UNIVERSITY OF TENNESSEE

INCIDENCE OF PRECIPITATIONS, TEMPERATURE, PRICES OF FERTILIZER, SEED, CHEMICALS, PRICES OF CORN AND PRICE OF SOYBEAN IN CORN PRODUCTION IN ILLINOIS

STATISTICAL METHODS
STATISTICS 571

Student: DELLACHIESA ALEJANDRO

Professor: Dr. LEON, RAMON

31 July 2003

<u>INTRODUCTION</u>:

In the last few decades agriculture has become more and more competitive. As proof of these agricultural producers have turned to agribusiness firms to remain competitive in a global business environment. Education and planning techniques are increasingly becoming a vital part of any successful business. For this analysis, JMP 5.0 is going to be used as a management tool to determine the incidence of each one of these variables on corn production. The objective of this project is to examine the relationship of Corn production in U.S. during the last 30 years* with variables that affects the production like:

- Temperature.
- Precipitations.
- Prices of fertilizer.
- Price of corn.
- Price of soybeans (Corn production substitute).
- Price of seed.
- Growing degree days.
- Acreage(We cannot used both, yield & acreage since yield is define as production /acreage)

When we work with agricultural projects we know that the weather is the factor that influences Production the most. Actually new hybrid varieties have a tremendous amount of genetic diversity that generates higher potential hybrids than in the past and have been adopted by almost all agricultural producers in U.S. The use of fertilizer as well as precipitations in the tasselins period ** and good temperatures are the main factors in higher the yield of Corn and Soybean. The prices of Corn and Soybeans are going to affect the acreage of both productions switching from one to the other depending on the grower prices.

* Climate data reflect the mean and variation of weather conditions during given time periods. By international agreement, a 30-year period is used to compute climate means.

** In this case as we show in the following pages we are going to take in account the precipitations and temperatures of the tasselins period (June-July-August) instead of taken in account the temperatures of the all year, since these are the critical month for corn production in Illinois.

VARIABLES TAKEN IN ACCOUNT:

Agriculture production is affected by several variables but the most important are:

1. **Precipitation** – Precipitation is the main factor that influences corn production.
2. **Temperature** – The yield can be influenced by other weather conditions as temperature. This factor influences the evapotranspiration (Removal of water from soil by the combination of evaporation from the soil surface and transpiration (loss of water vapor) from the plant leaves) rates.
3. **Price of corn** - The market price is affected by world production, demand and stocks. To run this model I will take the average price received by farmers in Illinois the last three decades.
4. **Price of soybean** - The price of soybean is going to affect the acreage of both productions switching from one to the other depending on the grower prices. I will take the average price of soybean received by farmers in Illinois the last three decades.
5. **Yield** – Crop yield is affected by the weather. Production variations can happens between Producers into the same State or County or Rural area. For this reason, the average yield of the State of Illinois for the last thirty years will be used.
6. **Costs of corn production** – This study uses the estimated cost of production typical for a farm in Illinois. This data is taken from the Economic Research Service of the U.S. Department of Agriculture. At this point the analysis will include the basic costs of production such as **Seed, Fertilizer and Chemicals.** The salary of the employees and any other hired labor as well as the cost of harvesting and marketing could be included in a more detailed study.

VARIABLES THAT AFFECT PRODUCTION BUT ARE NOT TAKEN IN ACCOUNT IN THIS STUDY:

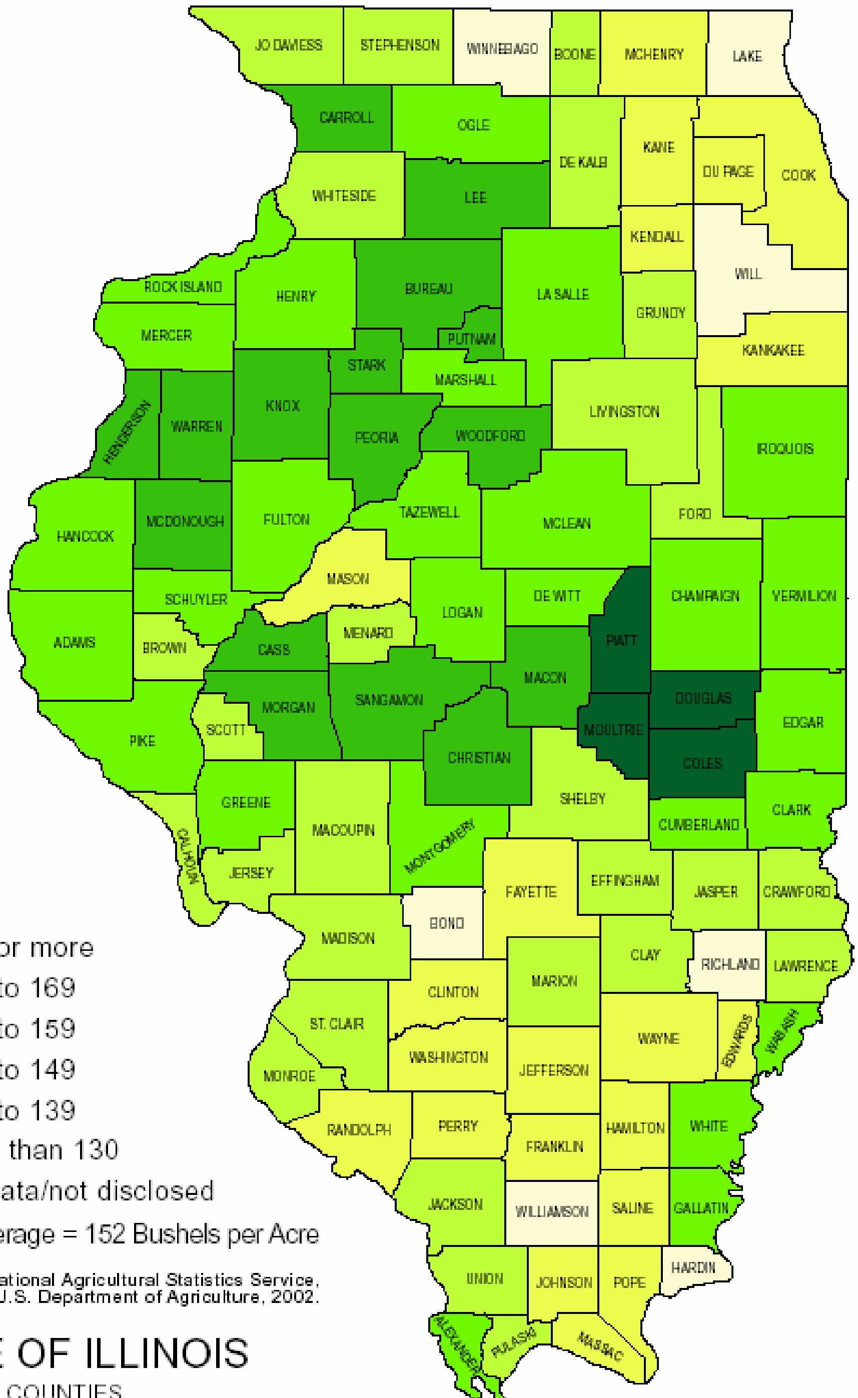
8. **Planting Date:** Long term studies show that the best time to plant corn in Illinois is the last Week of April. Yields decline slowly as planting is delayed up to May 10. From May 10 to May 20, the yield declines about one-half bushel for each day that planting is delayed. Weather conditions are the main reason for delaying the sowing process. This variable seems to be not very significant but no data are collected about this specific subject to prove it.
9. **Plant population:** The goal at planting time is to establish the highest population per acre that can be supported with normal rainfall without excessive lodging, barren plants, or pollination problems. We assume that all producers in Illinois have a plant population near to their optimum.

