



(RESEARCH ARTICLE)



Prevailing temperatures and cold units in the Yaqui and Mayo Valleys, Mexico, during the 2021-2022 fall-winter crop season

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Abstract

Agriculture is an activity dependent on climate and therefore highly sensitive to climatic changes and to the variability of weather factors, considering the temperature as the climatic element most related to annual crop productivity. The objective of this work was to analyze the temperature that prevailed in the Yaqui and Mayo Valleys during the crop season fall-winter 2021-2022. Data were obtained from the automated weather station network in the state of Sonora, which comprises nineteen stations in the Yaqui Valley and thirteen in the Mayo Valley. Data were captured in Excel with the hourly and daily recording from all the weather stations, covering from November 15, 2021 to April 30, 2022. The average of the minimum and maximum temperatures were calculated as well as the accumulation of cold units from each weather station. The temperature in the Yaqui and Mayo Valleys was rather similar oscillating between 2.14°C and 35.54°C with an average of 17.48°C. Cold units recorded in the Yaqui Valley were 572, while in the Mayo Valley there were 679. Most of the weather stations in the Mayo Valley recorded more than 600 cold units with the exception of Juliantabampo and Pueblo Mayo which recorded 454 and 465, respectively. In the Yaqui Valley, eleven weather stations recorded more than 600 cold units, seven recorded between 400 and 500, and only one recorded 314 cold units.

Keywords: Wheat; *Triticum* spp.; Yaqui Valley; Mayo Valley; Temperature; Cold units.

1. Introduction

Wheat (*Triticum* spp.) is an important crop worldwide, but the rapid change in weather conditions is affecting the productivity in many regions of the world. It is the cereal food crop with the highest area and the second most cultivated in the world after maize (*Zea mays* L.). Wheat world production in the year 2021 was 770,877,072.89 t, out of which Mexico contributed with 3,283,613 t [1]. Sonora is the main wheat-producing state in Mexico contributing with 58.1% of the total national production [2]. The Yaqui Valley is the region with the highest wheat production in the state followed by the Mayo Valley [3]. The wheat season in southern Sonora takes place during the fall-winter which comprises from the month of November to April; this period of time is characteristically dry and farmers in addition to the irrigation for seed germination, apply three complementary irrigations during the seasons in the Yaqui Valley, while in the Mayo Valley they apply two irrigations due to water shortage. According to Félix-Valencia *et al.* [4], wheat grain yield is influenced by several factors like sowing date, timely and sufficient irrigations, nutrient deficiency, salinity, soil type, timely control of pests and weeds. However, wheat development is influenced by weather factors like air temperature and photoperiod, which impact greatly the annual variation in grain yield. Independently of the mitigation strategies, climate has and will continue to change; agriculture is an activity that depends upon climate and therefore, it is sensitive to weather changes and to the climate variability [5]. The temperature is the weather element most related to annual productivity of a crop, controlling the rate of development of many organisms that require certain number of accumulated heat units, to go from a developmental stage to another during the crop season [6]. It also influences

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directly the development of leaves and stems, the size of the wheat spike, grain development, and the milling quality and flour baking [7]. High temperature favors greater metabolic activity of the plant, and an acceleration of the physiological processes that determine its growth and development; at lower temperature development slows, but it favors greater productive yield [8]. Learning about the temperature variation helps farmer to undertake decisions regarding adaptation and mitigation, among them, the use of specific technologies to increase productivity and to obtain a maximum exploitation of weather conditions during a particular crop season [4]. Since temperature is a the weather element that has a great impact on wheat development, the objective of this work was to analyze the temperature (minimum, maximum, average, accumulation of cold units), that prevailed in the Yaqui and Mayo Valley in the state of Sonora, Mexico, during the fall-winter 2021-2022 crop season.

2. Materials and methods

Data of air temperature were obtained from the automated weather station network [9] of the state of Sonora; the digital memory of each weather station records readings every 10 min and provide integrated hourly and daily data. The data set consisted of information from nineteen weather stations in the Yaqui Valley and thirteen in the Mayo Valley (Figure 1), during the fall-winter 2021-2022 crop season covering from November 15, 2021 to April 30, 2022. Data were captured in Excel with the hourly and daily recording from all the weather stations. The average of the minimum and maximum temperatures was calculated as well as the accumulation of cold units from each weather station, considering a cold unit as one hour recorded with a temperature below 10°C [4]; also, temperatures above 32°C were recorded.

