# Effects of Air Temperature on Head Development in Spring Wheat

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Head size in spring wheat is morphologically determined early in the growing season and can be strongly affected by air temperature. Air temperature is also the primary environmental factor influencing the rate of morphological development of the hard red spring wheat plant (*Triticum aestivum* L.). Spring wheat is a cool season grass that grows best at air temperatures of about 68°F. Bauer et al. (1) showed the rate of spring wheat leaf development is linearly related to growing-degree days. Spring wheat varieties grow eight leaves on the main stem, except James, which grows only seven leaves.

It is the growing point of the plant, called the apex, that morphologically becomes the head (spike) of spring wheat. The apex develops in two distinctive stages. Both stages are complete about 26 to 29 days after plant emergence (3). The first stage is called the vegetative phase. During this phase all the leaves that will eventually grow on the plant are initiated. At about 17 to 21 days after emergence or at Haun (7) growth stage 3.5 to 4.0, depending on air temperature which determines rate of growth, the apex goes through a transition from the vegetative to the reproductive phase. It is during this transition that double-ridges, the morphological structures that become seed-bearing spikelets, form on the apex. The grain-bearing spikelets form from the upper-most ridge of each double-ridge pair.

The number of spikelets formed on each head is strongly influenced by air temperature and to a lesser extent by available soil nitrogen and water (4). Spikelet formation on the head ends when the terminal spikelet forms at about 26 to 29 days after plant emergence or at about the 5.5 Haun growth stage. At this stage the maximum number of spikelets that form on the head of the main stem of the plant will generally be visible. At this time the head can be dissected from the stem and the number of spikelets counted easily using a hand-held magnification glass or a microscope of at least 7× magnification. Throughout this report the Haun growth scale will be used to indicate plant morphological development. Information on comparing the Haun, Feekes, Zadoks, and other growth scales has been published (2). As a comparison, a Haun 4 is equal to Feekes 3.5 and Haun 5.5 is equal to Feekes 6.

Tillers on the wheat plant go through the same process as the main stem except that each lags behind the main stem by about two to three days. The maximum yield potential of the crop can be determined at the apex terminal spikelet stage (Haun 5.5) by counting spikelets, knowing the plant population (determine by counting number of plants in a segment of row), and assuming a set number of kernels per spike and a certain kernel weight.

This research was conducted to evaluate the effects of temperature stress, especially warm temperatures, on morphological development of the wheat head and number of spikelets formed on the head. The research also included a determination of the effect of nitrogen level and available soil water on head development, but these results are not included in this report.

## Materials and Methods

The studies were conducted in a controlled environment chamber and in the field at Mandan, ND. The variety 'Sinton' hard red spring wheat was grown in a high light intensity growth chamber. The plants were fertilized at an equivalent of 90 pounds nitrogen per acre, 50 pounds phosphate per acre, and 40 pounds potassium per acre. The pots were watered to field capacity daily to eliminate any chance for water stress. Two growth chambers were used in the study. One growth chamber was maintained at a constant temperature of 65±1°F and the other at a constant temperature of 79±1°F. Three pots from each chamber were transferred to the other chamber at 4, 8, and 12 days after seedling emergence and remained in that growth chamber until the plants were sampled for apex observation.

Field studies were conducted on summer fallow with varieties of durum (*T. turgidum* L.) (Vic, Edmore, Cando) and of hard red spring wheat (Butte, Coteau, Lew, Waldron, and Len) and on recropping with all combinations of three fertilizer nitrogen levels (0, 40, and 100 lb N/ac), three soil water levels (dryland, supplemental irrigation, and double supplemental irrigation), and three varieties (Alex, Olaf, James) (1). Samples were taken at one to two-day intervals when apexes were near the double-ridge and terminal spikelet stages. The number of spikelets per head were counted using a dissecting microscope after the apex terminal spikelet was formed.

## Results and Discussion

Air temperature affects the duration of the apex vegetative and reproductive growth stages. Cool temperatures lengthened and warm temperature shortened duration of apex growth stages. As presented in Table 1, plants grown at 65°F (control) required 19.5 days for an

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Table 1. Effect of air temperature on development of the spring wheat head.