10. **Characteristics of the land:** The characteristics of the land is a very important factor in Corn production setting from farm to farm, county to county and state to state. For this reason the production will be studied in this case taken the averages of production of the last 30 years of the all the State of Illinois, and not from a particular farm.

11. **Effects of "*El Niño" and "La Niña"*:** When sea surface temperatures in the equatorial Pacific is above normal, "*El Niño"* event is occurring, when they are below, *"La Niña"* is occurring. Extreme weather situations occurs affecting agriculture when this events occurs. Yields tend to be above the trend when spring rainfall is below normal and summer rainfall is above normal.

12. **Other variables:** Insects, deceases and other not relevant and difficult to measure variables are not going to be taken in account for this study.

Illinois Corn Production by County
Crop Yield in Bushels per Acre, 2001



- 170 or more
- 160 to 169
- 150 to 159
- 140 to 149
- 130 to 139
- Less than 130
- No data/not disclosed

Illinois Average = 152 Bushels per Acre

SOURCE: National Agricultural Statistics Service, U.S. Department of Agriculture, 2002.

STATE OF ILLINOIS

COUNTIES

0 100 Miles

0 100 KM

Center for Governmental Studies - Northern Illinois University Rev. 11/21/2002

METHODOLOGY:

The objective of this study is to examine the relationship of corn production during the last 30 years with variables that could affects corn production like temperature, precipitation, price of fertilizer, price of corn, price of soybeans (Corn production substitute), price of seed and growing degree days.

The months that are going to be taken into account for each variable are:

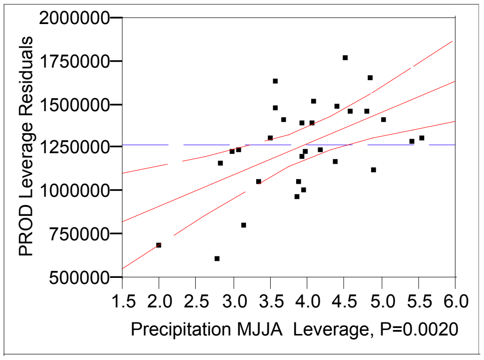
- Temperature: June – July – August
- Growing degree days: June – July – August – September
- Precipitation: Annual
- Price of fertilizer: Annual
- Price of seed: Annual
- Price of chemicals: Annual
- Price of corn: Annual
- Price of soybean: Annual
- Acreage: Annual
- Yield: Annual

Table 1:
Summary of the regression when it is run individually for each one of the variables:

	R square	F Ratio	Prob > $\|t\|$	Durbin-Watson
Precipitation	0.2939	0.0020	0.0020	-0.1341
Temperature	0.2988	0.0018	0.0018	0.3193
GDD	0.2124	0.0104	0.0104	0.1873
Fertilizer	0.2078	0.0114	0.0114	-0.1179
Seed	0.2871	0.0023	0.0023	-0.1389
Chemical	0.3357	0.0008	0.0008	-0.1918
U.S. Corn $	0.0101	0.5972	0.5972	0.1385
U.S. Soybean $	0.0598	0.1929	0.1929	0.2235
Acreage	0.4786	< 0.0001	< 0.0001	0.2197
Yield	0.9092	< 0.0001	< 0.0001	0.2014

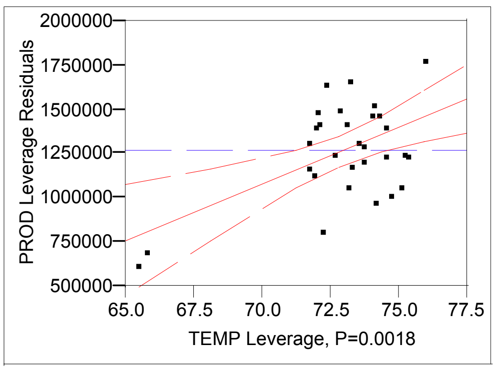
- Precipitation can be used to explain 29.39 % of changes in production.

Figure 1. PRECIPITATION M-J-J-A Leverage Plot



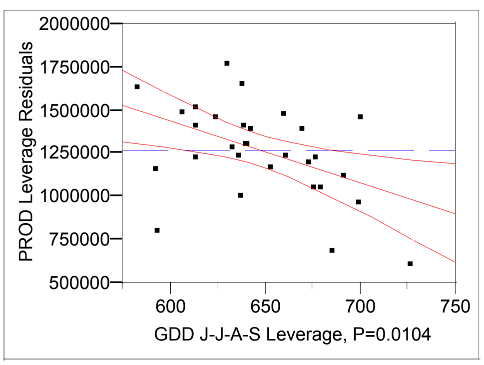
- Temperature can be used to explain 29.88 % of changes in production.

Figure 2. TEMPERATURE Leverage Plot



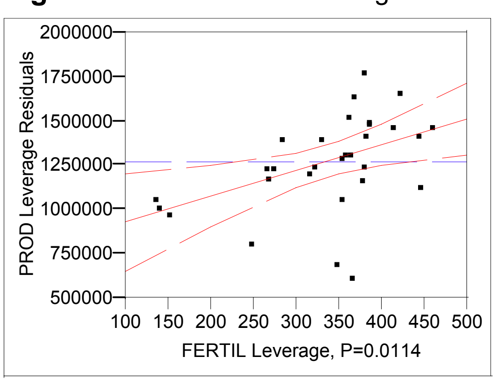
- Growing degree days can be used to explain 21.24 % of changes in production.

Figure 3. GROWING DEGREE DAYS Leverage Plot



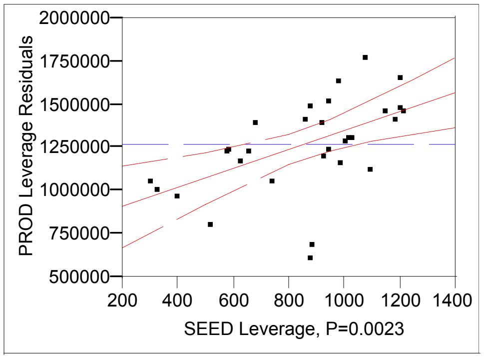
- Price of fertilizer can be used to explain 20.78 % of changes in production.

Figure 4. FERTILIZER Leverage Plot



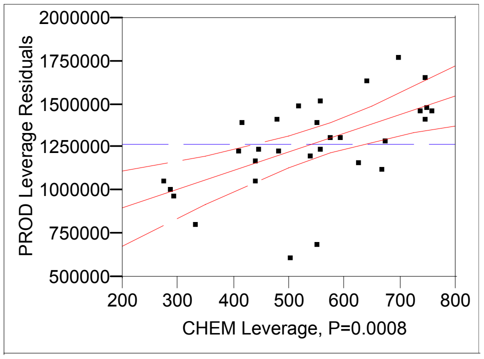
- Price of seed can be used to explain 28.71 % of changes in production.

