# A Study on Effectiveness of Seasonal Forecasting Precipitation on Crop Yields in Iowa.

Justin Hesse
*Department of Meteorology, Iowa State University*

Abstract

Using for cast precipitation from the PIRCS lab, I will use evaportranspiration to weight individual moths to create an index to compare to a model forecast, and the actual precipitation values. It is my hope to show that the index is correct and better than the raw forecasted precipitation.

## 1. Introduction

This study is going to evaluate a seasonal forecasting effectiveness. The forecast will be used specifically to forecast precipitation. The precipitation will then be related to crop yields in Iowa. The specific point of this report will be to determine the effectiveness of the seasonal forecasting models to predicting corn and soybean yields. This study will also fall within the time frame of 1979-1999.

The crop data is acquired from the U.S. Department of Agriculture National Agricultural Statistics Service (NASS). This study has received data for corn and soybeans. The data was broken down into county grids by NASS. The NASS gives information on all crops grown in the US. NASS also list prices and forecasted yields. The actual rain data was received from Carlson and Todey climatological data page at http://mesonet.agron.iastate.edu/climodat/. This product logs many weather parameters and climate data over much of Iowa.

The model data is from a forecast model run from the Project to Intercompare Regional Climate Simulations (PIRCS) lab in the Agronomy building on Iowa State University. Each month the lab runs a model that calculates precipitation, mean surface temperatures, and 200-mb pressures. Hindcast, the model name, runs are simulations that are forced with global observed SSTs. Hindcast run are for the 1979-1999 period, and for each year 10 simulations with different initial conditions are made. These initial conditions are 12 hourly apart atmospheric fields. Both the hindcast and the forecast are made for 6-month period. Monthly mean data from all the hindcast runs (21 years * 10 ICs =210 runs total; with each run for 6 month period) and the forecast runs (20 runs with each run for 6 month period) is saved. My data is the average of these runs for the last 21 years from 1979-1999 using hindcast.

## 1. Data, Index, and Analysis

The grid for this model is spaced every latitude degree and every longitude degree. So in finding my points for the precip data was challenging. First I tried breaking Iowa into five-grid point in a diamond shape with one in the middle. Only one grid latitude line went through Iowa. So I ended up with three points along central Iowa:

Central Iowa
(CEN) 42.1 N 93.75W
(Boone And Story Counties)

East Central Iowa
(EAC) 42.1 N 91.9 W
( Linn and Benton Counties)

West Central Iowa
(WEC) 42.1 N 95.62 W
(Monona and Crawford Counties)

There are two counties listed for each data point. The data came in mm/s for months from April to September. There is a specific reason for picking these months. Crop planting begins in April, and growing stops around September. So it is logical to get data in this time period. I left out October for the fact that corn stops growing therefore not needing water as much. Then I changed the data from mm/s to total precipitation. To do this I multiplied by a constant to get it into in/s. Then I multiplied to get in into in/day, and multiplied for given days in the corresponding months to finally get in/month. Then added up all the precip that fell, forecasted that is, in the time period April to September. These are the amounts I will use to compare.

I received crop data (bushels per acre, BPA) for each of the counties. The reason was to get an average over the area, because this is the way the model grid points are. They are a kind of spatial average. Also the grid points all fell very close to county lines anyway. The corn and soybean data all came in a county-by-county break down so averaging was easy. The actual precipitation data came by city identifier. I did not get an average for the area. I felt the spacing between cities in the area was not sufficient to constitute averaging. The cities I did use were: CEN, Ames; EAC, Cedar Rapids; WEC, Denison. The data came in monthly totals that I added up from April to September.

Next I developed an index. The index is based on work done by Daren Miller on a similar subject. He developed an index for precipitation and temperature for crop yield using standardized precipitation and temperatures monthly weighted. My index is not as complicated, but does use the monthly principal. The study found that for corn actual evapotranspiration is as seem in fig 0.

Fig 0

| Month | AET (actual evapotranspiration) | Precip |
|---|---|---|
| April | 1.6 | 1.7 |
| May | 3.2 | 4.4 |
| June | 3.9 | 5.1 |
| July | 6.0 | 3.4 |
| August | 5.1 | 3.9 |
| September | 2.6 | 3.2 |
| October | 1.4 | 2.3 |

This was an average from 1954-80.

This seemed a logical way to weight my monthly forecasted precipitation values. The AET values in some months out did the actual precipitation. This showed dependence of the corn on the previous months rain along with the precip in the month. So I decided to weight the months according to the previous months AET. So for example the forecasted data in April will be multiplied by 3.2. I believe that the AET is weighted accordingly to importance of a month's rainfall. So the index would look like this:

> 3.2(April) + 3.9(May) + 6.0(June) + 5.1(July) + 2.6(August) + 1.4(September) = Indexed forecasted precipitation

The months seem pretty well correlated with what would be peak growing time and with respect to the need for extra precipitation in previous months. I used the same index for soybean yields to compare the effectiveness.

Then I ran the data comparing corn and soybean yields to actual precipitation, forecasted precipitation, and the index forecasted precipitation (fig 1-18). I sorted the data by actual precipitation. Then I plotted the years that were below the median. Then on a separate plot were the other years. So for example (fig 1): this is a plot of corn and soybean yields vs. actual precipitation in Eastern Iowa. The light years in the title indicates that this is the years where precipitation was lighter than the median. Fig 2 shows the same thing except for the heavier years, years above the median. This was done to avoid an annual bias. For example: if lots of precipitation crop yield may go down, but also if it is extremely dry the crop yields will also be less. This would end up with a bell shaped curve and a trend line that is a strait horizontal line not representing what is actually happening. I did the same for forecasted and indexed precipitation. Note: all precipitation is in inches and all crops are in bushels per acre. So the trend we should see is the light years to have increasing trend, heavy years to have decreasing trend.

