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LETTERS



# The case of the missing wheat

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## PERSPECTIVE

# The case of the missing wheat

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In Lewis Carroll's *Through the Looking Glass*, Alice finds herself running as fast as she can but not moving anywhere. The Red Queen explains to her 'Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that.'

Such is the situation in global agriculture. Global demand for agricultural products continues to rise as population grows and people get richer. As they get richer, people have fewer babies but eat more. And they use a lot more energy, which is increasingly derived from agricultural products. Crop technologies have to move incredibly fast just to keep up. Remarkably, over the past 50 years they have, with yields (production per hectare of land) for most crops more than doubling since 1960, and real prices of food falling for most of the period. In many ways we have come to take continued yield growth for granted. But, as Lin and Huybers show [1] elsewhere in this issue, there is increasing evidence that this growth has stalled in many regions.

The question is not new—people have worried about the pace of yield growth since at least the days of Malthus [2, 3]. But Lin and Huybers [1] use updated data and bring a new rigor to identifying where stagnation is statistically significant, for example by taking care to account for year-to-year correlation in yields. They report that for slightly more than half of the regions that they inspected, it is likely (80% chance) that yield growth has already flattened out. For many of these countries, responsible for about one quarter of global wheat production, the stagnation has very likely occurred (95% chance).

Why are yields of wheat stagnating in so many areas? At least four suspects seem plausible. One narrative is that for years the real price of wheat was declining, providing little incentive for innovation. The most obvious consequence was a major decline in investment in research and development in most regions. The recent rise in prices has reversed the decline, but technologies take a long time to develop and get adopted [4]. So yield increases are in the pipeline but have not arrived yet.

A second narrative relates to farm policy. Farmers always have an incentive to improve profits, but this does not always mean raising yields, especially if policies encourage reducing input use. In Europe, where much of the stagnation identified by Lin and Huybers [1] is found, fertilizer rates have actually declined in recent years in response to policies. One line of evidence in support of this narrative is that total factor productivity appears to be rising steadily in many regions, including Europe, even as yields have stagnated [5].

A third story relates to biophysical limits. This narrative declares that the genetic potential of crops has not improved for a long time, and most yield growth in the past two decades was related to agronomic improvements [6, 7]. But once average yields approach genetic potential, it becomes very difficult to further raise yields, and yields will be stuck regardless of price until innovation raises genetic potential [8]. If innovation is simply a function of prices, then this story folds into the first, but it could also be that returns on breeding are becoming much harder to achieve relative to the transformative effect of dwarfing genes and rust resistance that occurred in the last century.

In the fourth corner is climate change. As Lin and Huybers [1] discuss, many of their stagnating countries have experienced adverse climate trends in the past few decades. Wheat has the lowest temperature optimum of any major crop, and has been among the most affected by climate change so far [9]. So maybe the stagnation is a sign of worse things to come. Interestingly though, they find stagnation even for Northern European countries where recent warming is more likely to have helped than hurt yields [10].

The easy answer is that a combination of these factors is to blame. The real answer is we do not yet know which of these, if any, are the most important. The implications of each for future research and policy are quite different, and so working out a clearer picture is an important task. The efforts of Lin and Huybers [1] provide a useful fingerprint on where and when stagnation has occurred. Now it is time to figure out which of the suspect's fingerprints is a match.

## References

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