Figure 5. SEED Leverage Plot



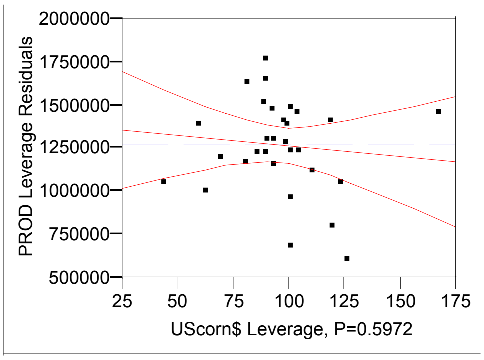
- Price of chemicals can be used to explain 33.57 % of changes in production.

Figure 6. CHEMICAL Leverage Plot



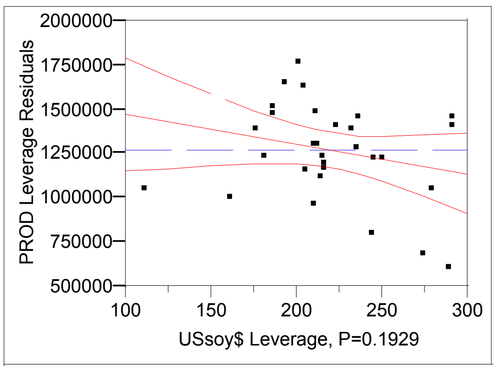
- Price of corn can be used to explain 1.01 % of changes in production.

Figure 7. U.S. CORN PRICES Leverage Plot



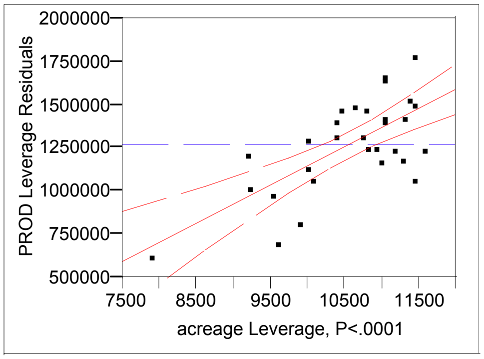
- Price of soybean can be used to explain 5.97 % of changes in production.

Figure 8. U.S. SOYBEAN PRICES Leverage Plot



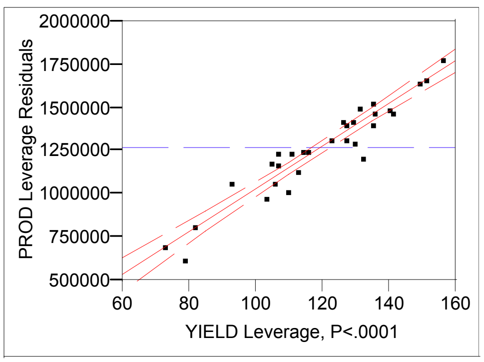
- Acreage can be used to explain 47.86 % of changes in production.

Figure 9. ACREAGE Leverage Plot



- Yield can be used to explain 90.9208 % of the change in production.

Figure 10. YIELD Leverage Plot



R^2 values are high for almost all the parameter except for U.S corn prices, that can explain just a 1.01 % of the changes in the production of corn in Illinois, and U.S. soybean prices, that can explain just a 5.98 % of the changes in the production of corn in Illinois. The prices of corn and soybeans are going to affect the acreage of both productions, switching from one to the other depending on the grower prices of these commodities. We can expect that the price of soybeans affects corn production more than corn prices affect corn prices since soybean is more profitable for growers than corn.

The variables listed in the previous pages are going to be placed in a standard least square regression to evaluate how appropriate the predictor values are for the response variable or corn production in Illinois.

General model equation:

P = a + b * seed + c * temp + d * acreage + e * soybean price + f * precipitation.

P = Corn production in Illinois during the period 1970-2000.

Precipitation = Historical precipitation registered in one of the meteorological station of Illinois (Station (118740) Urbana, IL).

Acreage = We can not used both, yield and acreage since yield is define as production /acreage).

Soybean price = Prices of soybean (Corn production substitute).

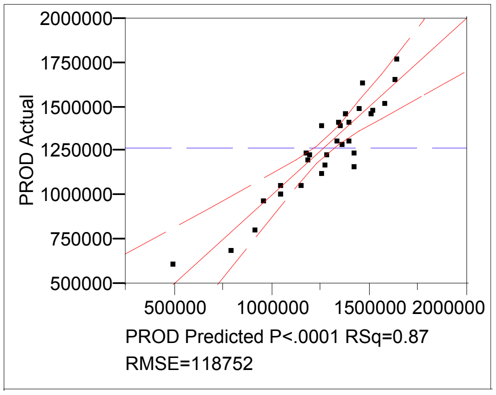
Temp = Temperature.

Seed = Cost of seed.

H_o: $b = 0$, $c = 0$, $d = 0$, $e = 0$, and $f = 0$

H_1: $b \neq 0$, $c \neq 0$, $d \neq 0$, $e \neq 0$, and $f \neq 0$ at $\alpha = 0.05$

Figure 11. Whole Model Actual by Predicted Plot



Summary of Fit

RSquare	0.867834
RSquare Adj	0.808359
Root Mean Square Error	118752
Mean of Response	1270717
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	9	1.85195e12	2.0577e11	14.5917
Error	20	2.82041e11	1.4102e10	Prob > F
C. Total	29	2.13399e12		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-1.8737e6	1064191	-1.76	0.0936
TEMP	30692.447	15355.77	2.00	0.0594
SEED	633.78306	452.0904	1.40	0.1763
FERTILIZER	-719.8442	1109.275	-0.65	0.5238
CHEMICAL	313.25255	603.0244	0.52	0.6091
ACREAGE	106.13119	45.7246	2.32	0.0310
U.S. CORN $	-744.69	1970.8	-0.38	0.7095
U.S. SOYBEAN $	-1248.803	1008.157	-1.24	0.2298
GDD J-J-A-S	-965.1244	782.5554	-1.23	0.2318
PRECIPITATION	89586.751	73781.16	1.21	0.2388

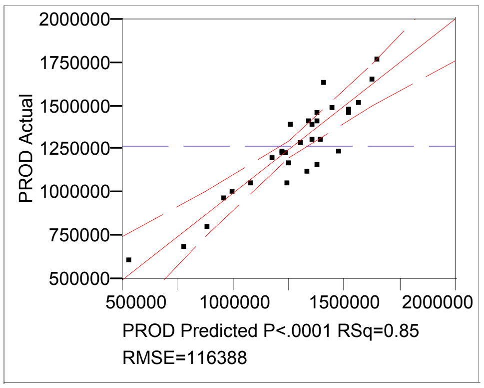
Durbin-Watson

Durbin-Watson	Number of Obs.	Autocorrelation
2.7558204	30	-0.3821

When the regression was run (Figure 11) with all the variables chosen for this analysis, an R^2 of 86.78 resulted. The P-value of the F test is equal to < 0.0001 < $\alpha = 0.001$ indicating that we have enough evidence to reject the null hypothesis for the whole model and accept the alternative hypothesis. For several individual parameters like fertilizer, chemical, and U.S. corn price we can not reject the null hypothesis at $\alpha = 0.05$. So, we can exclude them from further consideration.

