Catch the Pulse

Pulses are **smart food**

GOOD FOR YOU | GOOD FOR THE PLANET | GOOD FOR THE SMALLHOLDER FARMER

In support of

2016 INTERNATIONAL YEAR OF PULSES

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ICRISAT Science with a human face

International Crops Research Institute for the Semi-Arid Tropics

Contents

International Year of Pulses 2016

The UN General Assembly declared 2016 as the International Year of Pulses (IYP) with the aim to **heighten public awareness of the nutritional benefits of pulses as a part of sustainable food production aimed towards food security and nutrition**.

Pulses are under-recognized for their value and their importance in diversification and complementing other foods. They are critical for both farmers and consumers.

Pulses are Smart Food as they are:

Good for You

Pulse crops such as lentils, beans, pigeonpea and chickpea are a critical part of the general food basket

They are an important source of plant-based protein and amino acids

As part of a healthy diet they help address obesity, manage chronic diseases like diabetes and coronary conditions

Good for the Planet

Highly water efficient, pulses are smart crops that grow in drought prone areas

Helps improve soil fertility by fixing nitrogen and promoting soil microbes

Pulses make a positive contribution in reducing release of greenhouse gases

Good for the Smallholder Farmer

Pulses can better withstand climate change thus reducing risk for the smallholder farmer

Multi-use crop – food, fodder, fuel, building material – helps improve livelihoods of farmers

Particularly important for female farmers who are a major part of the labor force in pulses farming

@ ICRISAT

The pulses, pigeonpea and chickpea, in addition to groundnut, millets and sorghum, are the mandate crops of ICRISAT. Research focus is on (a) improved grain quality, nutritional traits, food safety, nitrogen fixing properties, hybrids, and (b) drought tolerance and adaptation to diverse dryland agroecosystems and to differing rotations with cereal crops. Breeding is enhanced with modern genomic and molecular tools, precise phenotyping and crop simulation modeling.

ICRISAT works along the whole value chain of pulses in an integrated manner to create a win-win situation for the farmer, consumer and the planet.

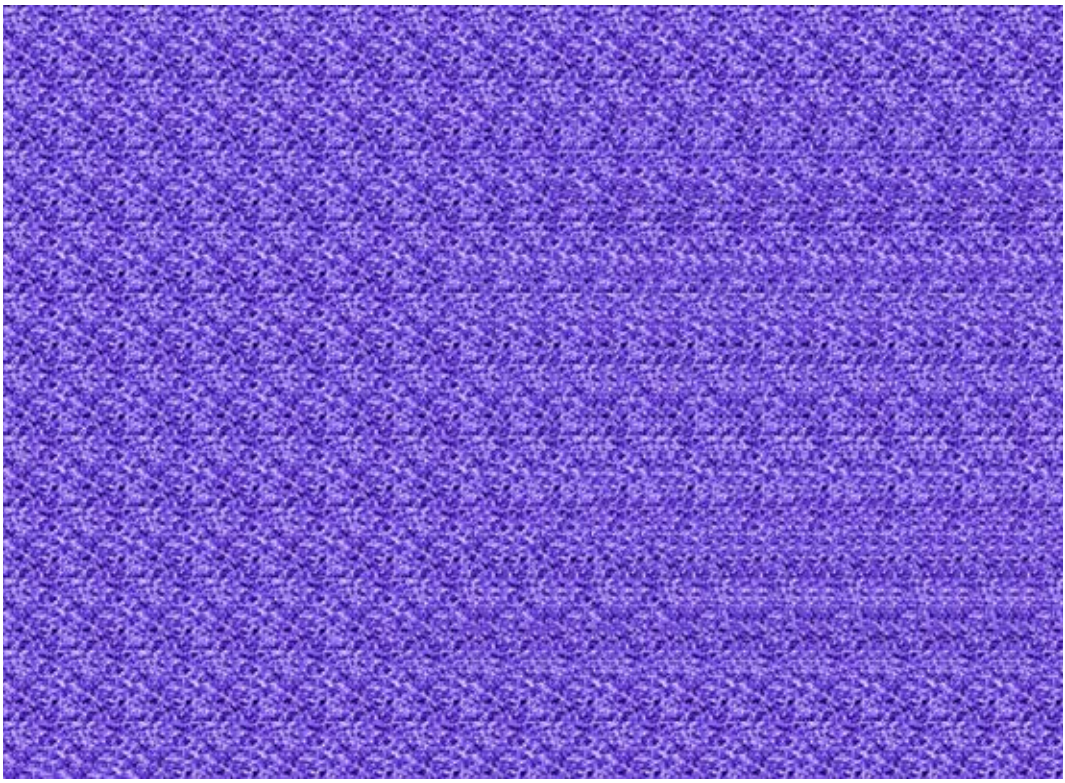
Cross-cutting issues

- **Mainstreaming nutrition**
- **Empowering women** – women are consulted, involved and supported to lead
- **Attracting youth** to agriculture

Approach for Adoption

- **Participatory approach and partnering** – working side by side
- **Building capacity** – at a national and local level
- **Integrating communications** - to build awareness and share knowledge
- **Monitoring and evaluation** – for feedback and adjustment
- **Policy support** – work closely with government to encourage the needed policies

Protein



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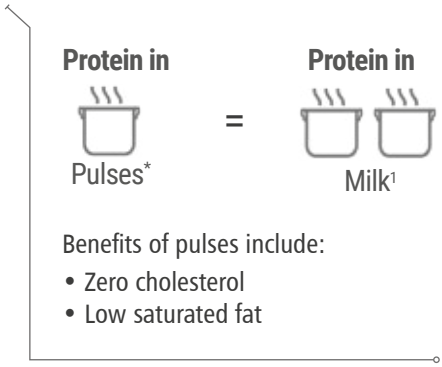


* 1 cup= 164 g

[1] Based on data from http://ndb.nal.usda.gov/ndb/foods

Pulses + Cereals provide balanced protein diet comparable to meat or dairy foods. Pulses are high in protein (23%)[1].

1 Protein deficiency is mainly observed among the poor, infants and young children in developing countries

2 Pulses are an affordable source of protein

3 Chickpea has the highest protein bioavailability among pulses

@ ICRISAT

An extra short duration pigeonpea variety (ICPL 88039[2]) developed by ICRISAT, matures in about four months, compared to the traditional variety that takes up to six months to mature. Recently, under a project in Rajasthan the short duration pigeonpea variety was introduced, with the aim to expand pigeonpea production through farmer participation.

"Before, we could not afford to buy *dal* (split pigeonpea) for our everyday meal. Now, with improved varieties, *dal* has become more available and affordable in the village, and I can prepare and serve my children *dal* anytime," says Prem Devi, Padasoli village, Jaipur district, Rajasthan, India.

Project: Enhancing the livelihoods of resource-poor farmers of Rajasthan through the introduction of ecofriendly pigeonpea varieties

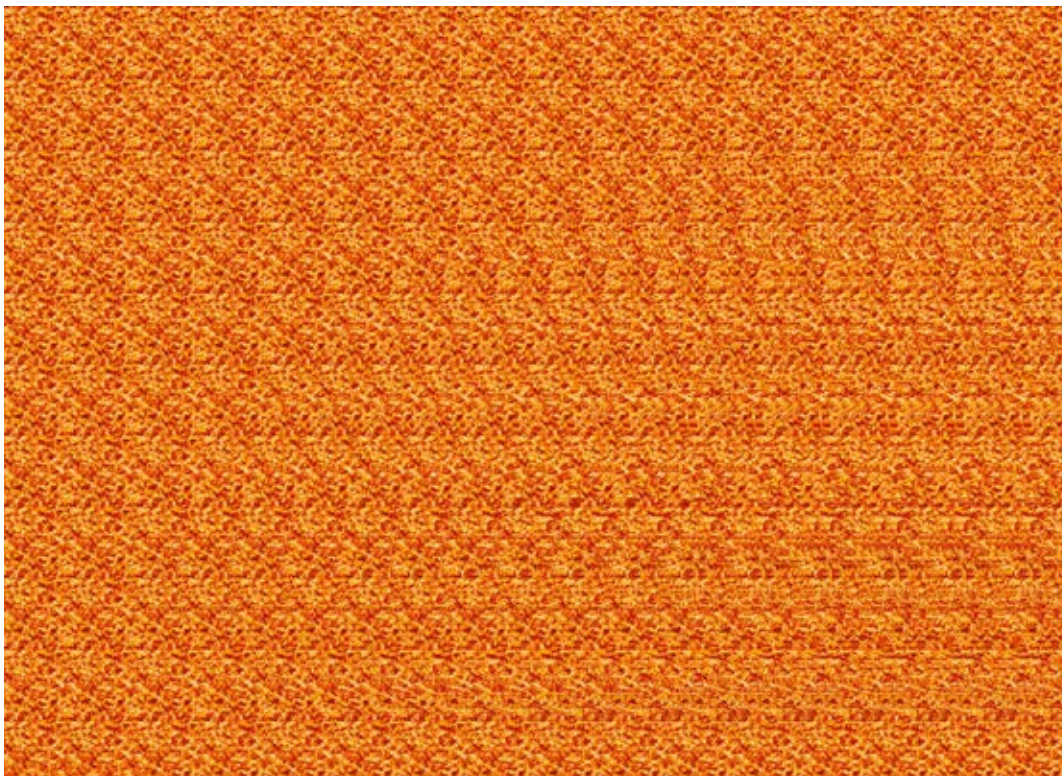
Investor: Directorate of Agriculture, Government of Rajasthan, under the Rashtriya Krishi Vikas Yojana
Partner: Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan and ICRISAT

CGIAR Research Program: Grain Legumes

[1] http://www.pulsecanada.com/uploads/dl/y5/dly5UDO9BpWjEAJb3YkQiA/Pulses-are-a-Superfood.pdf

[2] 'ICPL 88039' is the first variety of its kind among the global pigeonpea cultivars. Besides its extra-short maturity, this variety is less sensitive to the number of hours of sunlight compared to medium-duration varieties. These aspects help it to adapt well to different geographies including high altitudes (up to 2,000 m above sea level) and wide range of latitudes (up to 40^0 N and S).

