NC STATE UNIVERSITY

Phyllochron Interval and Yield Response to Starter Fertilizer and Planting Date in Wheat

J.C. Oakes and R.W. Heiniger

INTRODUCTION

The importance of leaf growth in wheat (*Triticum aestivum* L.) and its effect on grain yield has long been understood (Friend et al., 1962; Krenzer and Nip, 1991). To fully understand leaf growth and development, it is necessary to describe when new leaves appear and when expanding leaves mature (Cao & Moss, 1989). Both mainstem leaf development measured using the Haun scale (Haun, 1973) and tiller formation are plant measurements often used to examine the quality of the growth environment of wheat (Klepper et al., 1982).

The time interval between appearance of successive leaves is known as phyllochron interval (Baker et al., 1986). A phyllochron interval (PI) is defined as the developmental time it takes for elongation of successive mainstem leaves. Since leaf appearance rate is more strongly correlated with thermal units than it is with chronological time (Gallagher, 1979), PI is measured as the number of growing degree days (GDD) required to complete a mainstem leaf stage (Krenzer & Nipp 1991). Therefore, the smaller the PI, the faster leaves are appearing on the mainstem.

Several different environmental and management factors have been shown to influence the PI in wheat, including temperature (Boone et al., 1990), water stress (Baker et al., 1986), and nitrogen availability (Longnecker et al., 1993). However, little is known about the impact of common management practices such as planting date, seeding rate, and starter fertilizer on PI. Since PI is a good indicator of growth environment, understanding the impact of these management practices on PI could help determine the potential these practices have for improving yield in different environments.

OBJECTIVES

1. To examine the effect of starter fertilizer on main stem leaf growth, phyllochron interval, and grain yield.
2. To examine the effect of planting date on main stem leaf growth, phyllochron interval, and grain yield.

MATERIALS & METHODS

Research was conducted during the 2012-13 growing season at a location near Hertford, NC. The experimental design was a split plot design with main plots consisting of two planting dates, and subplots consisting of three starter fertilizers applied at planting. Individual plots were 24.4 m long and 1.98 m wide. The cultivar 'Dyna-Gro Shirley' was planted on 16.9 cm rows in a conventional tilled field on 12 Nov and 4 Dec. Three starter fertilizer solutions were applied along with a no-starter check. The starter treatments consisted of 33.6 kg ha^{-1} of 30% UAN, 233.75 L ha^{-1} of 11-37-0, and 280.5 L ha^{-1} of 9-18-9. Rates were selected to achieve the same total amount of N in each treatment. Nitrogen was applied to the check plot and to the starter treatment plots on 22 Mar with rates adjusted so that all plots received a total of 54.4 kg N ha^{-1}. Tiller counts were taken on 10 Jun from a 1 m section of row at one location within each plot. Plots were harvested on 15 Jun using a Wintersteiger Delta combine equipped with at Harvestmaster Grain Gage that recorded moisture, grain weight, and test weight.

Five plants were randomly chosen from each plot. Main stem leaves were marked and recorded according to the procedures described by Haun (1973). A leaf's Haun age is determined by the number of fully expanded leaves plus the ratio of the laminar length of the last visible growing leaf to that of the proceeding leaf. For the November planting leaves were marked and recorded on 19 Dec, 21 Jan, 6 Feb, 5 Mar, 20 Mar, 3 Apr, and 17 Apr and for the December planting leaf data were taken on 10 Jan, 6 Feb, 5 Mar, 20 Mar, and 10 Apr. The number of Haun scale growth units across the leaf count recording dates was regressed against the number of growing degree days (GDD) accumulated since planting. Phyllochron interval was calculated as the reciprocal of this slope (Baker et al., 1986). Tiller counts, grain yield, and PIs were analyzed across starter fertilizer treatments and planting dates using the Proc Mixed and Proc GLM procedures in SAS (SAS Institute, 2010). When differences were detected, Fisher's Protected LSD was used to separate means.