The coefficient of the US soybean price is negative as expected. The coefficient of fertilizer and U.S. corn price and growing degree days are negative but we would expect this parameter with a positive sign. This could happen because the growing degree days data was taken just of one of the meteorological stations of Illinois (The Station (118740) URBANA, IL) and it may not be representative of the whole state. (To get additional information I was asked to pay for). The autocorrelation statistic of -0.3821 indicate that autocorrelation is a problem.

Figure 12. Whole Model Actual by Predicted Plot



Summary of Fit

RSquare	0.847654
RSquare Adj	0.815915
Root Mean Square Error	116387.6
Mean of Response	1270717
Observations (or Sum Wgts)	30

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	1.80889e12	3.6178e11	26.7072
Error	24	3.25106e11	1.3546e10	Prob > F
C. Total	29	2.13399e12		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-2.8558e6	797311.9	-3.58	0.0015
TEMP	36368.972	13012.1	2.80	0.0100
SEED	611.52881	93.1791	6.56	<.0001
ACREAGE	115.89095	32.7137	3.54	0.0017
U.S. SOYBEAN $	-2007.971	609.5699	-3.29	0.0031
PRECIPITATION	52841.439	68068.24	0.78	0.4452

Durbin-Watson

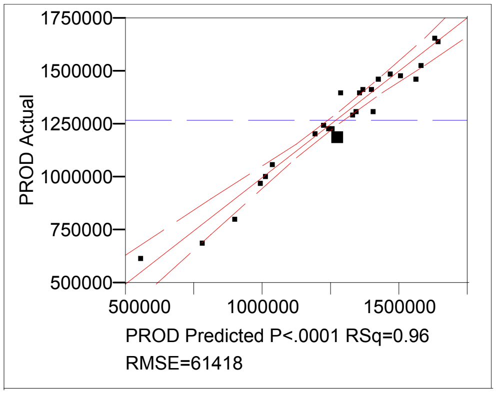
Durbin-Watson	Number of Obs.	Autocorrelation
2.7201235	30	-0.3639

When we run the analysis of Figure 12, an R^2 of 84.76 resulted. P-value of the F test is equal to <0.0001 < α = 0.001. The Durbin-Watson test is significant, showing a high negative autocorrelation (-0.3639).

The monthly rain average of the last 30 years was 3.25 inches. If we test the parameter rain as a single regressor for production, the result was an R^2 of 29.39. A cursory look at the data suggests that high production picks are affected mainly by increases of rain explained in some cases by climatically phenomenon called as the "*El Niño" and "La Niña"* current. Even though that, the historical peak of production in Illinois of this last 30 year happens in 1994 with 1786200 bushels and can not be explained by the variable precipitation (1994 precipitation value is below the 30 years precipitation average). That could means that the total amount of rain is not as crucial as timely rain. The lack of correlation between production and rain in these cases could also be explained by the source of the data. The information was taken from just from one of the meteorological stations of Illinois (Station 118740. Urbana, Illinois) and may not be representative of the whole state. Other factors as temperatures during the pollinization period and monthly distribution of the rain during the different biological development period of corn could be taken in account in further studies for more accurate results.

The next step is to test the model without the most significant outliers. This would lead to the result test in Figure 13.

Figure 13. Whole Model Actual by Predicted Plot



Summary of Fit

RSquare	0.9601
RSquare Adj	0.9496
Root Mean Square Error	61417.59
Mean of Response	1268689
Observations (or Sum Wgts)	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	1.72459e12	3.4492e11	91.4389
Error	19	7.16703e10	3.77212e9	Prob > F
C. Total	24	1.79626e12		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%	VIF
Intercept	-3.156e+6	463047.2	-6.82	<.0001	-4.1252e6	-2.1869e6	.
SEED	601.90598	53.44423	11.26	<.0001	490.04592	713.76603	1.4025269
TEMP	39245.644	7512.84	5.22	<.0001	23521.089	54970.2	2.1658812
ACREAGE	108.13966	18.21557	5.94	<.0001	70.014045	146.26528	1.6427435
$ U.S. SOYBEAN	-1564.655	353.9174	-4.42	0.0003	-2305.413	-823.8973	1.4156439
PRECIPITATION	84193.451	39630.92	2.12	0.0470	1244.9807	167141.92	1.8807476

When the most significant outliers were taken out of the model, the R^2 increases to 96.01. The P-value of the F test of < 0.0001. The sign of all the coefficients are as expected; Temperature, Rain, Seed, Acreage positive and US Soybean price negative. The correlation and variance inflation factor (VIF) values indicate that multicollinearity is not a problem in this model, since the values are below 10 for each predictor. The lower and upper 95% intervals are evaluated in the graph above. None of the confidence intervals include zero, which would indicate that none of the predictors should be excluded from the model.

Durbin-Watson

Durbin-Watson	Number of Observations	Autocorrelation
1.4942098	25	0.0086

The model have a Durbin-Watson of 1.4942098 and a autocorrelation of 0.0086, indicating that the null hypothesis of no autocorrelation is not rejected.

Figure 14.

Box-Cox Transformations (Box-Cox plot shows that we do not need to do any transformation)

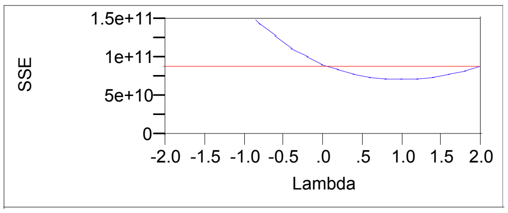
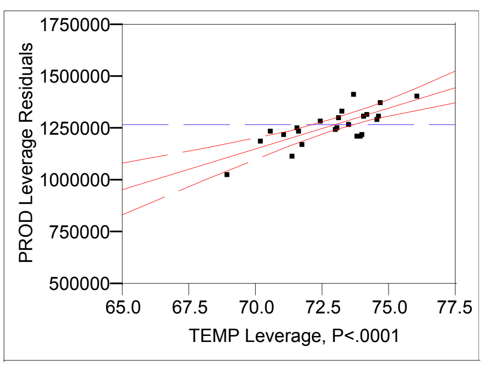


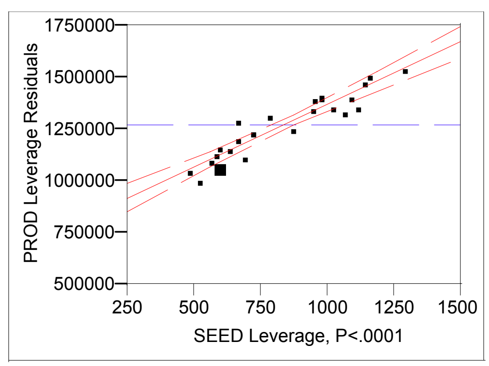
Figure 15, displays the leverage plots for each of the predictor variables, showing from a graphical perspective the significance of the variable.

Figure 15.

