Figures 3, 4, 5, and 6 provide comparisons of the rainfall, irrigation, and maximum GCS temperatures for the irrigated fields in the survey and the EXNUT managed fields during CYs 1987, 1988, 1989, and 1990. These comparisons are presented between EXNUT and the irrigated fields in the survey to contrast the irrigation strategies (timing and amount of application) in the fields managed by EXNUT with those managed by the farmers in the survey. During the crop years termed as drought (1987, 1988 and 1990), maximum GCS temperatures remained consistently higher in the irrigated survey fields than the EXNUT managed fields regardless of soil type or variety. On the average, irrigation in the survey was applied later in the fruiting period and less water was applied per application resulting in elevated soil temperatures and reductions in peanut yield and quality. Although cultural practices varied in the survey data sets and the EXNUT data set, EXNUT reduced GCS temperatures by irrigating earlier in the fruiting period and applying more water per application than the irrigated survey fields.

Table 3 indicates that EXNUT peanut yields were 797 kg/ha higher than the irrigated survey fields. EXNUT also increased farmers stock grade (SMK+SS) by 5 percentage points while increasing germination and jumbos and

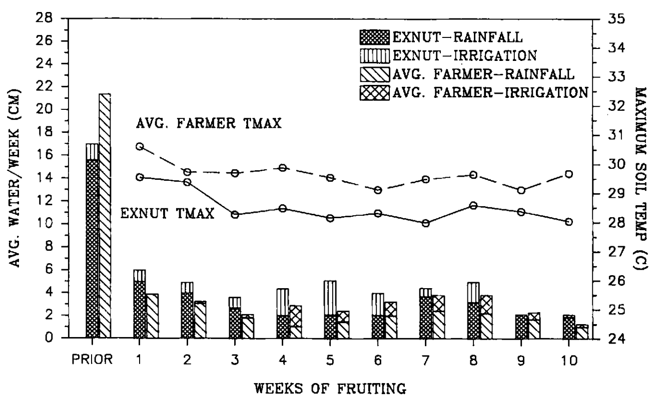

Fig. 3. EXNUT vs average irrigated farmers (1987).

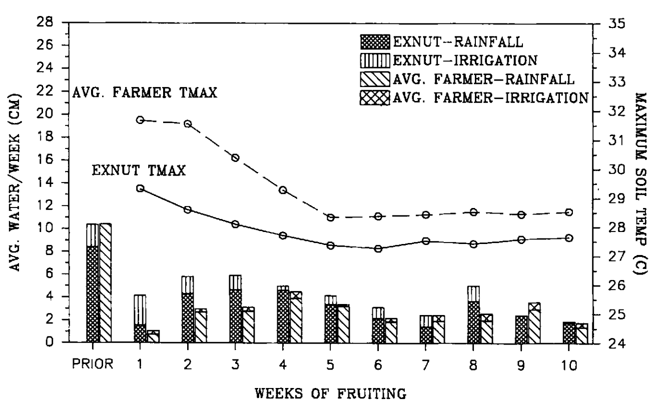

Fig. 4. EXNUT vs average irrigated farmers (1988).

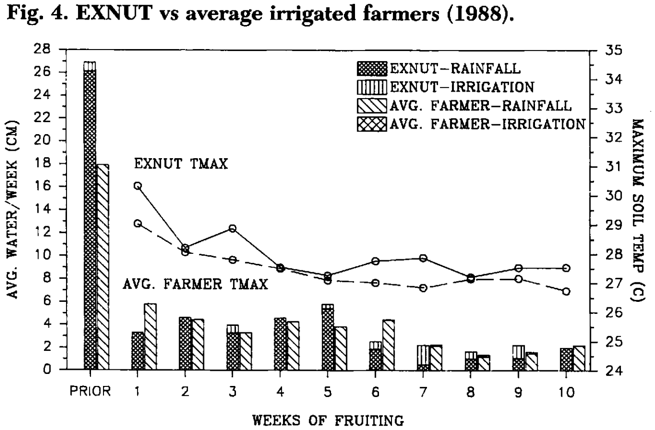

Fig. 5. EXNUT vs average irrigated farmers (1989).

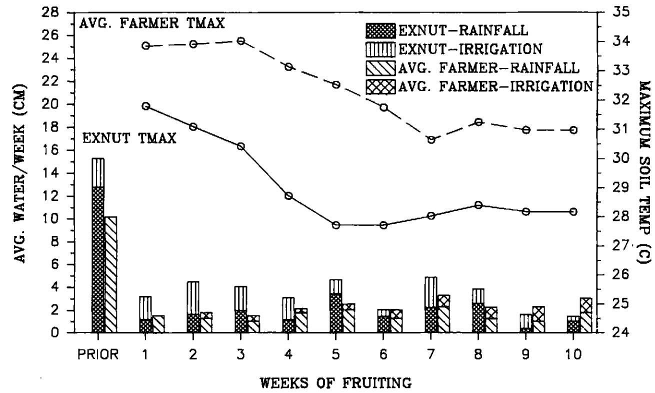

Fig. 6. EXNUT vs average irrigated farmers (1990).

eliminating aflatoxin at all detectable ppb levels (ppb <1). Significant aflatoxin levels were detected in some of the samples taken from the irrigated fields in the survey. The estimated cost of incorporating EXNUT into an actual farm situation is $5.41 per hectare. This estimate includes thermometer cost, labor, and mileage. Computer cost are not included because they are generally available at local county extension offices and mileage allowances for this are included in the cost estimate. On the average, EXNUT applied 8.33 cm more irrigation than was applied on the irrigated survey fields. Using the quota support price for each respective crop year, the estimated cost of running EXNUT, and the estimated variable cost of additional irrigation required by EXNUT, the potential estimated net return to EXNUT is $584.72 per hectare compared to the irrigated fields in survey.

Based upon this research, peanut yield decline trends in the Southeast can be reversed. Changes in agricultural policies and crop insurance regulations which promote better rotation sequences for peanuts would increase peanut yields. Increased irrigated peanut hectares with proper irrigation scheduling would increase peanut yields and improve quality. Through expert systems technology, management tools for peanut production, such as EXNUT, offer economically feasible solutions to increase peanut yields.

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