Geophysical Research Abstracts
Vol. 21, EGU2019-4686, 2019
EGU General Assembly 2019

Application of Distributed Temperature Sensing Using Optical Fibre to Understand Temperature Dynamics in Wheat (Triticum Aestivum) Canopies During Frost

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Frost events that occur during the reproductive stage of cereal growth can cause significant yield loss with damage occurring over a narrow temperature range. Wheat is the most widely grown crop globally (Monfreda et al., 2008; Thenkabail et al., 2012) and with increases in annual yields required to meet population demand, understanding and developing management options to reduce the impact of abiotic stresses such as frost is crucial. Especially as frost risk appears to be increasing despite higher average winter minimum temperatures attributed to climate change (Crimp et al., 2014; Ma et al., 2018).

This study demonstrates a new research tool for measuring air temperature within crops during frost, with high spatial and temporal resolution. We show how fibre optic Distributed Temperature Sensing (DTS), which has been increasingly applied in environment temperature monitoring since the mid-2000s, can be deployed at field frost trial sites. We measure air temperature with an average accuracy of 0.105°C, every 65 cm, and across 3,487 m of fibre optic cable to resolve the vertical temperature gradient that develops within a wheat crop during frost, and to understand the variability in frost severity within a field trial.

Showing that the coldest temperatures occur ∼100 mm to 200 mm below ear height, that temperature gradients of -0.24°C per 100 mm develop even in mild frosts and that duration of cold temperature is dependent on location relative to the crop boundary layer. We quantify the error that can be expected if loggers are not moved vertically during the growing season and demonstrate for the first time that there can be as much, as a 1.3°C range in minimum air temperature and a 5°C hr range in cold sum within a Times of Sowing (ToS), and that there was a larger range in cold sums and minimum temperature within a ToS than across the trial site and that this is likely driven by variety (canopy height and architecture). Highlighting the importance of considering canopy height and architecture when designing frost field trials to avoid false positive results from frost escapes in these trial when comparing commercial varieties for frost susceptibility or identifying frost resistant germplasm.

References

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