(The following article is a modified version of a "Science Success Story" written by the communications team at Agriculture and Agri-Food Canada)

New tools for the genetic selection of oats

When it comes to introducing new, higher yielding oat varieties, it's not a case of "one size fits all", as different varieties respond differently to the environmental conditions in different locations. This phenomenon, known as "genotype-by-environment interaction" or GE, is why multi-location variety trials are conducted every year in every oat-growing region of Canada. Finding a way to account for GE when developing new crop varieties has been the topic of much research since the 1930s, generating tens of thousands of published research papers and a number of different methods. At Agriculture and Agri-Food Canada (AAFC), scientists have recently developed a comprehensive strategy to deal with GE called "mega-environment (ME) analysis", a tool that is becoming more widely known.

Scientists found a way to quantify the GE seen at different locations in different years, and developed a graphical method to give a clear overview of these interactions. One of the best tools, the location-grouping (LG) biplot, produces a graphic that shows the correlations occurring between genotypes and environments at different trial locations in different years. It also shows which groups of locations consistently provide the same correlations across years. Each group of locations (or subregions) where similar interactions between the environment and an oat genotype occurred has been designated an ME.

AAFC scientists had been collaborating on oat trials with the University of Saskatchewan, the University of Guelph, and industry partners since 2013, so they had access to data from nationwide multi-year and multi-location trials that they could use to test the new ME analysis method. They found that Canada's oat growing regions represent three distinct MEs: southern and eastern Ontario (ME1), the rest of eastern Canada (ME2), and the Canadian prairies (ME3). The presence of different MEs implies that each ME requires distinct cultivars for optimal performance. In other words, ME-specific cultivars must be developed and used to maximize regional (and, therefore, overall) production.

Based on these discoveries concerning the regional adaptability of oat breeding lines, oat lines were tested in the regions found to be most suitable for them. This allowed the AAFC oat breeding program at the Ottawa Research and Development Centre to release oat cultivars specifically adapted for all three MEs:

- AAC Basil for ME1, AAC Wight for ME2, and AAC Anthony for ME3 (in 2022), and
- AAC Vernon for ME1, AAC Marquis for ME2, and AAC Fedak for ME3 (in 2023).

Since their release, these new cultivars have continued to be among the best performers in their respective MEs.

The term "mega-environments" has now become common among oat researchers in Canada and is the basis for a national oat breeding strategy. The use of this method will allow AAFC breeders and scientists to support Canadian cereal production more effectively, as it is under pressure from population growth and the challenges of climate change.

CONGRATULATIONS! In 2023, the article "Mega-environment Analysis and Breeding for Specific Adaptation" by AAFC researchers Weikai Yan (Ottawa) and Kirby T. Nielson (Brandon), was one of the most downloaded from the journal "Crop Science": Mega-environment analysis and breeding for specific adaptation - Yan - 2023 - Crop Science - Wiley Online Library

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1) Weikai Yan, Mehri Hadinezhad, Brad DeHaan, Matt Hayes, Savka Orozovic, Kirby T. Nilsen, Dan MacEachern, Genevieve Telmosse, Aaron Beattie, Helen Booker, Holly Byker, Allan Cummiskey, Isabelle Morasse, Nathan Mountain, Melinda Drummond, Zhanghan Zhang, Michael Holzworth, Julie Durand, and Yuanhong Chen (2023) Exploring the trait-yield association patterns in different oat mega-environments of Canada. Crop Science, **63**: 3356–3366. https://doi.org/10.1002/csc2.21106

2) Weikai Yan, Kirby T. Nilsen, and Aaron Beattie (2023) Mega-environment analysis and breeding for specific adaptation. Crop Science, **63:** 480–494. https://doi.org/10.1002/csc2.20895

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5) Weikai Yan (2019) LG biplot: a graphical method for mega-environment investigation using existing crop variety trial data. Scientific Reports, **9:** 7130. https://doi.org/10.1038/s41598-019-43683-9

6) Weikai Yan (2016) Analysis and Handling of G × E in a Practical Breeding Program. Crop Science, **56:** 2106-2118**.** https://doi.org/10.2135/cropsci2015.06.0336

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8) Weikai Yan, Judith Frégeau-Reid, Richard Martin, Denis Pageau, and Jennifer Mitchell Fetch (2015) How many test locations and replications are needed in crop variety trials for a target region? Euphytica, **202:** 361-372. https://link.springer.com/article/10.1007/s10681-014-1253-7

This work aligns with the AAFC Science and Technology Branch mission “Increasing the resiliency of agro-ecosystems”.