## 2. Results

The results in trends did somewhat represent what I expected. There were some surprises though. In fig 1 and fig 2 the corn showed he opposite trend. It had decreasing trend in the light years along with increasing trend in the heavy years. The soybeans where not a surprise. In fig 7 and 8 the corn had no surprise in the light years but continued to rise in the heavy. The soybeans kept pretty much a strait line in fig 8 showing no trend at all. In fig 16 corn once again had a downward trend in the light years, but it did decrease in the heavy years though. Soybeans once again stayed pretty strait.

The correlations should have been the best with the actual precipitation, and the least with forecasted precipitation. For eastern Iowa (fig 1-6) the correlations showed that soybeans where not effected too much by any of the addition of the index in light years or heavy years, but if I had to pick one I would go with forecasted numbers doing a better job than the index. Also note in figure 2 that there was an anomaly on both soybeans and corn. For central Iowa fig (7-12) the forecast and index trends where hard to tell because they are really close to strait lines. The correlation seemed to be the best with forecasted totals with the exception of heavy years corn, which did a better job than forecasted. In western Iowa fig (13-18) both the trends and correlation of forecasted and indexed precipitation were poor. The data did not get much correlation here.

## 3. Conclusion

In all the graphs there tended to be a lot of noise(example the anomaly in fig2). The correlations did not pick up as well as the actual precipatation, which was expected. The forecasted precipitation totals on average did better than the index I developed. The index just tended to increase the noise and decrease correlation. The forecasted numbers did all right in showing trends, but did not do so well with correlation.

Over all I believe that my index was a failure. Some improvements can be made though. Maybe adjusting the values to lower the importance of previous months data, and increasing the growing needs of corn at the time of a rain event. Also maybe the rainfall resolution could be weighted and total with the timing of maybe every week or so. The strait forecasted numbers from the model did better than the index, but still I do not believe it to be sufficient to be reliable.

There are some faults with this study that could be improved on. The data was only available over the last 21 years. This allowed for much noise, especially in the corn yields. Longer data time will allow for less noise to enter into the data. Also the index only accounts for precipitation when it comes to yields. There are countless parameters that effect crop yield.

There are many areas for future research though. The index could be made to include other parameters such as growing degree-days or temperature. The resolution of the data could be increased. Also the crop yield could be averaged over a larger area to facilitate averaging of rainfall, and become more representative of the spatial averaging given by the model.


ACKNOWLEDGEMENTS

Darren Miller for the evapotranspiration data.

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REFERENCES


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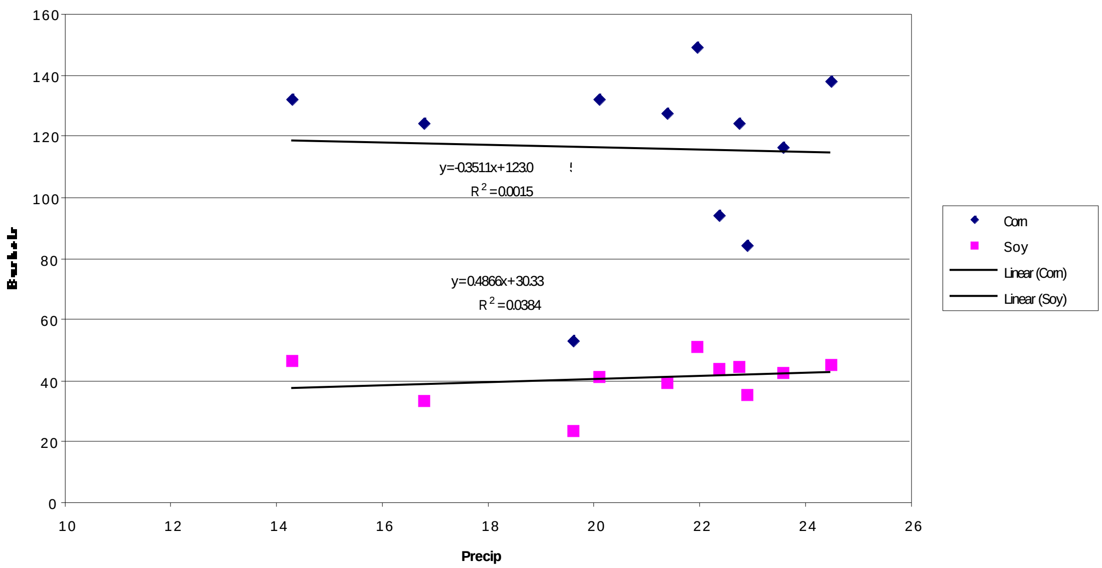
Miller, Darren, 2001: Adaptation of Aridity for Predicting Midwest Corn Yeild. Unpublished, 7 pp.

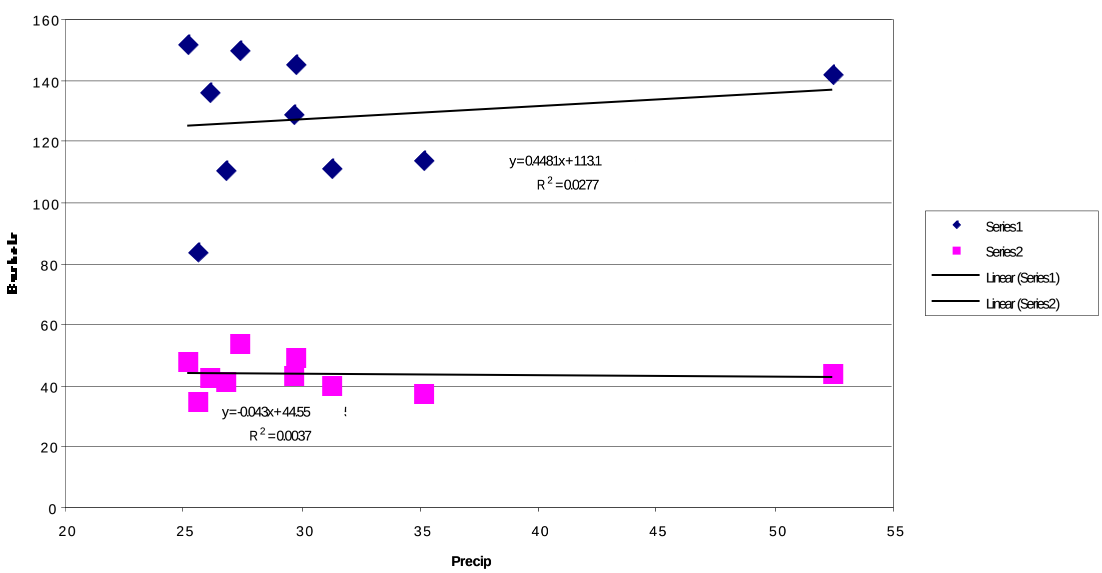
National Ag Statistical Service: Corn and Soybean Crop yields 1979-1999. Department of Agriculture, United States Government.

