Effect of ENSO on Corn Aflatoxin Contamination in South Georgia

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Introduction

El Niño Southern Oscillation (ENSO) has been associated with climate variability on different parts of the world. Such variability in climate has become source of uncertainty in agricultural production systems. In the Southeast US, several studies have showed how ENSO influence agricultural crop production (Hansen et al., 1998; Royce et al., 2011).

Multivariate ENSO Index (MEI) and Niño 3.4 are two indices normally used to characterize a particular ENSO event into El Niño, La Niña, and Neutral. MEI uses observed variables (i.e. sea level pressure, surface zonal wind component, meridional wind component, sea surface temperature, surface temperature, and cloudiness) over the tropical Pacific (Wolter and Timlin, 1998) while Niño 3.4 uses monthly sea surface temperature departure from its long-term mean averaged over the Niño 3.4 region (Trenberth, 1997).

This study attempts to establish the possible relations between ENSO and corn aflatoxin contamination in the Southeastern US by utilizing available records of county level corn aflatoxin survey, historical weather data, and MEI and Niño 3.4 indices.

Objectives

The specific objectives of this study are to determine:

1. How weather variables such as rainfall and maximum temperature during critical corn growth stage (reproductive) for aflatoxin contamination differ by ENSO phase in South Georgia.
2. What is the likelihood of getting aflatoxin contamination above the threshold (20 parts per billion, ppb) given a particular ENSO phase.

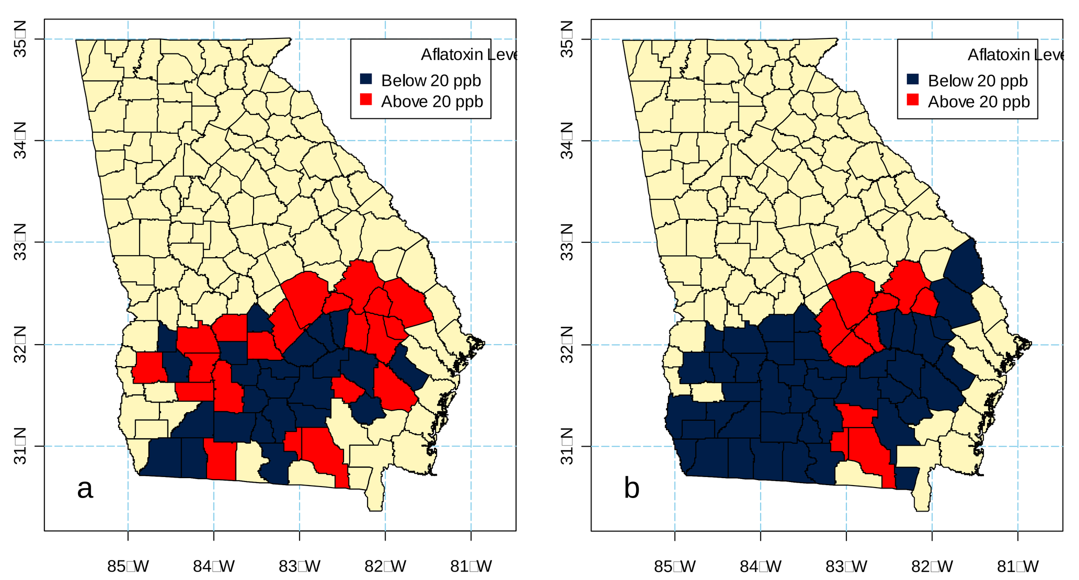
Data

Corn Aflatoxin Contamination Data. County level aflatoxin data was collected from 1977 to 2004 by the, University of Georgia - Coastal Plain Experiment Station (Tifton, GA). Data were collected using a grab sampling technique with an average of 3 replications per county in 53 counties located in South Georgia (Fig. 1).

Weather Data. Historical weather records from 21 weather stations covering the 53 sampling sites obtained from the Center for Ocean-Atmospheric Prediction Studies (COAPS), Florida State University.

