Science for the Drylands

Inclusive Transformative Scalable

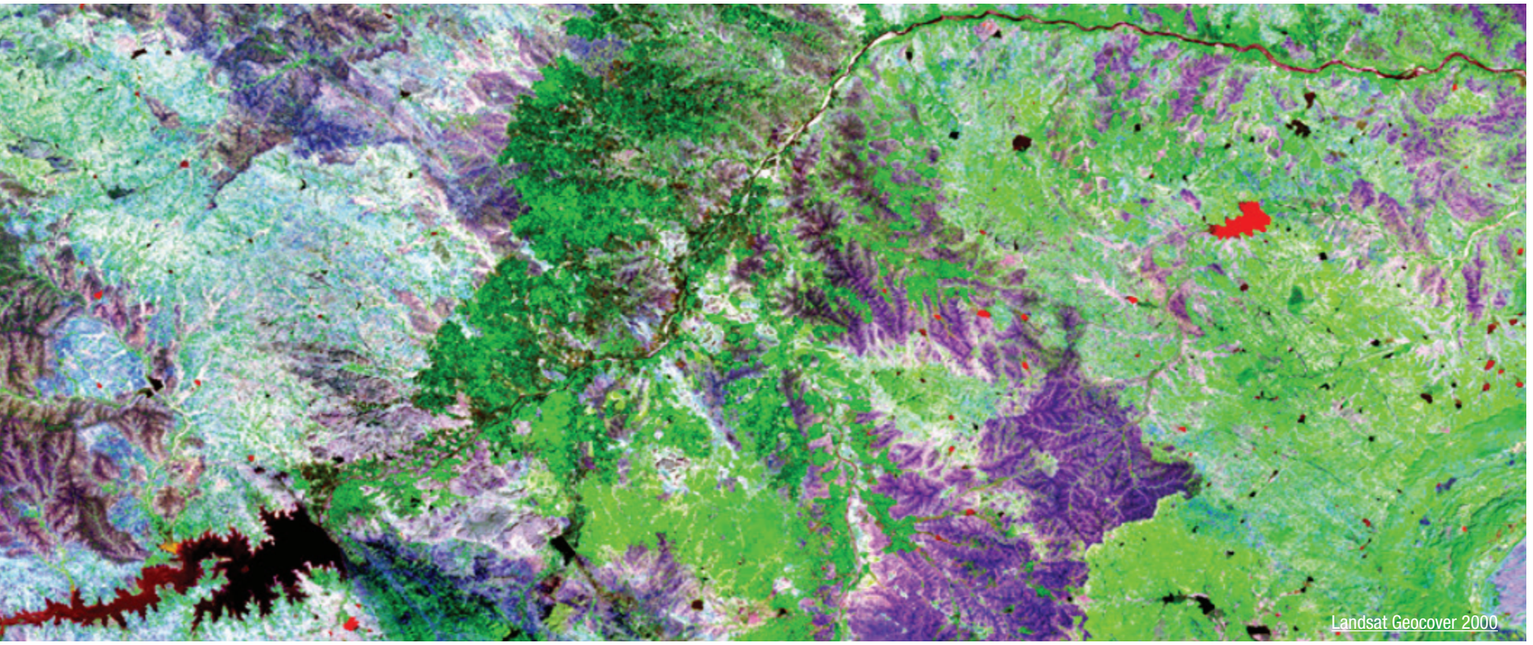
ICRISAT Annual Report 2020

ICRISAT

INTERNATIONAL CROPS RESEARCH
INSTITUTE FOR THE SEMI-ARID TROPICS

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

We think of them as visionary funders – far-sighted governments, development banks, foundations, charitable organizations, private sector companies, and individuals who recognize that the elimination of poverty is the key to a peaceful world with food security and prosperity for all.



Multiresolution seamless image database (MrSID) shows GeoCover of Maharashtra and Andhra Pradesh states, India.

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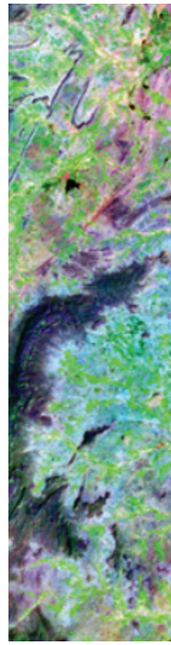

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Front Cover: *Photos: ICRISAT*

Photo: Srujan Punna, ICRISAT

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Message from the **Board Chair**

Dr Prabhu Pingali

Globally, the drylands are the most vulnerable to climate change and need dedicated interventions to make agriculture in these regions more productive. In its nearly 50 years of existence, ICRISAT has focused on developing agri-food system technologies and crop varieties which contribute to better lives and livelihoods in the drylands of Asia and Africa.

In 2020, despite a global pandemic, ICRISAT has stayed on course and has been able to release many new varieties in Asia and Africa contributing to better nutrition and food security in the drylands. I am proud to share that ICRISAT has released 24 varieties across 5 crops, 314 varieties are in various national trials, 2,490 tons of all classes of seed have been shared with National Agricultural Research Systems (NARS) and farmer groups and more than 6 million hectares have been improved through soil and water management efforts.

As ICRISAT enters its golden jubilee year, I wish it success in its continued efforts towards improving productivity in the drylands through consistent and rigorous research, commitment to improving farmers' incomes and food accessibility.

The Governing Board strengthens its commitment to upholding good governance through robust policies, and will continue to leverage ICRISAT's strategic advantage in this time of enhanced risk and global disruption.

Message from the **Director General**

Dr Jacqueline d'Arros Hughes

The year 2020 has tested our resilience. Our "business as usual" attitude saw us through the challenging times, and the significant achievements documented in this Annual Report spur us on to fulfil our planned targets and the Sustainable Development Goals in the drylands of Asia and Africa.

