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The Impact of Weather Patterns on Planting Date of Wheat in North Carolina

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INTRODUCTION

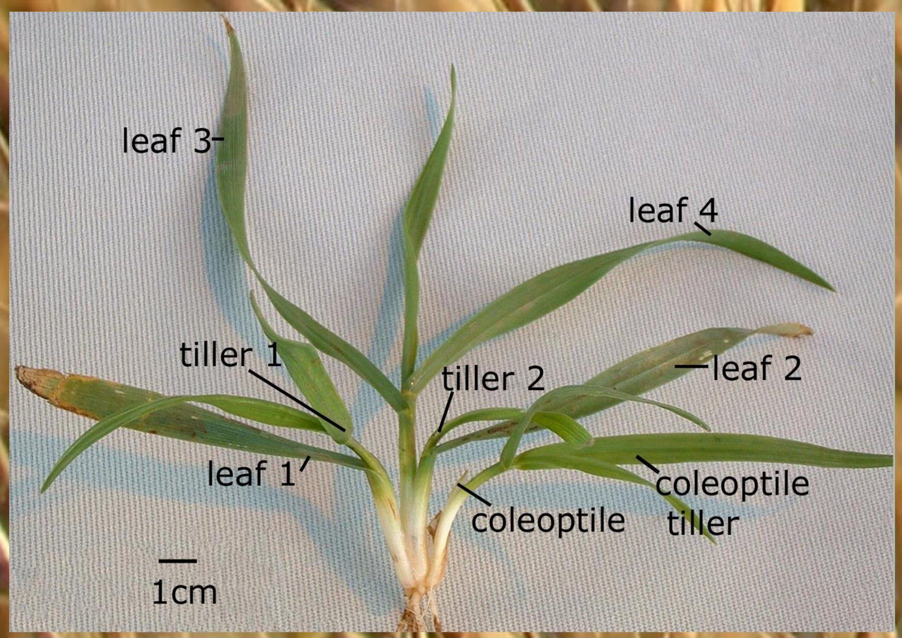
Wheat (*Triticum aestivum* L.) production in North Carolina is often subject to season to season fluctuation in weather and climate patterns. Management and production practices that are favorable one year may be totally different the next year when the weather conditions are different. An abnormally warm winter which favors fall tiller production may be present one year, and may afford the grower to plant later. However, the following year, cold weather may arrive early in the fall to necessitate early planting to achieve adequate tillers. Therefore, planting date is one of the most important factors that can be controlled by the producer (Campbell et al., 1991).

Tillers that develop in the fall are one of the most essential factors to high yields since they have two key components of a high yielding crop: large heads with kernels and kernels with a high test weight. Adequate growing degree day accumulation allows the plant to accumulate as many fall tillers as possible. In 2012, wheat planted in December produced more tillers than wheat planted in November and subsequently had a higher yield. However, in 2013 wheat planted in November had more tillers and a higher yield, while wheat planted in December much fewer tillers and lower yields (Oakes & Heiniger, unpublished data).

The El Nino Southern Oscillation (ENSO) phenomenon is one of the strongest drivers of year to year climate variations in the world (Ropelewski & Halpert, 1986), and has an important and predictable effect on climate in the Southeastern U.S. (Fraisse et al., 2007). During El Nino years, Southeastern U.S. states tend to be cooler and wetter overall (Fraisse et al., 2007). A second pattern that may influence the planting date of wheat in North Carolina is the North Atlantic Oscillation (NAO). During a cool NAO, the eastern U.S. experiences colder and drier air masses during the winter and there is an increased potential for wintry weather. Meanwhile, during a warm NAO period there is a lack of cold air available, and a decreased potential for winter weather.

OBJECTIVES

1. To examine the effects of ENSO and NAO on tiller production and yield potential
2. To determine when a grower is best suited to plant wheat based on the ENSO and NAO phase



MATERIALS & METHODS

Phyllochron interval (PI) was used to determine how many growing degree days (GDD) are necessary for the plant to develop its first tiller (Oakes & Heiniger, unpublished data). In order to measure PI, mainstem leaves were counted during the vegetative phase and regressed against accumulated GDD since planting. Mainstem leaves were counted and recorded at bi-weekly to monthly intervals beginning at emergence and continuing to flag leaf. These mainstem leaves were counted according to the Haun scale (Haun, 1973). Since three mainstem leaves are required for the plant to produce a tiller, the PI was multiplied by three to determine the number of GDD required to produce one tiller. The threshold used for this study is 310 GDD per tiller, since it was the average number of GDD required for the first tiller across several locations and planting dates. In order to determine how climate patterns affect GDD accumulations, climate data was examined for sixty-one years from 1950 to 2011. For these years the ENSO and NAO climate patterns were examined in order to determine which climate pattern minimized the number of days required to develop a new tiller at each potential planting date from October 1-November 15.