MEI and Nino 3.4. Bimonthly MEI data were taken from the Earth System Research Laboratory (ESRL), National Oceanic & Atmospheric Administration (NOAA) while Niño 3.4 monthly indices data were retrieved from Climate and Global Dynamics (CGD), University Corporation for Atmospheric Research (UCAR).

Figure 1. Corn aflatoxin contamination in South Georgia during (a) La Niña (1978) , and (b) El Niño (1997) years



Methodology

- Climatic normals (30-year average) of rainfall and maximum temperature for the month of June (corn flowering period with high risk for aflatoxin) as well as monthly climate summaries were derived from historical weather data.
- Deviation from climatic normals for each year with aflatoxin contamination data were computed by subtracting the historic average from the observed monthly values per year.
- Using logistic regression, the probability of getting aflatoxin contamination based on monthly rainfall and temperature deviation from the normals were estimated.
- Using the MEI and Niño 3.4 indices, yearly deviations of rainfall and maximum temperature for the month of June were classified into different ENSO phases. Then using the develop logistic regression model, probability of getting corn aflatoxin contamination above the threshold were estimated per ENSO phases.

Results

Deviation from the Normals and Aflatoxin Contamination

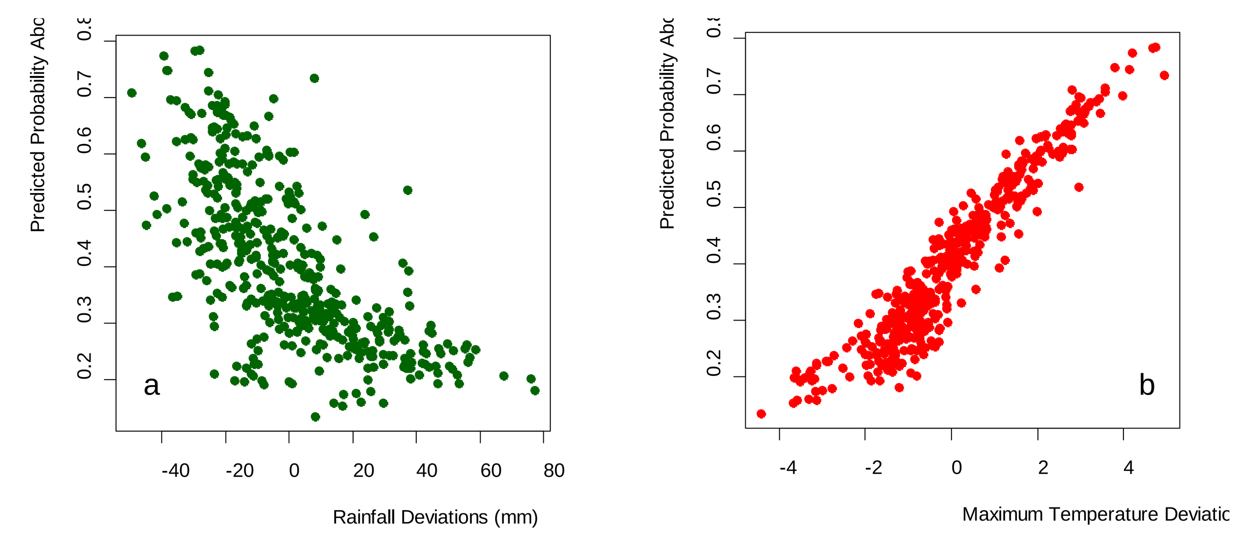


Figure 2. Predicted probability of aflatoxin contamination above threshold (20 ppb) based on monthly deviations of (a) rainfall, (b) maximum temperature from climatic normals for the month of June