Dietary Fiber



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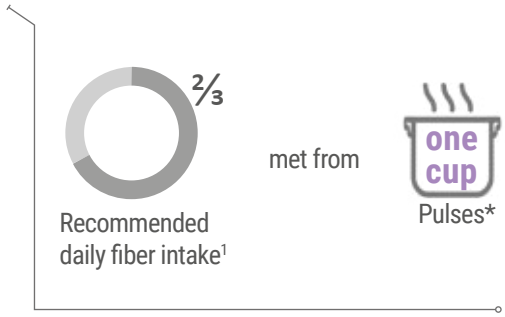

[1] Half cup pulses/day provides 7-17 g fiber accounting for 18-45% of recommended daily fiber intake in men and 28-68% in women. Calculation based on data from United States Department of Agriculture, National Nutrient Database for Standard Reference Release 28

*1 cup= 448 g

Pulses are smart food

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While high fiber diet is healthy, drinking plenty of water is recommended as fiber works best when it absorbs water.

Benefits of a high fiber (60-70%) diet

- Soluble fiber helps lower "bad" cholesterol
- Aids weight loss (more filling with fewer calories)
- Maintains bowel health and lowers risk of colon diseases
- Lowers risk of heart disease (reduces blood pressure and heart inflammation), stroke, hypertension, diabetes (slows sugar absorption and improves blood sugar levels), and gastrointestinal diseases
- Whole pulses have more fiber content than refined, processed pulse products and are better than fiber supplements
- Several cultivars [both *desi* (brown-seed) and *kabuli* (white-seed) types] developed by ICRISAT and others include - Early (90-100 days), Extra early (85-90 days) varieties, and Super-early desi (75-80 days) breeding lines

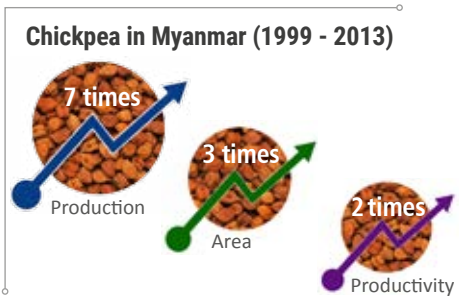
Cooked chickpea has 12.5g dietary fiber, meeting 50% of **daily requirement**[1]

@ ICRISAT

Chickpea variety ICCV 2 is the first extra-short-duration (85-90 days) kabuli variety with Fusarium wilt resistance and heat tolerance, and was initially released in Sudan, Myanmar and India.

Adoption of early-maturing chickpea cultivars led to an increase in area and productivity in Myanmar.

Six early-maturing chickpea cultivars (Yezin 3, 4, 5, 6, 8 and 11) developed from the breeding material supplied by ICRISAT covers over 95% of the total chickpea area in Myanmar.



Project: Multidisciplinary legume based farming systems in the central dry zone of Myanmar to improve food security and farmer livelihoods

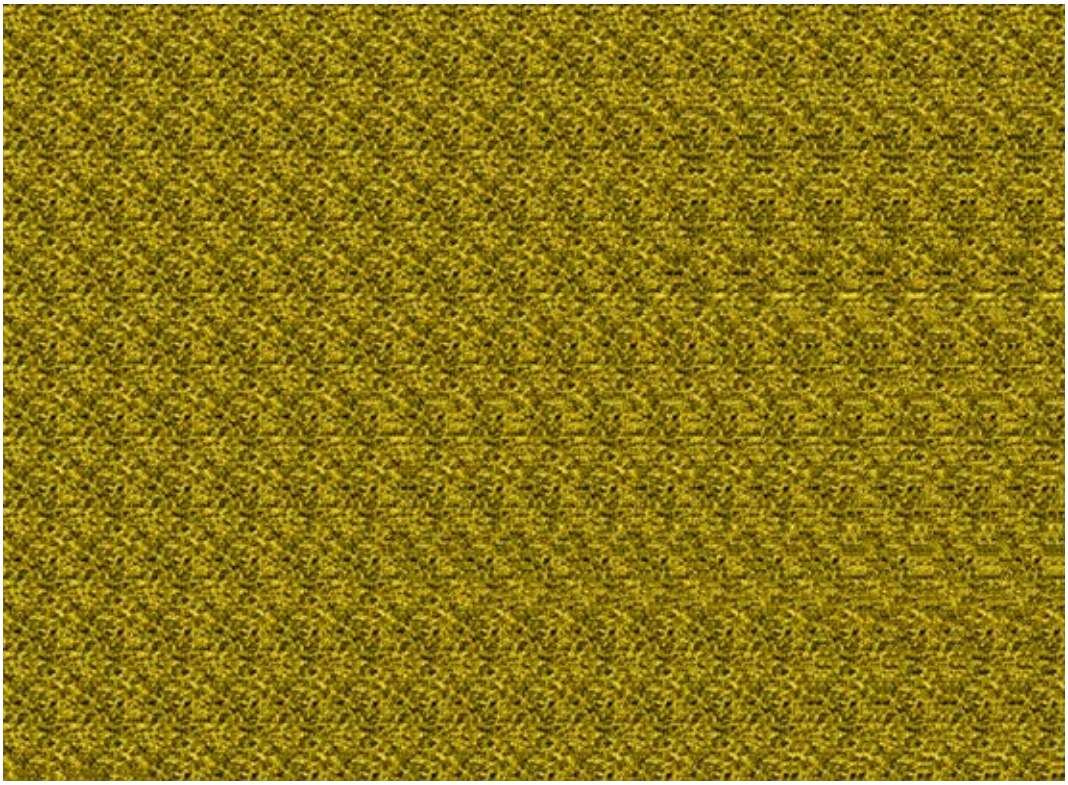
Investor: International Fund for Agricultural Development-European Commission, Australian Centre for International Agricultural Research

Partners: Indian Council of Agricultural Research, Department of Agricultural Research, Myanmar Agriculture Service, Yezin Agricultural University and ICRISAT.

CGIAR Research Program: Grain Legumes

[1] http://www.cicilsiptic.org/downloads/cicils_mag_dubai_2012.pdf

Vitamins



Instructions to view this stereogram are on the last sheet.

Pulses provide substantial amounts of **Vitamin E, Vitamin B6** and **folic acid** (as folate)

Germinated pulses have higher levels of Vitamin B12 which increases 48 hrs after germination and is highest after 96 hrs[1].

- Percentage of daily recommended intake found in 100 g of cooked chickpea and pigeonpea[2]

Cooked chickpea

- 44.5% Folic acid (as folate)
- 24.5% Vitamin E
- 10.5% Thiamin
- 10.3% Vitamin B6
- 4.3% Vitamin K

Cooked pigeonpea

- 28.7% Folic acid (as folate)
- 13.3% Thiamin
- 5.4% Riboflavin
- 3.7% Vitamin B6

- Major vitamins found in cooked pulses are Vitamin B6, Vitamin E, Vitamin K, thiamin, riboflavin and folic acid (as folate)
- Chickpea and pigeonpea are mainly cooked before consumption, and water soluble vitamins are less in the cooked form
- Pigeonpea is also popular as a green vegetable

@ ICRISAT

ICPH 3762: The first pigeonpea hybrid crop released for Odisha in 2014.

ICRISAT with the support of the Odisha government promoted improved chickpea and pigeonpea cultivars, production technologies and seed systems while strengthening farmer capacities in various districts of the state. Early duration varieties for central Odisha and medium duration varieties for south-western regions will be released in the next 2-3 years.

Only one-third of farmers in Odisha grow pulses and seeds are saved for the next season. Low, unstable yields discourage them from growing pulses in large areas. Since 2011, high yielding varieties and hybrids are being popularized along with demonstrations of improved crop management technologies and seed systems in 8 districts of the state. New chickpea varieties appropriate for Odisha are being identified. This will help improve pulse consumption from the current level of 26.6 g/day/capita, which is lower than the intake of 35 g/day/capita recommended by the Indian Council of Medical Research.

Projects: Promotion of improved chickpea varieties in rice-based cropping systems of smallholder farmers in Odisha; Introduction and expansion of improved pigeonpea production technology in rainfed upland ecosystems of Odisha

Investor: Department of Agriculture, Government of Odisha, India

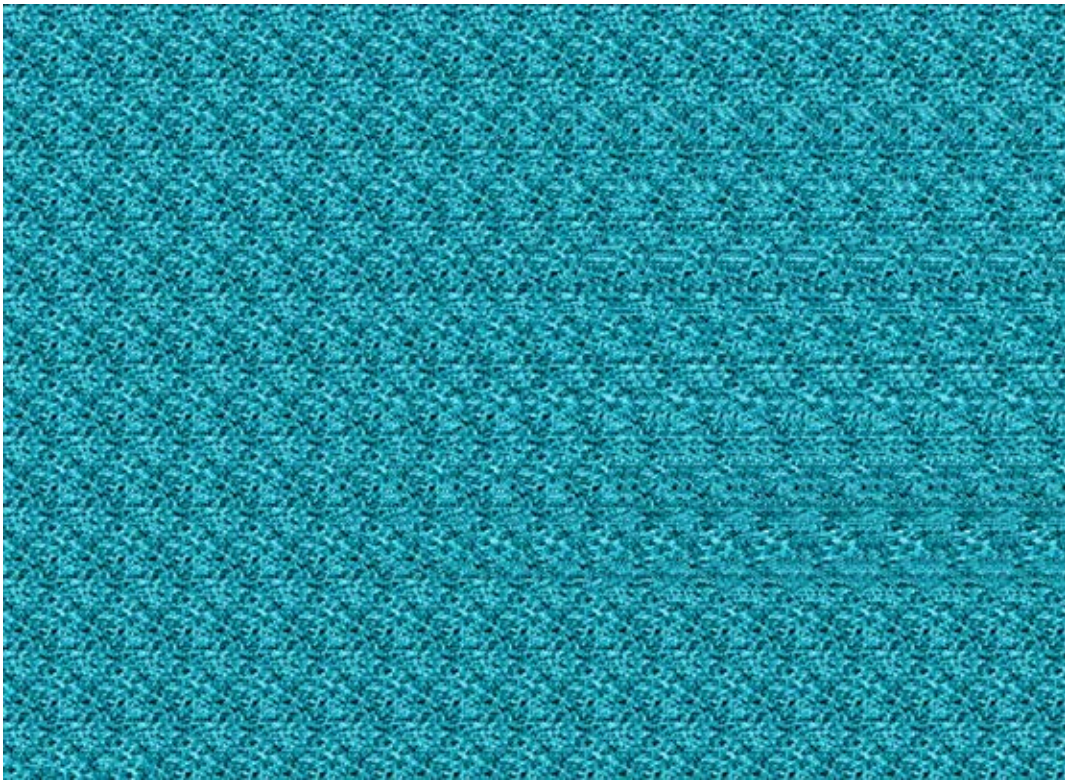
Partners: Department of Agriculture, Government of Odisha; Orissa University of Agriculture and Technology, Bhubaneshwar; Odisha State Seeds Corporation.