| Initial temp | Days at initial temp | Days to double-ridge | Days to terminal spikelet | Number of spikelets per head |
|---|---|---|---|---|
| 65 | Control | 19.5 | 26.3 | 17.8 |
| 65 | 4 | 16.3 | 19.7 | 12.9 |
| 65 | 8 | 17.3 | 21.7 | 12.0 |
| 65 | 12 | 18.0 | 22.7 | 13.1 |
| 79 | Control | 18.0 | 23.7 | 13.8 |
| 79 | 4 | 21.7 | 27.3 | 17.3 |
| 79 | 8 | 21.3 | 27.0 | 17.4 |
| 79 | 12 | 19.3 | 28.0 | 16.9 |
| LSD .05 | | 1.3 | 1.4 | 1.3 |

apex to reach the double-ridge stage, whereas an apex of plants grown at 79°F (control) required 18 days. Plants grown at 65°F for 4, 8, or 12 days after emergence, then at 79°F required fewer days than the 65°F control to reach apex double-ridge and terminal spikelet stage of development. However, plants grown at 79°F for 4, 8, or 12 days after emergence, than at 65°F required more days than the 79°F control plants to reach apex double-ridge and terminal spikelet stages. All plants grown at 65°F after 12 days following emergence produced large heads and greater number of spikelets per head. These data suggest that mechanisms controlling duration of the apex vegetative stage are probably initiated between the 12th day following emergence and the actual formation of double-ridges on the apex (Fig. 1). The apex of plants grown at 65°F were well developed morphologically when compared to those of plants grown at 79°F (Fig. 2). The apex of plants grown at 79°F were distorted near the location of the terminal spikelet.

Differences in days of vegetative growth of the apex were present among varieties of both field grown hard red spring and durum wheats (Table 2). Apex vegetative growth for

Table 2. Days of apex vegetative development prior to forming double-ridges for varieties of hard red spring and durum wheat grown in 1980 and 1981 on summer fallow.

| Variety | Days of vegetative development |
|---|---|
| **Hard Red Spring** | |
| Butte | 16.5 |
| Coteau | 19.2 |
| Lew | 15.7 |
| Waldron | 16.8 |
| Len | 17.5 |
| Mean | 17.1 |
| **Durum** | |
| Cando | 20.2 |
| Edmore | 19.8 |
| Vic | 20.7 |
| Mean | 20.2 |
| LSD 0.05 Varieties | 1.0 |
| CV (%) | 4.3 |

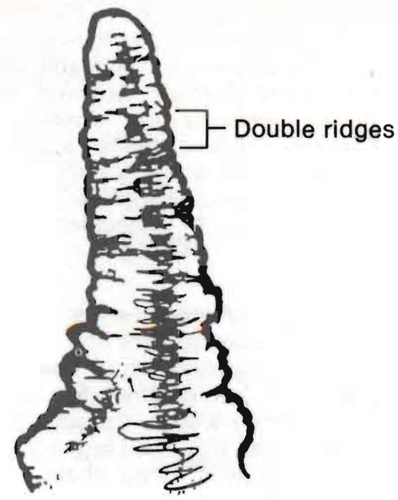


Figure 1. Spring wheat apex (head) at the double-ridge stage of development. Double-ridges generally form on the apex between 17 and 21 days after plant emergence. (Magnification is 60 ×)

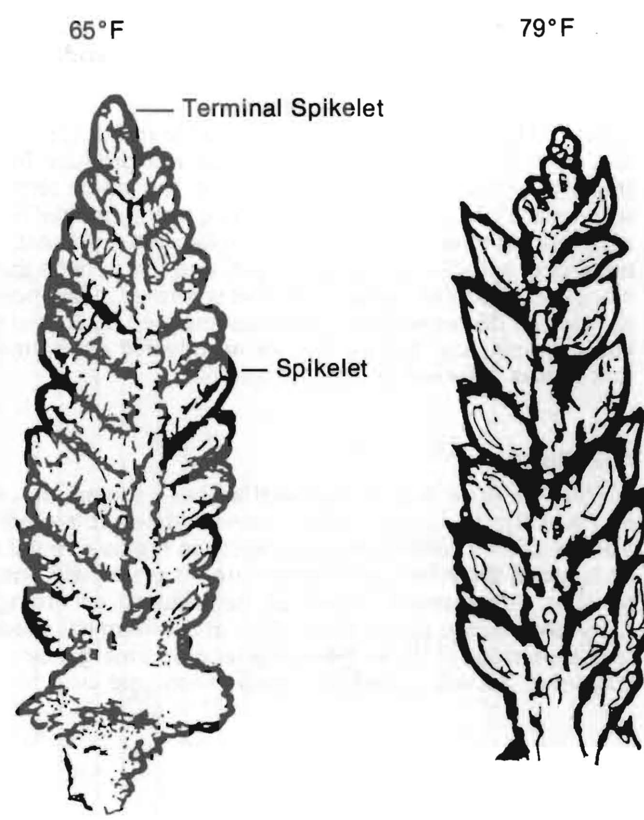


Figure 2. Spring wheat heads at the terminal spikelet stage of development when grown at 65°F (left) and 79°F (right). The terminal spikelet forms at about Haun 5.5 or 26 to 29 days after crop emergence. (Magnification is 45 ×)