RESULTS

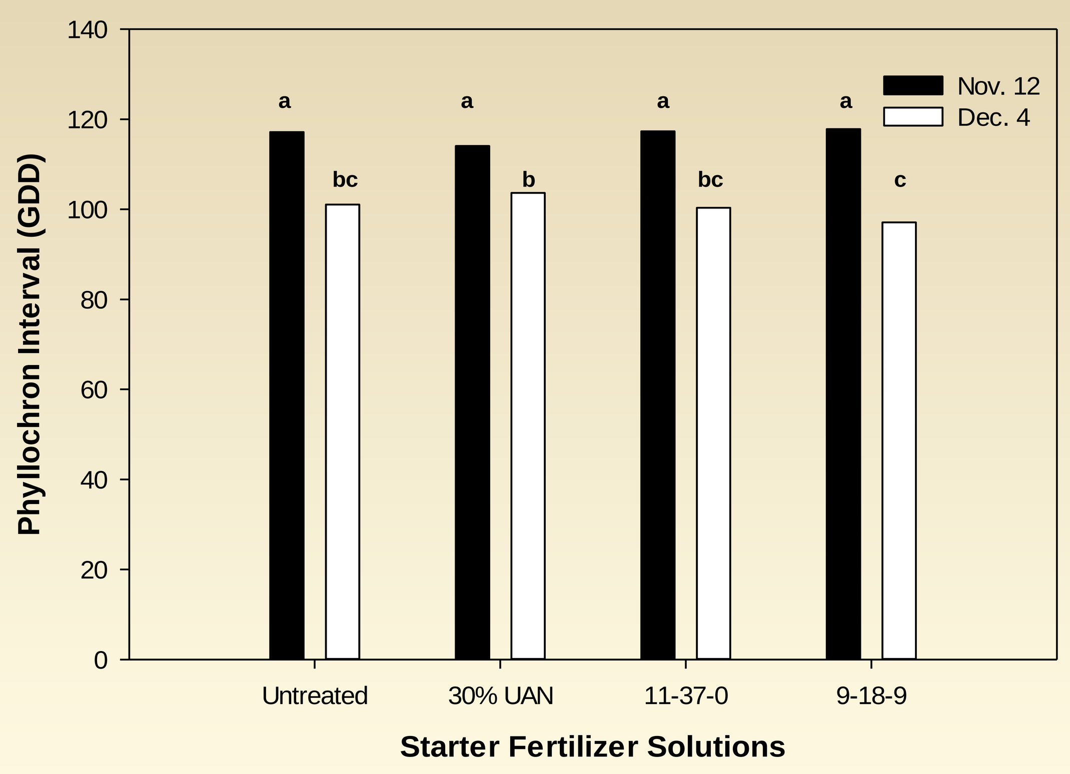

Figure 1: Effect of starter fertilizer & planting date on phyllochron interval. Differing letters represent LSD at P <0.05.

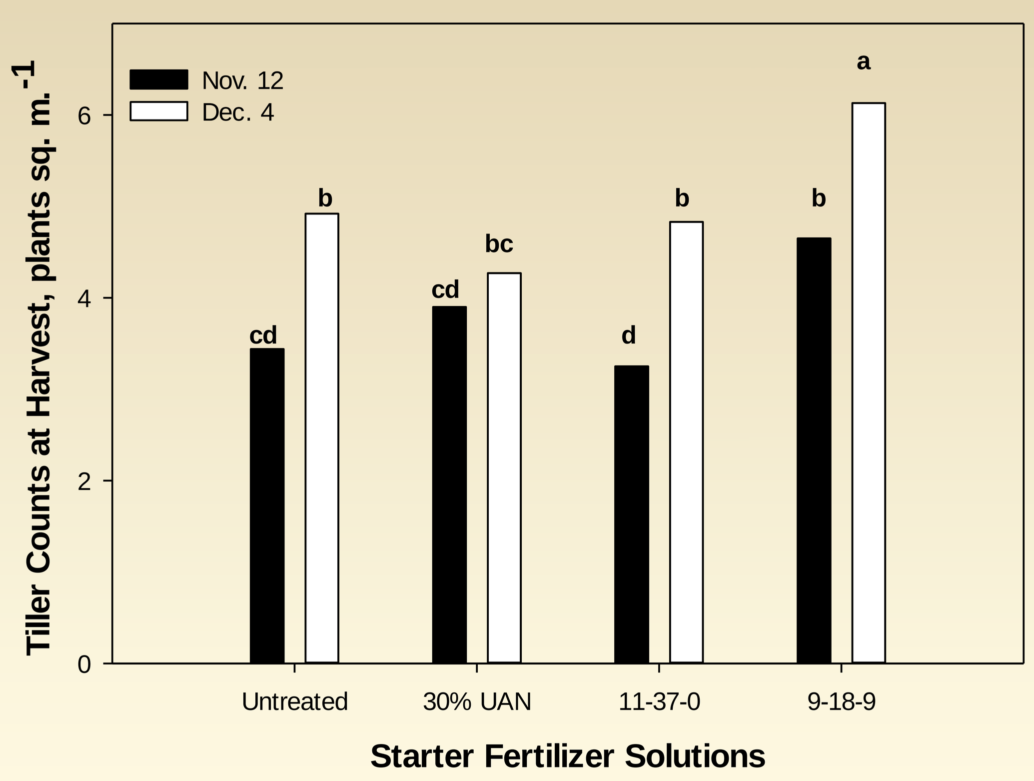

Figure 2: Tiller response to starter fertilizer & planting date. Differing letters represent LSD at P <0.05.