CGIAR Research Program: Grain Legumes

[1] Rohatgi K, Banerjee M and Banerjee S. 1955. Effect of germination on vitamin B12 values of pulses (Leguminous seeds). The Journal of Nutrition (http://jn.nutrition.org/content/56/3/403.full.pdf)

[2] Calculation based on data from United States Department of Agriculture, National Nutrient Database for Standard Reference Release 28 (http://ndb.nal.usda.gov/ndb/foods)

Minerals



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Pulses provide **iron, potassium, magnesium calcium, phosphorus, sulfur** and **zinc,** to our diet

Micronutrients, (vitamins and minerals) are essential for the utilization of proteins and calories and to fight infections[1].

- Iron deficiency anemia is a serious health issue[2,3,4] and ranges from 50-70%, in women and children, with pregnant women being particularly susceptible
- Zinc deficiency is prevalent in 31% of the world's population[5]
- The poor are most affected as their diet is generally low in bioavailable zinc and may contain inhibitors of zinc absorption
- Chickpea and pigeonpea are great sources of iron, manganese and zinc

Percentage of daily recommended intake of minerals in 100 g of cooked chickpea and pigeonpea[6]

Cooked chickpea

- 52.2% Manganese
- 27.5% Iron
- 19% Phosphorus
- 16.5% Zinc
- 14% Magnesium

Cooked pigeonpea

- 25.4% Manganese
- 13.5% Phosphorus
- 13.2% Magnesium
- 10.5% Iron
- 10% Zinc

1. Magnesium is critical for proper maintenance of body weight and for a number of metabolic syndromes related to cardiovascular disease[7]
2. Minerals required for bone formation and for bone related metabolic processes include calcium, magnesium, phosphorus, potassium, manganese, copper, iron, zinc[8]
3. Green pigeonpea seeds has 28.2% more of phosphorus, 17.2% potassium, 48.3% zinc, 20.9% copper and 14.7% iron compared to *dal*. The dal, however, has 19.2% more calcium and 10.8% more manganese[9]

[1] Indian National Science Academy. 2011. Micro-nutrient security for India–priorities for Research and action (insaindia.org/download%20form/Micronutrient_final_with_cover.pdf)

[2] National Nutrition Monitoring Bureau (NNMB), Prevalence of micronutrient deficiencies; Technical report No.22, National Institute of Nutrition, ICMR, 2003

[3] National Nutrition Monitoring Bureau (NNMB), Diet and nutrition status of populations and prevalence of hypertension among adults in rural areas;. Technical Report No 24. National Institute of Nutrition, ICMR, 2006

[4] National Family Health Survey (NFHS-3), International Institute of Population Sciences, Mumbai, India, 2005-2006; Jan.2011, 96 (1):

[5] Caulfield L E and Black R E. 2004. Zinc deficiency in Comparative quantification of health risks : global and regional burden of disease attributable to selected major risk factors Volume 1. Edited by Majid Ezzati, Alan D. Lopez, Anthony Rodgers and Christopher J.L. Murray. World Health Organization Geneva

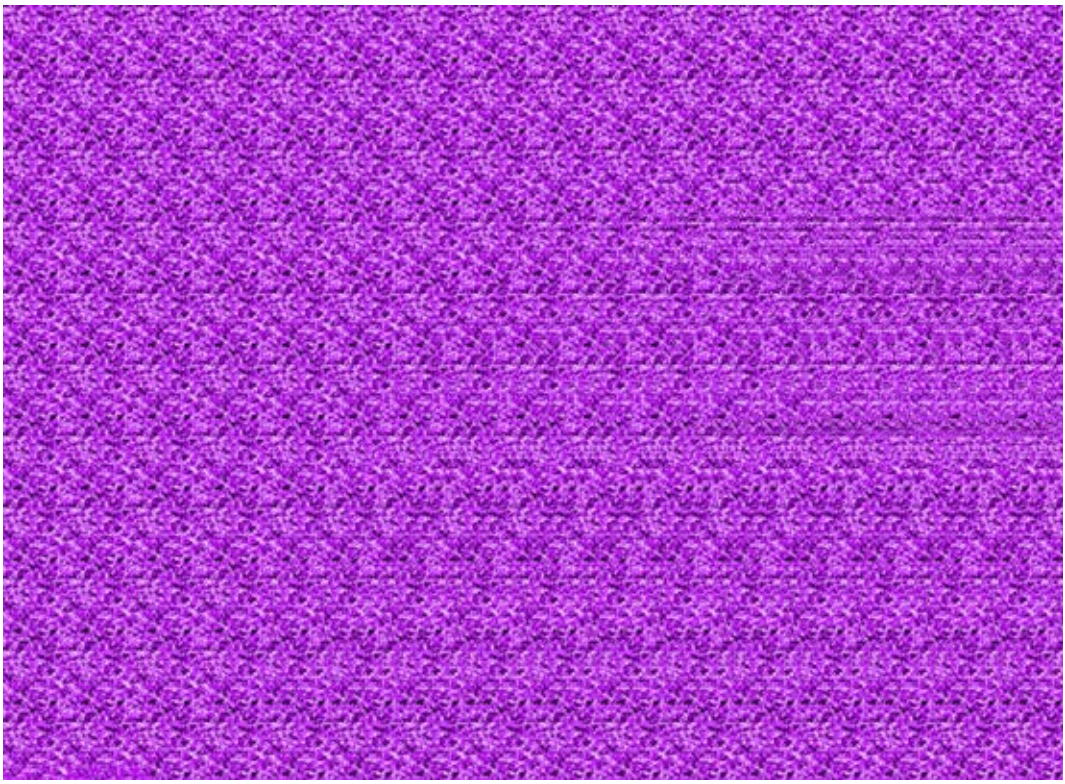
[6] Calculation based on data from United States Department of Agriculture, National Nutrient Database for Standard Reference Release 28 (http://ndb.nal.usda.gov/ndb/foods)

[7] Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, Gordon DJ, Krauss RM, Savage PJ, Smith SC Jr, Spertus JA and Costa F. 2006. Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement: executive summary. Circulation 112, e285–e290.

[8] Palacios Cristina. 2006. The Role of Nutrients in Bone Health, from A to Z. Critical Reviews in Food Science and Nutrition Vol.46 (8)

[9] Faris, D.G. and Singh, U. (1990) Pigeonpea: Nutrition and Products. In: Nene, Y.L., Hall, S.D. and Sheila, V.K. Eds., The Pigeonpea, CAB International, Wallingford, 401-434.

Carbon footprint



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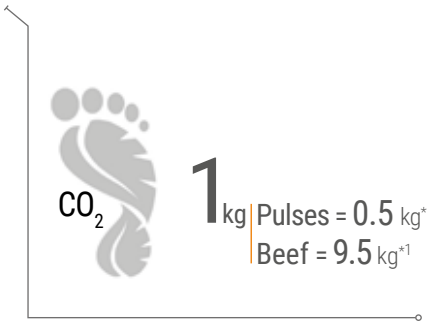

*CO_2 equivalent

Pulses are smart food
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Pulses production has lower carbon footprint than most animal sources of protein.


Pigeonpea pod

CO_2 Low in pulses because

- Low water use results in low energy use
- Reduces nonrenewable energy in the entire crop rotation by 22-24%[2]
- Pulse-Pulse-Wheat cropping has 34% less carbon footprint compared to a Cereal-Cereal-Wheat cropping pattern[3]

- Better farming practices, including use of pulse crops, can lower the average carbon footprint by 24 to 37%[4]
- Nitrogen fertilizers contribute to carbon footprint as its energy footprint is over 7.5 times more than other fertilizers such as phosphate and potash[5]
- Pulses help reduce use of chemical fertilizers by fixing nitrogen

@ ICRISAT

An innovative climate change research initiative

A large genetic variation in chickpea, capable of fixing nitrogen symbiotically in early stages of growth, may exist. Further research is needed to capitalize on this.

Research on developing climate resilient chickpea using germplasm including cultivated chickpea introgressed with wild ancestors from a unique, diverse, and recent collection in Turkey, is underway.

Trait differences across 20 wild chickpea populations that affect the crop's responses to drought, heat and climate-resilient nitrogen fixation is being studied.

"LeasyScan", a high-throughput phenotyping platform at ICRISAT, is being used to measure:

(a) leaf canopy development in low and high nitrogen soil

(b) maximum nitrogen concentration in leaf tissue and stem tissue, at flowering time.

