

Discovering Lentils



APPLICATION OF GENOMICS
TO INNOVATION IN THE LENTIL ECONOMY



AGILE (Application of Genomics to Innovation in the Lentil Economy) describes the diversity of lentil species by characterizing more than 300 lentil varieties in different parts of the world.



Albert Vandenberg and Kirstin Bett lead the AGILE project from the University of Saskatchewan.

Breeding better lentils

Lentils are one of humanity's oldest crops. High in protein, fibre and essential nutrients, they are a dietary staple and an important part of nutritional security on dinner tables all over the world. Canada is the world's largest producer of lentils, growing more than half of the global crop, mostly in Saskatchewan.

Different growing conditions in Canada and around the world mean farmers need new varieties to cope with current and changing environmental conditions. As well, consumers in different countries have widely varied preferences in terms of taste, texture, and cooking characteristics.

In the field, lentils play an important role, fixing nitrogen from the atmosphere to help fertilize the next crops and create a healthy, resilient soil ecology.

Research and innovation continue to be the foundation of Canada's dominance in global lentil production. The Canadian lentil breeding program is located at the University of Saskatchewan. Since the 1980s, germplasm exchange has taken place among the University and gene banks at the United States Department of Agriculture (USDA) and the International Center for Agricultural Research in the Dry Areas (ICARDA).

A close-up, slightly blurred photograph of a field of green lentil plants. The plants are densely packed, showing their characteristic trifoliate leaves and thin, winding tendrils. Some small, light-colored flowers and developing pods are visible among the foliage. The overall color palette is various shades of green, from vibrant to muted, with some brownish spots on the leaves.

ORIGINS

Lentils originated in the Mediterranean and Central Asia. Lentils are one of humanity's oldest known food crops, having been consumed since at least 11,000 BCE.

TOP LENTIL CHALLENGES

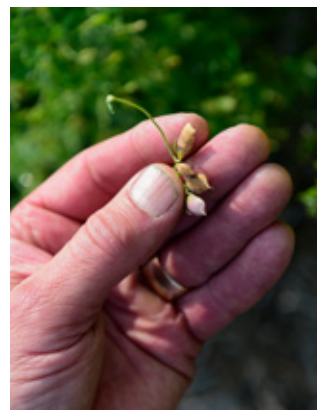
What makes a good lentil? For farmers, it means plants that produce good yields under local conditions, such as disease pressure, available moisture, temperature, and length of day (photoperiod).

While in general lentils prefer cool weather, on the dry side, maturity is particularly dependent on photoperiod and temperature.

Genomics has become essential to modern crop breeding. Knowing which genes are associated with drought tolerance, disease resistance, yield, and quality is essential. Of course, all of these characteristics must yield a lentil that people want to eat, in terms of looks, taste, and texture.

Genomics, specifically knowledge of genotype (genetic makeup) combined with phenotype (physical characteristics), gives breeders more options when choosing which parent lentils to cross together. This allows them to target their efforts to produce new varieties faster than ever before. This is critical to preserve profitable production of lentils in the face of changing climates and to provide sustainable nutrition for growing populations world-wide.

AGILE seeks to describe and define variability found in an expansive collection of lentils. The aim is to determine the genetics that underlie lentils' ability to grow well in different environments. With this knowledge, the AGILE team will develop breeder-friendly genetic markers. These will aid efforts to introduce advantageous genes into new Canadian varieties while maintaining the characteristics that make them well-adapted to this country's growing conditions.



Lentils usually produce two or three pods per branch, with an occasional four-podded branch. Albert Vandenberg explains these “quads” are a good indicator of a healthy crop that will yield well.



ENERGY AND NUTRITION FOR THE WORLD

The Nepalese have a saying: “dal bhat power, 24-hour.” They have learned that dal bhat – rice and lentils (and usually some vegetables) – offer both energy and nutrition to keep you going all day.

Lentils are a staple food in much of the Middle East and South Asia, and are equally popular in sub-Saharan Africa, West Asia, North America, Middle East, Europe, and Australia.

Production of lentils has quintupled in the past 50 years and demand is expected to increase even further as populations grow and people adopt more plant-based diets.

AGILE is working to provide faster access to lentil varieties that are better adapted to local environments and more resilient to climate changes. While this goal is national, AGILE is an international effort and its pre-breeding research, genomics resources and partnerships will help farmers around the world.

Ashutosh Sarker discusses lentil production with local farmers in India.

For many years, Sarker was the senior lentil breeder at ICARDA, the International Center for Agricultural Research in the Dry Areas. Today, he is Coordinator for ICARDA’s South Asia and China Regional Program.

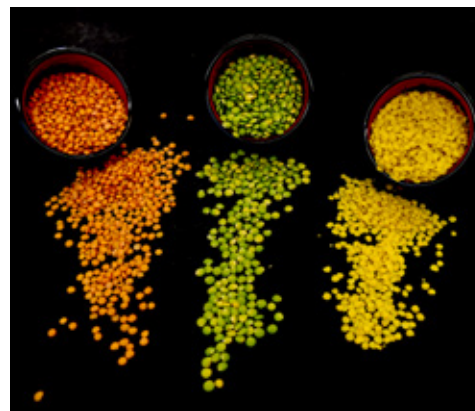
For more than 20 years, Sarker has collaborated with lentil developers all over the world, including close working relationships with the University of Saskatchewan team.

