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Regional Response of Crop Productivity to Global Warming - A Case Study of the Heat Stress and Cold Stress on UK Rapeseed Crop Over 1961-2020

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Abstract : Global climate change introduces both opportunities and challenges for crop productivity, with differences in temperature stress across latitudes and crop types, one of the most important meteorological factors impacting crop productivity. The development and productivity of crops are particularly impacted when temperatures occur outwith their preferred ranges, which has implications for global agri-food sector. This study investigated the spatiotemporal dynamics of heat stress and cold stress on UK arable lands for rapeseed cropping between 1961 and 2020, using a 1 km spatial resolution temperature dataset. Stress indices, including heat stress index (fHS), cold degree days (CDD) and a normalized rapeseed production loss index (fRPL) were established, and stress values and percentages of days experiencing each stress investigated. Results found increasing fHS and the areas impacted by heat stress during flowering (from April to May) and reproductive (from April to July) stages over time, with the mean fHS being negatively correlated with latitude. This pattern of increased heat stress agrees with previous research on rapeseed cropping, which have been noted at global scale in response to changes in climate. The decreasing number of CDD and frequency of cold stress suggest cold stress decreased during flowering, vegetative (from September to March next year) and reproductive stages, and the magnitude of cold stress in the south of the UK was smaller to that compared to northern regions over the studied periods. The decreasing CDD matches observed declining cold stress of global rapeseed and of other crops such as rice in the northern hemisphere. Notably, compared with previous studies which mainly tracked the trends of heat stress and cold stress individually, this study conducted a comparative analysis of the rate of their changes and found heat stress of rapeseed crops in the UK was increasing at a faster rate than cold stress, which was seen to decrease during flowering. The increasing values of fRPL, with statistically significant differences ($p < 0.05$) between regions of the UK, suggested an increasing loss in rapeseed due to heat stress in the studied period. The largest increasing trend in heat stress was observed in South-eastern England, where a decreasing cold stress was taking place. While the present study observed a relatively slowly increasing heat stress, there is a worrying trend of increasing heat stress for rapeseed cropping into the future, as the cases of other main rapeseed cropping systems in the northern hemisphere including China, European counties, the US, and Canada. This study demonstrates the negative impact of global warming on rapeseed cropping, highlighting the adaptation and mitigations strategies for sustainable rapeseed cultivation across the globe.

Keywords : rapeseed, UK, heat stress, cold stress, global climate change, spatiotemporal analysis, production loss index
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