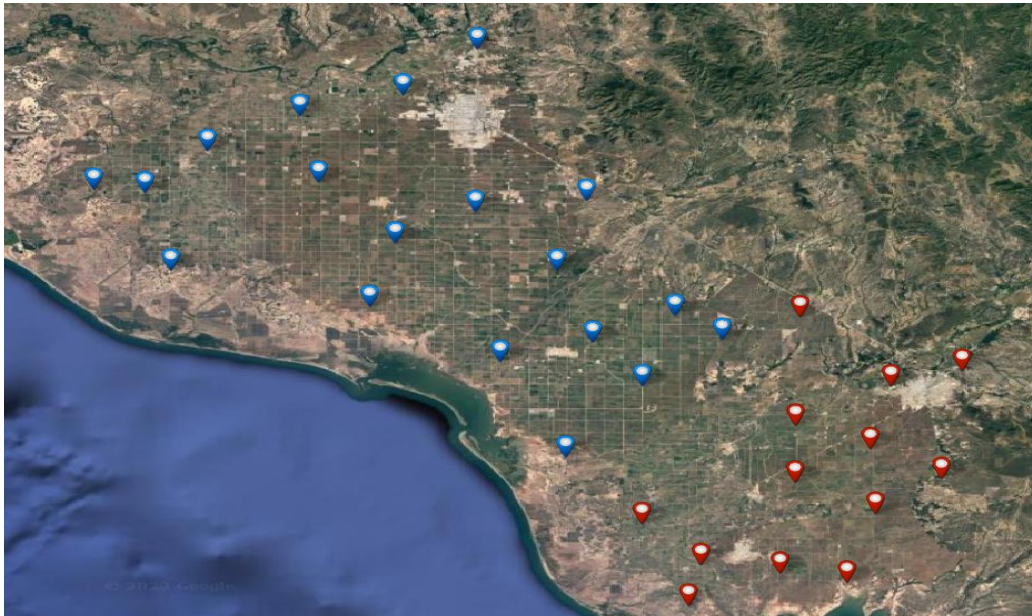


Figure 1 Geographic location of the automated weather station network in southern Sonora, Mexico, installed in the Yaqui Valley (blue), and Mayo Valley (red).

3. Results and discussion

During the fall-winter 2021-2022 crop season, the temperature fluctuated between 2.37°C and 35.54°C with an average of 17.43°C in the Yaqui Valley (Figure 2). Recording of cold units initiated on December 6, 2021, accumulating an average of 572 (Figure 3). The week of March 7 to 13, 2022, accumulated the highest number of cold units with a total of 62, followed by the weeks of January 31 to February 6, and February 7 to 13, with a total of 52 and 51, respectively. The weather stations that recorded the highest number of cold units were B-1730, B-2918, and B-609 with 938, 792, and 775, respectively, while those with the lowest number of cold units recorded were B-1423 and 720 with 314 and 418, respectively (Figure 4).

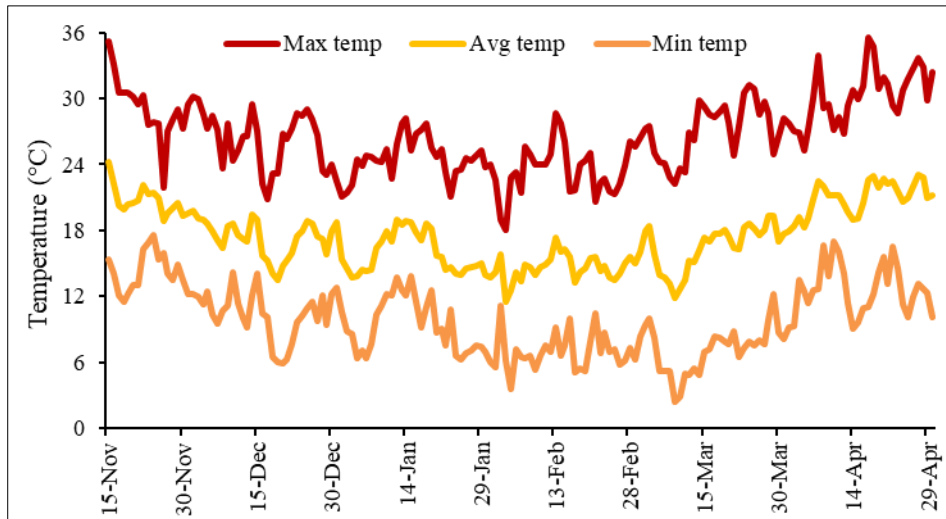


Figure 2 Maximum, minimum, and average temperatures prevailing during the fall-winter 2021-2022 wheat season, in the Yaqui Valley, Sonora, Mexico.