Project: Global Hunger and Food Security Research Strategy: Climate Resilience, Nutrition, and Policy – Feed the Future Innovation Lab for Climate Resilient Chickpea

Investor: United States Agency for International Development (USAID)

Partners: The University of California (UC) and ICRISAT

CGIAR Research Program: Grain Legumes

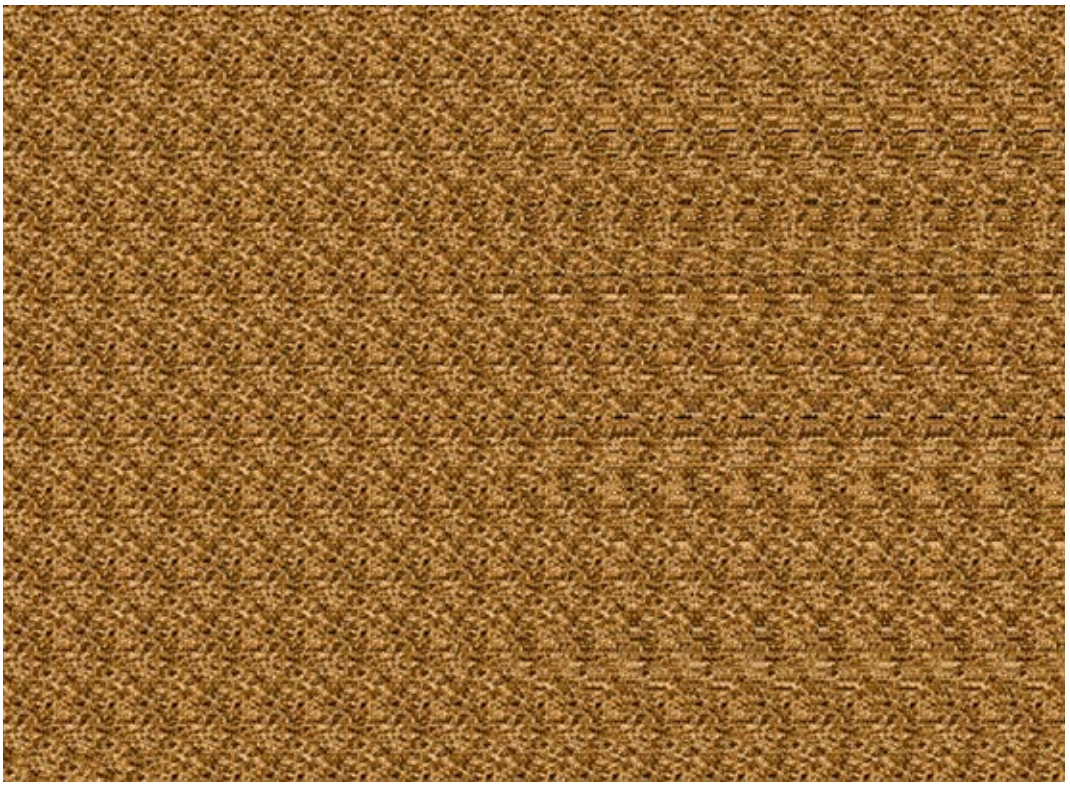
[1&3] http://www.cicilsiptic.org/pulses.php?id=25

[2] Life Cycle and Socio-Economic Analysis of Pulse Crop Production and Pulse Grain Use in Western Canada. Saskatchewan Research Council Publication No. 12135-1E11, March 2011. (not published as of February 2012)

[4] Zentner RP, Lafond GP, Derksen DA, Nagy CN, Wall DD and May WE. 2004. Effects of tillage method and crop rotation on non-renewable energy use efficiency for a thin Black Chernozem in the Canadian Prairies. Soil & Tillage Research. 77: 125-136.

[5] http://www.pulsecanada.com/environment/sustainability/non-renewable-energy

Water footprint



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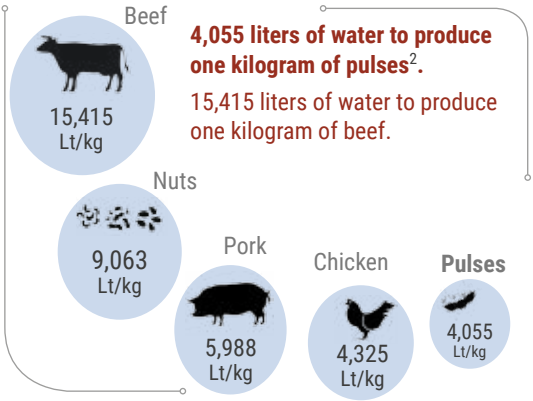
Well adapted to
semi-arid regions
pulses use

- **less water**
  and are
- **drought tolerant**

More efficient to obtain protein from crop products than animal products.

Water used to produce 1g protein in milk, eggs and chicken meat is 1.5 times, for mutton it is 3.3 times and for beef 6 times more than that used for pulses[1].

- Dryland tropics are generally water deficient and water management is a primary requirement
- Here it is critical to calculate water footprint of crops
- Many pulses use water differently by extracting water from shallower depths, leaving deep soil water for the following crop[3]
- Water use characteristics of pulses effectively increases the water use efficiency of the entire crop rotation

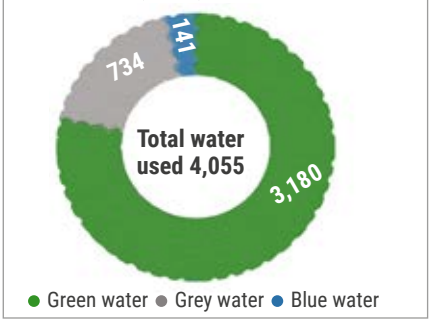


4,055 liters of water to produce one kilogram of pulses[2].

15,415 liters of water to produce one kilogram of beef.

Green, blue and grey water use[4]

Water used to produce 1ton (in m³) of pulses[5]



@ ICRISAT

In Muduvatti village, Kolar district, Karnataka, two farmers have water collection ponds to collect untreated wastewater and use it to irrigate their vegetable crops. These ponds, have been converted into a decentralized wastewater treatment system, using constructed wetlands. This system piloted by an ICRISAT-led consortium of 11 partners in India, as a business model, treats grey water through constructed wetlands and render it safe for agricultural use.

ICRISAT in collaboration with Coca-Cola Foundation and MYRADA, an NGO, work with the Muduvatti village farmers on agricultural productivity and livelihoods.

Project: Integrated Water Resource Management in Kolar District of Karnataka for Increasing Agricultural Productivity and Improved Livelihoods

Partners: District administration, Government of Karnataka, MYRADA and ICRISAT

Investor: Coca–Cola India Foundation for Rural Water Infrastructure

CGIAR Research Program: Resilient Dryland Systems

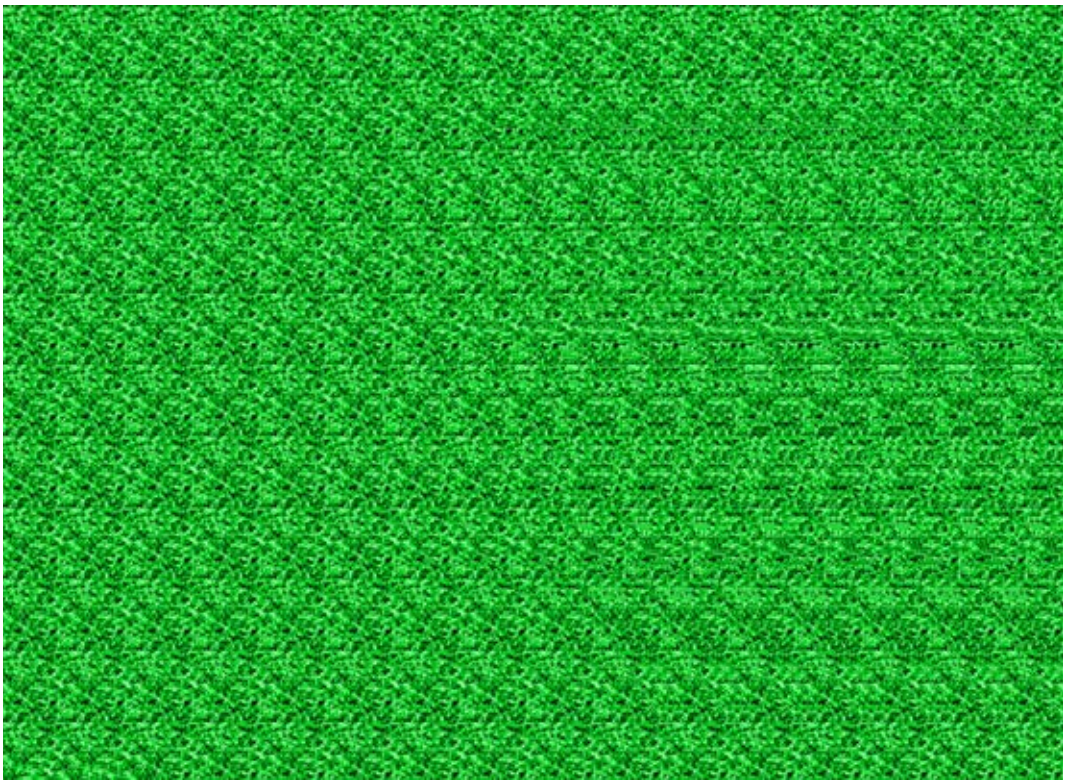
1&2 http://temp.waterfootprint.org/?page=files/Animal-products

3 Gan YT, Zentner RP, Campbell CA, Biederbeck VO, Selles F and Lemke R. 2002. Conserving soil and water with sustainable cropping systems: Research in the semiarid Canadian Prairies. Presentation to 12th ISCO Conference, Beijing, China.

4 **Green water**= rainwater consumed; **blue water**= surface and groundwater consumed and **grey water**= freshwater required to assimilate pollutant load based on existing ambient water quality standards.

