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Feed the Future Innovation Lab for Climate Resilient

Chickpea

Climate Resilience and Nutrition in Chickpea

The Climate Resilient Chickpea Innovation Lab emphasizes crop-based traits of climate resilience and nutrition, focusing genetic improvement on the needs of smallholder farmers in Ethiopia and India. In both countries, chickpea is key to food security, providing a vital source of protein nutrition and income. In Ethiopia, smallholder farms dominate chickpea's production acreage, with low and variable yields. Though India is both the largest producer and consumer of chickpea, yields are significantly below those in intensively managed systems. Year-to-year climatic variation is a key factor in variable yield and thus addressing climate resilience is a key priority. Moreover, women's labor dominates smallholder farming in Ethiopia and thus year-to-year variation in chickpea production has a disproportionate impact on rural women and their children.

Background

Grain legumes were not beneficiaries of the Green Revolution. Policy and investment since the 1960's have favored Green Revolution cereal crops, which were planted on the best agricultural land and also received the lion's share of investment. Legumes, on the other hand, were often relegated to marginal lands where elevated temperatures, rain fed cropping systems, short growing seasons and poor soils conspired to limit yield potential. As a result, enhancing climate resilience – including resilience to environmental extremes, variable climate and marginal soils – is an ongoing challenge to most legume crops. Moreover, legume breeding has largely ignored legumes' chief advantage, namely their capacity for biological nitrogen fixation, which underpins their agricultural sustainability and high content of nutritional protein. Climatic factors such as moisture, heat and salinity impact nitrogen fixation, and thus developing climate-resilient nitrogen fixation is a corresponding need.

Our Project

Like the majority of cultivated legumes, chickpea has exceedingly narrow genetic and phenotypic diversity. This has consequences for breeding of climate-resilient crop varieties because much of the historical phenotypic plasticity necessary to tolerate environmental extremes may have been lost through domestication. Breeding for climate resilience as well as other high value traits will be greatly accelerated if we can expand the range of adaptations accessible to breeders. Towards this end, we are characterizing wild *Cicer* species from a representative range of environments; introducing wild diversity into phenology-normalized backgrounds so that it is amenable for trait assessment and breeding; characterizing the material by systematic phenotyping; developing a digital information network that explicitly identifies and quantifies the contributions of agronomically useful alleles; and developing improved chickpea varieties using an international consortium of chickpea breeders. We aim to foster breeding of high-yielding, climate-resilient chickpea within the context of user-preferred traits. Our upstream activities (i.e., germplasm collection, genomics and population development) are predicated on the need to facilitate downstream phenotyping and breeding activities. Our efforts emphasize the identification and introduction of newly collected wild alleles into diverse high performing elite cultivars creating novel varieties that are optimized for climate resilience and nutrition.

Our Team

Across the spectrum of activities, we engage world-class researchers to harness the extra-ordinary potential of natural genetic variation to meet the challenges of modern agriculture. From genetics, genomics and breeding with Professor and Project Director Douglas Cook at the University of California Davis, computational biology and modeling with Professor Sergey Nuzhdin at the University of Southern California, agro-ecology and statistical analysis with Professor Eric von Wettberg at Florida International University, the physiology of drought stress with Dr. Vincent Vadez at the International Crops Research Institute for the Semi-Arid Tropic in India, to germplasm curation and pre-breeding with Professor Abdullah Kahraman at Harran University in Turkey, and breeding, genetics and variety assessment with Dr. Asnake Fikre of the Ethiopian Institute for Agricultural Research and Dr. Kassahun Tesfaye of Addis Ababa University in Ethiopia. More broadly, we engage many of the world's top chickpea scientists through collaborative efforts involving private foundations and national programs in a range of countries and through a variety of funding mechanisms.

Partners and Expertise

Our combined research activities span from basic research focused on bridging key knowledge gaps, to directed efforts that emphasize applied outcomes of impact to farmers. Our members and partners include academic and national program laboratories in the United States of America, Ethiopia, India, Pakistan, Lebanon, Kenya, Turkey, Morocco, Canada and Australia. Our collective expertise is intentionally multi-disciplinary, spanning genetics and genomics to quantitative biology, ecology to breeding, seed nutrition and agronomy, to plant pathology.

Sponsors

USAID • National Science Foundation • Global Crop Diversity Trust • CGIAR Consortium Research Program 3.5 on Grain Legumes • Grains Research and Development Corporation • 2Blades Foundation • Saskatchewan Pulse Growers • Saskatchewan Ministry of Agriculture • Western Grain Research Foundation • Mars Incorporation • Indo-U.S. Science and Technology Forum

For more information or to contact our team, please visit **ChickpeaLab.ucdavis.edu**

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Research Goals

The Feed the Future Innovation Lab for Climate Resilient Chickpea research focuses on multiple allied projects.

- The USAID project fosters breeding of high-yielding, climate resilient chickpea within the context of user-preferred traits: seed quality and nutrient density, reduced inputs due to climate resilient nitrogen fixation, and biotic stress resistance among them.
- The NSF project bridges ecology and molecular biology by means of genomics and quantitative biology to identify and subsequently analyze genes involved in the establishment of the legume rhizobial symbiosis.
- The Global Crop Diversity Trust effort includes the dual focuses of (1) curation, increase and distribution of wild germplasm, and (2) analysis of drought tolerance among representative wild accessions.
- The CGIAR Consortium Research Program 3.5 on Grain Legumes (1) assesses molecular diversity among *C*. reticulatum and *C*. echinospermum accessions held by CGIAR repositories, and (2), contributes to establishing the genome structure of wild *C*. reticulatum and *C*. echinospermum based on long-read sequencing and linkage mapping.
- The 2Blades Foundation project, in partnership with the USAID project, focuses on genomics-aided breeding for disease resistance against the devastating fungal wilt pathogen, *Fusarium* oxysporum.
- Funding from MARS Inc. facilitates genotying of pre-breeding populations, accelerating the incorporation of useful wild genetic variation into elite cultivated varieties of chickpea.