For this study, the August-September-October (ASO) Oceanic Nino Index (ONI) was used to determine ENSO phase. The ONI describes the sea surface temperature relative to the average for a certain swath of the Pacific Ocean known as the Nino 3.4 region (Dahlman, 2009). The average temperature in this region is used to indicate the current ENSO phase. El Nino conditions are considered to be present when the ONI is 0.5°C warmer than average, while La Nina conditions are considered to be present when the ONI is 0.5°C cooler than the average. When the ONI is between +0.5 and -0.5, conditions are considered to be ENSO neutral. The current NAO index corresponds to NAO patterns which generally vary from month to month. Current monthly indices are for the past 120 days, and for the purposes of this study the October NAO will be used. When the index is greater than 0.674, a warm NAO period is present. Likewise, when the index is less than -0.674, a cool NAO period is present. When the index is between +0.674 and -0.674, conditions are considered to be NAO neutral.

RESULTS

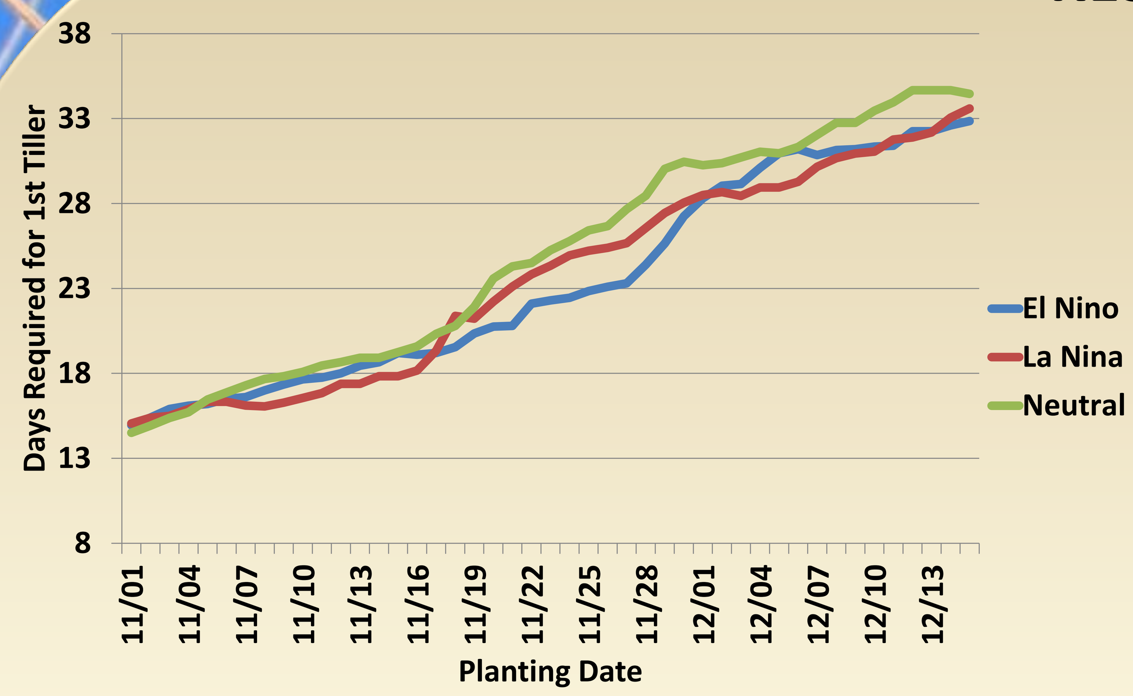


Figure 1: Days required to reach 310 GDD (1st tiller) based on ENSO phase

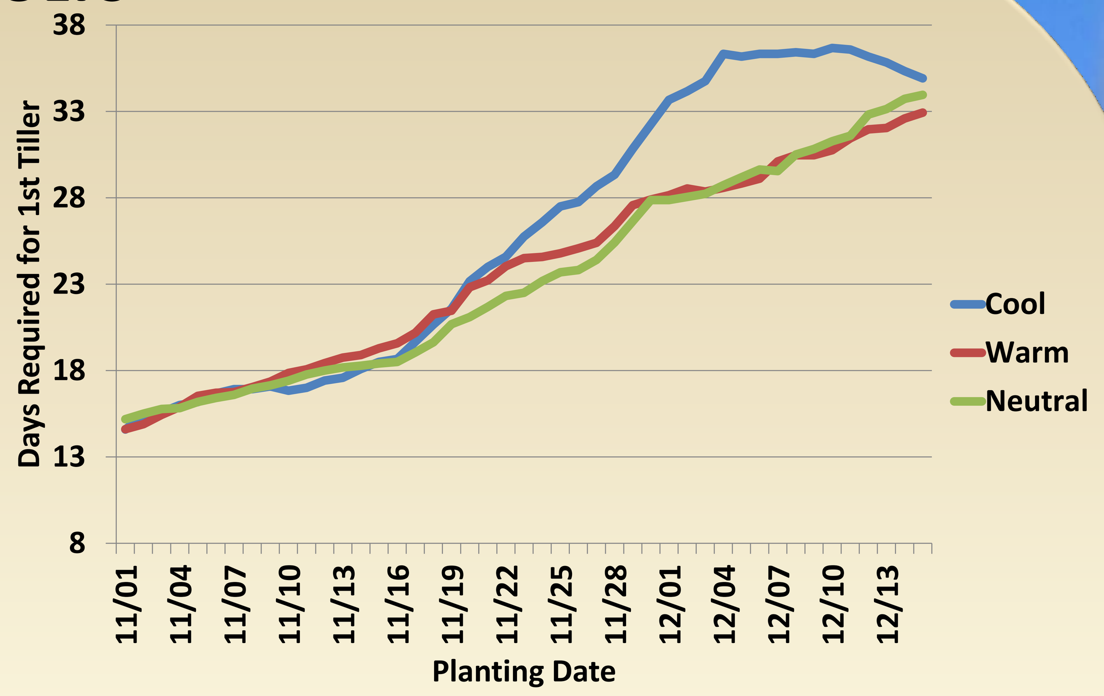


Figure 2: Days required to reach 310 GDD (1st tiller) based on NAO phase

Since fall tillers are critical to high yields, the main objective of this study was to determine which weather phase minimized the amount of time necessary to reach 310 GDD or first tiller. Both the ENSO and NAO exhibited differences in the amount of time required for the plant to achieve its first tiller. From November 7 to November 17, La Nina minimized the amount of time it took to reach 310 GDD. Meanwhile, from November 18 to November 28, El Nino minimized the time required to reach 310 GDD (Figure 1). From December 2 until December 9, La Nina again minimized the amount of time required to reach 310 GDD (Figure 1). However, throughout a majority of the fall, from November 5 to December 15, the neutral phase maximized the time it took to reach 310 GDD and for the plant to produce its first tiller. An important factor in fall tiller development is that