Landmark varietal releases in Asia and Africa in 2020 highlight the relevance and impact of ICRISAT's collaborative research with National Agricultural Research Systems. In India, Prime Minister Narendra Modi dedicated to the nation two high-oleic acid biofortified groundnut varieties; in Malawi, improved varieties of finger millet and chickpea made their first official entry; and Burkina Faso released its first commercial pearl millet hybrid developed through public-private partnerships.

Widespread uptake of ICRISAT technologies by local and national governments and the private sector in Asia and Africa speak of the impact of our work. Our crop innovations for abiotic and biotic stress resistance, seed systems approach, digital technologies and soil and water management initiatives have made remarkable contributions in their respective fields.

The impact of ICRISAT's work transcends Asia and Africa to many countries across continents that benefit from the International Public Goods we develop. The year 2020 saw a fresh consignment of accessions from ICRISAT make its way to the Svalbard Global Seed Vault for safety duplication. Advanced genomic breeding approaches developed by ICRISAT were shared as public resources.

In 2020, I spoke about the need for a dynamic and innovative strategy to position ICRISAT in this changing world and I am proud to share ICRISAT's Strategic Plan 2021-25 that will guide us in the years ahead to contribute to achieving the Sustainable Development Goals in the drylands of Asia and Africa.

We are grateful for the commitment of our funders and partners to our mission in the drylands. Our partnerships with governments, public and private sectors, and thought leaders have helped achieve the impacts showcased in this report.

ICRISAT's genomics laboratory in India.

RESEARCH HIGHLIGHTS

ICRISAT plays a dynamic role in enhancing incomes and improving the livelihoods of smallholder farmers in the dryland regions of Asia and Africa. In 2020, in spite of COVID-19 uncertainties, ICRISAT successfully implemented its research for development activities to contribute to improved climate resilience and enhanced nutritional status of farmers and consumers. In partnership with governments, public-private sector institutions, non-government organizations, National Agricultural Research Systems, CGIAR institutions and farmers, ICRISAT has successfully developed several nutritious and climate-resilient varieties of its mandate crops. ICRISAT has been successful in the deployment of genomic technologies, development and use of climate-smart technologies and contributed to the development and dissemination of digital tools for timely weather information and crop advisories as well as the promotion of efficient seed systems in different countries. ICRISAT thanks all its donors and contributors for their generous support to research for improving the lives of smallholder farmers in the dryland regions.

Dr Arvind Kumar
Deputy Director General-Research, ICRISAT

QUICK STATS

CROP IMPROVEMENT

Variety releases

24 Varieties **5** Crops

Varieties in National Performance Trials

314* germplasm/breeding lines/experimental hybrids

AGRI-FOOD SYSTEMS

Soil management coverage

~6,028,173 ha*

Land management coverage

257,795 ha*

SEED PRODUCTION

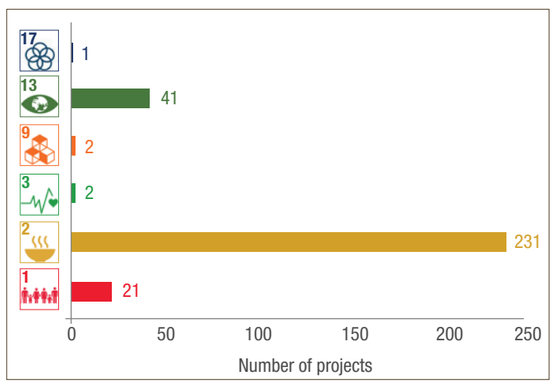
2,490 tons*

All classes of seed shared with farmer groups, NARS[1] and NGOs[2]

DIGITAL AGRICULTURE

881,471*

farmers reached through 10 digital initiatives



[1] National Agricultural Research System; [2] Non-Governmental Organizations

*Figures as of December 2020. *Sourced from ICRISAT's M&E tool MEASURE.*

Inside ICRISAT's Rapid Generation Advancement facility: Pilots for Rapid Generation protocols being scaled up for deployment in pearl millet breeding programs.

OUR WORK IN ASIA

Two high-oleic groundnut varieties bred from ICRISAT material were released to the nation by Prime Minister of India, Narendra Modi. A total of 13 improved varieties of chickpea, groundnut, sorghum and pearl millet were released in 2020 across India. Increased farmers' income of 10-40% through Natural Resource Management and the use of climate-smart high-yielding varieties provided proof of concept that science-led interventions can double farmers' incomes.

> "I congratulate all those who are tirelessly working across the globe to fight malnutrition."
>
> **Prime Minister of India, Narendra Modi,** at the national release of 17 biofortified varieties on 16 October 2020.

New varieties released

- High-oleic groundnut
- Drought-tolerant chickpea
- Machine-harvestable chickpea
- Forage sorghum
- High oil and confectionery groundnut

Varieties in the pipeline

- Biofortified sorghum, pearl millet and finger millet
- High biomass sorghum and pearl millet

Soil and water management

- Soil Fertility Atlas and Geo-portal created for Odisha, India
- Landscape restoration and revival of ancient water harvesting structures in Bundelkhand, India

Digital apps and tools

- Pan-India reach: Meghdoot app for crop advisories
- Web tool developed for open access to district-level data

Modernization of breeding

- Rapid Generation Advancement facilities, new crop improvement equipment, digitalization and genomic technologies

Climate research

- Effects of elevated CO_2 on chickpea crop studied

Pest and disease studies

- Fall armyworm management strategy developed
- Wilt and Blast-resistant lines identified

Crop improvement

Groundnut

Two high-oleic groundnut varieties developed by ICRISAT and the Indian Council of Agricultural Research (ICAR)-Directorate of Groundnut Research, are among the 17 biofortified varieties of eight crops that Indian Prime Minister Narendra Modi dedicated to the nation, on World Food Day (16 October 2020).

