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A systemic approach to genetics and crop management, leading to a sustainable wheat revolution

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The systemic approach gave faster genetic progress in bread wheat for complex goals, both in Canada and in Brazil. More attention must be given to the relationships between genetics and the projected environment in which cultivars are due to be grown 15 years later. If selection is done in less sustainable conditions (high inputs), a genetic base adapted only to high inputs will be develop over time. If selection is done only for the current climate, which is due to change over 15 years, this becomes a high-risk scenario. New cultivars may well be maladapted to a changing environment, on the very day they are released. Scientific collaboration between Canadian and Brazilian scientists on those issues helped major methodological progress. We became able to create germplasm and cultivars adapted to a wide range of environments and cultural methods. Fusarium Head Blight (FHB), for which resistance factors are quite complex, was one test case. The systemic approach gave evidence of true victory against FHB in less than 4 years, in Canada: we got very good resistance with good agronomics. Other methods had allowed only slow progress against this disease. Complex traits, for which the systemic approach works well, include many yield factors, bread-making quality, straw strength, and other valuable traits. In the near future, a scenario for a pesticide-free wheat culture may evolve, based on more research towards this desirable result. Replacing fertilizer in part by symbiotic bacteria and fungi is a logical step envisioned. The systemic approach concept is partly published in a book chapter. Making better use of the complex relationships between traits (including genes) and environments is at the core of the approach. A genome allows interactions (GxE, gene x gene, etc.) that are often many orders of magnitude more numerous than the number of genes. Multivariate analysis revealed many unexpected relationships between traits and environments. Methods based on the understanding of interactions were developed. This shortens the time to cultivar creation by 40% and increases the annual rate of genetic progress for difficult goals. Moreover, the systemic approach is unique in allowing the use of much broader genetic diversity in crosses, faster recycling of good genetics into crossing blocks, and faster selection of genotypes that embody multiple disease and stress resistance. In fact the annual progress rate is still accelerating. Systemic methods enjoyed rapid, convincing success and must receive much more attention from breeders of wheat and other crops. Collaboration with crop management experts is needed for coevolution of genetics with sustainable cropping methods.

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