Peixoto, Jose P., 1992: Physics of Climate. Spriner, New York, 520 pp.

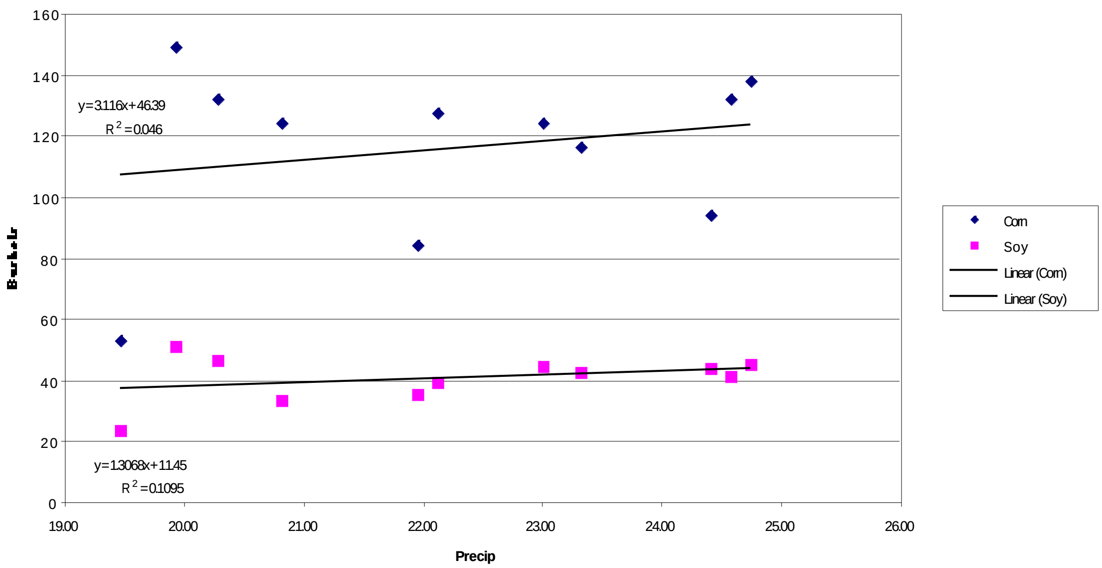
## Corn & Soy vs. Actual Precip Eastern IA light years(fig1)