The varieties contain about 80% oleic acid compared to 45-50% in regular varieties, making them a healthier choice and suitable for the confectionery industry given their longer shelf life. The Telangana state government expressed its support in seed production of varieties Girnar 4 (ICGV 15083) and Girnar 5 (ICGV 15090) to promote the high-oleic groundnut value chain in India.

A high oil variety (ICGV 06420) with 52% kernel oil was released for the state of Chhattisgarh and a large-seeded (100-seed mass of 65-75 g) and low oil (43%) variety (ICGV 06189) was released for use in the confectionery industry.

High-oleic groundnut (Girnar 4 and Girnar 5) recorded breeder seed demand of 9 tons in 2020. A total of 126 high-oleic lines were shared with partners for multi-location evaluation. Phosphorus-efficient lines, improved Spanish lines with fresh-seed dormancy, and early lines with bold seeds were also shared.

Chickpea

Six chickpea varieties with machine harvestability and large-seeded traits were released in India through ICAR-ICRISAT collaboration (national releases: RLBGK 1, RVG 204, JGK 6, NBeG 810 and state releases: Phule Vishwaraj, NBeG 452).

Ongoing research: 71 advanced ICRISAT breeding lines were tested in national trials. The new rapid generation advancement protocol that allows 6 generations per year facilitated advancement of 10 crosses and 1 population of Recombinant Inbred Lines.

Pearl millet

Two forage varieties, resistant to leaf spot and blight and having 5-7% higher green forage yield compared to national check Giant Bajra were released for cultivation in five south Indian states. The varieties (TSFB 15-4 and TSFB 15-8) were developed in collaboration with Professor Jayashankar Telangana State Agricultural University, Hyderabad.

Ongoing research: The breeding materials evaluated by national centers included 30 biofortified progenies, 20 forage type open-pollinated varieties, 18 forage type hybrids, 12 brown mid-rib (bmr) lines, 30 high biomass R-lines and 29 trials with high Fe hybrids/parents.

Sorghum

Three multi-cut forage varieties (Pant Chari-12, Pant Chari-13 and Pant Chari-15) were released in India.

Ongoing research: Red grain sorghum varieties and hybrids with high yield, grain mold tolerance, high protein digestibility and polyphenol content were identified. A biofortified red grain sorghum variety is ready for release and high brix sweet sorghum lines and high biomass lines were identified from multi-location trials. Breeding optimization through simulation was completed and a structured sorghum seed and restorer parents breeding scheme established.