Image: ICARDA

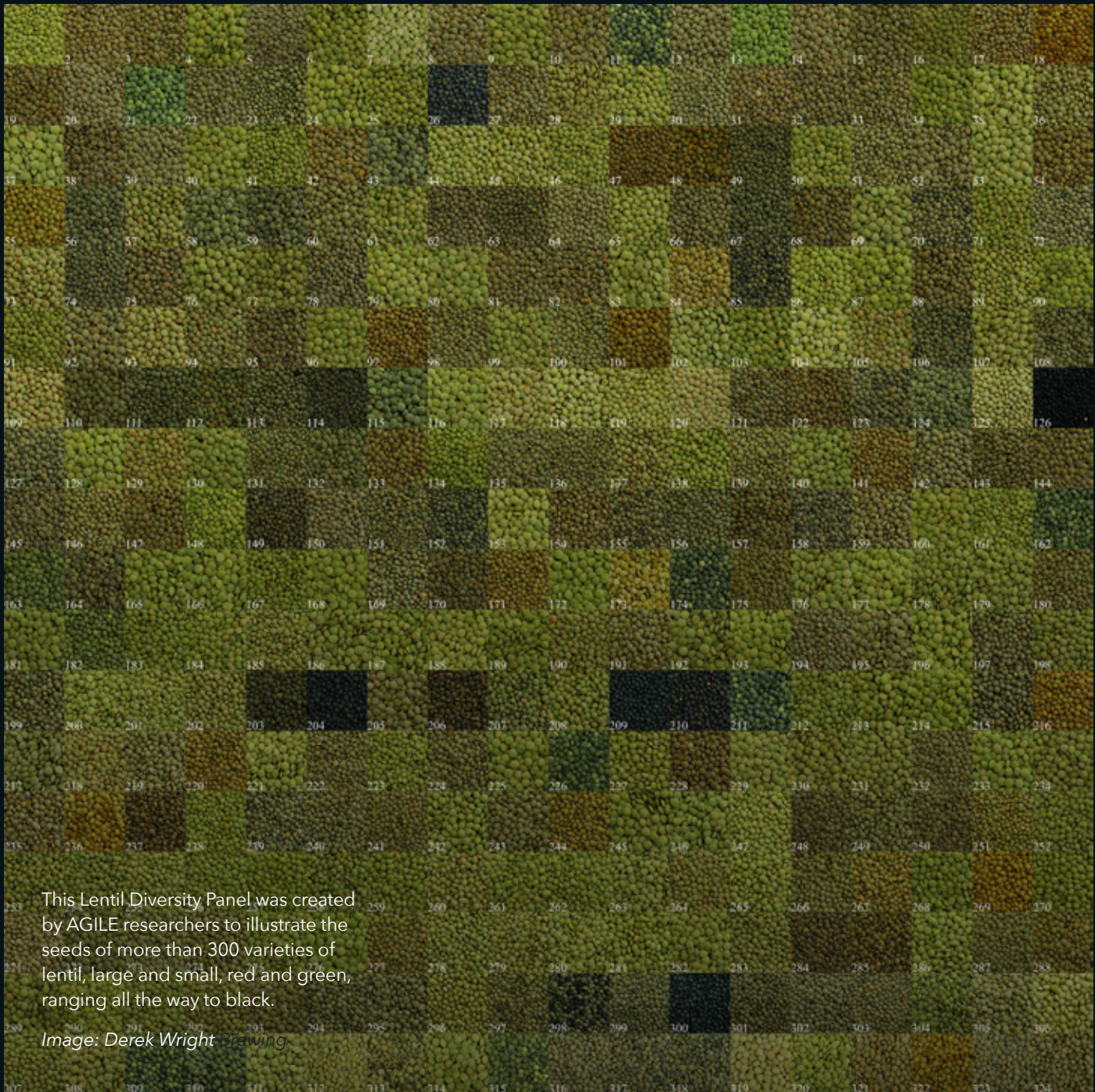


T-shirts for sale at a street vendor in Nepal.

Image: Kirstin Bett



Lentils offer great versatility in the kitchen, with varieties that feature different cooking times, colours and tastes to suit many cuisines.



This Lentil Diversity Panel was created by AGILE researchers to illustrate the seeds of more than 300 varieties of lentil, large and small, red and green, ranging all the way to black.

Image: Derek Wright

A WORLD OF VARIETY

Lentils come in many different varieties around the world. AGILE created genotype and phenotype knowledge for more than 300 varieties, including some ancestral types.

WHERE IN THE WORLD ARE LENTILS?

Canada produces more than half of the world's lentils - 51 per cent, or 3.2 million tonnes in 2016; 95 per cent of Canadian lentils are grown in Saskatchewan. In the United States, lentils are grown chiefly in Washington (Palouse region) and the Idaho panhandle.