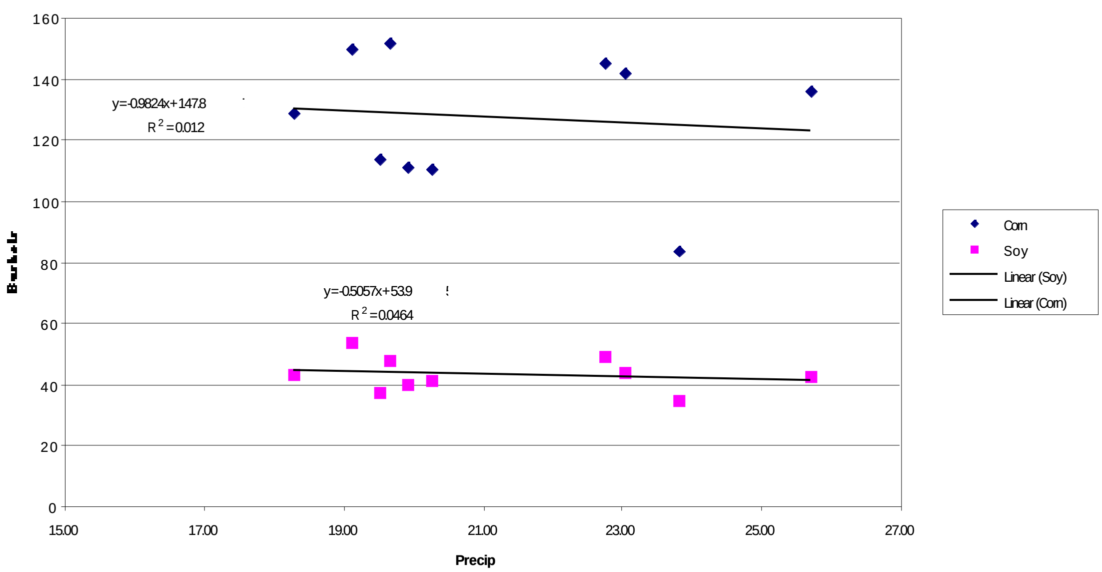

## Eastern IA Corn & Soy vs Precip heavy years(fig2)



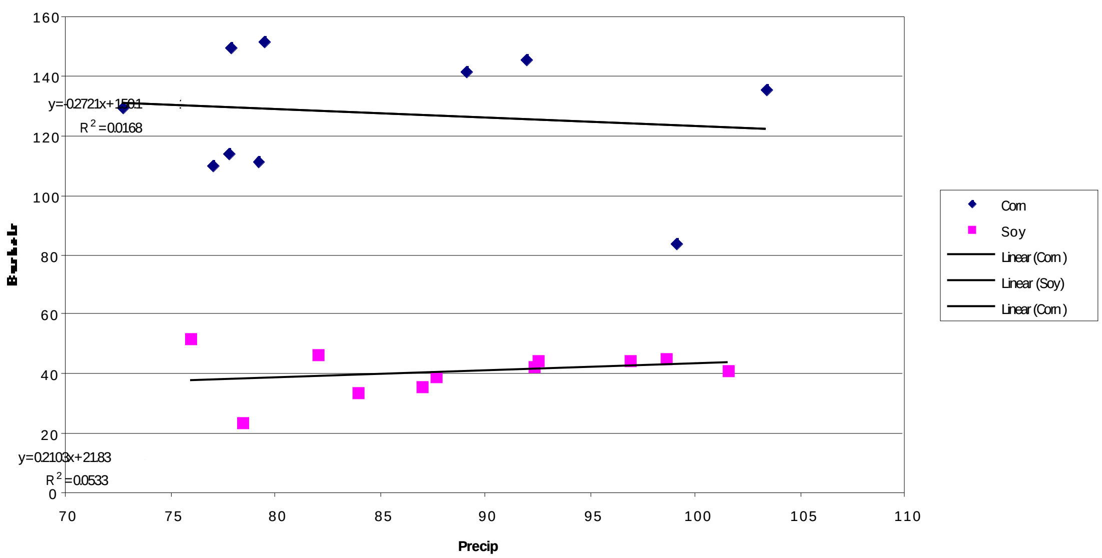
## Eastern IA Corn & Soy vs Forecast Precip Light Years(fig 3)



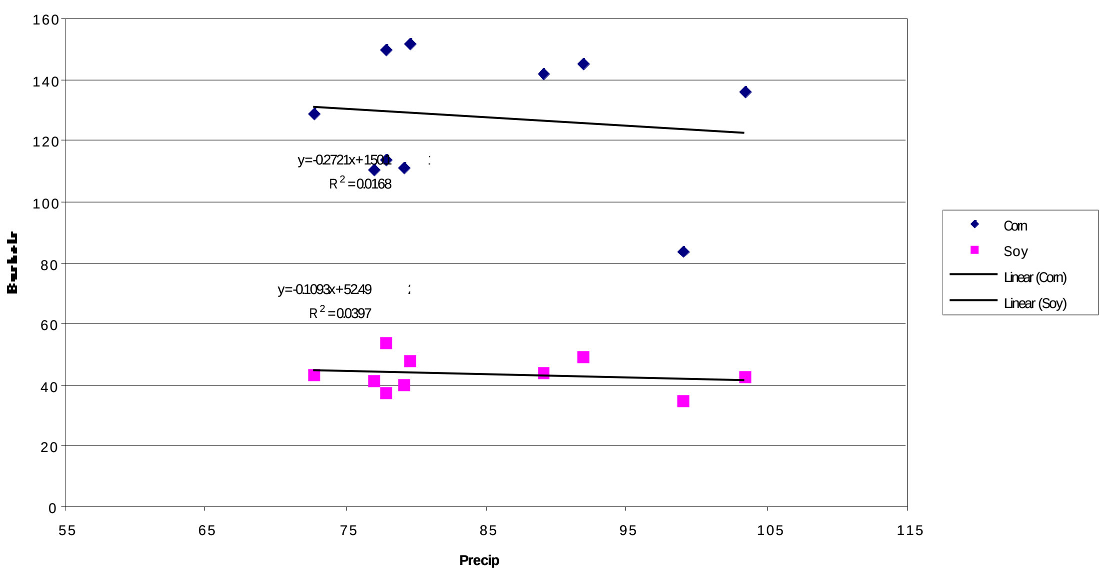

## Eastern IA Corn & Soy Forecasted Precip Heavy Years(fig 4)



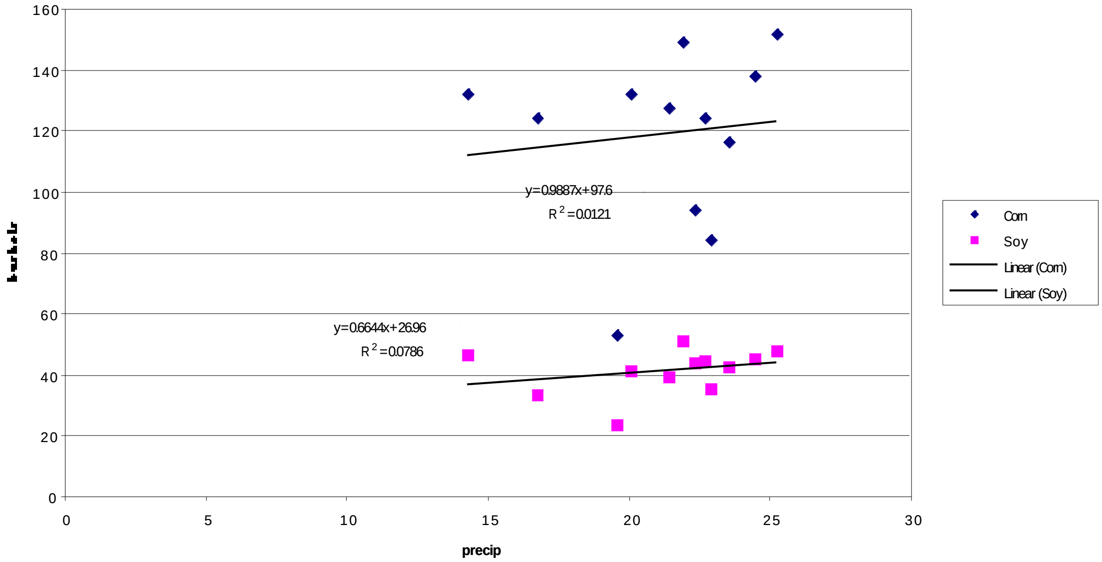
## Eastern IA Corn & Soy Forecasted Precip Heavy Years(fig 5)