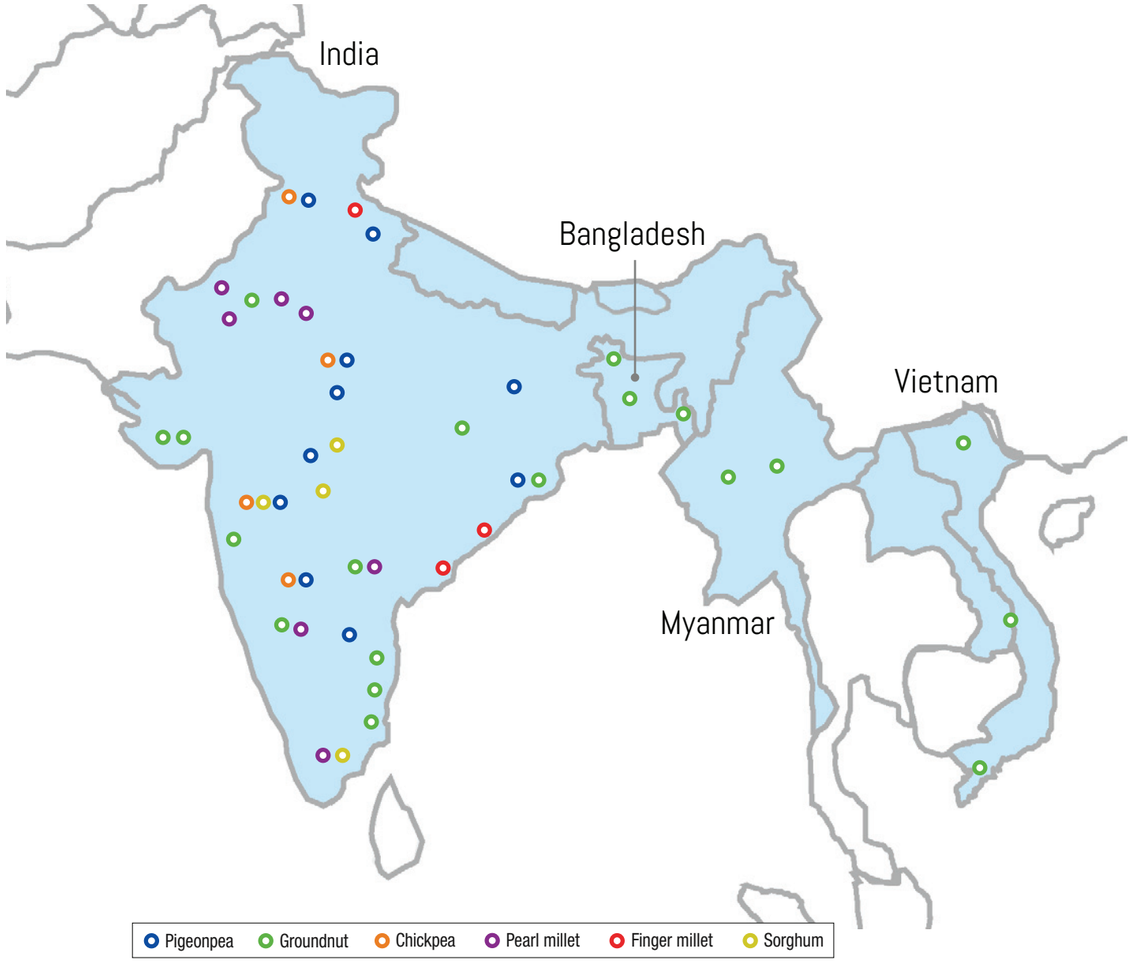
Pigeonpea

Ongoing research: Seven hybrids, three super-early lines and one mid-early line were evaluated in national trials and 16 advanced breeding lines of mid-early duration with Fusarium wilt and Sterility mosaic disease (SMD) resistance were evaluated at 6 locations. Twenty-nine super-early entries were evaluated at 6 locations. Subsequent back crosses were made with the identified cytoplasmic male sterility (CMS) lines from *Cajanus cajanifolius* and its maintainer lines to maintain promising CMS lines by paired row crossing.

Finger millet

Ongoing research: Heat-tolerant progenies were identified from lines received from Kenya following screening through two summer seasons. A calibration curve was developed for screening finger millet genotypes for iron and zinc and 15 advanced breeding lines were evaluated at 4 locations in multi-location trials in Telangana, Andhra Pradesh and Uttarakhand states. Emasculation in finger millet using hot water and GA3 has been standardized.

Ongoing early generation material testing sites of ICRISAT crops in India, Bangladesh, Myanmar and proposed sites in Vietnam



Stage 1 and stage 2 trials undertaken in Asia for data-driven decision-making.

Genomic technologies

Molecular breeding products

A drought-tolerant chickpea variety that is high-yielding and Fusarium wilt resistant developed by ICAR-Indian Agricultural Research Institute (IARI) with support from ICRISAT was released for commercial cultivation in Central India.

The new chickpea variety (Pusa Chickpea 20211) recorded an average yield of 2,392 kg/ha and a 28% yield advantage over the recurrent parent (Pusa 391).

Products under advanced varietal trials include high-oleic and rust-resistant groundnut, drought-tolerant and disease-resistant chickpea, downy mildew-resistant pearl millet and drought-tolerant sorghum among other targeted key traits in mandate crops.

In pearl millet, an improved hybrid with downy mildew resistance, improved grain yield (3.51%) and dry stover yield (20.11%) over the original hybrid is being considered for release as Maru Sona in the State of Gujarat.

Genomic prediction-based selection

ICRISAT, in partnership with NARS and Agricultural Research Institutes, has been working on optimization and deployment of genomic prediction-based selection strategy for ICRISAT mandate crops. About 800 chickpea lines, 1528 groundnut advanced breeding lines, 1891 sorghum lines and 370 pearl millet inbreds in various breeding trials were evaluated for target traits.

ICRISAT developed cost-effective mid-density assays with 5000-4000 SNPs for genotyping the extended training population and routine deployment in breeding.

The performance of 104 parental lines of pigeonpea hybrids was evaluated using genomic best linear unbiased prediction (G-BLUP) method and 78 crossing combinations were selected and shared with breeding programs at ICRISAT and ICAR-Indian Institute of Pulses Research (IIPR).

Photo: Srujan Punna, ICRISAT

A seed belt grader in the CIOT seed processing facility.

Modernizing breeding technologies

A new seed processing facility launched by the Crop Improvement Operations Team supports primary processing (threshing, drying, fumigation by CO_2), secondary processing (blowing, grading, sorting), grain quality assessment (by X-ray Fluorescence and Near-Infrared Spectroscopy), post-harvest data collection and seed inventorying.

A dedicated portal facilitates online requests for crop improvement operations by all crop units. RapidGen facilities were established and pilot experiments on pearl millet, sorghum and groundnut were conducted.

Early generation multi-environment testing of advanced breeding lines of six crops was done in 239 trials (83 unique trials) in 72 environments.

Photo: Srujan Punna, ICRISAT

ICRISAT's Center of Excellence in Genomics & Systems Biology in India.

Crop protection initiatives

Chickpea

Six genotypes with new, stable and durable sources of resistance to Fusarium wilt were identified. Combined resistance to wilt and SMD was found in 5 lines which were shared with the breeding program and NARS.

Sorghum

Standardized screening, rearing protocols and an integrated pest management (IPM) strategy for Fall armyworm in sorghum/millets was developed. Organophosphate was identified as the active compound that inhibits charcoal rot pathogen growth in sorghum.

Pearl millet

Thirty-six blast isolates collected from Karnataka were characterized for virulence diversity; isolate Pg 380 from Raichur was selected for greenhouse screening. Five blast-resistant lines (≤10% neck and finger blast), 12 lines tolerant to charcoal rot and shoot fly and 31 white/red grain sorghum lines resistant to grain mold (≤3 score) were identified under field conditions at Patancheru, Hyderabad.

Digital apps and tools

Meghdoot App supports digitalization of agro-advisories in India

A joint initiative of ICRISAT, the India Meteorological Department, Indian Institute of Tropical Meteorology and ICAR, the Meghdoot app seamlessly aggregates contextualized district and crop-wise advisories issued by Agro Met Field Units every Tuesday and Friday with forecast and historic weather information for farmers in their vernacular language. Meghdoot has disseminated more than 350,000 advisories to 45,000 active users.

District-level data for India

A new web tool developed in 2020 provides open access to an ICRISAT-collated database of district-level information on agriculture and allied sources. The web tool provides dashboards and data visualization.

During the pandemic, critical activities were carried out to save precious breeding material.