ideally the first tiller should be developed within 21-23 days after planting. During an El Nino year, wheat can be planted as late as November 27 and it would only take an average of 23 days to produce its first tiller. During a neutral year, wheat would have to be planted by November 20 for it to only take 23 days to produce its first tiller. By waiting until November 27 to plant in a neutral year, it would take 28 days to reach 310 GDD. Therefore during a neutral year, it would be best to plant as early in November as possible. During a La Nina year, a grower could afford to plant as late as November 17. If planting the middle of November through the first of December, the El Nino phase provides the best conditions for GDD accumulation and minimizes the time required to reach first tiller. Thus, the El Nino phase affords the grower the opportunity to plant much later into November than normal.

The first trend to stand out from the NAO was the sharp increase in days required to reach first tiller during a cool NAO after November 21 (Figure 2). Throughout the rest of November and the first part of December, the number of days required to reach first tiller was much higher than in either a warm or a neutral phase. During a cool NAO period, wheat would have to be planted by November 20 in order to reach first tiller in 23 days. During a warm October NAO, planting could be delayed by one day to November 21 to reach first tiller in 23 days, and during a neutral year, wheat could be planted as late as November 26 to reach first tiller in 23 days. This indicates that a cool October NAO causes much colder temperatures from late November through the middle of December. Therefore, during a cool October NAO year, wheat should not be planted after the middle of November. Planting earlier in November during a cool NAO phase will allow the crop to produce adequate fall tillers before the cold weather arrives. A second trend noticed was that the neutral October NAO phase minimized the number of days required to reach 310 GDD from November 17 through November 29. Thus, during a neutral phase one could afford to plant later than during a cool or warm NAO phase.