Deviation from the Normals by ENSO Phases

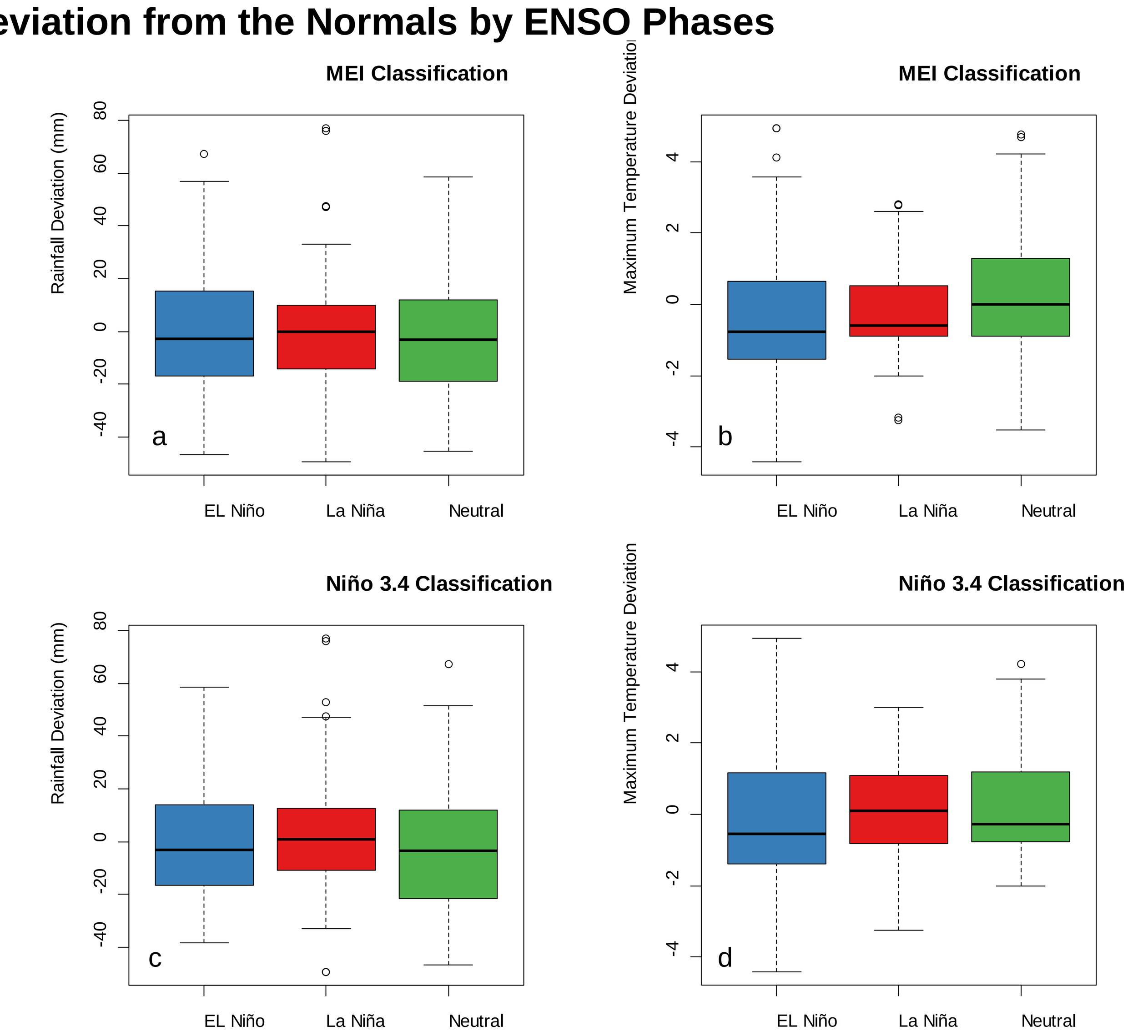


Figure 3. Rainfall and maximum temperature deviations from the normal using MEI (a and b) and Niño 3.4 (c and d) indices.