Working through the COVID-19 pandemic

Institutional support was provided to staff to manage the COVID-19 pandemic with precautions while working on site as well as while away from home. Guidelines for staff to maintain protocols, training sessions with emphasis on following institutional procedures were organized. Wherever needed, medical assistance was provided by the ICRISAT medical unit, including assistance with vaccination.

In spite of the pandemic, all possible efforts were made to carry out critical activities to save precious breeding material and pathogenic isolates essential for phenotyping for various diseases and pests. To meet the outputs of ongoing projects, some staff were housed on campus. Nearly 300 virtual meetings were held by different project teams to keep track of project implementation. Online platforms were used extensively for capacity building and knowledge sharing, planning and execution of work plans and reviewing the progress.

Farmer collectives work during the lockdown

During the lockdown period, March-June 2020, farmers in an Integrated Watershed Management project in Maharashtra, India, supported by the CSR initiative of JSW Foundation, reported 140% returns on resources. With harvest-time coinciding with the lockdown period and export markets closed, farmer collectives devised ways to sell their produce in local markets and gain profits.

Farm and Engineering Services

The Farm and Engineering Services (FES) provided comprehensive support to research on 72 ha of experimental fields and controlled environment research facilities under a risky COVID-19 situation. It successfully oversaw the construction of a seed processing and preparation facility for Crop Improvement Operations Team (CIOT) and Genebank; modified six plot threshers supplied to locations in Eastern and Southern Africa (ESA) and West and Central Africa (WCA); and the fabrication of farm machinery (ridgers, roller packers and bedshaper) for Zimbabwe. Two locally procured tractors (1 each for ESA and WCA) were modified for operations at 60 cm spacing and were supported in farm mechanization and upgradation of research infrastructure.

Natural Resource Management

Soil Fertility Atlas and Geo-portal

About 40,265 georeferenced soil samples from 30 districts in Odisha state were analyzed at ICRISAT's Charles Renard Analytical Laboratory under the Bhoochetana project. The data fed into an interactive geo-portal provides information on soil nutrient status and nutrient requirements. The Soil Fertility Atlas serves as a ready reckoner for policymakers, government extension staff and farmers.

Landscape restoration

Efforts were made to revive traditional water harvesting structures for ensuring water availability under the KISAN MITrA-Doubling Farmers' Income initiative in all seven districts of Bundelkhand region.

Forty rainwater harvesting structures with 2.5 MCM harvesting capacity facilitated 6.0 MCM groundwater recharge per year in Bundelkhand region of Uttar Pradesh, India. In addition, over 1,600 ha of field bunding along with surplusing arrangement was undertaken. Annually, about 3,500 demonstrations on balanced fertilizer application, improved crop cultivars and organic farming and about 1,500 demonstrations on improved fodder production technologies (cereals, legumes and perennial grass species) were undertaken. In Telangana, Andhra Pradesh, Odisha, Karnataka and Maharashtra states in India, around 7,500 demonstrations per year on crop nutrient management, varieties, IPM and diversification enhanced farmers' capacities for improving productivity and incomes. Around 1,200 ha of farmland was rejuvenated through balanced application of plant nutrients. While the use of micronutrients gave farmers 10-30% higher yields, the use of climate-smart, high-yielding varieties improved yields by 20-40%.

> New technologies have a huge role to play in future farming and the modern soil labs are a step in that direction, equipping the state to meet international standards.
>
> **Dr Jacqueline Hughes**
> Director General, ICRISAT

A renovated traditional water harvesting structure in Bundelkhand.

ICRISAT scientist in a farmer's field in Nigeria.

OUR WORK IN AFRICA

Malawi officially released its first chickpea and finger millet improved varieties while Burkina Faso released its first commercial pearl millet hybrid. More than 3,256 MT of seed was produced and distributed across Africa. Climate-smart and water-efficient technologies showed big impact – a project in Zimbabwe recorded an income increase of 43-94% in farmer households.

New varieties released

Improved varieties released for the first time in a country

- Improved finger millet and chickpea varieties released in Malawi
- Commercial pearl millet hybrid IKMH 18001 released in Burkina Faso

New releases

- Three drought-tolerant groundnut varieties released in Malawi
- Sorghum hybrid for the brewing industry in Zimbabwe

Varieties in the pipeline

- Forage sorghum, double-podded and machine-harvestable chickpea in Eastern and Southern Africa
- Pearl millet to combat type 2 diabetes in African population

Pest and disease mitigation

- Fall armyworm management and aflatoxin mitigation
- Genomic technologies focus on *Striga* resistance and stay-green alleles in sorghum, groundnut rosette disease and blast resistance in finger millet

Soil and water management

- Climate-smart and water-efficient technologies show big impact in Mali and Zimbabwe
- Technology parks in Mali work through the pandemic

Seed systems

- More than 3,256 MT of seed produced and distributed

Crop improvement

Variety releases in Malawi

Finger millet

The three new varieties released in Malawi are Acc # 14 FMB /01 WK, KNE # 688 and P 224.They are rich in zinc and iron and have an average yield of 2,176 kg/ha compared to the local varieties that have an average yield of 350-500 kg/ha.

Chickpea

The three new chickpea varieties released are two Desi genotypes (ICCVs 97105 and 97114) and one Kabuli genotype (ICCV 96329) with an average yield of 2,100 kg/ha against 965 kg/ha for the local landraces released in Malawi.

Drought-tolerant groundnut

Three Spanish type drought-tolerant groundnut varieties that mature within 90-110 days were released in Malawi. They are tolerant to groundnut rosette disease and leaf spot, have a yield potential that is more than 30% of the commercial check (JL 24), thrive under low rainfall and poor soils and fit well as an intercrop with other crops, particularly cereals. The varieties are ICGV-SM 08528 (CG 15), ICGV-SM 03530 (CG 16) and ICGV-SM 03517 (CG 17).