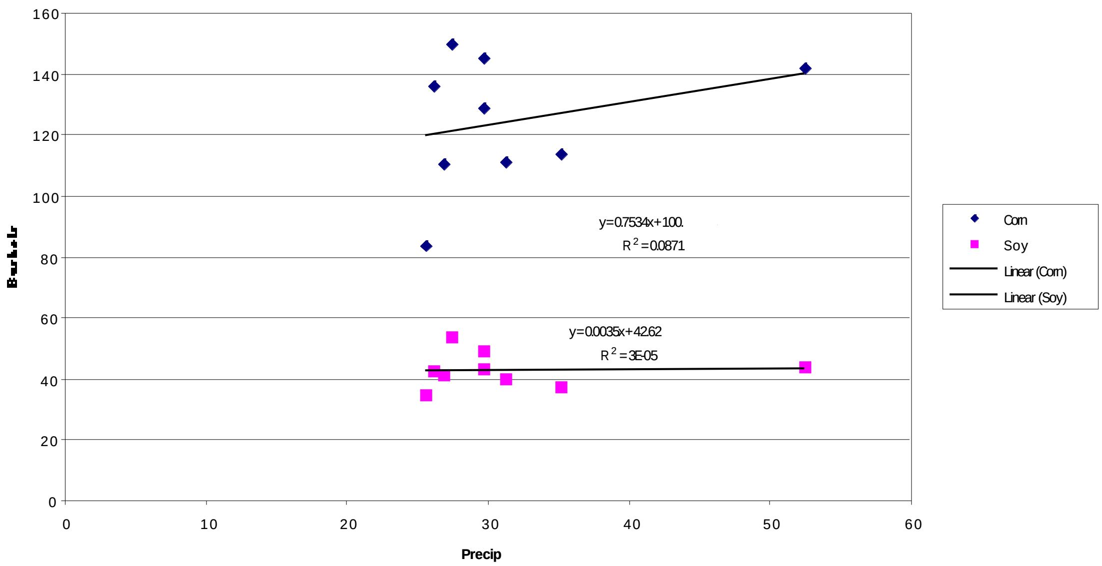

## Eastern IA Corn & Soy Forecasted Precip Heavy Years(fig 6)



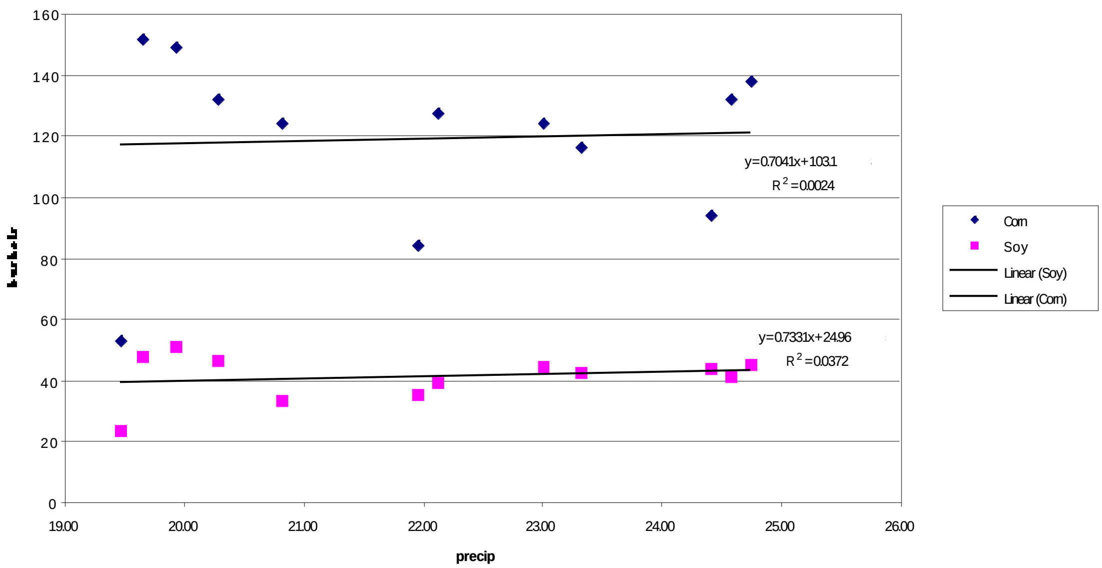
## Central IA Corn & Soy vs precip light years(fig 7)