Statistical analysis of PI found a significant planting date by starter treatment interaction . The key difference was between the two planting dates (Figure 1), with the 12 November planting date requiring an average of 117 GDD per leaf and the 4 December planting requiring an average of 100 GDD per leaf. A shorter PI means that the leaves grew faster and appeared quicker. The shorter PI at the 4 Dec planting date was surprising and was most likely due to the better growing conditions in December compared to November. From 12 Nov to 3 Dec only 198 GDD were accumulated. However, from 4 Dec to 25 Dec, 230 GDD were accumulated. The only significant difference in PI among the three starter fertilizer solutions and the untreated control was between 9-18-9 and 30% UAN at the December planting date where 9-18-9 had a significantly lower PI than did 30% UAN. None of the remaining starter fertilizer solutions produced significantly different PI's within either planting date.

There was also a significant planting date by starter treatment interaction for tiller counts. Tiller counts at harvest were higher in the 4 Dec planting date for all starter fertilizer solutions except the 30% UAN (Figure 2). As with PI, the fact that the tiller counts were higher in the later planting date was surprising. Again, it appears that the favorable growing conditions that contributed to the faster leaf appearance rate also contributed to the higher tiller counts. As with PI and tiller counts, there was a significant planting date by starter treatment interaction for yield . The 4 Dec planting date resulted in a significantly higher yield (96 bu ac^{-1}) than did the 12 Nov planting date (83 bu ac^{-1}). Among the starter fertilizer solutions, the 9-18-9 applied on 4 Dec resulted in a higher yield than the other starter solutions or the untreated control (Figure 3). This is most likely due to the impact of potassium in the solution. At the 12 Nov planting date, 30% UAN resulted in a higher yield than did the untreated control (Figure 3).

Better growing conditions at the 4 Dec planting date resulted in a faster leaf appearance rate, more viable tillers, and therefore a higher yield even though the planting date was later. While it is unlikely that a later planting date will always result in a higher yield, this study shows the importance of early growing conditions in determining final stand and yield.