A hybrid for the brewing industry

ICRISAT supplied sorghum inbreds to Seed Co, a primary and founding member of the Sorghum and Pearl Millet Hybrid Parents Research Consortium and a leading producer and marketer of certified seed in Eastern and Southern Africa. Of the hybrid combinations derived from the inbreds, SCXH102 outperformed all the check hybrids and open-pollinated varieties used in the trials. It has a yield potential of upto 8 t/ha, matures in 92-115 days, offers good resistance to lodging and is resistant to leaf blight and sooty stripe. It is brown seeded and good for alcoholic and non-alcoholic beverages. ICRISAT and Seed Co collaborated with Delta Corporation, the largest brewery in Zimbabwe on malting quality evaluation.

First commercial pearl millet hybrid released in Burkina Faso

The hybrid pearl millet IKMH 18001 has 35 to 40% higher yield compared to the local and improved OPV Misari-1 with high yields of up to 2.8-3.2 tons/ha. It has a double advantage because it matures while the leaves are still green and hence has high added value as fodder for animal feed. It has a short cycle of 85-90 days.

Commercial hybrid seed production is being done in collaboration with Nafaso Seed Company which produced seed on 3 ha in 2020. IKMH 18001 was bred by the ICRISAT pearl millet breeding program in Niger and tested in multi-locations in partnership with National Institute for Environment and Agricultural Research (INERA) and Nafaso Seed Company in Burkina Faso. It is recommended for the Sudanian zone of Burkina Faso.

> The process took about 10 years, from the creation of the parents to the first crosses between parents, the selection of the hybrid, the multi-location tests in the station and on the farm, and the registration in the national seed catalog in Burkina Faso.
>
> **Dr Inoussa Drabo**
> Pearl millet breeder at INERA

Ongoing crop improvement

Pearl millet to combat type 2 diabetes

Forty-eight pearl millet hybrids with low glycaemic index (GI) were developed and tested in seven locations in West Africa and three locations in East Africa with funding from UK Innovate, United Kingdom, in collaboration with Aberystwyth University, UK and Ainoma seed farm in Niger. The best hybrid combination with low GI across the locations will be promoted in West and East Africa.

Promising lines in ESA

High quality forage sorghum lines

A total of 300 sorghum germplasm lines were evaluated for their fodder quantity and quality in a collaboration between ICRISAT-Nairobi, Kenya and the International Livestock Research Institute (ILRI), Ethiopia in 2019. Genotypes IS 11861 and IBS 19 had grain yields of 1.48 t/ha and 1.27 t/ha, respectively with potential for dual-purpose cultivation with high biomass yield and fodder quality.

Dryland cropping systems evaluation in Tanzania

The team is evaluating cropping systems needed to improve productivity of dryland agriculture in low production potential agroecologies of central Tanzania. Sorghum and pearl millet were tested for intercropping with pigeonpea. Findings show that pearl millet (IP 8774) was best adapted for most stressed environments.

High-yielding and drought-tolerant pigeonpea varieties

A total of 28 medium-duration and drought-tolerant genotypes were evaluated under rainfed conditions at Kampi Ya Mawe, Kenya, for drought tolerance. The study identified high-yielding genotypes ICPVs 182299, 182291, 182281, 182297, 182286 and 192142 with > 2 t/ha of grain yield which is 50% higher than the best check.

Fusarium wilt-tolerant pigeonpea genotypes

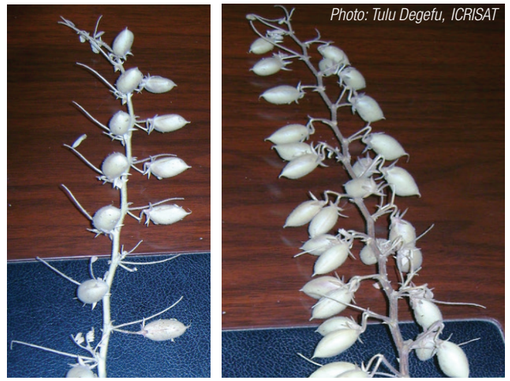
Twenty medium-duration and 30 long-duration elite lines were evaluated in a wilt sick plot in Kiboko-Kenya. Promising genotypes having high yield coupled with wilt resistance were identified in two major product concepts – PCN1-medium duration (ICPVs 172009,172010,172022, 172024,172015 and ICEAP 01150-1) and PCN2-long duration (ICPVs 182120, 182101, 182113, 182114, 182125 and ICEAP 01519).

Identification of elite chickpea lines suitable to ESA agroecologies

Chickpea lines suitable for mechanical harvesting are in demand to reduce drudgery, especially for women. Forty-one lines were evaluated, of which ICCV 03201, ICCV 04111, ICCX 110049 F3-P26-BP, ICCX 110055 F3-P61-BP and ICCX 110055 F3-P16-BP were identified as promising. The plants are high yielding, bold seeded, early maturing, drought resistant and erect.

Ascochyta blight is quite common now in ESA target countries and the extent of yield losses could be as high as 100% (Kimurto, 2014). A total of 19 new lines were evaluated in Kenya under natural epiphytotic conditions, of which ICCVs 07114, 16507, 16502 and 16509 were identified as high yielding-cum-ascochyta blight resistant.

Characterization for doubled-podded trait of chickpea



Single podded Double podded

Sixteen double-podded chickpea lines were evaluated in Ethiopia and two most-promising lines were identified. The performance of the lines compared to the single-podded Desi line DZ-10-11 is given below.

