
PREVAILING TEMPERATURES, COLD AND HEAT UNITS IN THE YAQUI AND MAYO VALLEYS, MEXICO, DURING THE 2019-2020 WHEAT SEASON

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ABSTRACT

Development of the wheat plant is influenced by sowing date, irrigation, soil type, pest and weed control, but also by weather factors. The objective was to analyze the temperatures that prevailed in the Yaqui and Mayo Valleys during the 2019-2020 wheat season. Temperature data were obtained from the automated meteorological station network in Sonora state comprising 22 stations in the Yaqui Valley and 13 in the Mayo Valley. The data were collected on a 10 minute frequency, every hour, and daily. The average of each weather station was calculated, taking into consideration the maximum and minimum temperature, the cold units and the heat units for each season. The data were captured in excel with the daily-hourly records from all the stations. During the wheat season, the temperature ranged from 1.4°C to 35.6°C with an average of 17.8°C; 385 and 439 cold units were recorded in the Yaqui and Mayo Valleys, respectively. Most of the weather stations in the Mayo Valley had a similar pattern of cold unit occurrence which were around 400, with the exception of Capetamaya which registered more than 700. In the Yaqui Valley, there were six weather stations that recorded around 400 cold units, five with more than 500, and only one with more than 600 cold units.

Keywords: Temperature, cold units, wheat, crop season 2019-2020, Yaqui Valley, Mayo Valley, Mexico.

1. INTRODUCTION

The state of Sonora is the leader in wheat production in Mexico, representing 51.7% of the national production. Climatic conditions favor wheat production in Sonora, particularly in the southern part of the state in the Yaqui Valley and to a lesser extent in the Mayo Valley (Márquez Berber *et al.*, 2014). Average grain yield in the 2019-2020 crop season was 6.66 t ha⁻¹ from 230,087.29 ha; 151, 122 ha were from the District of Rural Development (DDR) 148-Cajeme (Yaqui Valley) and 62,416.31 ha from the DDR-149-Navojoa, for a total of 213,538.31 ha for this region of the state (SIAP, 2021). The Yaqui Valley is one of the most important areas for agricultural production in Mexico (27° N, 110° W); the climate in this valley is semi-arid, with an average annual precipitation of 317 mm falling mainly between June and September, and the average temperature during the wheat season (fall-winter) is 21°C and 30°C during the spring-summer season (Parra-Cota *et al.*, 2018). Similarly, the Mayo Valley is located at the extreme southern region of Sonora, with a very warm and arid climate with an annual average temperature of 23-27°C, maximum of 43-48°C during June, July, and August, and minimum of

3.5-4°C in December and January. The annual average rainfall varies from 200 to 400 mm which is concentrated (70%) during July to September (Padilla Valenzuela *et al.*, 2008). Both valleys are regions where climatic conditions are different, as it was shown in 1991, when the presence of karnal bunt was greater in the Mayo than in the Yaqui Valley (Lira, 1992). A similar situation occurs with the presence and development of stripe stripe (Fuentes-Dávila *et al.*, 2019), leaf rust (Singh *et al.*, 2004), and spot blotch according to the reports by the local plant health authorities. The wheat growing season (November-April) is characteristically dry, and farmers typically apply 3-4 complementary irrigations throughout the crop season in the Yaqui Valley, while in the Mayo Valley farmers generally apply 2 due to the shortage of water in that region. According to Félix-Valencia *et al.* (2009), wheat grain yield is determined by several factors like sowing date, timely and enough irrigations, nutritional deficiencies, salinity, soil type, timely control of pest and diseases. However, the development of wheat is influenced by environmental factors like air temperature and photoperiod, which impact to a greater or lesser extent the annual variations of grain yield. Temperature is the weather factor most related to crops annual productivity (Félix-Valencia *et al.*, 2009), which also controls the rate of development of many organisms that require the accumulation of a certain amount of heat, in order to go from one phase to the another during the agricultural cycle (Soto *et al.*, 2009).

The knowledge about temperature variation help farmers in the adaptation and mitigation decisions, among them, the use of specific technologies in order to increase productivity and to obtain the maximum use of environmental factors in a given crop season (Félix-Valencia *et al.*, 2009). In the case of wheat, all phenological stages are sensitive to the oscillation of air temperature; high temperatures favor a greater metabolic activity of the plant, as well as an acceleration of the physiologic processes that determine its growth and development (Moreno Dena *et al.*, 2018). On the contrary, wheat requires the accumulation of cold units, to prolong its biological cycle, and generally this renders greater grain yield (Félix-Valencia *et al.*, 2009). Since the temperature has a great impact on the development of the wheat plant, the objective of this work was to analyze the temperature (minimum, maximum, and number of cold units) that prevailed during the 2019-2020 wheat season in the Yaqui and Mayo Valleys.