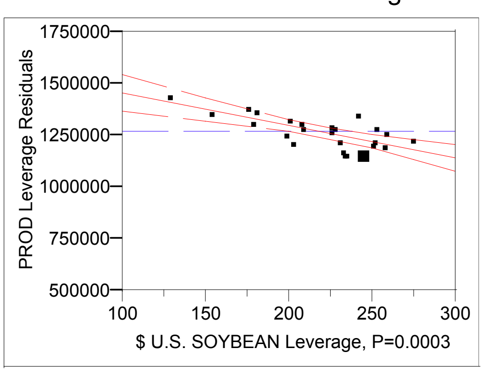
TEMPERATURE Leverage Plot



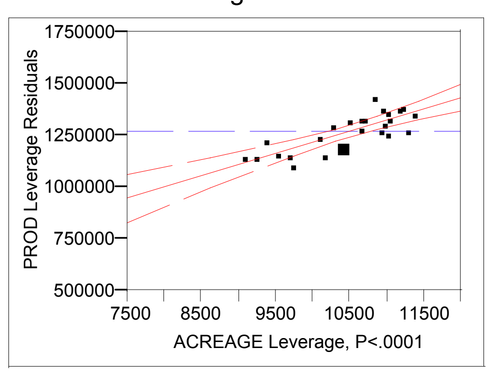
SEED Leverage Plot



U.S. SOYBEAN PRICES Leverage Plot



ACREAGE Leverage Plot



PRECIPITATION Leverage Plot

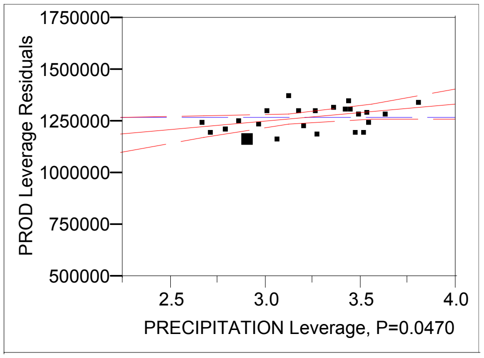


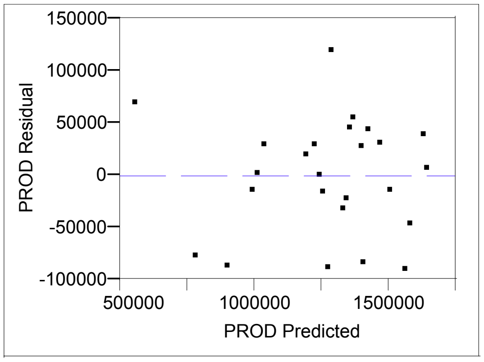
Table 2.

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1981	1982	1983
0.725	0.725	0.072	-0.219	-1.529	0.560	-0.260	-1.522	0.030	2.101	0.504	0.613	1.760

1985	1986	1987	1988	1989	1990	1992	1993	1996	1997	1998	1999	2000
-0.776	0.840	0.424	-1.624	-0.355	-1.398	0.157	-0.516	0.837	1.049	-1.601	-0.226	0.728

Analyzing the Studentized residuals allow us to check for influential observations. An observation can be influential because it has an extreme x-value, an extreme y-value, or both. We can see in the table below that only 1979 lies outside + / - 2 (2.10080361). The reason for this outlier could be explained by timely rain better than the total amount of rain, since the rain in 1979was almost in the average of the last 30 years and production was above the average of the last three decades in almost a 10.50 %. We use Hats to check if 1979 observation is an influential observation and it result to be 0.10661693. So, we can say that the observation is not high leverage since it is not influential.

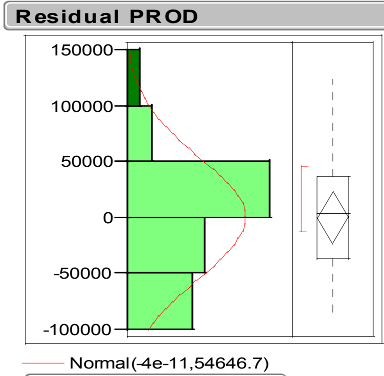
Figure 15. Residual by Predicted Plot



The distributions of the residual look normally disperse, since we assume the model is correct when the residuals should be randomly scattered around 0 and should show no obvious systematic pattern. This tells us that the predictor explained most of the pattern in the model.

Figure 15.

Residual PROD



Quantiles

100.0%	maximum	121954
99.5%		121954
97.5%		121954
90.0%		62748
75.0%	quartile	36412
50.0%	median	3559
25.0%	quartile	-36665
10.0%		-84858
2.5%		-87224
0.5%		-87224
0.0%	minimum	-87224

Moments

Mean	-3.73e-11
Std Dev	54646.704
Std Err Mean	10929.341
upper 95% Mean	22557.051
lower 95% Mean	-22557.05
N	25

Fitted Normal

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Location	Mu	-0.0	-22557.1	22557.05
Dispersion	Sigma	54646.7	42669.7	76021.88

Goodness-of-Fit Test

Shapiro-Wilk W Test

W	Prob<W
0.950044	0.2630

The attained significance level in the Shapiro-Wilk W test of 0.2630 is not small. Consequently one should not reject the null hypothesis that the data are normally distributed.

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
TEMP	1	1	1.02934e11	27.2882	<.0001
SEED	1	1	4.78455e11	126.8398	<.0001
ACREAGE	1	1	1.32944e11	35.2440	<.0001
$ U.S. SOYBEAN	1	1	7.37257e10	19.5449	0.0003
PRECIPITATION	1	1	1.70245e10	4.5132	0.0470

Sequential (Type 1) Tests

Source	Nparm	DF	Seq SS	F Ratio	Prob > F
SEED	1	1	5.58301e11	148.0071	<.0001
TEMP	1	1	9.04572e11	239.8045	<.0001
ACREAGE	1	1	1.42451e11	37.7643	<.0001
$ U.S. SOYBEAN	1	1	1.02244e11	27.1052	<.0001
PRECIPITATION	1	1	1.70245e10	4.5132	0.0470

In the Sequential (Type I) error test all the variables are significant.

Table 3.

Lower 95% Mean PROD	Upper 95% Mean PROD	Lower 95% Indiv PROD	Upper 95% Indiv PROD
944102	1128795	878169	1194729
934463	1087920	861485	1160898
924045	1061859	847100	1138804
839934	952540	755899	1036575
1172214	1272305	1084313	1360206
1178300	1327954	1104386	1401868
1217886	1321892	1131220	1408558
1183760	1292586	1098583	1377764
1239422	1323370	1146168	1416623
1190027	1347667	1118058	1419636
1354302	1439952	1261633	1532622
1400011	1532748	1321709	1611050
456190	649568	392027	713732
1458443	1535416	1362743	1631116
1527046	1630190	1440110	1717126
1308000	1404365	1218901	1493464
1121500	1263964	1045767	1339697
692549	860225	622915	929859
1283258	1400136	1200489	1482905
1364299	1441191	1268571	1536920
1327054	1422159	1237545	1511668
1581254	1694275	1497343	1778186
1284341	1374982	1193358	1465965
1566741	1724750	1494860	1796631
1297805	1385438	1205810	1477432
1362322	1484941	1281211	1566052
1308830	1427872	1226691	1510011
1501305	1620042	1419078	1702269
1433955	1571525	1356945	1648534
1574000	1681974	1488562	1767412

As a result the preferred model is the Figure 3. were the estimate regressions for corn Production in Illinois in the 1970-2000 period is:

R^2 = 0.9601

F-value = 91.4389

Durbin-Watson statistic = 1.4942

Autocorrelation = 0.0086

Based on the results of the Figure 3, we can say that the predictor variables chosen for this analysis do a good job explaining the response variable.