5 Mekonnen MM and Hoekstra AY. 2010. The green, blue and grey water footprint of crops and derived crop products, Value of Water Research Report Series No. 47, UNESCO-IHE, Delft, the Netherlands.

Nitrogen fixing and soil phosphorus release



Instructions to view this stereogram are on the last sheet.

Pulses produce about **21 million tons** of nitrogen per year[1]

[1] Herridge DF, Peoples MB, Boddey RM (2008) Global inputs of biological nitrogen fixation in agricultural systems. Plant Soil 311:1–18

Pulses in the crop cycle play a major role in nitrogen fixation and in reducing carbon footprint worldwide.

Pigeonpea flower

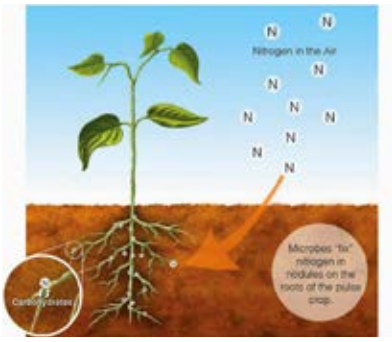
- Pulses fix atmospheric nitrogen through a symbiotic relationship with nitrogen fixing soil bacterias living inside their root systems
- Chickpea leaves 20.4 kg/ha of residual nitrate in the soil after harvesting which is the highest among pulses[1]
- Production and application of nitrogen fertilizer accounts for 57% to 65% of the carbon footprint of each crop[3]
- Pulses help in efficient use of soil phosphorus by breaking down insoluble phosphates in the soil

Pigeonpea adds[2]
8-16 kg N/ha;
2.5-5 kg P/ha;
13.5-24 kg K/ha
(in entire crop cycle as leaf drop)

@ ICRISAT[4]

Access to good pigeonpea seeds transformed the lives of John Msuku and his family. As part of ICRISAT's smallholder farmer seed production clubs in Chambogho, Karonga district, North Malawi, he grew high-yielding certified seeds, contributing to a successful seed distribution system. In this unique agribusiness model, smallholder farmers grow certified seed that are loaned to other smallholder farmers.

John started in 1 ha land, to grow a new variety of pigeonpea, maturing in six months rather than nine and is less prone to water stress and risk of being eaten by livestock. John reaped a healthy harvest and re-invested to increase his production.



Pulse crop fixing Nitrogen[5]

"I had never thought of agriculture having a business potential," he says. "I am happy to admit now I was wrong. Nothing goes waste. I use the stalks as fodder for my animals, and the leaves are good for fertilizing the soil," says John who now has two houses, 6 ha land, oxen, pigs and goats.

"We have nutritious food to eat and a good life," says Linley, John's wife. The key for him was to diversify and keep evolving.

Project: Malawi Seed Industry Development Project (MSIDP)

Partners: Ministry of Agriculture, Irrigation and Water Development, Smallholder Producer Groups, the private sector and ICRISAT

Investor: Irish Aid

CGIAR Research Program: Grain Legumes

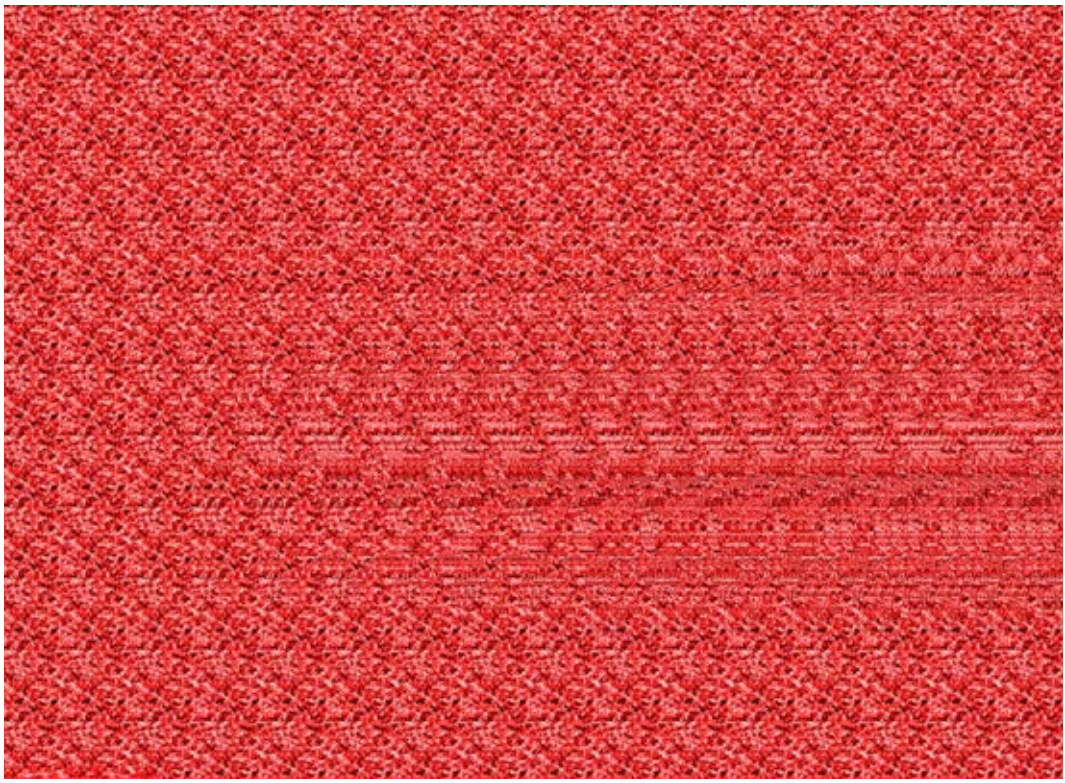
[1, 2] Singh KK, Ali M and Venkatesh MS. 2009. Pulses in Cropping Systems. Technical Bulletin, IIPR, Kanpur

[3] Gan, Liang, Hamel, Cutforth, Wang. Strategies for reducing the carbon footprint of field crops for semiarid areas. A review. Agronomy for Sustainable Development, Springer Verlag, 2011, 31 (4), 643-656. pp. <10.1007/s13593-011-0011-7>.<hal-00930478>

[4] Story first appeared on the Thomson Reuters Foundation website. Read the full story here http://www.trust.org/item/20151009123820-sbq6o/

[5] http://www.pulsecanada.com/environment/sustainability/non-renewable-energy/how-do-pulses-help

Soil microbe diversity



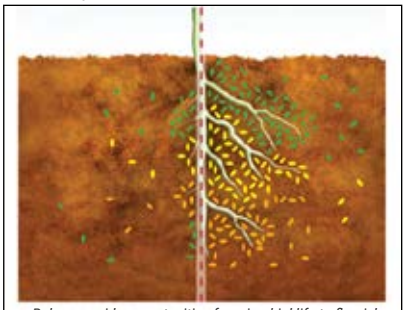
Instructions to view this stereogram are on the last sheet.

Different compounds from pulses feed soil microbes and this benefits overall soil health

Crops grow better in soils with diverse soil organisms as they help break down and cycle nutrients more efficiently.

- Crops grow better in soils with diverse soil organisms as they help break down and cycle nutrients more efficiently
- Presence of diverse soil organisms tend to 'crowd out' disease-causing bacteria and fungi, resulting in healthier plants
- Growing pulse crops in rotation enables the other crops to benefit from these large, diverse population of soil organisms

Diversity in rotations[1]



- *Pulses provide opportunities for microbial life to flourish*
- *Breaks disease, weed and insect cycles*
- *Increases microbial diversity, helping crops to access nutrients*

@ ICRISAT

"I would never have thought chickpea could bring me such high returns," said 53-year-old Ms Temegnush Dhabi in 2013, standing in her grain store, filled with bags of harvested chickpeas. "From 1.5 ha, I harvested 42 bags (about 4 tons) of grain."Temegnush a farmer for 29 years now, saw dramatic changes, when in 2008 she started working with researchers from the Ethiopian Institute for Agricultural Research and ICRISAT to test improved resistant chickpea varieties. Temegnush has since seen dramatic increases in her chickpea yields. Earlier, she grew teff (a popular cereal native to Ethiopia), that fetched a reasonable price at her local market, but required expensive fertilizer and was labor-intensive to harvest.

The project works closely with smallholder farmers to ensure that they access seed of improved grain legume varieties developed under the projects.

Project: Tropical Legumes II

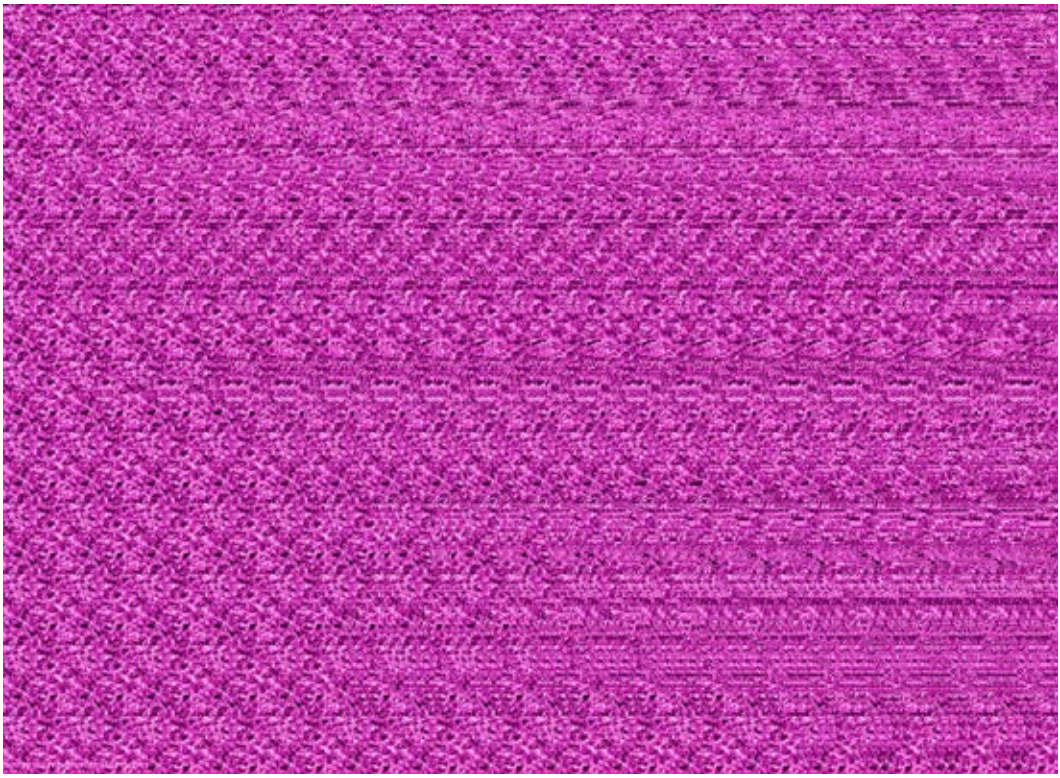
Partners: The International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA), National Agricultural Research Systems (NARS) partners in target countries across sub-Saharan Africa and India, and ICRISAT