durum averaged 2.2 days longer than for spring wheat varieties. The duration of the apex vegetative growth stage also was related to the degree of water and temperature stress imposed on the plant (data not shown). Greater water and nitrogen stress shortened the duration of .apex vegetative growth phase and also resulted in smaller plants with fewer tillers (6). Less stress extended the apex vegetative and spikelet development phase and resulted in larger, more vigorous plants with more tillers, and hence a higher yield potential.

The mechanisms which control the termination of the apex vegetative stage of development and the initiation of the reproductive stage in spring wheat are not known. Although vernalization is not required for initiation of a reproductive head in spring wheat, the physiological and biochemical processes that occur during vernalization of winter wheat may also occur in spring wheat.

The duration of the spikelet development stage, which occurs from time of apex double-ridge formation (Haun stage 4.0) to terminal spikelet formation (Haun stage 5.5), is the critical period in determining the number of spikelets that form on the head. In the controlled environment study the spikelet development stage was longer and more spikelets were formed on plants grown at 65°F from 12 days after emergence through terminal spikelet formation than at 79°F (Table 1). Data from both the field and controlled environment study showed that as air temperature increased during the critical spikelet development phase (Haun 4.0 to 5.5 stage) the number of spikelets produced per head decreased (Fig. 3). Fewer spikelets per head result in lower grain yield potential.

Stage of morphological development of the wheat plant can be used as an indication of stage of apex development. The apex differentiates from vegetative to reproductive at about Haun stage 4.0 and the terminal spikelet forms at Haun stage 5.5 (5). Initiation of tillers in spring wheat begins at about Haun stage 3 and stops about Haun 5.5 (1). Tillers that form after Haun 5.5 generally do not produce heads (personal observation). Formation of the apex terminal spikelet is a critical stage in determining yield potential of the crop. At this time tillers that will form heads are present, the number of spikelets per head are set, and the stem begins to elongate. After the terminal spikelet is formed, yield potential may be decreased through stress imposed by limited soil water supply, low soil fertility, or an adverse environment that cuases spikelets to become infertile.

## Summary

The data show that air temperature has a major influence on head size and grain yield of spring wheat. It is obvious that we cannot control air temperature in the field, but if we understand the effects of temperature on grain yield potential then management input can be adjusted accordingly. Early observation of the plant apex at the terminal spikelet formation stage at 26 to 29 days after crop emergence or at a Haun of 5.5 will provide a means to estimate yield potential with sufficient time for making management decisions to correct deficiencies associated with nitrogen and for pesticide applications. Planting as early as possible can improve the chances of avoiding high air temperatures that may reduce the number of spikelets formed.

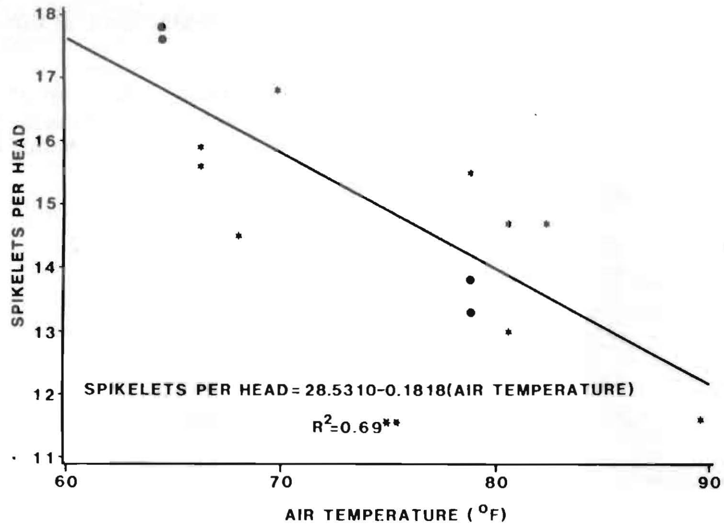


**Figure 3. Relationship between maximum daily air temperature during the 4.0 to 5.5 Haun growth stage and number of spikelets per head. Data are from field (*) and controlled environment (•) studies. From Frank et al. (5).**

### Literature Cited

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