“Contributions of cultivars, management and climate change to winter wheat yield in the North China Plain in the past three decades”

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European Journal of Agronomy, Volume 52 (Jan. 2014), Pages 112–122

The complex impacts of climate change on crop growth and yield are confounded by changes in cultivars and agronomic management. To accelerate understandings of climate impacts, among other things, we need to disentangle the relative contributions of cultivars, agronomic management and climate change to crop yields change.

In the study, the detailed field experiment data from 1980 to 2009 at four stations in the North China Plain (NCP), together with a crop simulation model (APSIM-Wheat model), were used to disentangle the relative contributions of cultivars renewal, fertilization management and climate change to winter wheat yield, as well as the relative impacts of different climate variables on winter wheat yield, in the past three decades.

The field experiment data showed wheat cultivars phenotypic traits, such as the grain-weight, gain number per spike, harvest index, accumulated thermal development unit during vegetative growth period and reproductive growth period, changed significantly from 1980 to 2009. The data were further used to calibrate and validate APSIM-Wheat model, then several modeling experiments were designed to evaluate the impacts of changes in cultivar, fertilization management, as well as changes in different climate variables on winter wheat yield/yield components.

We found that during 1980–2009 cultivars renewal contributed to yield increase by 12.2–22.6%; fertilization management contributed to yield increase by 2.1–3.6%; and climate change contributed to yield generally by −3.0–3.0%, however by −15.0% for rainfed wheat in southern part of the NCP.

Modern cultivars and agronomic management played dominant roles in yield increase in the past three decades, nevertheless the estimated impacts of climate change on yield accounted for as large as −23.8–25.0% of observed yield trends. During the study period, increase in temperature increased winter wheat yield by 3.0–6.0% in northern part of the NCP, however reduced rainfed winter wheat yield by 9.0–12.0% in southern part of the NCP. Decrease in solar radiation reduced wheat yield by 3.0–12.0% across the stations. The impact of precipitation change on winter wheat yield was slight because there were no pronounced trends in precipitation.

The results are supported by previous studies of field trials that used 47 leading common wheat cultivars released during 1960–2000 in the NCP, which showed that average annual genetic gain in grain yield ranged from 32.07 to 72.11 $kgha^{-1}$ $year^{-1}$ or from 0.48 to 1.23% per year. Another field trial showed that the average genetic gain of winter wheat in grain yield was about 0.60% per year in Henan province of the NCP during 1981–2008. The genetic improvement in grain yield was primarily attributed to increased grain weight per spike, reduced plant height, and increased harvest index.

The results highlight that modern cultivars and agronomic management contributed dominantly to yield increase in the past three decades, nevertheless the impacts of climate change were large enough in some areas to affect a significant portion of observed yield trends in the NCP.

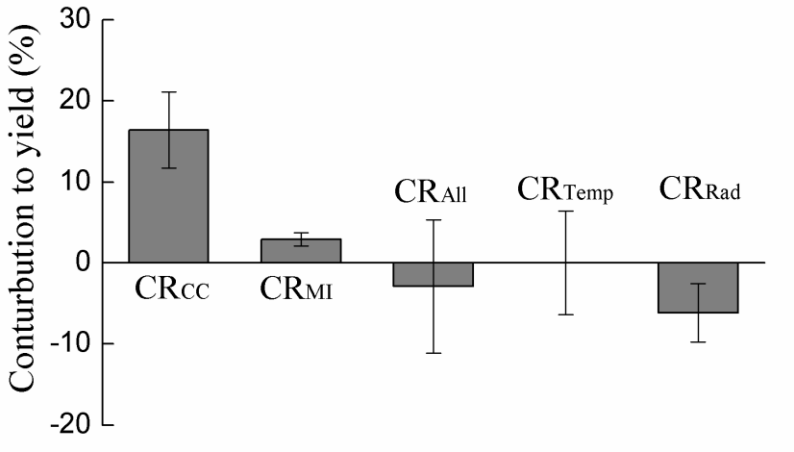

Fig.1. Contributions (%) of cultivar renewal (CR_{CC}), new fertilization management (CR_{MI}), all climatic variables (CR_{All}), temperature (CR_{Temp}) and solar radiation (CR_{Rad}) to yield of winter wheat in the North China Plain for 1980-2009

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