Resilience for sustainability

The year 2020 was dominated by COVID-19 and the multiple unforeseen challenges it created. As we enter a second year of the pandemic those difficulties continue, but so too does the resilience of the research community.

February may be the shortest month of the year but it contains plenty of annual milestones: the Chinese New Year, Valentine's Day, President's Day, Super Bowl Sunday, and so on. This year the excitement of such events is muted, with many people unable to engage in their usual family reunions or holiday parties. February also marks a full year since the official designation by the World Health Organization of COVID-19 and SARS-CoV-2 as the disease and causal virus of the pandemic that has forced travel restrictions and social distancing across the world.

Along with all of the losses COVID-19 has brought, the past year has also seen a remarkable explosion of COVID-19-related research and the startlingly rapid development of vaccines. Several governments are already carrying out detailed vaccination plans with the multiple different vaccines available. The prospect of a population-level immunity to COVID-19 that could end the pandemic seems tantalizingly close, but there will undoubtedly be many obstacles on the way to that goal. For example, there are already data suggesting that new variants of the virus could evade immune responses triggered by previous infections or vaccinations¹. Such challenges continue to spur the research community to greater efforts.

We have previously talked about the challenges and obstacles of doing science during a pandemic (see ref. ²). Even during widespread lockdowns, researchers have found ways to maintain their precious experimental materials and continue their research activities remotely. We have all learned to employ virtual meeting and interacting tools to allow us to communicate and adapt to the 'new normal'. Research unrelated to COVID-19 has continued, demonstrating the resilience of the research community.

The studies published in this issue and in recent issues of *Nature Plants* are a testament to how the plant and agricultural research community not only perseveres but continues to thrive. You might even suggest that such adversity acts as an encouragement for working scientists. But this is nothing new.

The first and second Agricultural Revolutions, occurring more than 10,000 and 200 years ago, respectively, are too distant for their effect on scientific research

to be easily explored in detail. The third Agricultural Revolution took place between the 1950s and the 1970s, a period which also witnessed the Korean War, the Vietnam War, the Cold War and various other natural and anthropogenic disasters.

The post-World War II baby boom created serious concerns about food security. To address the concerns, technological progress and scientific innovation (boosted in part by intense international competition) gave birth to the so-called 'Green Revolution', whereby an industrial and scientific lens was applied to agriculture to increase crop productivity. The selections of pure lines from elite crosses occurred in almost all major crops, and the vegetative propagation of certain crops (such as sugarcane and banana) expanded their cultivations across continents. In addition, routine and substantial applications of fertilizers significantly enhanced farmland productivity. From 1960 to 2000, the application of new technologies, including crop breeding and the use of agrochemicals, increased the yield of wheat by 208%, rice by 109%, maize by 157% and potatoes by 78% (ref. ³). The most public recognition of this enormous achievement was the awarding of the 1970 Nobel Peace Prize to Norman Borlaug — often referred to as the 'father of the Green Revolution' — for breeding higher-yielding wheat that increased food supply in Asia and Africa.

As well as advances in crop breeding, the era of the Green Revolution also heralded important progress in the understanding of basic physiological processes in plants, such as transpiration and photosynthesis. The identification and characterization of plant hormones, particularly auxin and cytokinin, greatly advanced the understanding of plant growth regulation and enabled manipulation of plant growth by hormone or hormone-related chemical application.

Moreover, the discovery of the structure of DNA in 1953, and the development of a recombinant DNA technique in 1973, paved the way for genetic engineering and molecular biotechnology. The most recent fruits of these fields are transgenic crops, which ushered in a new era of plant biotechnology and agricultural development. For example, crops expressing *Bacillus thuringiensis* (Bt) insecticidal proteins have provided effective crop protection against

many insect pests. Transgenic crops are also constructed for herbicide resistance and disease resistance. A more recent trait introduced is browning resistance, which prevents 'enzymatic browning' in apples and potatoes after cut or injury. There is currently a broad array of transgenic crops, including (but not limited to) corn, soybean, cotton, potato, papaya, canola, alfalfa, apple and sugar beet.

This new era brings new challenges and goals, not least amongst them climate change and developing resilient agriculture systems. The changing of average weather patterns and the greater frequency of extreme weather events makes it essential to consider the breeding of traits like stress resilience into crops, rather than concentrating solely on higher yields. Meanwhile, political separatism and instability raise barriers to sustainable public support and international cooperation in science, delaying the progression of research improvements.

The past twenty years of globalization have changed not only business layouts but also research relationships. International researchers sharing similar enthusiasms would travel and gather together to study in the same area, or cooperate to solve the same problems. Many scientific and technological advances have resulted from international movement and communication predicated on equality and respect. The pandemic and subsequent travel restrictions, as well as a more nationalistic political atmosphere, are making such collaborations harder to maintain. Let us hope this situation is only transitory.

Thanks to the resilience of the researchers and the various supports from both the public and private sectors, the plant and agricultural research community continues to thrive. Even after the pandemic has passed, we are unlikely to return to the 'old normal' — but then, sustainable development has always been built in a changing world. □

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References

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