We can conclude that acreage of corn production, rainfall, temperature and price of soybean in Illinois during the last three decades can be used to explain a 96.01 % of the changes of corn production in this state during the last 30 years.

REFERENCES:

1. Economic Research Service. U.S. Department of Agriculture
   http://www.ers.usda.gov/data/costsandreturns/

2. United States Agricultural Department. Statistical Bulletin Number 974. August 2001.
   http://www.ers.usda.gov/publications/sb974-1/sb974-1.pdf

3. National Agricultural Statistics Service. Agricultural Prices 1999 Summary. July 2000.
   usda.mannlib.cornell.edu/reports/nassr/price/zap-bb/agpran00.txt

5. United States Department of Agriculture. Economic and Statistics System.
   http://usda.mannlib.cornell.edu/

6. Agricultural Extension Service. The University of Tennessee.
   http://economics.ag.utk.edu/budgets.html

7. Tennessee Agricultural Statistic Service. "*Tennessee Agriculture 2002*".Bulletin Nr.37, prepared by the National Agricultural Statistic Service in partnership with the Tennessee Department of Agriculture. Pages 3 to 37.

8. National Climatic Data Center (NCDC)
   http://www.ncdc.noaa.gov/oa/ncdc.html

APPENDIX

ILLINOIS ANNUAL PRECIPITATION (1971-2000)

Month / Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1971	1.37	2.96	1.53	1.25	3.49	2.98	5.05	1.85	3.38	1.67	1.61	5.53	2.72
1972	1.07	1.21	2.94	5.57	2.54	3.88	3.89	5.45	5.12	2.65	4.36	3.49	3.51
1973	1.81	1.12	6.48	5.71	4.53	4.16	3.64	2.09	3.53	2.90	3.27	3.17	3.53
1974	2.27	2.30	2.50	2.76	3.01	3.70	1.74	3.31	2.73	1.75	3.16	2.21	2.62
1975	3.54	3.06	3.39	4.36	4.28	4.02	3.32	5.04	2.79	1.82	3.07	2.62	3.44
1976	1.03	2.16	4.56	2.70	3.70	2.97	3.35	1.87	2.23	3.20	0.62	0.45	2.90
1977	1.13	1.37	5.54	2.04	3.21	3.74	3.57	6.91	4.97	4.09	2.60	2.63	3.48
1978	1.25	0.68	3.05	3.55	3.85	3.10	4.61	3.24	2.86	1.91	3.44	3.31	2.90
1979	2.86	1.78	4.52	5.95	2.33	2.93	5.54	4.88	0.49	1.86	3.29	2.12	3.21
1980	0.93	1.28	3.46	2.48	2.84	4.40	2.97	5.32	4.73	2.15	1.26	1.75	2.80
1981	0.31	2.29	1.15	5.09	6.23	5.50	6.36	5.89	2.73	2.48	2.04	1.76	3.49
1982	4.29	1.30	3.74	3.19	4.55	3.73	5.89	3.38	2.69	2.67	4.24	7.17	3.90
1983	0.67	1.17	3.23	4.24	5.61	3.94	1.93	2.43	2.59	3.75	3.50	3.53	2.47
1984	0.77	2.23	4.09	4.99	5.05	2.42	3.09	1.69	4.43	4.79	4.12	3.77	3.45
1985	1.65	3.51	5.21	2.23	3.22	4.52	3.34	5.24	1.71	3.96	8.94	2.34	3.82
1986	0.25	2.78	1.50	2.91	4.60	3.87	5.62	3.51	6.29	4.90	2.90	1.79	3.41
1987	1.58	0.77	2.05	2.51	2.58	3.29	4.29	5.53	2.03	1.32	3.66	5.12	2.89
1988	2.12	1.96	3.26	1.85	1.76	1.05	2.60	2.52	2.37	2.61	5.24	2.37	2.48
1989	1.59	2.12	3.00	3.23	3.45	3.09	3.49	3.91	4.85	1.56	1.42	0.88	2.72
1990	2.08	4.12	3.38	2.88	6.95	6.32	4.20	3.67	1.88	3.27	3.16	4.46	3.20
1991	1.68	1.00	3.98	3.41	4.95	1.68	1.95	2.70	3.12	5.96	3.79	2.12	3.03
1992	1.20	1.48	2.50	2.97	1.26	1.74	7.25	1.95	4.56	1.33	6.50	2.76	3.96
1993	3.63	1.94	3.16	3.14	3.34	4.29	4.27	3.88	3.31	2.55	4.18	1.58	3.27
1994	1.96	1.78	1.32	6.04	2.06	4.23	2.68	3.48	2.36	2.11	5.50	1.95	2.96
1995	3.20	1.04	2.43	4.47	8.73	3.66	3.10	4.07	1.31	3.14	2.52	1.43	3.26
1996	2.39	0.83	2.09	4.98	7.69	4.16	4.48	2.00	2.94	2.45	3.17	1.74	3.24
1997	2.53	3.88	3.04	2.34	4.02	3.57	2.22	4.81	2.34	1.95	2.46	1.95	2.93
1998	2.74	2.57	4.57	4.92	4.79	7.68	3.43	3.25	2.34	4.35	2.49	1.64	3.73
1999	4.24	2.31	1.74	5.57	3.62	5.22	2.77	2.65	2.22	1.72	0.55	2.76	2.95
2000	1.70	2.58	3.17	3.57	4.36	7.27	4.56	3.95	3.84	2.19	3.18	1.97	3.53
Monthly Average	1.87	1.92	3.12	3.64	3.99	3.78	3.72	3.56	2.99	2.74	3.33	2.62	3.11

Data: National Climatic Data Center (NCDC)
http://www.ncdc.noaa.gov/oa/ncdc.html

ILLINOIS GROWING DEGREE DAYS (1971-2000)

Month / Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual GDD
1971	0	14	55	256	362	753	679	669	598	424	130	30	3970
1972	5	23	61	194	500	575	728	716	528	186	25	5	3546
1973	13	16	127	199	349	686	796	746	567	372	85	17	3973
1974	7	10	121	241	374	529	794	670	379	271	66	0	3462
1975	12	3	52	147	502	659	726	759	398	293	168	30	3749
1976	0	75	138	281	363	642	729	640	441	169	32	4	3514
1977	0	14	119	353	640	601	796	672	541	189	113	4	4042
1978	0	0	37	189	381	662	729	695	618	221	104	7	3643
1979	0	0	69	160	416	661	699	689	518	268	58	22	3560
1980	5	0	23	168	477	586	814	776	537	220	72	26	3704
1981	4	29	89	282	340	686	723	675	468	217	107	2	3622
1982	0	0	50	163	577	524	780	638	483	284	92	65	3656
1983	0	30	92	124	326	684	837	835	547	258	91	0	3824
1984	0	27	2	143	340	744	694	733	469	333	57	47	3589
1985	0	7	93	319	495	577	729	623	522	301	81	1	3748
1986	13	11	138	302	483	652	810	616	597	263	25	0	3910
1987	1	6	123	242	600	693	771	704	523	167	112	5	3947
1988	9	9	83	221	511	640	789	770	541	169	67	22	3831
1989	19	0	114	219	355	633	757	708	459	309	79	6	3658
1990	25	22	132	203	340	654	703	668	535	252	140	19	3693
1991	0	16	100	294	626	737	767	738	527	315	71	19	4210
1992	0	29	103	192	410	578	696	583	472	271	38	7	3379
1993	8	11	41	158	447	624	791	739	376	223	37	5	3460
1994	0	18	66	222	391	688	733	626	471	282	110	24	3631
1995	7	24	126	174	335	666	782	859	456	272	32	17	3750
1996	8	50	39	158	388	627	673	726	468	270	24	10	3441
1997	16	20	79	164	299	603	729	632	488	283	25	4	3342
1998	18	23	89	199	526	627	758	775	637	292	93	60	4097
1999	12	29	58	218	467	656	826	660	494	277	156	23	3876
2000	8	62	133	203	470	608	715	729	499	333	51	0	3811
Monthly Average	6	19	85	213	436	642	752	702	505	266	78	16	3721