Investor: Bill & Melinda Gates Foundation

CGIAR Research Program: Grain Legumes

[1] http://www.pulsecanada.com/environment/sustainability/sustainability-cropping-systems/whats-the-pulse-impact-on-soil

Multiple use of pulse crops



Instructions to view this stereogram are on the last sheet.

Pulses are

- Consumed by humans
- Used as livestock feed
- Green manure
- Fencing, and basket weaving

Leaves, pod coats and bran are fed to animals as dry fodder. Some pulse crops are also fed as green fodder.

Multiple Uses of Pigeonpea

- As green manure, pigeonpea produces 13,619 kg/ha of dry matter and 23 kg of N/t of dry matter[1]
- Pigeonpea leaves and forage, high in protein and easily accessible, are largely used as fodder for cattle and other animals
- The stems and branches of pigeonpea are used to prepare baskets, fencing and thatch, and serve as an additional income source for women
- In Thailand, pigeonpea is host to insects that produce lac, used for various products such as:
  - Color-fast dye used on animal fibers (wool and silk) and for coloring soft drinks and food
  - Shellac used for painting and furniture manufacturing[2]
- Farmers in Africa grow pigeonpea for its firewood more than for its grain. The calorific value of the pigeonpea stalks is about ½ that of the same weight of coal[3]
- A wind breaker/shade crop for young cocoa plants in Nigeria[4]
- Pigeonpea acts as a cover crop or support crop for vanilla in Southeast Asia and as a substrate for mushroom production in China[5]

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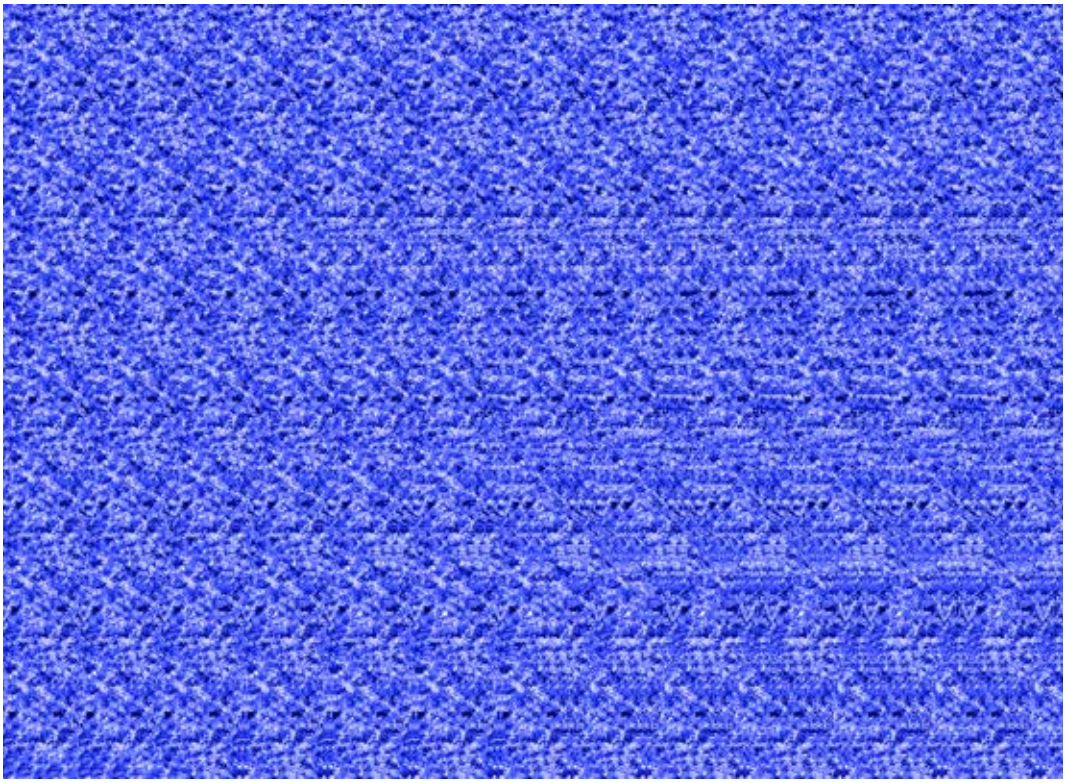
About 90% of southern China is covered with mountains bare of vegetative cover, resulting in soil erosion and landslides. In 1997, the first set of newly developed ICRISAT medium-duration pigeonpea varieties was sent to China, which showed high adaptation in various agro-ecological zones of southern China. It helped conserve valuable topsoil and rejuvenate infertile marginal lands. It led to greening of 25 million ha of degraded mountain slopes, and is an afforestation crop in major government reconstruction projects, growing on roadsides, hillsides and riverbanks. Southern China's shortage of quality fodder has been resolved by introducing pigeonpea.

[1,3&5] Mula M G and Saxena K B. 2010. Lifting the Level of Awareness on Pigeonpea - A Global Perspective. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Hyderabad, Telangana, India. ISBN 9789290665359

[2] FAO, 1994. Non-Wood Forest Products in Asia. Eds. Patrick B. Durst Ward Ulrich M. Kashio. RAPA Publication, FAO, Bangkok

[4] Ogbe FMD and Bamidele JF. 2007. Potential of pigeonpea (Cajanus cajan) for planted fallow in Edo State, Nigeria. Asian Journal of Plant Sciences 6(3): 490-495.

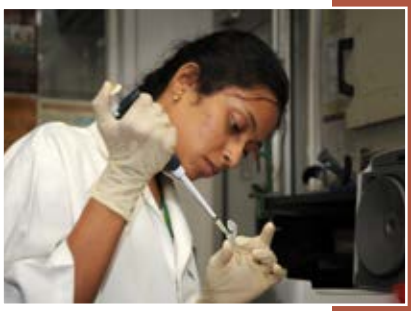
New varieties and hybrids



Instructions to view this stereogram are on the last sheet.

Known as orphan crops, pulses **receive much less attention** from researchers and policy makers compared to major commercial crops

There is a great scope for developing improved varieties of pulses, with higher resilience to drought, salinity and diseases, as they will play a vital role in the face of adverse climate change impacts on crop productivity.



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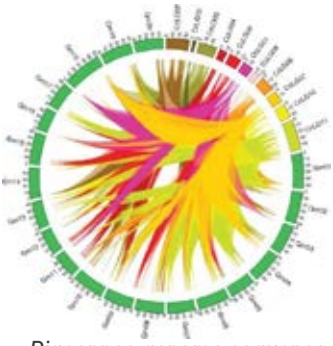
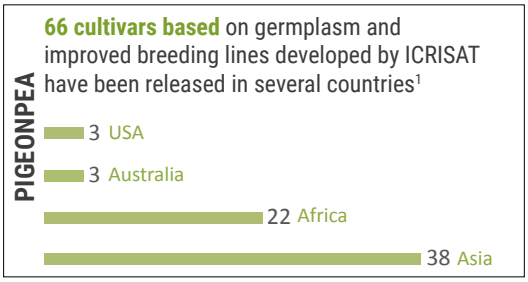
- ICRISAT has been involved in dryland crop research since the 1970s, including research on chickpea and pigeonpea, which are among its mandate crops
- ICRISAT phenotype and genotype research makes adoption of these crops profitable for the smallholder farmers
- Working with several partners, ICRISAT has decoded genome sequence of pigeonpea and chickpea
- Large-scale genomic resources have been developed in these crops and resulted in being elevated to "genomic resources rich crops"
- These genomic resources are being used to develop improved varieties through molecular breeding approaches
- Several drought tolerant and disease resistant lines have already been developed in chickpea using molecular breeding approaches