Probability of Aflatoxin Contamination by ENSO Phase

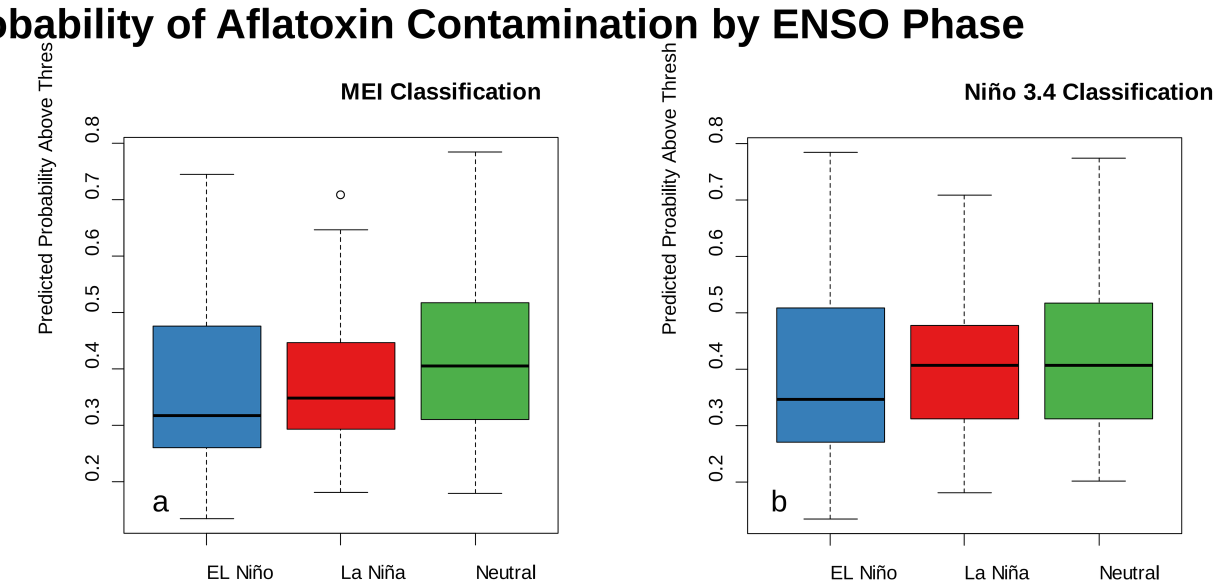


Figure 4. Predicted probability above the 20 ppb threshold by ENSO phase based on (a) MEI and (b) Niño 3.4 Indices

Discussion

Results showed that there is a significant relationship between corn aflatoxin contamination and deviations of rainfall (p-value = 0.032) and maximum temperature (p-value<0.0001). Such relationship can be seen in Fig. 2. Lower rainfall and higher temperature than the normal during corn reproductive stage increases the likelihood of having aflatoxin contamination greater than the set threshold.

There is no significant differences by ENSO phases with respect to rainfall deviation (Fig. 3a and 3c) using both MEI (p-value= 0.95) and Niño 3.4 (p-value= 0.17) indices. However, in terms of maximum temperature (Fig. 3b and 3d) significant difference was detected by ENSO phases, MEI (p-value<0.0001) and Niño 3.4 (p-value=0.03). El Niño years showed consistently lower maximum temperature deviations from the normals on both ENSO indices.

Predicted probability of aflatoxin contamination above threshold is significantly different by ENSO classification (Fig. 4). When MEI classification was used, significantly higher probabilities were observed during Neutral years (Fig. 4a) while higher probabilities was observed for La Niña and Neutral year using Niño 3.4 classification. However, it can be observed that El Niño years for both indices showed lower likelihood of aflatoxin level above the threshold compare to both La Niña and Neutral years.

Concluding remarks

Probability of aflatoxin contamination is highly associated with deviation of maximum temperature from historic average values. Although higher deviations from the normals differs by ENSO index, consistent lower temperature is observed for El Niño phase. These results can be used to advise producers on implementing specific management practices based on monthly rainfall and maximum temperature as well as ENSO forecast.

References

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