Data: Urbana, Illinois. Station (118740)
Modified growing degree days (Base: 50F Ceiling: 86F)

ILLINOIS Jun-Jul-Aug-Sep GROWING DEGREE DAYS (1971-2000)

Year / Month	Jun	Jul	Aug	Sep	Average J-J-A-S	Average J-J-A-S	Annual Average	Difference
1971	753	679	669	598	674.75	674.75	330.83	-343.92
1972	575	728	716	528	636.75	636.75	295.50	-341.25
1973	686	796	746	567	698.75	698.75	331.08	-367.67
1974	529	794	670	379	593.00	593.00	288.50	-304.50
1975	659	726	759	398	635.50	635.50	312.42	-323.08
1976	642	729	640	441	613.00	613.00	292.83	-320.17
1977	601	796	672	541	652.50	652.50	336.83	-315.67
1978	662	729	695	618	676.00	676.00	303.58	-372.42
1979	661	699	689	518	641.75	641.75	296.67	-345.08
1980	586	814	776	537	678.25	678.25	308.67	-369.58
1981	686	723	675	468	638.00	638.00	301.83	-336.17
1982	524	780	638	483	606.25	606.25	304.68	-301.57
1983	684	837	835	547	725.75	725.75	318.67	-407.08
1984	744	694	733	469	660.00	660.00	299.08	-360.92
1985	577	729	623	522	612.75	612.75	312.63	-300.12
1986	652	810	616	597	668.75	668.75	325.83	-342.92
1987	693	771	704	523	672.75	672.75	328.92	-343.83
1988	640	789	770	541	685.00	685.00	319.25	-365.75
1989	633	757	708	459	639.25	639.25	304.83	-334.42
1990	654	703	668	535	640.00	640.00	307.75	-332.25
1991	737	767	738	527	592.25	592.25	350.83	-241.42
1992	578	696	583	472	582.25	582.25	281.58	-300.67
1993	624	791	739	376	632.50	632.50	288.33	-344.17
1994	688	733	626	471	629.50	629.50	302.58	-326.92
1995	666	782	859	456	690.75	690.75	312.50	-378.25
1996	627	673	726	468	623.50	623.50	286.75	-336.75
1997	603	729	632	488	613.00	613.00	278.50	-334.50
1998	627	758	775	637	699.25	699.25	341.42	-357.83
1999	656	826	660	494	659.00	659.00	323.00	-336.00
2000	608	715	729	499	637.75	637.75	317.58	-320.17
Monthly Average	642	752	702	505	650.28	650.28	310.12	-340.17

Data: Urbana, Illinois. Station (118740)
Modified growing degree days (Base: 50F Ceiling: 86F)

ILLINOIS ANNUAL TEMPERATURES (1971-2000)

Year \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1971	30.90	40.00	47.10	52.50	65.60	71.20	73.60	74.60	66.40	58.20	41.30	22.80	53.68
1972	31.60	39.50	39.70	56.00	63.60	72.30	78.50	73.40	66.10	55.10	49.80	35.90	55.13
1973	36.60	40.80	42.80	53.40	67.20	72.10	75.50	74.80	71.20	57.20	46.80	37.90	56.36
1974	27.60	37.70	45.70	48.70	57.80	69.90	75.30	71.50	66.20	55.00	40.50	34.60	52.54
1975	28.50	33.30	37.10	50.70	63.40	71.60	73.00	73.40	64.70	55.40	38.10	35.80	52.08
1976	30.70	32.70	45.60	52.60	61.20	71.50	76.10	78.50	64.40	56.20	38.70	31.10	53.28
1977	24.30	32.40	42.90	55.20	59.70	73.80	74.50	71.60	64.90	56.10	48.40	38.70	53.54
1978	32.90	30.50	39.40	50.90	63.00	70.70	77.50	75.40	63.80	52.80	42.50	34.50	52.83
1979	33.60	39.40	43.90	53.00	61.00	68.10	74.30	69.20	65.30	53.70	43.30	34.20	53.25
1980	29.40	37.30	46.10	56.80	68.80	74.00	76.70	74.50	66.80	56.70	40.50	37.20	55.40
1981	39.00	40.00	46.60	52.40	60.10	71.70	74.50	73.00	68.20	54.30	48.50	35.80	55.34
1982	37.60	28.60	43.90	52.50	59.90	70.50	75.10	72.90	64.50	55.80	43.30	21.90	52.21
1983	27.10	30.40	43.00	53.00	63.70	72.50	76.80	77.10	66.80	49.20	44.70	34.10	53.20
1984	30.00	36.90	45.80	53.00	68.00	73.70	76.70	75.20	66.90	49.60	47.10	36.70	54.97
1985	31.40	34.80	45.20	56.60	64.60	73.20	77.90	71.10	69.60	56.40	42.00	34.50	54.78
1986	22.50	28.50	46.40	57.30	64.30	69.30	74.70	71.90	66.70	58.00	47.20	26.30	52.76
1987	25.70	38.70	36.90	51.50	59.80	73.90	73.00	74.30	64.70	59.60	42.30	40.50	53.41
1988	31.60	36.10	43.60	48.40	59.80	71.00	77.90	78.50	67.60	56.60	45.50	23.50	53.34
1989	23.20	30.50	43.70	49.10	67.20	67.80	75.90	71.50	65.00	55.90	45.20	40.80	52.98
1990	27.20	34.30	41.80	58.60	59.30	72.80	75.50	72.30	65.00	53.40	45.10	30.70	53.00
1991	31.00	26.80	38.70	51.60	63.20	70.60	78.90	77.70	69.30	52.40	42.50	33.80	53.04
1992	20.10	23.20	43.90	51.80	61.70	70.70	73.50	72.90	65.90	55.00	43.40	36.00	51.51
1993	20.30	20.60	37.60	54.40	61.30	71.80	75.50	73.90	70.30	53.10	46.20	33.90	51.58
1994	15.10	31.80	47.70	57.70	67.70	70.90	77.50	73.60	68.80	52.90	45.30	30.80	53.32
1995	27.30	41.40	48.20	54.60	59.10	70.60	74.10	71.00	64.40	49.50	35.90	28.40	52.04
1996	34.10	33.80	38.90	50.40	65.90	72.00	74.60	75.50	62.90	57.00	47.40	35.20	53.98
1997	33.60	34.80	46.60	54.90	62.80	67.60	76.00	72.60	61.90	54.00	44.10	34.40	53.61
1998	31.50	33.10	49.90	51.90	59.70	72.90	75.60	74.30	69.00	59.70	46.40	33.20	54.77
1999	30.80	31.90	42.30	53.10	63.50	68.70	74.10	73.30	68.80	52.90	40.70	33.40	52.79
2000	27.10	32.20	39.30	52.70	59.60	74.80	72.90	71.90	69.60	62.00	44.00	40.80	53.91
Monthly Average	28.14	32.65	41.95	51.46	60.73	69.10	73.09	71.34	64.38	53.35	42.47	32.50	51.76