Performance of the two most promising double-podded chickpea accessions compared to the check.

Accession	Days to flowering	Days to maturity	Plant height (cm)	Total number of pods	Total number of seeds	Yield/plot in gm (1.6) m^2	Biomass/ plot (gm)	100-seed weight (g)
IE-19-11	45	94	42.8	99.6	136.4	487	700	11
IE-19-14	43	93	45.2	97.2	146.6	529	700	12
DZ-10-11 (single podded)	50	97	40.8	42.4	56.8	415	800	10

Genomic technologies

Molecular breeding products in the pipeline

Groundnut: New sources of resistance to groundnut rosette disease and markers highly associated with the disease located in two syntenic regions of the genome were identified after screening core collections in Uganda. Seventeen primers designed for the region are undergoing validation across a segregating mapping population.

Sorghum: Marker-assisted backcrossing of two stay-green QTLs (stg3A and stg3B encoding transpiration efficiency and Water Use Efficiency) into three genetic backgrounds was initiated at ARI-Makutupora, Tanzania. Similar work in Senegal is underway to introgress stg3A and stg3B QTLs in three genetic backgrounds. Both these introgression programs are using markers developed by ICRISAT.

For drought tolerance, 44 landraces and wild relatives were evaluated under well-watered and drought-stressed conditions at ICRISAT Kiboko station. For Striga resistance, 64 genotypes consisting of 17 wild relatives, 8 landraces, 13 improved varieties and 26 F_4 progenies of selected parents were screened at ICRISAT Alupe station. More resistant and high-yielding genotypes than the conventional checks were identified, especially among the F_4 crosses. Future studies will need to look for more diverse sources of Striga resistance and pyramid different mechanisms of resistance into farmer-preferred varieties.

Finger millet: The response of cultivated and wild relatives of finger millet to an isolate of blast disease from western Kenya was investigated. Scientists observed high heritability (81%), indicating that the variations observed were predominantly genetic. Wild accessions were generally more resistant to the disease in comparison to the cultivated accessions. Studies led to the identification of 19 markers associated with blast disease that were incorporated into a 50-SNP marker set to be developed into assays for genotype quality control (QC) and trait introgression. Wild accessions and landraces of finger millet are a good reservoir of novel genes that can be incorporated into crop improvement programs.

Biotechnology advances: Over 15 stable and heritable novel variants for durable resistance to *Striga hermonthica* developed using reverse genetics approaches were evaluated for efficacy in Niger and Mali. The trials revealed high levels of resistance in over 7 mutant lines. A stage-gate process is being used to integrate these novel variations in ongoing WCA and ESA sorghum breeding pipelines. Gene editing is being done parallely for pre-and post-attachment Striga resistance directly in the regionally adapted elite backgrounds for accelerated trait deployment.

Seed production and delivery

3,256 MT seed reaches farmers in Malawi

In Malawi, 3,256 MT of certified seed of groundnut (1352 MT), common bean (1880 MT), sorghum (17 MT) and pigeonpea (7 MT) was produced. The seed will cover around 54,266 ha with improved varieties. Increased access to seed via formal and informal channels and capacity building in improved technologies (i.e., improved seed, agronomic practices and pest management) resulted in coverage of 89,152 ha.

In Tanzania, pearl millet variety IP 8774's promotion is underway. Improved pearl millet lines were submitted for variety release. A total of 501 farmers (262 women and 239 men) were trained in improved production systems for the 2019-20 season. The farmers produced 8.4 tons of quality declared seed of pigeonpea and 2.6 tons of cereals (2.0 tons of sorghum and 0.6 tons of pearl millet). Private sector and civil society agencies, Dodoma Agricultural Seed Producers Association, Kibaigwa Flour Supplies Company and the local government are engaged in last mile delivery.

118 tons of certified biofortified pearl millet seed produced in Niger

Chakti: Africa's first iron biofortified pearl millet variety is popular in Niger for its early maturity, high yield, downy mildew resistance and improved iron and zinc content. According to the Government of Niger, a total of 118 tons of certified seed were produced in 2020.

Seed systems: Through the AVISA project, 57 varieties were prioritized for commercialization

A total of 22,081 tons of seed, i.e., 96 tons of breeder seed, 1,179 tons of foundation seed and 20,806 tons of certified and quality declared seed of modern varieties were produced through innovation and diversified private and public partnerships and made available to farmers.

To enhance farmers' uptake of new technologies, 495 variety demonstrations, 85 field days, 63 seed fairs/agriculture shows, and 40 radio/TV events were conducted. About 40,513 small seed packs of new and high-yielding varieties were made available to farmers. About 20,493 stakeholder farmers, seed producers, NARS partners, NGO staff, extension services, farmer organizations and other value chain actors were trained on good agronomic practices and quality seed production and 1,766,253 farmers were reached. **Reference:** AVISA Result tracker & annual reports documents.

Tanzania Seed Revolving Fund initiative – Youth Engagement and Gender Inclusion (SRF-YEGI) model launched

SRF-YEGI involves local public and private institutions to produce breeder and foundation seeds while ICRISAT facilitates and backstops through its projects. Through a competitive process, seed companies applied to participate in the SRF-YEGI for groundnut and sorghum. Six companies were nominated to participate with initial financial support to de-risk the investments. Youth involvement is operationalized through a youth-run enterprise and income generation center. SRF-YEGI will track rural women's access/use/control of seed/grain/benefits to monitor their empowerment and gaps for improvement.

Innovation platforms: The ability of innovation platforms to fix systemic problems and improve farmers' access to seed of improved legume varieties has been documented in a study across Eastern and West Africa.

Women seed producers in the sorghum seed farm in Tanzania.

