Exploring the Potential of Using ENSO Forecasts to Select Nitrogen Fertilizer Application Strategies for Winter Wheat in Alabama

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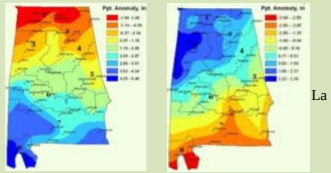
Wheat is an important cash, grain and fodder crop for winter season in Alabama (AL). Despite a strong difference during ENSO phases, changes in temperature and rainfall between northern and southern regions of AL exist for either El Niño or La Niña phases. El Niño Southern Oscillation (ENSO) plays a greater role in variation of normal winter weather of AL as well as whole southeast region of USA which result as well in wheat yield differences. Selection of a suitable nitrogen (N) application strategy especially an adjustment in N splits during spring is the key to maximize the yield potential in AL wheat growing regions. Possibilities of using ENSO forecast in selecting a better N strategy to avoid loss of yield or increase nitrogen use efficiency due to weather changes during El Niño and La Niña is the main idea of this study.

Objectives

- To evaluate the CERES model to simulate different nitrogen strategies for winter wheat planted at two different locations of Alabama.
- To analyze the effect of ENSO phase on nitrogen fertilization strategies for two locations of AL using the CSM-CERES-Wheat model.

Materials and Methods

Two separate experiments were conducted in north and south AL respectively at Tennessee Valley Research Station (TVS), Belle Mina, AL and Wiregrass Research Station (WGS), Headland, AL during 2009-10 and 2010-11. The changes in precipitation during two ENSO phases which are also contrast in North and South AL can be clearly seen in the figures below.

El Niño  La Niña

Evaluation of the DSSAT Crop Model:

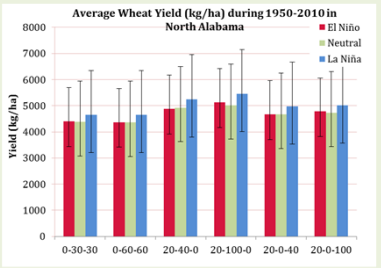
Wheat cultivar AGS 2060 was adopted for the study in both North (N) and South (S) AL. In both the experiment tillage was conventional and no irrigation was applied. N application was in two splits during planting and in spring in 6 different combinations. N application was during plating (0 or 20 lbs/ac) and either or both *Feekes* 4 (the 2nd value in the combination) and *Feekes* 6 (3rd value in the combination) stages. *Feekes* 4 occurred during February last week to March 1st week and *Feekes* 6 occurred during the 2nd quarter of March in N AL; while in S AL, *Feekes* 4 occurred during February last week to March 2nd week and *Feekes* 6 occurred during March 2nd week to April 1st week. The N application strategies were: T1(0-30-30), T2 (0-60-60), T3 (20-40-0), T4 (20-100-0), T5 (20-0-40) and T6 (20-0-100).

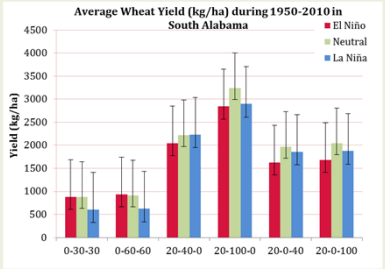
DSSAT 4.5 crop model suite was used to simulate the wheat yields with the soil and weather details of these two sites. The model was first calibrated and validated for two years (2009-10 and 2010-11) data. The CSM-CERES-Wheat model performed well in 2010-11 than 2009-10 for TVS (Root Mean Square Error (RMSE) = 1343.873, d-stat=0.255 in 2009-10; RMSE = 401.174, d-stat = 0.459 in 2010-11). However, model performed well in 2009-10 than in 2010-11 for WGS (RMSE = 197.833, d-stat= 0.942; RMSE = 682.756, d-stat = 0.582).

Seasonal Analysis:

Seasonal Analysis Program was used with 60 years (1950-2010) weather data and site-specific soil data to predict the yield trends under these 6 different N strategies for both TVS and WGS. ENSO Index according to Japan Meteorological Agency (JMA) SSTA was used to classify the years for different ENSO phases. The simulated yields were later distributed based on ENSO affected years and plotted to judge the effect of timings and rate of N applications for both the places.

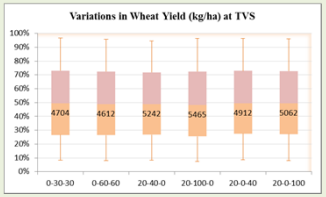
Variations in Wheat Yields during Three ENSO Phases in North and South Alabama

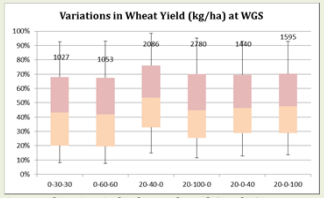




- *The variations in yields in case of different N application strategies during the three ENSO phases were higher in South than in North AL.*
- *In North AL, during La Niña (LN) phase when Spring is usually wet, the average yield in north AL was higher than El Niño (EN) as well as neutral years*
- *In North AL, more precipitation and a basal application of 20lbs/ac at planting along with either early or late spring N application increased the yield irrespective of ENSO phases and yield was maximum when the application was higher in early spring.*
- *In South AL, average yields in normal years were usually more than ENSO affected years.*
- *In South AL, application of N @20lbs/acre during planting along with spring application produced higher yields during EN affected years when precipitation is more in south AL*
- *In North AL 20-40-0 and 20-100-0 both provided better yield with a maxima in case of 20-100-0. However, in South AL 20-100-0 was noticeably promising in all three ENSO phases.*

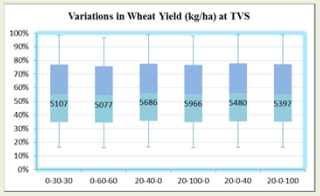
Differences in Wheat Yields during El Niño affected Years in North and South Alabama

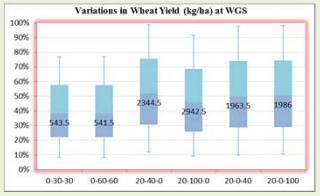




- *An early Spring application of N increased the yield of wheat than late spring application in both North and South AL.*
- *From late Spring application to early spring application of N increased the wheat yield by 300-400 kg/ha in North but 600-1200 kg/ha in South where precipitation is more in South during EN affected years.*
- *Highest yield during El Niño was in 20-100-0 in both North and South AL.*

Differences in Wheat Yields during La Niña affected Years in North and South Alabama





- Yields under different N combinations were higher in North (where LN affected years generally gets more rainfall than neutral years) than South AL .
- Differences in yields are very pronounced in South Alabama where effect of ENSO is more prominent than in North. Moreover, increase in rate of N under same kinds of treatments did not reflect much on yields in case of first and last two treatments.
- An early spring application along with a basal dose of 20lbs/ac resulted prominent variations in yield during LN affected years.

Conclusions

- Differences in yields under varied rates of N application are more in south Alabama where impact of ENSO phases (both EN and LN) are more pronounced.
- Maximum wheat yields can be achieved if the early spring N is 100 lbs/ac along with a basal rate of 20lbs/ac is applied in both North and South AL during EL Niña and La Niña affected years.

References

Kipling S. Balkcom and Charles H. Burmester (2011). Optimize nitrogen for Alabama wheat yields with and without fall tillage. Better Crops. 95(3):8-11