Other current top producers are India, Turkey, Australia, Nepal, Bangladesh, US, Ethiopia and China.

Lentils are also grown in more than 35 other countries around the world, in regions including the Middle East, the Mediterranean, eastern Europe, Asia, North and South America. Potential is being explored for other parts of the world such as the United Kingdom.



Lentil varieties from around the world differ in plant size, seed shape and colour. To be successful, they must not only grow and yield well under local conditions, they must produce a lentil with the taste and cooking qualities people will want to use.



Kirstin Bett from the University of Saskatchewan works with international pulse crop specialists Diego Rubiales and Eleonora Barilli from the Instituto de Agricultura Sostenible based in Cordoba, Spain.

Lentils are a traditional part of diets in many Mediterranean countries. Europeans are also increasingly embracing lentils as a protein source and in such novel uses as gluten-free pasta.

Image: Diego Rubiales

AGILE ACCOMPLISHMENTS

Today, what drives all successful crop improvement is an understanding of the underlying genetics and lentils are no exception. Other major crops have benefited from development of well-funded efforts to create databases of genotypes and phenotypes.

AGILE has made great strides in filling this knowledge gap by sequencing more than 300 varieties of lentils around the world, including several never-before-sequenced wild lines or accessions. The team is already testing the first set of molecular markers for predicting flowering time response (such markers are a sort of “tag” that shows whether genes of interest are present). Using these markers, breeders can better target their efforts, bringing new varieties to farmers faster.

Genomic data for these varieties are now available online at knowpulse.usask.ca/portal/AGILE. Bioinformatics specialists at the University of Saskatchewan have developed a unique suite of powerful tools to help lentil breeders as they make crossing and selection decisions. The gene bank at ICARDA provides access to the seeds.



Kirstin Bett and Tania Gioia collecting data from the Lentil Diversity Panel field trial in Metaponto, Italy. Gioia, from the University of Basilicata, contributes her phenotyping skills to the AGILE project.

Image: Karsten Nielsen



Saskatchewan-based AGT Food and Ingredients approached Rebellion Brewery in Regina and Lobethal Bierhaus near Adelaide, Australia to explore an untraditional use - using lentils in beer to produce their Lentil Ale.

Photo: Matthew Barton, Rebellion Brewing



Britley Barrett demonstrates delicious lentil cooking at the National Lentil Festival in Pullman, Washington, heart of American lentil country.

Photo: Andrew Lang

LENTILS COME TO NORTH AMERICA

Canada's lentil industry has its roots in the Palouse region of Idaho and Washington states. In the early 1970s, crop scientist Al Slinkard brought his expertise from the University of Idaho to the University of Saskatchewan's Crop Development Centre (CDC) to develop lentils for the Prairies. His first variety, Laird, is a green, large-seeded variety that would become the most widely cultivated lentil in the world, covering more than a million acres in Saskatchewan by 1998. Eston, a successful variety of small-seeded green lentils, was released in 1980.

Both Laird and Eston lentils have been superseded by much improved varieties over the years. However, both names are still used to describe types of lentils in commodity markets and on bags of lentils at local supermarkets.

In the early 1990s, Albert Vandenberg joined the CDC lentil development program, ushering in the use of advanced genetic tools. He leads efforts to diversify lentil offerings to meet the needs of farmers, such as imidazolinone-tolerant varieties (Clearfield® system). His work has also tailored lentils to a wide variety of customer preferences around the world. With more than 100 varieties now available, there is a lentil for all market classes.



Decades of work by plant breeders such as Albert Vandenberg at the University of Saskatchewan have created numerous varieties suited to the Prairies. As a result, Canada now produces more than half of the world's lentils, with a full 95 per cent of the nation's production coming from Saskatchewan.



Albert Vandenberg, Derek Wright, and Kirstin Bett work with lentil plants at the Crop Science Field Facility at the University of Saskatchewan.

Observing and categorizing the physical characteristics of the lentils is part of phenotyping, that is, the result of interaction among plant genes and the environment in which the plants are grown.

AGILE includes a genome-wide association study or GWAS, which looks at the genomes of many varieties of lentil and how they interact with their environments.

By determining which genes are responsible for which characteristics, researchers can develop genetic markers that indicate when certain traits are present. These markers are powerful tools that plant breeders use to more quickly develop new varieties.

HOW TO ACCESS AGILE

1. Visit the Knowpulse web portal (knowpulse.usask.ca/portal/AGILE to find):
 - A list of the 300+ lentil varieties whose germplasm has been genotyped
 - Genomic and marker information of the 300+ germplasm
 - Bioinformatic tools for lentils and other legumes
2. Physical resources (i.e. seeds) are available for researchers and plant breeders developing varieties for local conditions through ICARDA. Visit <https://www.icarda.org/research-sub/biodiversity-and-its-utilization> or contact Ahmed Amri, Head of Genetic Resources Unit, ICARDA, at A.Amri@cgiar.org.
3. Our phenotyping collaborators are:



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AGILE is based at the University of Saskatchewan and is funded and supported by Canadian producer groups, national funding agencies, and the provincial government.

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