International Wheat Yield Partnership
Research to Deliver Wheat for the Future

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Climate Resilient Wheats Require Tolerance to High Nighttime Temperatures

In many wheat growing areas, high temperatures lead to significant yield losses. Furthermore, night temperature, which is warming faster than day temperature globally, has a more negative effect on yield than hot day temperatures. The data in **Figure 1** (compiled by CIMMYT) show yield reductions of ~700 kg/ha for each 1°C degree increase in daily minimum (nighttime) temperature in Northwest Mexico between 1981 and 2016, during which temperatures have continued to rise. This knowledge implies that breeding for resilience to nighttime temperatures should be a very important objective for breeding programs in many places across the world, especially those experiencing increased heat associated with changing climates.

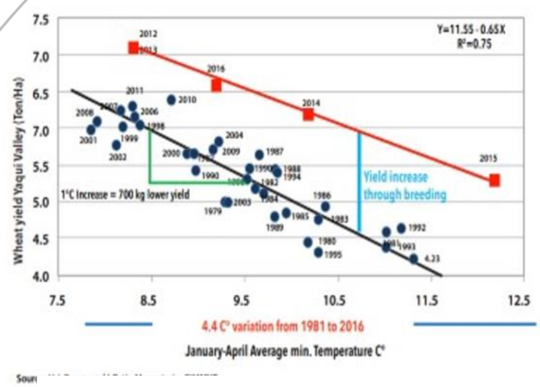

Fig 1. Nighttime temperature response to of on-farm wheat yields in NW Mexico from 1981-2016. Bottom line shows on-farm average yields by year. Top line shows increase in yield through breeding that also declines.

Other publications have reported spring wheat yields decline 3.2–8.4% for every 1°C increase in daily minimal temperature (Lobell et al., 2005; Lobell & Ortiz-Monasterio, 2007) or 4% decline for every 1°C increase over 14°C (Fischer, 1985). High nocturnal temperatures overall have been found to decrease wheat seed set, grain number and final grain yield between 13 and 43% (Narayanan et al., 2015). These yield losses have been attributed to rapid depletion of the photoassimilates required for growth, increases in photorespiration and other physiologically induced changes such as decreased reproductive fertility (Garcia et al., 2016). The findings are also consistent with the decreases in flag leaf carbon content due to night warming found by Mc Ausland et al, 2023 (**Figure 2**). In the latter studies, researchers found significant differences in the magnitude of nocturnal stomatal conductance of between 9% and 33% of those measured in the daytime, while respiration appeared to acclimate to higher temperatures. Noteworthy was the demonstration that decreases in grain yield due to night temperature increases were genotype-specific indicating that this effect could be mitigated by deterministic breeding. Furthermore, genotypes categorized as generally heat tolerant demonstrated some of the greatest declines in yield in response to warmer nights, implying that the heat tolerance was selected against higher daytime temperature. Thus, essential components of nocturnal heat tolerance can be uncoupled from resilience to daytime temperatures and can be addressed by breeders.

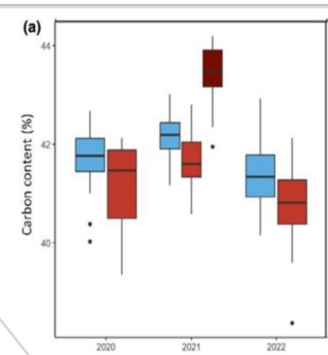

Fig 2. Flag leaf carbon (%) in the regular-sown control (blue) and nocturnally heated (light red) and late-sown plots (dark red) across 12 genotypes at heading over 3 years (2020–2022).

There is an urgent need to clarify (i) the various processes that are differentially affected by nighttime temperatures, including stomatal conductance, (ii) how they vary between genotypes, (iii) the genetic basis of resilience to high nighttime temperatures and iv) how breeders can select resilient types in breeding programs to protect future yields from both high day and night temperatures. Fortunately, there are new approaches available to assay such traits in high throughput ways. Sensor technology and automation enable populations to be assayed 24 hours per day. IWYP recommends research programs designed to alleviate night-time temperature losses. They could be critical as nights continue to get warmer.

Lobell et al., Field Crops Research (2005) 94.2-3, 250-256.
Lobell and Ortiz-Monasterio (2007) Agronomy Journal 99 469-477.
Fisher (1985) Journal Agricultural Science 105.2 447-461.
Narayanan et al., (2015) Journal of Agronomy 201 206-218.
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McAusland et al., 2023. New Phytologist 239:1622-36.