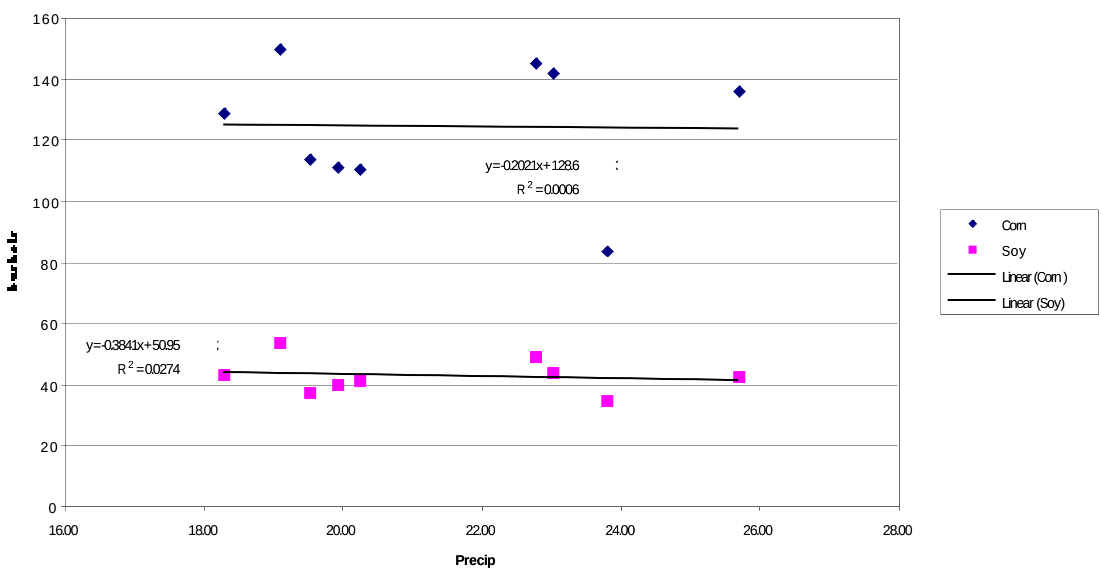

## Central IA Corn & Soy vs Precip Heavy Years(fig 8)



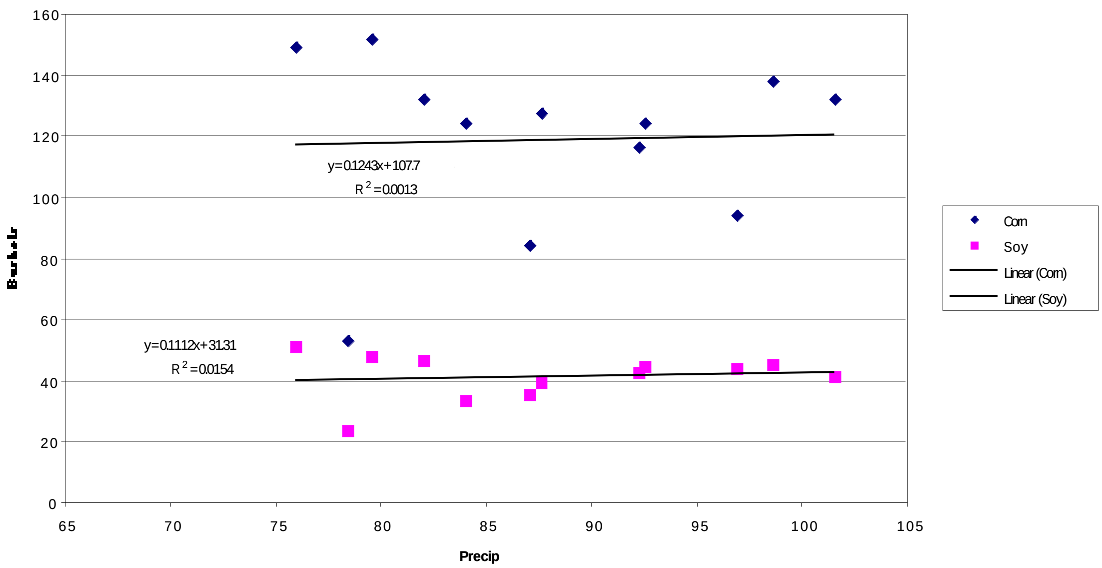
Central IA Corn & Soy vs Forecasted Precip Light Years(fig 9)



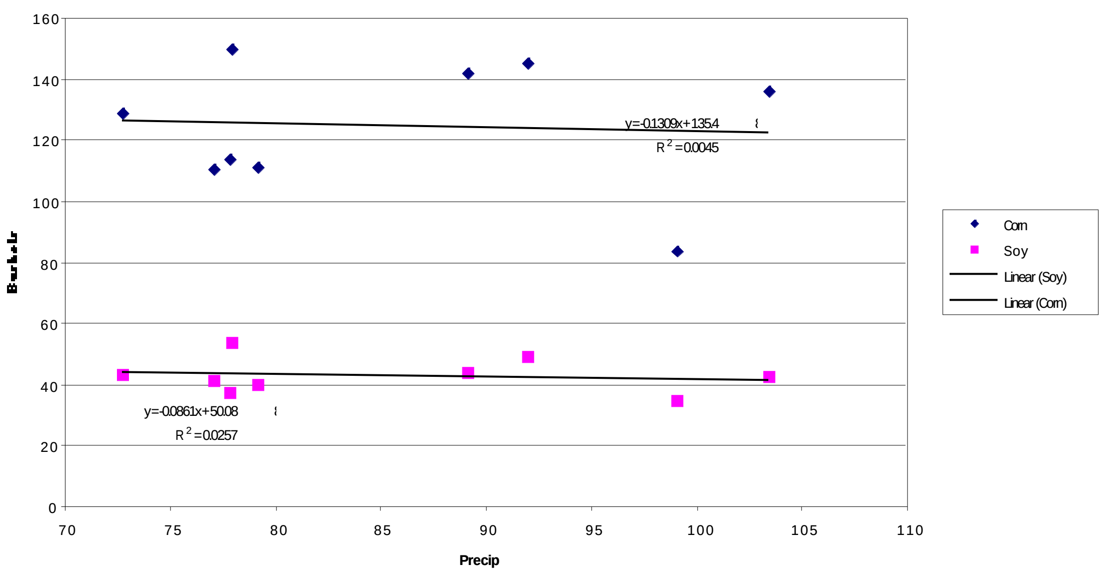

Central IA Soy & Corn vs Forecasted Precip Heavy Years(fig 10)