2. MATERIALS AND METHODS

Temperature data were obtained from the automated meteorological station network in Sonora (REMAS, 2021) comprising 22 stations in the Yaqui Valley and 13 stations in the Mayo Valley (Fig. 1). The digital memory of the meteorological station records readings every 10 min and provides integrated data per hour and daily. The data set comprises the crop season fall-winter 2019-2020, from November 15 to April 30. A cold unit was considered as one hour recorded by a given weather station with a temperature below 10°C, while a heat unit was considered as one hour recorded by a given weather station with a temperature above 30°C



Figure 1. Location of the weather stations in the Yaqui and Mayo Valleys.

(Félix-Valencia *et al.*, 2009). The average of each weather station was calculated, taking into consideration the maximum and minimum temperature, the cold and heat units. The data were captured in excel with the daily-hourly records from all the stations; the average hourly was calculated, so that it could be determined if cold or heat units occurred on given day in the valleys. From the same data base, it was calculated the cold and heat units for each weather station, and graphics were built with the information obtained.

3. RESULTS AND DISCUSSION

During this crop season, in the Yaqui Valley the temperature ranged from 1.471°C to 35.66°C with an average of 17.67°C (Fig. 2A), while in the Mayo Valley the range was 1.4°C to 35.50°C with an average of 17.87°C (Fig. 2B). An average of 385 cold units were recorded in the Yaqui Valley and 439 in the Mayo Valley.

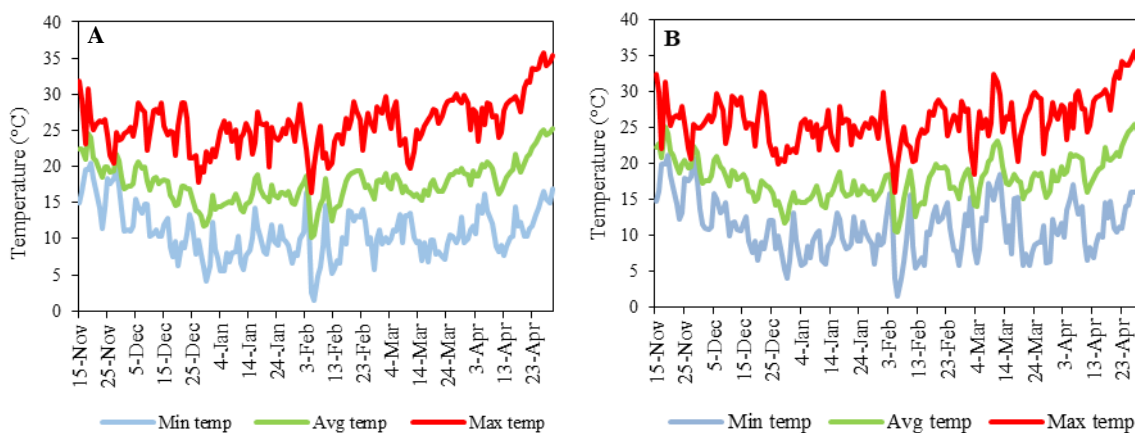


Figure 2. Minimum, maximum, and average temperature that prevailed during the wheat season 2019-2020 in the Yaqui (A) and Mayo (B) Valleys.

The occurrence of cold units in both valleys initiated on week 5 (December 13 to 19). Weeks 7 and 8 (December 27 to January 2 and January 3 to 9, respectively) had the highest number of cold units in both valleys, with a total of 46 and 44 each in the Yaqui Valley, and 43 each in the Mayo Valley (Fig. 3).

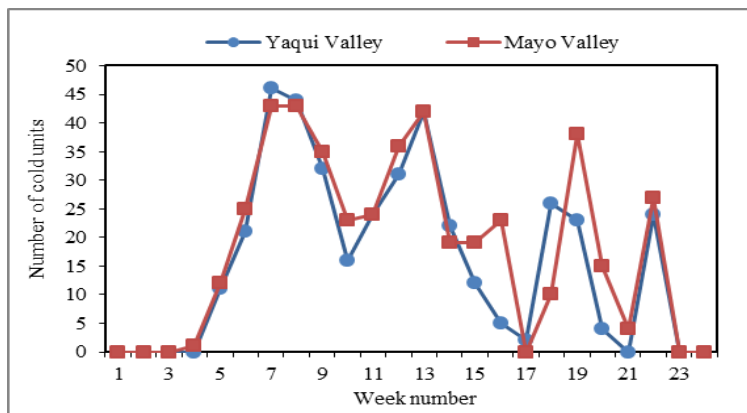


Figure 3. Cold units accumulated per week in the Yaqui and Mayo Valleys during the wheat season 2019-2020.

The weather stations in the Yaqui Valley with the highest number of cold units were blocks 1730, 609, and Estación Corral with 663, 594, and 563 cold units, respectively (Fig. 4A), while in the Mayo Valley stood out the weather station Capetamaya with 736 cold units, followed by Tres Carlos and La Regla with 503 and 500, respectively (Fig. 4B). The weather stations with the lowest number of cold units in the Yaqui Valley were block 419 and 1423 with 297 and 209 cold units, respectively, and in the Mayo Valley the stations Pueblo Mayo and Juliantabampo with 341 and 277, respectively.