Pigeonpea genome sequence

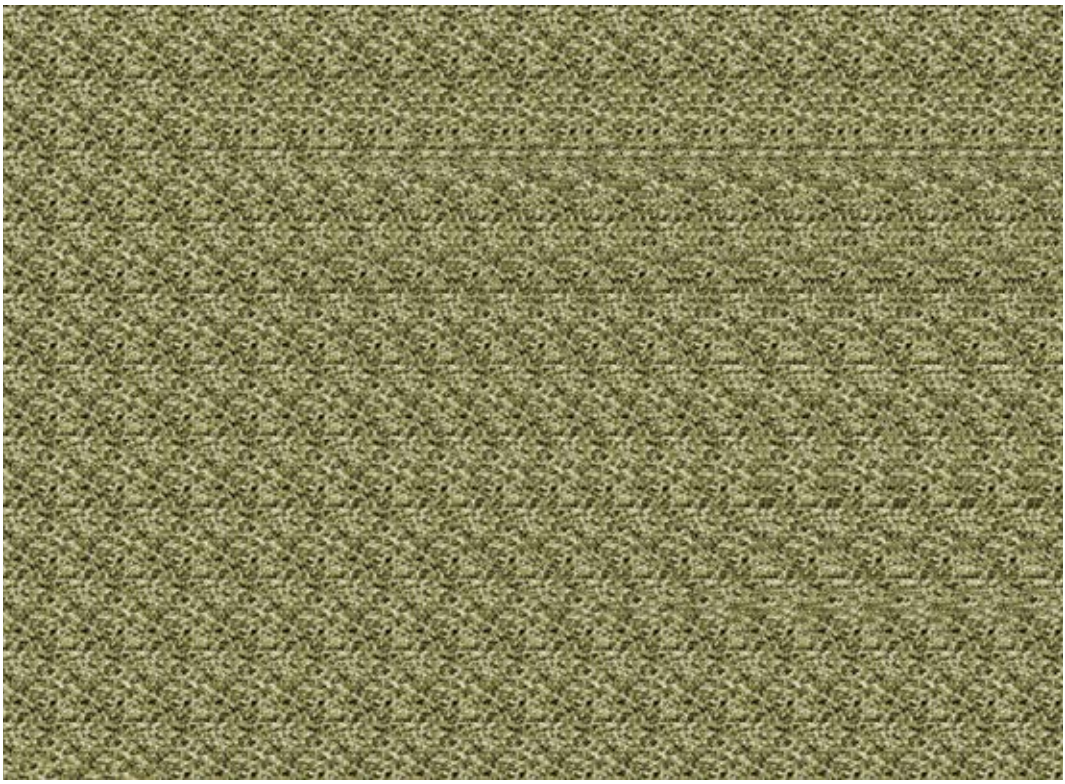


Major contribution to work on developing improved varieties and hybrids has been under the projects, Tropical Legumes I & II. Some broad impacts in chickpea research are -

1. Wilt and sterility mosaic **disease resistant** varieties and recently released short and medium duration **hybrids** have **made a significant impact** in Asian countries
2. **Long and medium duration** varieties with **Fusarium wilt resistance** and **consumer preferred** large, cream colored seeds have **created impacts** in eastern and southern Africa
3. In India during 2013-14, **49%** of the **total indent for chickpea breeder seed** was from ICRISAT-India partnership varieties

Projects: Tropical Legumes I & II
Investor: Bill & Melinda Gates Foundation
Partners: The International Center for Tropical Agriculture, International Institute of Tropical Agriculture, National Agricultural Research Systems (NARS) partners in target countries; private sector and NGO partners and ICRISAT
CGIAR Research Program: Grain Legumes

Strengthening Value Chain



Instructions to view this stereogram are on the last sheet.

Huge untapped potential of pulses
can be enhanced by

- **Increasing production**
- **Value addition**
- **Building better marketing options**

Smallholder farmers and rural poor, can benefit from development of institutions and strategies that promote market coordination and reduce transaction costs.


Chickpea pod

- Helping smallholder farmers break the vicious cycle of subsistence production and poverty is a great challenge to ongoing research in reducing poverty and hunger worldwide
- Underdeveloped and imperfect agriculture commodity markets undermine smallholder farmers participation and hinder their ability to benefit from improved agricultural technologies and policy reforms
- Linking farmers to markets through efficient value chains will reduce intermediaries in the chain
- Strengthening value-adding by improved technology, infrastructure and inputs, processing and exports, can raise farmers' income and provide incentives to improve their management practices towards higher farm productivity

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Mini *dal* mills increase income

A group of 20 women belonging to the Garima self-help group, in Padasoli village, Tahsil-Bassi of Jaipur, Rajasthan, were trained in *dal* making and a mini *dal* mill was established through an ICRISAT project in 2012-13.

The mini *dal* mill became operational from 2013 onwards, making *dal* initially for family use, but later they began selling *dal* in the local market and doubled their profit.


Mini dal Mill

The women plan to increase the members in the group, register the SHG and create awareness among women in the neighboring villages.

Additional benefit to the women is the use of *dal* husk for livestock feed, and the income from the sale of pigeonpea stalks as fuel wood (₹20,000/ha).

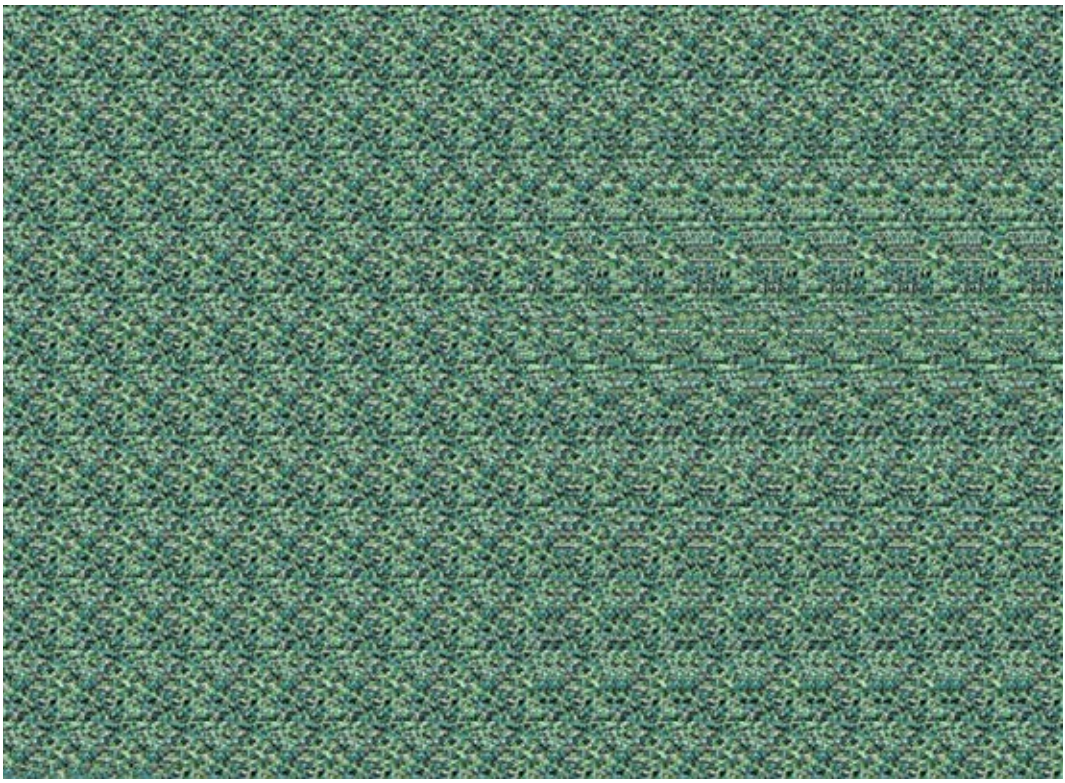
Project: Enhancing the livelihoods of resource-poor farmers of Rajasthan through the introduction of ecofriendly pigeonpea varieties

Investor: Directorate of Agriculture, Government of Rajasthan in collaboration with Swami Keshwanand Rajasthan Agricultural University, Bikaner, under the Rashtriya Krishi Vikas Yojana

Partners: Swami Keshwanand Rajasthan Agricultural University, Bikaner and ICRISAT

CGIAR Research Program: Grain Legumes

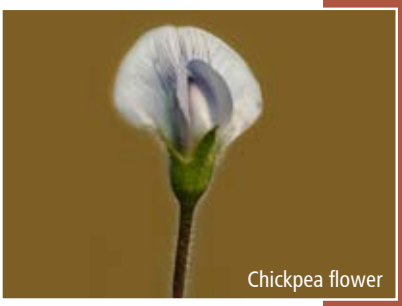
On-farm diversity



Instructions to view this stereogram are on the last sheet.

Short duration pulses
have paved the way for
crop diversification
& **intensification**

Diversification strategies include crop rotation, double cropping and intercropping.


Chickpea flower

- Diversity is the relative abundance of each crop in the overall cropping pattern
- Major benefits of farm diversification to smallholder farmers are increased revenue, low input costs, adaptability to climate variation, and resilience to overcome risks and uncertainties
- Pulses are grown as a sole crop, intercrop, catch crop, relay crop, cover crop, green manure crop, etc, in different agroecological regions
- Intercropping helps obtain sustainable production even under adverse weather conditions
- On hill slopes, pulses act as an excellent cover crop and are also grown on rice bunds
- Relay cropping (paira) facilitates double crop and is sustainable. Here, pulse seeds are broadcast in the standing crop of rice about two weeks before harvest, enabling use of available soil moisture. Pulse yield was more than when planted after harvesting rice
- Catch crop is a short duration crop grown between successive plantings of main crops or are crops sown to prevent minerals being flushed away from the soil. It may be harvested or plowed under to improve soil fertility
- Ratoon cropping, a multiple-harvest system, where instead of cutting the crop, pods are picked and plants allowed to bear next flush of pods. Short-duration pigeonpea has created ratooning interest

@ ICRISAT

Studies[1] in Wenchi and Kade in Ghana indicate strong potential of pigeonpea in improving soil fertility and farm profitability. Crop rotation with pigeonpea as a long-term soil fertility management strategy is popular, and according to farmers, crops grown after pigeonpea (especially maize), look greener, grow faster, and yield more.

- In Kade, Ghana, pigeonpea in the cropping cycle resulted in 100–200% increase in maize grain yield, over continuous maize.
- It gave a 108% return on investment compared to 31% by continuous maize without fertilizer application to maize crop.

The above responses were recorded under the International Development Research Centre funded, climate change adaptation in Africa project in 2008, where farmers evaluated three early maturing and three late maturing pigeonpea varieties obtained from ICRISAT, India.