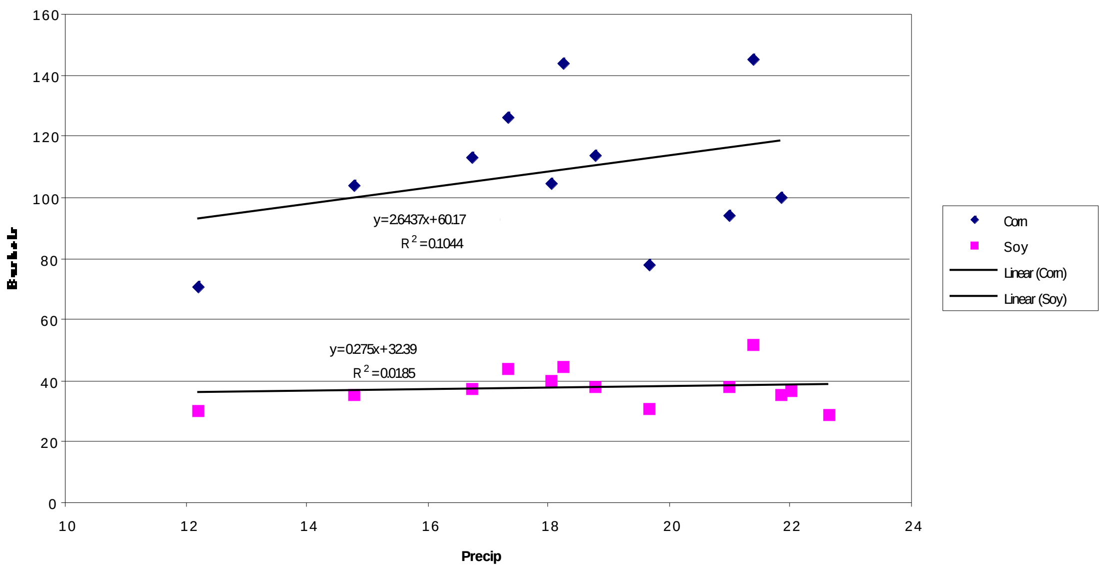
## Central IA Corn & Soy vs Indexed Precip Light Years(fig 11)



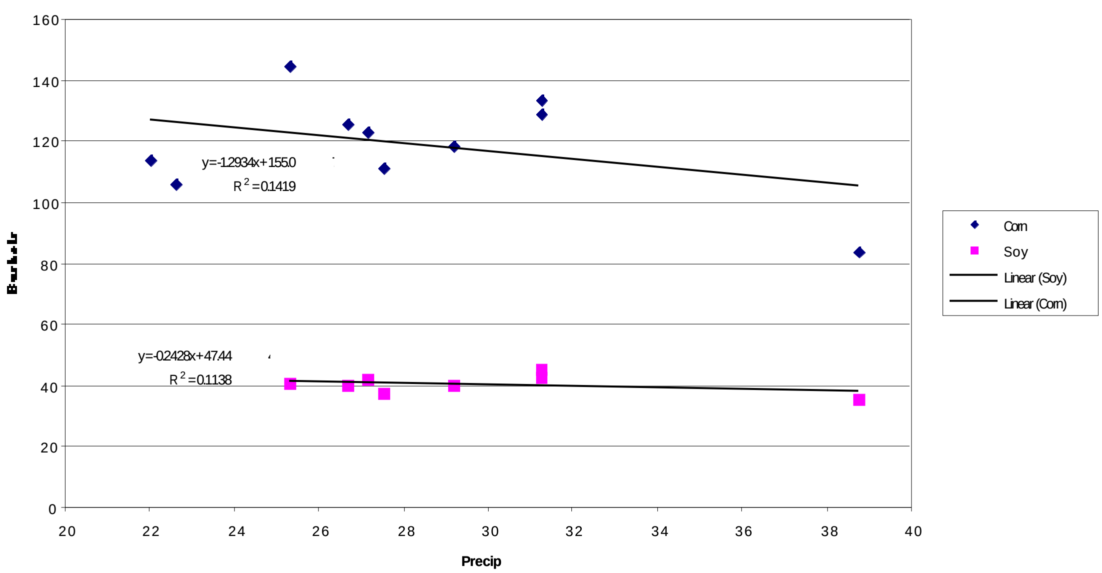

## Central IA Corn & Soy vs Indexed Precip Heavy Years(fig12)



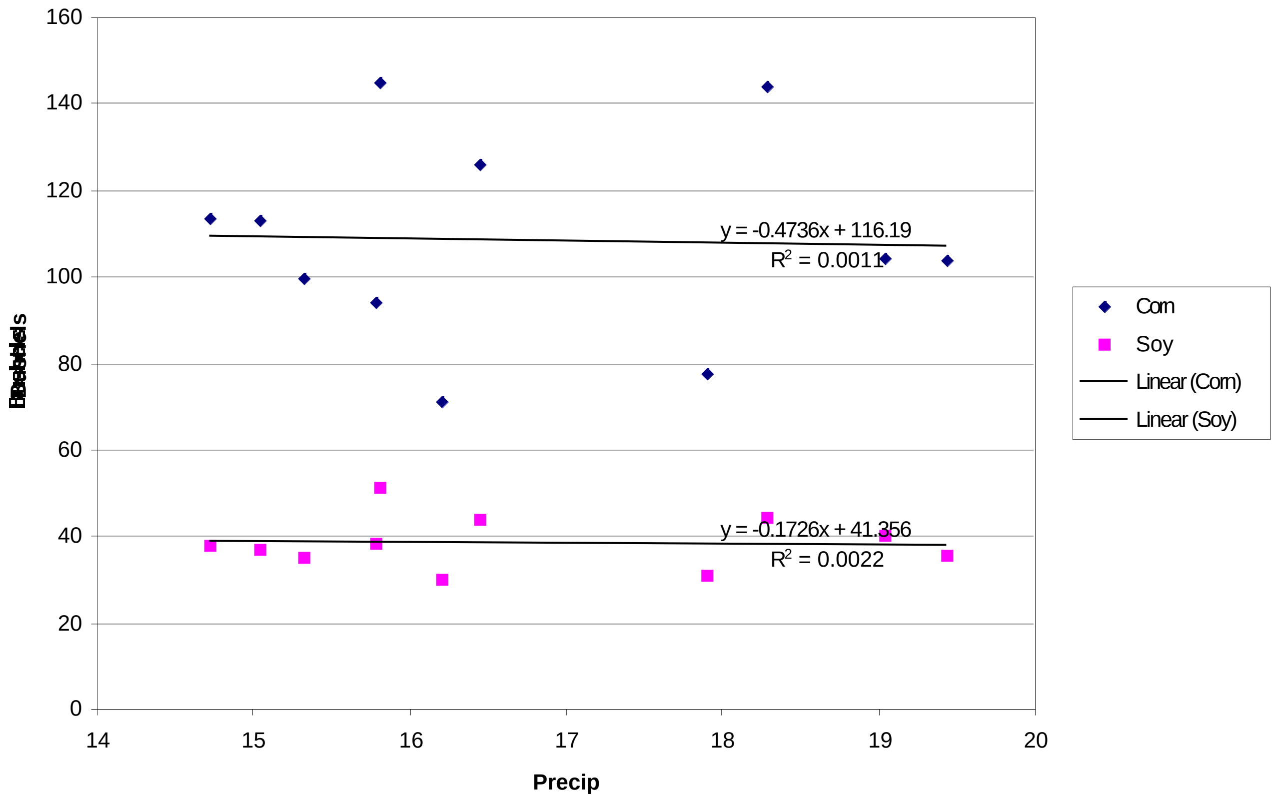
**Western Corn & Soy vs Precip Light years(fig 13)**



