Optimising the resilience of wheat to a changing climate in North Kashmir, India

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Three field experiments were conducted to assess the performance of various spring wheat genotypes, viz., SKAU-101 (V_1), SKAU-102 (V_2) and Shalimar Wheat-2 (V_3). These genotypes were sown on different dates: 15 October (S_1), 1 November (S_2) and 15 November (S_3) during the 2020–2021 winter (*rabi*) season. Randomised complete block design (RCBD) was employed for the experimental setup in North Kashmir, India. This design facilitated a thorough examination of each genotype's response to the different planting dates within the specified agroecological context. The crops sown on 15 October showed superior growth, phenology and yield (4.01 t ha^{-1} for grain). The SKAU-102 variety required less time to reach various phenological stages, matured 5–12 days earlier than the other two genotypes, and produced a higher yield; the highest yield (4.4 t ha^{-1}) was observed with the SKAU-102 genotype when sown early (V_2S_1). Furthermore, climate change trends in the region from 1980 to 2021 revealed statistically significant increases in maximum and minimum temperatures at a rate of 0.02°C per year, accompanied by a decreasing trend in precipitation at a rate of -4.53 mm per year, which, if they continue, can adversely affect wheat growth, development and yield. Considering the ongoing climate changes and the findings from field experiments, it is advisable to sow the wheat genotype SKAU-102 by 15 October to achieve the earliest maturity and the highest yield, in contrast to the typical sowing date of mid-November in the region.

Keywords: Climate change, India, North Kashmir, phenology, sowing window, wheat.

WHEAT (*Triticum aestivum* L.) is a dual-purpose crop yielding grain and fodder. It is the most extensively cultivated crop worldwide, covering an area of 219 million ha[1]. With over three billion people relying on wheat for sustenance in various forms[2], it is a highly adaptable crop, capable of thriving in diverse soil and climatic conditions[3,4]. In India, wheat cultivation spans 31.6 million hectares, yielding an average annual production of nearly 110 million tons, corresponding to approximately 3.48 t ha^{-1}. While predominantly cultivated in the plains, wheat also finds its place in the mountainous regions of North India, being grown on hills[6].

As temperatures continue to rise due to climate change, the agricultural sector in India faces a significant threat, particularly regarding wheat production and national food security. Studies project that for every one-degree Celsius increase in temperature, wheat production in India could decrease by four to six million tons[7,8]. Despite this challenge, the national government aims to gradually increase wheat production to 140 million tons annually by 2050 (ref. 9). Achieving this target would necessitate a rise in productivity from 3.48 t ha^{-1} to 4.43 t ha^{-1}, assuming the surface area available for wheat cultivation remains unchanged[10].

In the state of Jammu and Kashmir in North India, wheat is cultivated in 244,000 ha with an average yield of 1.98 t ha^{-1} (ref. 11), which is very low compared to the national average. Moreover, wheat cultivation is primarily confined to the Jammu region, of which only 1,300 ha are in the Kashmir Valley. The usual planting time for wheat cultivation in Kashmir is the first fortnight of November. Although Kashmir's climate is temperate and suitable for wheat cultivation, its acreage has remained low due to the long cultivation period (approximately 245 to 250 days). This duration does not allow sufficient time for a rice crop, the preferred crop in the region, to be planted and harvested on the same land. Therefore, efforts are needed to identify and develop wheat genotypes that mature more quickly (preferably by the end of May)

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