Data: National Climatic Data Center (NCDC)
http://www.ncdc.noaa.gov/oa/ncdc.html

ILLINOIS Jun-Jul-Aug TEMPERATURES (1971-2000)

Month / Year	Jun	Jul	Aug	Average J-J-A	Annual Average	Average J-J-A	Difference
1971	71.20	73.60	74.60	73.13	53.68	73.13	19.45
1972	72.30	78.50	73.40	74.73	55.13	74.73	19.60
1973	72.10	75.50	74.80	74.13	56.36	74.13	17.77
1974	69.90	75.30	71.50	72.23	52.54	72.23	19.69
1975	71.60	73.00	73.40	72.67	52.08	72.67	20.59
1976	71.50	76.10	78.50	75.37	53.28	75.37	22.09
1977	73.80	74.50	71.60	73.30	53.54	73.30	19.76
1978	70.70	77.50	75.40	74.53	52.93	74.53	21.60
1979	68.10	74.30	69.20	74.53	53.25	74.53	17.28
1980	74.00	76.70	74.50	75.07	55.40	75.07	19.67
1981	71.70	74.50	73.00	73.07	55.34	73.07	17.73
1982	70.50	75.10	72.90	72.83	52.21	72.83	20.62
1983	72.50	76.80	77.10	65.47	53.20	65.47	12.27
1984	73.70	76.70	75.20	75.20	54.97	75.20	20.23
1985	73.20	77.90	71.10	74.07	54.78	74.07	19.29
1986	69.30	74.70	71.90	71.97	52.76	71.97	19.21
1987	73.90	73.00	74.30	73.73	53.41	73.73	20.32
1988	71.00	77.90	78.50	65.80	53.34	65.80	12.46
1989	67.80	75.90	71.50	71.73	52.98	71.73	18.75
1990	72.80	75.50	72.30	73.53	53.00	73.53	20.53
1991	70.60	78.90	77.70	71.73	53.04	71.73	18.69
1992	74.70	76.50	75.90	76.37	51.51	76.37	25.86
1993	71.80	75.50	73.90	73.73	51.58	73.73	22.15
1994	70.90	77.50	73.60	76.00	53.32	76.00	22.68
1995	70.60	74.10	71.00	71.90	52.04	71.90	19.86
1996	72.00	74.60	75.50	74.03	53.98	74.03	20.05
1997	67.60	76.00	72.60	72.07	53.61	72.07	18.46
1998	72.90	75.60	74.30	74.27	54.77	74.27	19.50
1999	68.70	74.10	73.30	72.03	52.79	72.03	19.24
2000	74.80	72.90	71.90	73.20	53.91	73.20	19.29
Monthly Average	69.10	73.09	71.34	71.18	51.76	71.18	19.42

Data: National Climatic Data Center (NCDC)
http://www.ncdc.noaa.gov/oa/ncdc.html

PRODUCTION AND PRICES OF CORN AND SOYBEAN (1971-2000)

YEAR	ILLINOIS Corn Production	CORN YIELD Kilogram / ha	CORN PRICES Dollars / tone	SOYBEAN PRODUCTION Acres	SOYBEAN YIELD Kilogram / ha	SOYBEAN PRICES Dollars / tone
1971	1067420	5,527	43	18,263,635	1852	111
1972	1014750	5,527	62	17,281,856	1870	161
1973	981590	6,089	100	18,486,992	1870	209
1974	811800	5,727	119	22,527,328	1869	244
1975	1253960	4,511	100	20,776,672	1593	181
1976	1240130	5,421	85	21,697,728	1942	250
1977	1184400	5,520	80	19,991,600	1754	216
1978	1239870	5,701	89	23,402,640	2055	245
1979	1403350	6,342	99	25,763,776	1974	231
1980	1063920	6,873	123	28,466,400	2161	279
1981	1426320	5,711	97	27,442,608	1782	223
1982	1498640	6,838	100	26,774,800	2033	210
1983	624100	7,108	126	28,101,808	2121	288
1984	1247160	5,089	104	25,302,608	1759	215
1985	1534950	6,698	88	26,755,008	1893	186
1986	1404000	7,407	59	24,922,000	2292	176
1987	1214400	7,493	69	23,590,000	2241	216
1988	700800	7,522	100	23,136,000	2279	273
1989	1322250	5,310	93	23,218,000	1815	209
1990	1320800	7,297	90	24,033,008	2178	211
1991	1177000	7,438	93	22,869,008	2292	205
1992	1646450	6,817	81	23,476,000	2303	204
1993	1300000	8,252	98	23,566,000	2529	235
1994	1786200	6,321	89	23,191,000	2194	200
1995	1130000	8,699	110	24,608,000	2781	214
1996	1468800	7,123	290	24,906,000	2375	167
1997	1425450	7,977	291.91	25,636,000	2527	118
1998	1473450	7,952	236.00	27,967,000	2616	102
1999	1491000	8,438	186.00	28,506,800	2616	91.50
2000	1668550	8,397	193.50	29,318,000	2463	88.80
Average	1.270,717	6,704	107.31	24.099,883	2134	188.73

PLANTING AND HARVESTING DATE FOR ILLINOIS:

CROP	PLANTING DATES		HARVESTING DATES		
	Begin	End	Begin	Most active	End
Corn Grain	April 5.	June 1.	Sep 1.	Sep 20 - Oct 15	Nov 10.
Soybean Grain	May 10.	July 10.	Oct 5.	Oct 20 - Nov 15	Dec 5.

Data: "Tennessee agriculture 2002" Bulletin No.37 prepared by the National Agricultural Statistic Service in partnership with the Tennessee Department of Agriculture.

PRICE OF SEED, FERTILIZER AND CHEMICALS (1971-2000)

Year	Price of Seed	Price of Fertilizer	Price of Chemical
1971	296	134	274
1972	321	138	284
1973	397	150	292
1974	512	246	329
1975	583	320	443
1976	573	272	481
1977	622	266	439
1978	650	265	409
1979	679	283	413
1980	735	353	439
1981	858	381	476
1982	876	384	515
1983	877	365	540
1984	938	379	554
1985	943	360	554
1986	916	329	549
1987	922	314	538
1988	931	346	549
1989	1027	363	573
1990	1012	356	590
1991	983	376	624
1992	976	366	638
1993	1002	352	672
1994	1071	378	695
1995	1088	444	717
1996	1142	458	736
1997	1179	443	745
1998	1208	412	756
1999	1201	385	747
2000	1198	420	745
Average	857.2	334.6	543.87