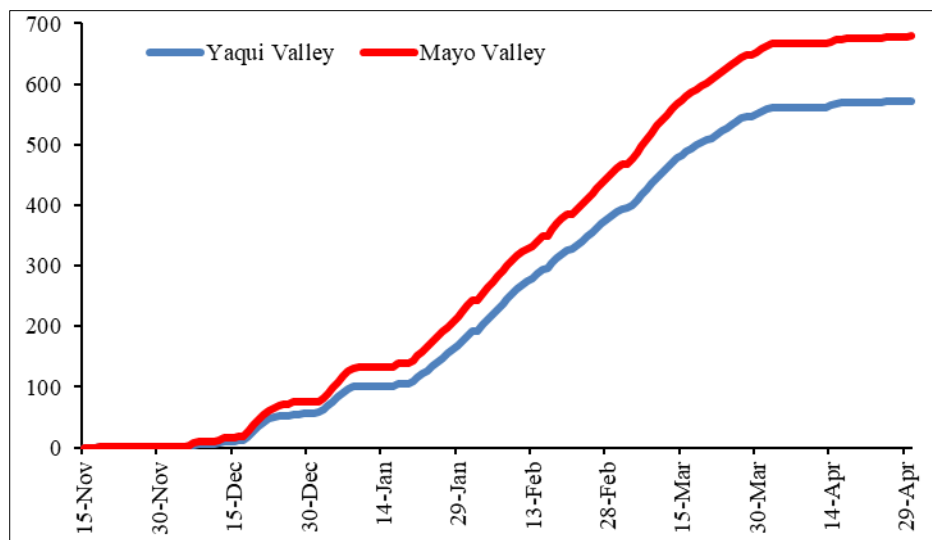


Figure 3 Accumulated cold units from 15 November to 30 April, during the fall-winter 2021-2022 wheat season, in the Yaqui and Mayo Valleys, Sonora, Mexico

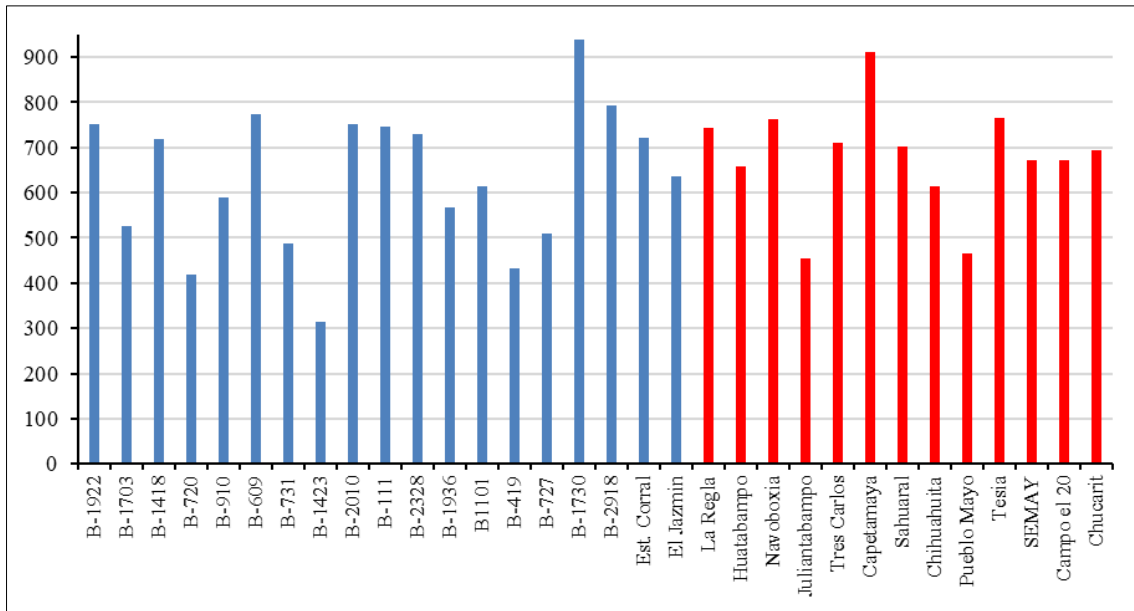


Figure 4 Cold units in each weather station during the fall-winter 2021-2022 wheat season, in the Yaqui (blue) and Mayo Valleys (red), Sonora, Mexico

The temperature fluctuated between 2.14°C and 35.34°C with an average of 17.54°C in the Mayo Valley (Figure 5). In this region, recording of cold units initiated also on December 6, 2021, and the average number of accumulated cold units was higher than in the Yaqui Valley with 679 (Figure 3) which is an opposite trend as it was reported by Félix-Valencia *et al.* [4], where the difference range of the accumulated cold units between the Yaqui and Mayo Valley was 36 to 199 higher in the former Valley, and an average difference of 66 cold units during the crop seasons 2004-2005 to 2008-2009. Similar to the Yaqui Valley, the week of March 7 to 13, 2022, also accumulated the highest number of cold units with a total of 72, when most of the wheat fields were at the initiation of grain-filling (Zadok’s stages 71-81 [10]), followed by the weeks of January 31 to February 6, and January 24 to January 30, with a total of 59 and 57, respectively. The weather stations that recorded the highest number of cold units were Capetamaya with 911, followed by Tesia and Navoboxia with 766 and 763, respectively, while those stations with the lowest number of cold units recorded were Juliantabampo and Pueblo Mayo with 454 and 465, respectively (Figure 4).