[1] S. Adjei-Nsiah, "Role of Pigeonpea Cultivation on Soil Fertility and Farming System Sustainability in Ghana," International Journal of Agronomy, vol. 2012, Article ID 702506, 8 pages, 2012. doi:10.1155/2012/702506

Instructions for viewing the stereograms

Stereograms create the illusion of a third dimension. The trick to viewing a stereogram is to diverge one's eyes as if looking through the paper showing the picture (which is, admittedly, easier said than done until you get the hang of it). Given below are three methods to make it easy for you to view the stereogram.

One common rule – keep your hands steady and don't let anyone interrupt you. It may even be a good idea to find a quiet well lit room.

You don't need special glasses, just your own eyes!

Method one

Hold the image right up to your nose, relax your eye muscles allowing the image to blur and slowly move the image away from you.

Method Two

Hold your finger before your eyes and focus on it. Then let your eye muscles relax and your finger will appear to double. Apply this principle to the images and the 3D image will appear magically!

Method Three

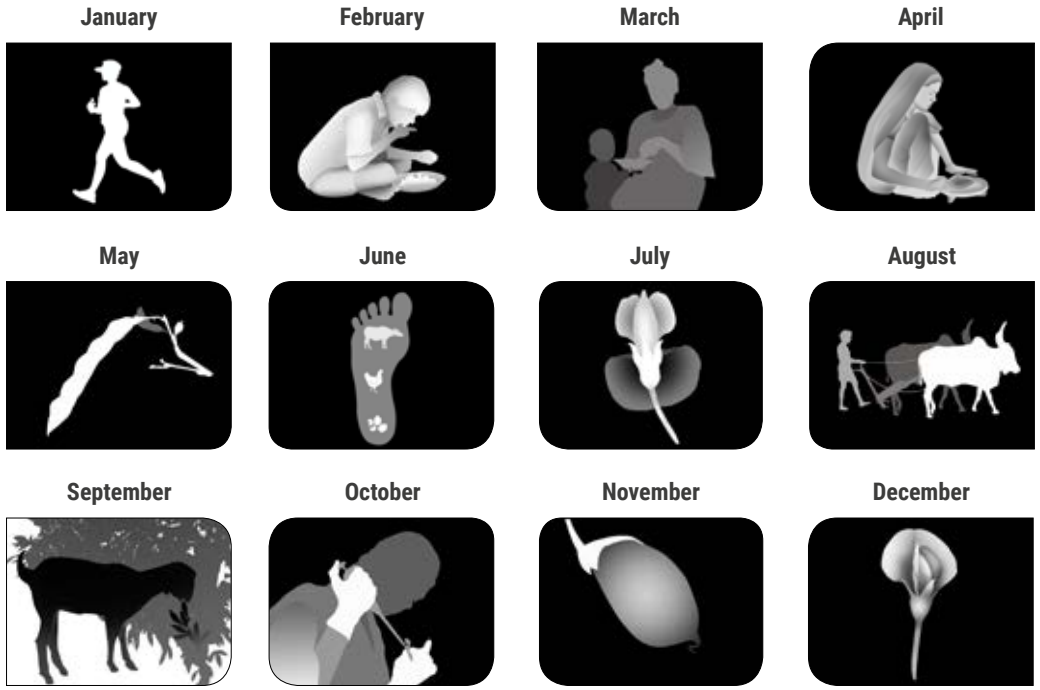
Look at the picture but don't focus. Allow your eyes to relax and try to look through the picture as if you were looking at an object further away.

Every photograph has to be converted to a depth map before a stereogram can be made.*

The depth map for each months' stereogram is given below. This gives you an idea of what you will see in 3D, on each calendar page.

* Depth map is a black and white image used to determine the height and depth of the hidden image. White comes forward the most while black recedes the most, and shades of grey fall in-between - to give a 3D image.

Month wise depth maps

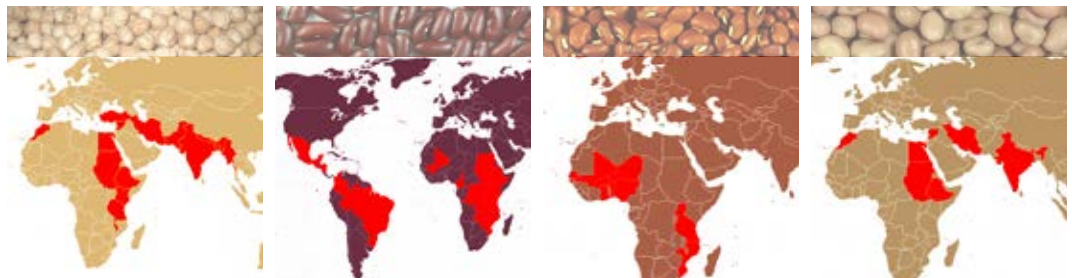


Most of ICRISAT's work on pigeonpea and chickpea is carried out under the

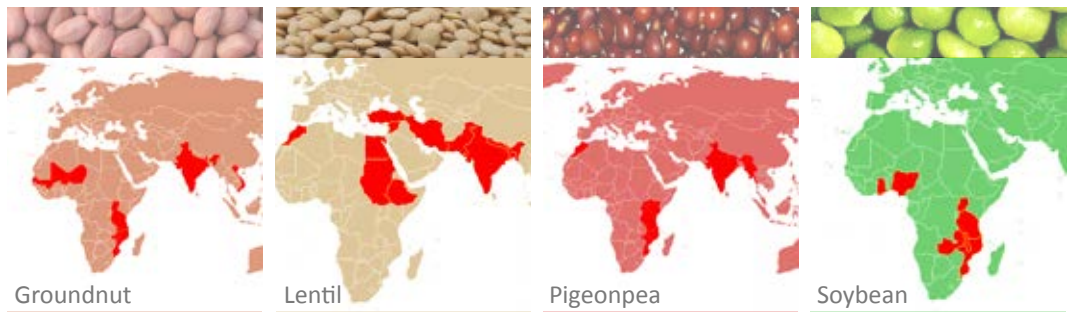
CGIAR Research Program on Grain Legumes

The CGIAR Research Program on Grain Legumes (Grain Legumes) aims to improve health, food and nutrition security, environmental sustainability, and income for smallholder farmers through increased legume productivity, production and consumption. Grain Legumes is a global partnership involving four CGIAR Research Institutes namely ICRISAT (Lead center), CIAT, ICARDA and IITA, together with several public and private institutes and organizations including the USAID's Feed the Future Innovation Labs for Collaborative Research on Grain Legumes (Legume Innovation Lab) and Peanut Productivity and Mycotoxin Control (Peanut & Mycotoxin Innovation Lab). The program focus is on chickpea, common bean, cowpea, faba bean, groundnut, lentil, pigeonpea and soybean in the smallholder communities of Africa, Asia, and Latin America.

CROPS AND FOCUS COUNTRIES



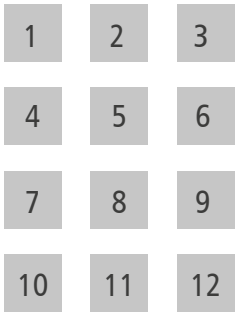
Chickpea	Common bean	Cowpea	Faba bean
Bangladesh | Egypt | Ethiopia India | Iran | Kenya | Malawi Morocco | Myanmar | Nepal Pakistan | Sudan | Syria Tanzania | Turkey	Brazil | Burundi | Columbia | DR Congo | Ethiopia| Guatemala Honduras | Kenya | Malawi Mali | Mexico | Mozambique Nicaragua | Puerto Rico | Rwanda Sudan | Tanzania | Uganda	Benin | Burkina Faso | Ghana Mali | Mozambique | Niger Nigeria | Senegal | Tanzania Uganda	Egypt | India | Iran Morocco | Sudan | Syria



Groundnut	Lentil	Pigeonpea	Soybean
India | Mali | Niger | Senegal Tanzania | Uganda | Vietnam	Bangladesh |Egypt India | Iran |Morocco Nepal | Pakistan | Syria Turkey	India | Morocco | Myanmar Nepal | Tanzania | Uganda	Ghana | Nigeria | Tanzania Uganda | Zambia

CGIAR RESEARCH PROGRAM ON Grain Legumes — LED BY ICRISAT — IN PARTNERSHIP WITH CIAT, ICARDA, IITA and public and private institutes and organizations, governments, and farmers worldwide

Cover photo credits



1, 3, 6, 9, 12	ICRISAT
2, 11	PS Rao
4	PM Gaur
5, 7, 10	L Vidyasagar
8	S Punna

Photo credits

January	Photo 1: Srujan, Photo 2: L Vidyasagar, Photo 3: A Paul-Bossuet
February	Photo 1: L Vidyasagar
March	Photo 1: ICRISAT
April	Photo 1: L Vidyasagar
May	Photo 1: PS Rao, Photo 2: ICRISAT
July	Photo 1: PS Rao
August	Photo 1: L Vidyasagar, Photo 2: A Paul-Bossuet
September	Photo 1: ICRISAT, Photo 2: L Vidyasagar
October	Photo 1: L Vidyasagar
November	Photo 1: PS Rao, Photo 2: PS Rao
December	Photo 1: L Vidyasagar, Photo 2: ICRISAT

A Big Thank You

We would like to thank all who helped in creating this calendar.

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ICRISAT
Science with a human face

International Crops Research Institute for the Semi-Arid Tropics

CGIAR

ICRISAT is a member of the CGIAR Consortium

We believe all people have a right to nutritious food and a better livelihood.

ICRISAT works in agricultural research for development across the drylands of Africa and Asia, making farming profitable for smallholder farmers while reducing malnutrition and environmental degradation.

We work across the entire value chain from developing new varieties to agri-business and linking farmers to markets.

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ICRISAT appreciates the support of CGIAR donors to help overcome poverty, malnutrition and environmental degradation in the harshest dryland regions of the world. See http://www.icrisat.org/icrisat-donors.htm for full list of donors.

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Feb 2016