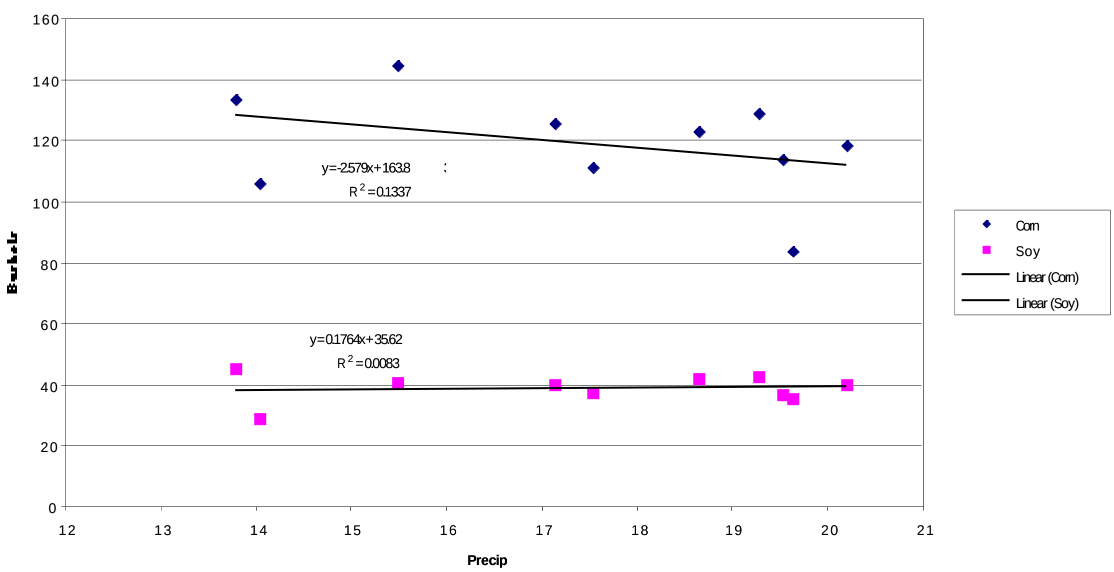

**Western Corn & Soy vs Precip Heavy years(fig 14)**



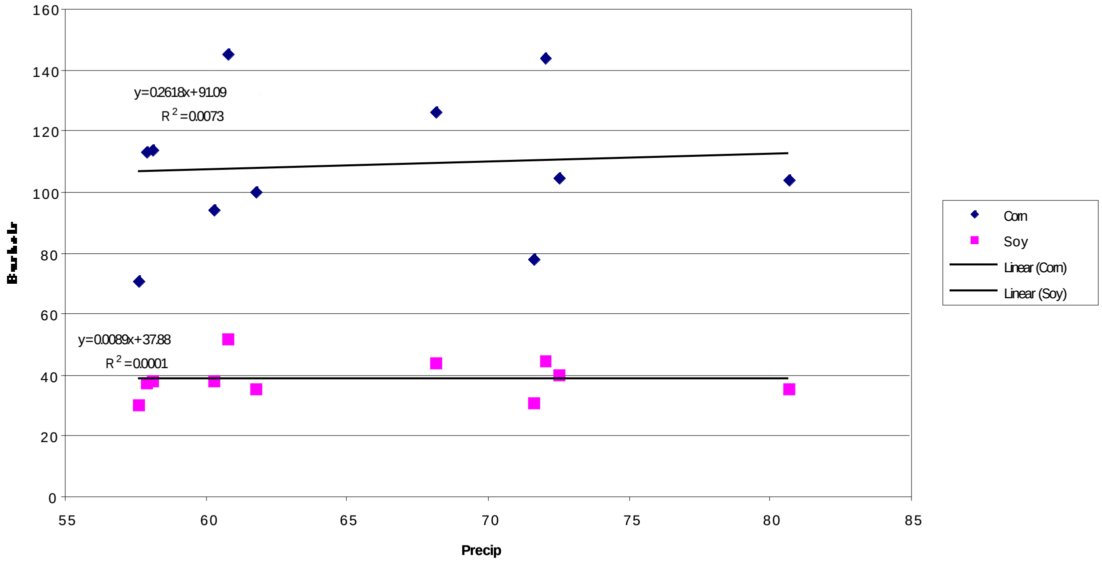
**Western IA Corn & Soy vs Forcasted Precip Light Years(fig 15)**




**Western IA Corn & Soy vs Forecasted Precip Heavy Years(fig 16)**



## Western IA Corn & Soy vs Indexed Precip Light Years(fig 17)




## Western IA Corn & Soy vs Indexed Precip Heavy Years(fig 18)