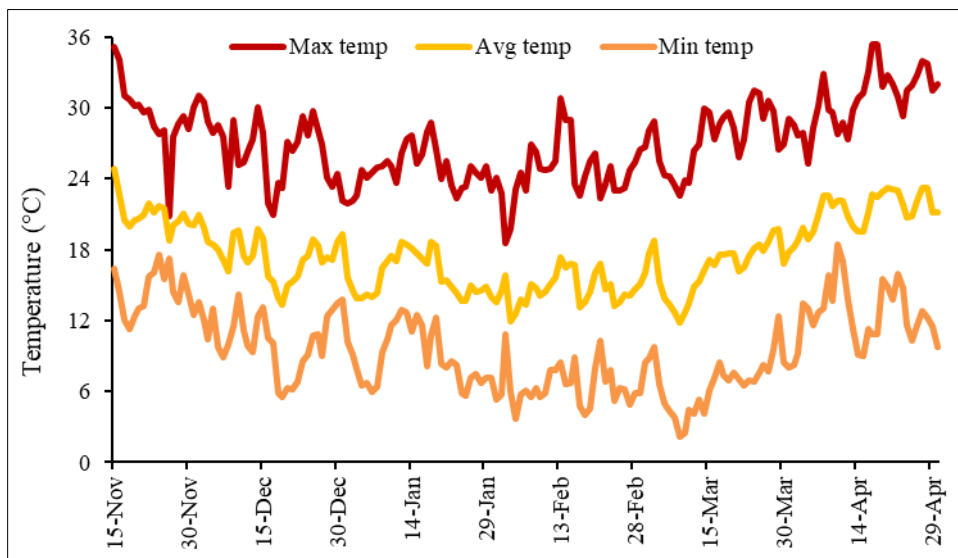


Figure 5 Maximum, minimum, and average temperatures prevailing during the fall-winter 2021-2022 wheat season, in the Mayo Valley, Sonora, Mexico.

During the weeks of December 27 to 31 and January 10 to 16, the minimum temperature remained over 10 °C in both valleys, therefore, there were no cold units recorded (Figure 3). Temperatures above 32 °C occurred primarily during April when most of the wheat fields had already completed the grain-filling stage. This stage is the most susceptible to the negative effects caused by high temperature which lead to a reduction in grain yield and may reach 35% [11,12,13]. In the Yaqui Valley there were 47 hours with this temperature, while there were 66 in the Mayo Valley. Weather conditions that prevailed during the crop season were favorable for wheat in both valleys; average grain yield in the Yaqui Valley was 7.58 t ha⁻¹ and 6.10 t ha⁻¹ for the Mayo Valley [2]. Wheat cultivars with the highest sown area in both valleys were durum wheats CIRNO C2008 [14] and Quetchehueca Oro C2013 [15] with 177,946.39 and 7,813.49 ha, respectively, while the bread wheat cultivar Borlaug 100 [16] occupied 10,954.60 ha [17]. Despite that the average number of cold units was greater in the Mayo Valley than in the Yaqui Valley, this result does not agree with the reports by Félix-Valencia *et al.* [4] and Cortés Jiménez *et al.* [18], who found a positive correlation between number of cold units and grain yield. Although low temperatures slow down the growth of tillers, they favor tillering production, since leaf growth is reduced and therefore competition among tillers [19]. However, in our work, the shortage of water in the Mayo Valley influenced the grain yield reduction which coincides with the report by Buenrostro Rodríguez *et al.* [20], where the application of one complementary irrigation improved biomass production and grain yield.

4. Conclusions

During the fall-winter 2021-2022 wheat crop season, the temperature in the Yaqui and Mayo Valleys in the state of Sonora, Mexico, was rather similar oscillating between 2.14°C and 35.54°C with an average of 17.48°C.

Average cold units recorded from nineteen weather stations in the Yaqui Valley were 572, while in the Mayo Valley there were 679 from thirteen stations.

Most of the weather stations in the Mayo Valley recorded more than 600 cold units with the exception of Juliantabampo and Pueblo Mayo which recorded 454 and 465, respectively. In the Yaqui Valley, eleven weather stations recorded more than 600 cold units, seven recorded between 400 and 500, and only the one in B-1423 recorded 314 cold units.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare that No conflict of interest.

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