During the two years of 2012-13 and 2013-14 when the phyllochron study was performed, the ENSO period was neutral and the NAO phase was cool. Therefore, the results from the phyllochron study that was mentioned in the introduction is surprising. It would have been expected for the December planting to have a lower tiller counts and yields both years considering the cool NAO and neutral ENSO phases. As previously mentioned, both of these phases require wheat to be planted the earliest to achieve first tiller within 23 days. However, in 2012, the later planting date rather than the early planting date produced the highest yields (Figure 3). Since there was a cool NAO and a neutral ENSO, the fact that the late planting had the higher yields is surprising and is not what would be expected based on the ENSO and NAO phases. Results from the 2013-14 growing are what would be expected based on the ENSO and NAO phases as the December planting date resulted in much lower yields than did the November planting date (Figure 4). Tiller counts were also much lower at the later planting date. The neutral ENSO and cool October NAO resulted in much colder than normal December temperatures, and therefore adequate fall tillers were not produced in the late planting and yields were much lower.

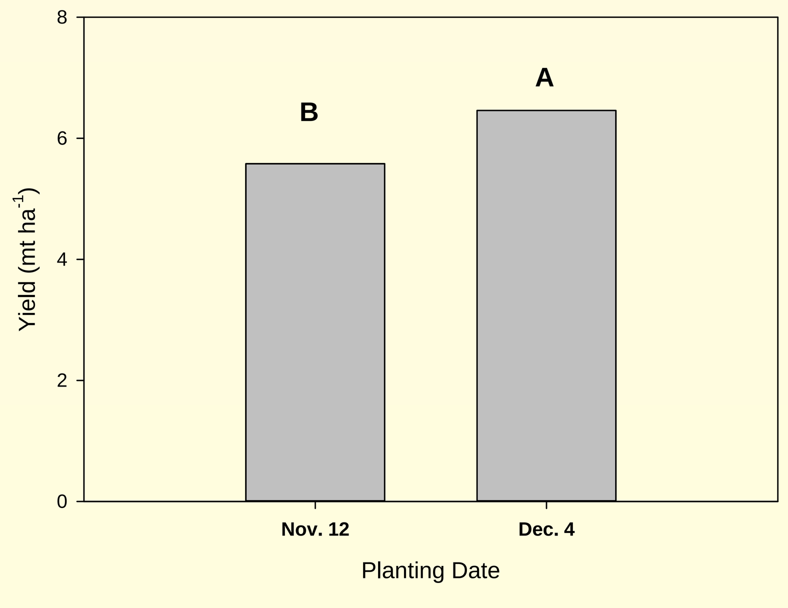


Figure 3: Grain yield at Pasquotank in 2012-13

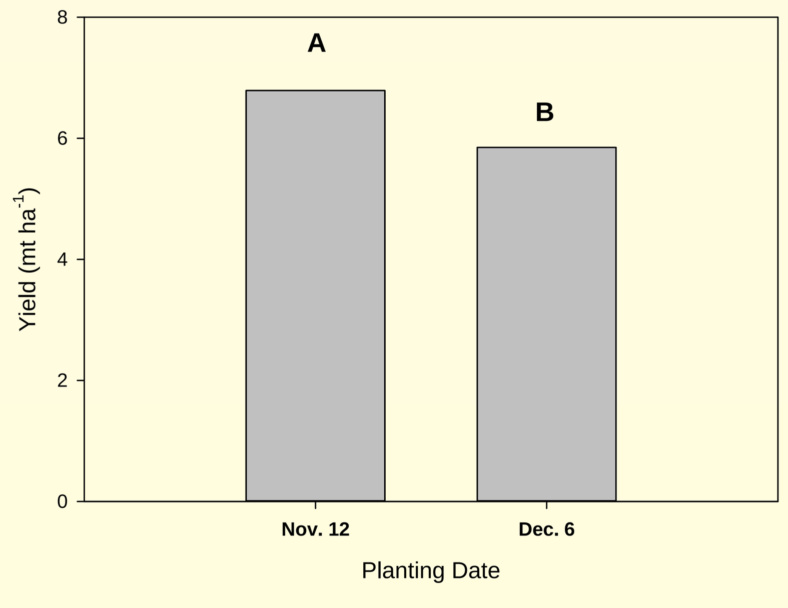


Figure 4: Grain yield at Plymouth in 2013-14

CONCLUSIONS

- The majority of differences among the ENSO and NAO phases occurred between November 1 and December 15.
- The ENSO phase that is most favorable for growing wheat in the fall is El Nino, and enables a much wider planting window than either a La Nina or neutral phase.
- A cool NAO phase causes days required for first tiller to increase substantially, and wheat should be planted as early as possible during this phase.
- The neutral NAO phase is the most favorable NAO phase for early tiller production as it enables later planting than does either a cool or warm phase.
- It is essential for a wheat grower in North Carolina to become familiar with both the NAO and ENSO phase and use them as a decision aid when selecting a planting date.
- Since other factors also influence fall weather, these patterns should only be used as a general guide for planting date. Therefore, more work is necessary to properly identify planting date based on weather.

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