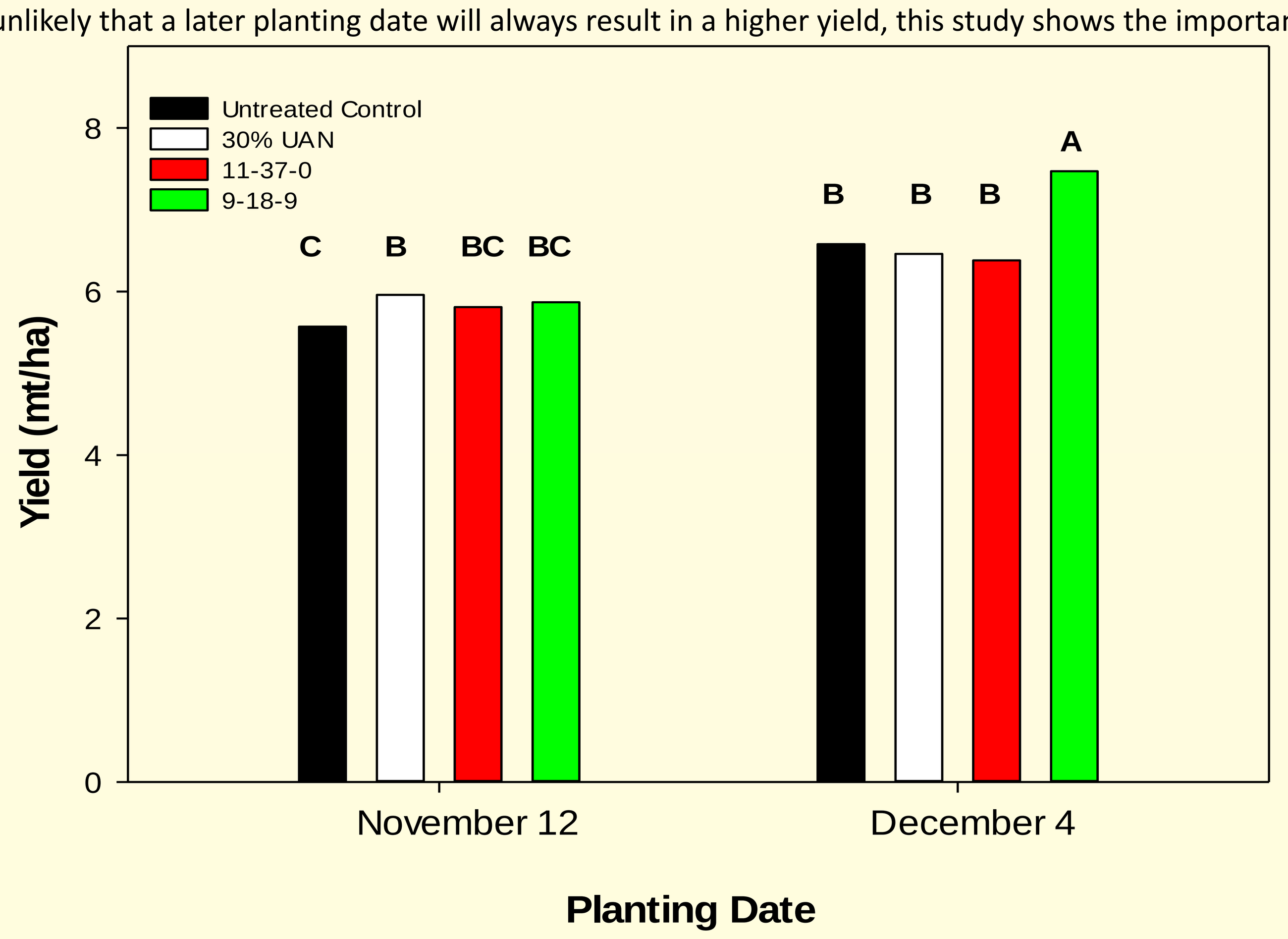

Figure 3: Grain yield response to starter fertilizer and planting date. Differing letters represent LSD at P <0.05.

CONCLUSIONS

- Planting date was the key element in this study, with the 4 Dec planting date having a faster rate of leaf appearance, more tillers , and greater yield than the 12 Nov planting date.
- Starter fertilizer had less of an impact on PI, tiller density, and yield than did planting date; however, the application of 9-18-9 at the later planting date resulted in the highest yield.
- The length of the phyllochron interval is an integral factor in determining grain yield. There was a strong negative correlation between PI and yield, r= -0.897, p= 0.0025.
- Maximizing the rate of leaf appearance and shortening the phyllochron interval is paramount to achieving high yields.

REFERENCES

Baker, J.T., Pinter, Jr., P.J., Reginato, R.J., & Kanemasu, E.T. (1986). Effects of Temperature on Leaf Appearance on Spring and Winter Wheat. Agronomy Journal. 78:605-613

Bauer, A., Frank, A.B., & Black, A.L.. (1984). Estimation of Spring Wheat Leaf Growth Rates and Anthesis from Air Temperature. Agronomy Journal. 76:829-835.

Boone, M.Y.L., Rickman, R.W., & Whisler, F.D. (1990). Leaf Appearance Rates of Two Winter Wheat Cultivars under High Carbon Dioxide Conditions. Agronomy Journal. 82:718-724.

Cao, W., & Moss, D.N. (1989). Temperature Effect on Leaf Emergence and Phyllochron in Wheat and Barley. Crop Science. 29:1018-1021.

Friend, D.J.C., Helson, V.A., & Fisher, J.E. (1962). Leaf Growth in Marquis Wheat as Regulated by Temperature, Light Intensity, and Daylength. Canadian Journal of Botany. 40:1299-1311.

Gallagher, J.N. (1979). Field Studies of Cereal Leaf Growth. I. Initiation and Expansion in Relation to Temperature and Ontogeny. Journal of Experimental Botany. 30:625-636.

Haun, J.R. (1973). Visual Quantification of Wheat Development. Agronomy Journal. 65:116-117

Klepper, B., Rickman, R.W., & Peterson, C.M. (1982). Quantitative Characterization of Vegetative Development in Small Cereal Grains. 74:789-792

Krenzer, Jr., E.G., & Nipp, T.L. (1991). Mainstem Leaf Development and Tiller Formation in Wheat Cultivars. 83:667-670

Longnecker, N., Kirby, E.J.M., and Robson, A. (1993). Leaf Emergence, Tiller Growth, and Apical Development of Nitrogen-Deficient Spring Wheat. Crop Science. 33:154-160.

ACKNOWLEDGEMENTS

Special thanks to the North Carolina Small Grain Growers Association, Inc. for their funding of this project.

CROP SCIENCE