Science Impacts

ICARDA
Science for resilient livelihoods in dry areas

Harnessing food legumes for climate-smart agriculture

Food legumes are particularly suited to sustainable agriculture. ICARDA is developing and disseminating improved varieties and production technologies so farmers can benefit from the increasing demand for these climate-smart crops. The result: stable yields, healthier soils, and enhanced food and nutritional security.

Food legumes offer important benefits for sustainable smallholder production systems. Inter-cropped or double-cropped with cereals or used as part of a crop rotation, they add nitrogen to the soil through a natural process known as biological nitrogen fixation, which enhances soil fertility and health. Their resilience allows minimum fertilizer inputs, which can reduce the costs of production substantially. They provide an excellent source of nutrients and proteins – enhancing food and nutritional security for people and animals.

This hardy food source can have a positive effect on climate change and variability adaptation: food legumes can tolerate harsh conditions, survive with limited amounts of water, and have a low carbon footprint. They use less than half the non-renewable energy inputs of cereals and can therefore help to reduce greenhouse gas emissions. As temperatures rise and water becomes more scarce, food legumes become an important component of climate-resilient production systems. In South Asia, lentil, chickpea, grasspea, and faba bean are grown in residual soil moisture as post-rainy season crops with little rain during the crop season. In West Asia and North Africa, these crops are grown in Mediterranean environments with 200-550 mm rainfall zones. They can be successfully grown in 5^{O}C-30^{O}C temperature zone.

The rising global demand for food legumes presents farmers with a unique opportunity to raise their incomes and benefit economically from their production. According to figures published by the International Food Policy Research Institute (Joshi and Rao 2017)[1], for instance, there has been a four-fold increase in pulse trade since the 1980s.

[1] Joshi, P.K. and P.P. Rao. (2017). Global pulses scenario: status and outlook. *Annals of the New York Academy of Sciences* 1392: 6-17.

The constraints holding back potential

Despite this potential, food legumes are highly vulnerable to insect pests, parasitic weeds, and diseases, which limits productivity. Farmers also have limited access to new knowledge and technologies, and the dissemination of improved varieties is held back by weak seed systems and unfavorable policy in many countries.

The ICARDA Food Legumes Improvement Program is a multidisciplinary and multi-location research for development initiative designed to promote food legume productivity and consumption to combat poverty, hunger, malnutrition, and environmental degradation. The program is linked to national agricultural research systems, CGIAR Research Program Grain Legumes and Dryland Cereals, and advanced research institutes worldwide.

It also supports ICARDA's global mandate for the improvement of lentil, faba bean, grasspea, and chickpea. The Center's genebanks contain unique collections of genetic materials (landraces and wild relatives) that help advance the development of improved and resilient crop varieties, including: 14,597 lentil, 10,034 faba bean, 15,749 chickpea, and 4,457 grasspea accessions. ICARDA also conserves 1,380 rhizobia strains in its genebank, a rare source for making legumes fix nitrogen efficiently.

Moving beyond a narrow focus on yield

ICARDA's efforts to extend the benefits of food legumes for climate-smart agriculture go beyond the development of improved varieties and a single focus on yield and performance; they adopt integrated systems approaches that also encompass adaptation and mitigation strategies. Recent initiatives provide national governments with models they can adapt for their own contexts, incorporating food legumes into resilient production systems, rural development plans, and climate change adaptation strategies.

Impacts across the dry areas

An initiative with the Ethiopian Institute for Agricultural Research has developed and delivered improved lentil, chickpea, faba bean, and grasspea cultivars to highland farmers in **Ethiopia**. Tested on farmed fields and adapted to local conditions, they have steadily increased yields: a three-fold increase in production in the last 15 years. A participatory legume-seed system that involves farmers in quality seed production has also enhanced adoption and dissemination of improved technologies. Between 2015 and 2018 alone, almost 100,000 farmers directly accessed improved chickpea and faba bean varieties and rhizobia technology. Pulses are now the third-largest crop export from Ethiopia after coffee and oil seed, representing a US$90 million export industry annually. The chickpea and lentil genotypes released in Ethiopia have helped farmers to shift late planting to early planting thanks to their resistance to foliar and root diseases and tolerance to the transient waterlogging problem.

Cultivating land left fallow after the rice crop harvest boosted pulse production across **Bangladesh**, **India**, and **Nepal**, reducing dependence on imports. The approach combined the development of early-maturing, high-yielding and disease-resistant varieties alongside relay-cropping techniques. Farmers' capacity was strengthened by building local systems to enhance seed production and improve adoption.

In **Bangladesh**, lentil production increased by 10.9% between 2011 and 2015 – generating higher yields (356 kg/ha) and net returns (US$93/ha) for farmers. Specifically, about one million small-scale farmers obtained a harvest of lentils from the same piece of land. It has improved their livelihoods and nutrition for their families. Approximately 99% of the 150,000 hectares of lentil area in the rice-lentil system is used to plant improved varieties in Bangladesh.

In **India**, lentil production has jumped to 1.6 million tonnes, doubling the output of 10 years ago, as the adoption of improved varieties has contributed to increased yield.

In **Nepal**, more than 918,260 farm families have benefitted from the adoption of improved production technologies with 36,128 tonnes of additional lentil production worth US$28.9 million annually. In addition to meeting national demand, lentil is now the number one export commodity in Nepal.

ICARDA's work in South Asia also includes the development and dissemination of low-toxin and toxin-free grasspea varieties. A versatile crop that can withstand extreme heat and drought, grasspea can be grown under low-input with fewer costs. It offers leafy vegetables and seeds for human consumption, and green fodder and residues for animals. Improved cultivars are making this hardy pulse an increasingly viable option. Combined with high-yielding traits, the improved varieties have low levels of the toxin ODAP with higher yields of 43% over traditional varieties.

Finally, in **Egypt**, the introduction of faba bean varieties resistant to Orobanche – a parasitic herbaceous plant – combined with disease and pest management practices have boosted domestic production. The varieties are now part of a nationwide campaign that produced an impressive 200,000 tonnes of faba bean in 2017. For farmers, an increase in productivity of 3.5 t/ha has translated into increased revenue of US$550/ha and reduced production costs to US$350/ha.

New scientific frontiers

The advancement in legume research has been possible thanks to efforts to identify and deploy genes associated with traits of earliness, disease resistance, Orobanche tolerance, as well as micro-nutrients from landraces and wild crop relatives.

Chickpea is traditionally planted in spring. By advancing planting time to November and making use of the winter rainfall, yield of winter chickpea can be increased by 100%. Ascochyta blight, the most devastating disease, is a major threat to chickpea grown in winter. Through identification of new sources of resistance and use of gene pyramiding, the breeding programs have managed to increase ascochyta resistance in chickpea.

ICARDA scientists are infusing novel genetic variability for desired traits into the breeding pipeline to deliver improved germplasm with integrated crop management technologies. Additionally, efforts are underway to make crop-input use more efficient, so that it improves production, while reducing production cost.

Donors:

- Agricultural Research Center – Egypt
- Arab Fund for Economic and Social Development
- Austrian Development Agency
- CGIAR Research Program, Grain Legumes and Dryland Cereals
- The Crop Trust
- European Commission
- Government of India (Odisha, Madhya Pradesh and West Bengal states)
- Grain Research and Development Corporation – Australia
- HarvestPlus
- Indian Council of Agricultural Research
- International Fund for Agricultural Development
- OCP Foundation – Morocco
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