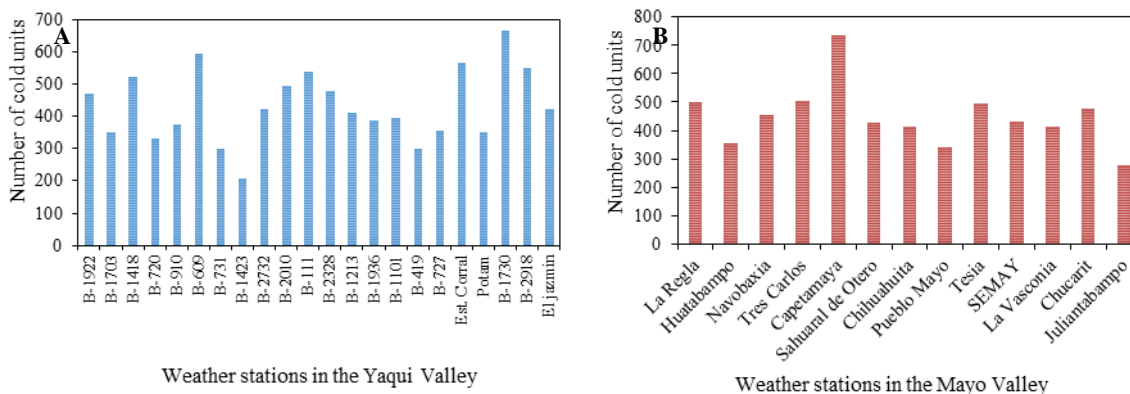


Figure 4. Cold units recorded in each weather station from the Yaqui (A) and Mayo (B) Valleys, during the wheat season 2019-2020.

However, there were heat waves or sudden temperature rise during the initial to intermedium phase of grain formation, which generally occurs during the month of March (Fig. 5). This factor and the limitation of water for irrigation influenced a reduction of grain yield, as it was the case of the Mayo Valley where the average grain yield obtained was 6.18 t ha^{-1} , lower than the yield obtained in the Yaqui Valley (6.89) (SIAP, 2021), despite the greater number of cold units in the Mayo Valley.

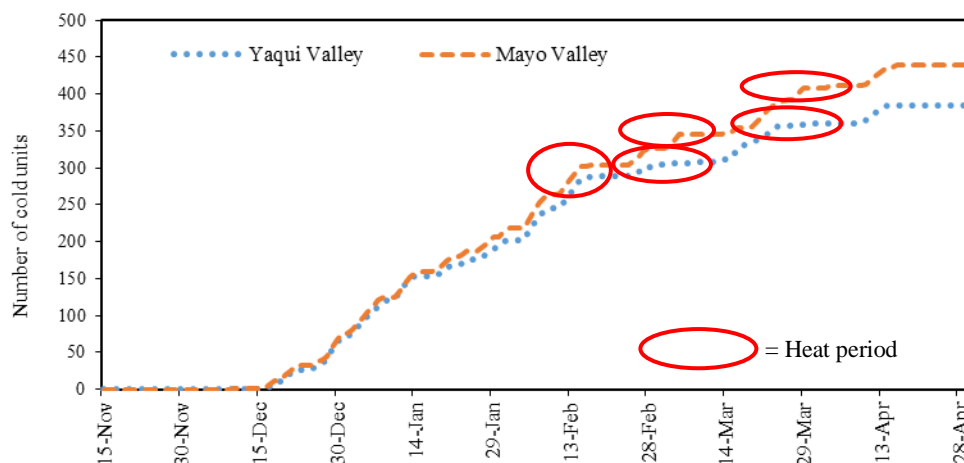


Figure 5. Heat waves in the Yaqui and Mayo Valleys during the wheat season 2019-2020.

The effect of high temperature during most of the grain filling period, with moderate temperature ($< 32^{\circ}\text{C}$) for a long time or during short periods with high temperature ($>35^{\circ}\text{C}$), causes a reduction in grain yield which can reach up to 35% (Shpiler and Blum, 1986; Ishag and Mohamed, 1996; Tahir and Nakata, 2005; Wardlaw and Wrigley, 1994; Tewolde *et al.*, 2006). High temperatures have a complex effect on crops which in turn will affect negatively yield and quality. The occurrence of such temperatures depend on factors like sowing date and altitude, among others.

4. CONCLUSION

During the crop season 2019-2020, the temperature in the Yaqui and Mayo Valleys was rather similar oscillating between 1.4°C and 35.6°C with an average of 17.8°C ; an average of 385 and 439 cold units were recorded in the Yaqui and Mayo Valleys, respectively. Most of the weather stations in the Mayo Valley had a similar pattern of cold unit occurrence, which were around 400, with the exception of Capetamaya which had more than 700 cold units. In the Yaqui Valley, there were six stations with around 400 cold units, five with more than 500, and only one with more than 600.

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