Systems Analysis

Climate-Smart Agriculture (CSA): Our research provided evidence of substantial yield increase and income improvement from the adoption of CSA options in West Africa. The dissemination of weather and climate information services was found to have positively impacted users' livelihood improvement. Other studies have investigated the relationship between farmers' perceptions of weather variability and climate change, which have significantly influenced their choices of coping, and adaptation strategies towards climate change. **References** 1, 2, 3 and 4

Gender-responsive research: Research activities were tailored to support and improve equity through the identification of cost-effective CSA options in the Climate Smart Villages as well as the development of climate-smart value chains in close linkage with development projects and programs in Ghana, Mali and Senegal. Several research undertaken in the region highlighted the higher risks faced by African women and the negative impacts from climate change due to their relatively higher household responsibilities coupled with limited access to agricultural resources (such as land, extension services) and inputs.

References: 1, 2, 3, 4, 5 and 6

Country-specific CSA options: Three CSA country profiles were developed for Ghana, Mali, and Niger. A synthesis of CSA options for food system adaptation in the Gambia has been produced. The CSA country profiles synthesize the opportunities for addressing climate change challenges and economic growth prospects in the agriculture sector from the perspective of climate-smart agriculture.

Contour bunding is a relatively simple and low-cost way to reduce land degradation.

Integrated Crop Management

Contour bunding: The technology resulted in increased crop yields of more than 30% and improving household economy by 20%. The technology benefits the environment by recharging shallow ground water aquifers and increasing soil moisture availability. When integrated with fast-growing nitrogen-fixing tree species, the technology had better environmental impact by mitigating greenhouse gas emission through carbon sequestration. Farmer exchange visits and trainings provided the social cohesion that allowed the extension of this innovation system to rural areas.

Technology parks: A total of 332 farmers (30% women) participated in a technology validation experiment in Mali. In addition, farmers' field days were held in four technology parks from 16-20 November 2020 under strict COVID-19 regulations (a maximum of 30 participants per site). Participants were oriented on contour bunds with fast-growing tree species, dual-purpose sorghum varieties, sorghum hybrids (Fadda, Tieble and Soumba), different technologies of Integrated Striga and Soil Fertility Management, fodder species that include *Brachiaria*, mucuna and cowpea, vegetable sack gardens and post-harvest technologies.

Impact leads to scale-up of water management technologies: Findings from the use of two synergistic interventions – Smart Water Management tools and Agricultural Innovation Platforms – published in the special Issue of the International Journal of Water Resources Development reveal big gains accrued from using simple technologies embedded in a wider learning environment. Outcomes reported from project sites in Mozambique, Tanzania and Zimbabwe pointed to increased crop yields ranging from 28–313%, income increase of 43–94% in farmer households, 43–60% increase in off-farm income due to less time spent irrigating and 40–85% of farmers reducing irrigation frequency. The results convinced the National Zimbabwe Government's Director of Irrigation to scale this strategy out in Matabeleland North.

Crop-Livestock Systems: The Crop-Livestock Integration and Marketing in Malawi (CLIM^2) project implements a multi-stakeholder innovation platform-driven action research approach to illustrate how smallholder farmers can better participate in high potential livestock value chains (chickens, goats, dairy and feeds). More than 1000 farmers engaged in crop demonstrations and reducing post-harvest losses in grain and feed. Farmers prioritized feed technologies that they could integrate into their cropping activities, such as crop residues from dual-purpose crops and intercropping maize with pigeonpea, cowpea and sorghum. Farmers invested part of their income gains from livestock sales to buy quality seed and fertilizer. Such income gains for resource-poor households provide an option to acquire less costly nutrient-dense foods, like eggs or pulses, and reduce trade-offs with food production, given the limited land. To create income opportunities from feed processing, the project supported 12 farmer groups with hammer mills and four registered as small and medium enterprises (SMEs) following training.

Crop protection initiatives

Fall armyworm: Host plant resistance is an important approach to controlling the pest. About 246 accessions from the sorghum mini-core collection were screened for resistance to fall armyworm at Chitedze research station in Malawi. Accessions IS27557, IS14010, IS11026, IS6351 and IS4515 showed a consistent level of high resistance.

Aflatoxin mitigation: The efficacy of combining Aflasafe (biocontrol) and good agricultural practices (GAPs) to reduce aflatoxin contamination has not been documented globally (Njoroge, 2018). A pilot project was implemented in Malawi to test this strategy. Our research shows that biocontrol has the potential to reduce aflatoxin to safe levels for consumption, but its efficacy is enhanced when applied together with GAPs. This research has the potential to restore international markets for Malawi's groundnuts and improve livelihoods. The experiments will be repeated in the next few years and in farmers' fields to develop the most efficacious combination/treatment.

Over 2,000 frontline health workers and 22,000 households in Malawi trained on various agriculture and nutrition trainings. We also documented knowledge gaps on aflatoxin contamination among agriculture extension officers and frontline community health workers.

Capacity building

To enhance crop-livestock integration and improve utilization of crop residues in the target areas, the Sorghum and Millet Compact of the Technologies for African Agricultural Transformation (TAAT) took to mass dissemination of selected proven technologies. The aim is to address food insecurity in seven countries in the Sahel with the objective of turning the region into a food basket.

The training sessions were on stalk treatment with urea to improve protein content, chopping of stalk with a manual and motorized chopper to increase the digestibility and conservation of the product, making mineral licks blocks from bone meal, cement, table salt and earth from termite mounds. About 380 agro-pastoralists from Mali, Nigeria, Senegal and Sudan were trained.

Policy and impact

A study was carried out on the Welfare Effects of the Adoption of Pearl Millet Technologies in Nigeria. The study recommends further strengthening of scaling out efforts of existing pearl millet technologies.

European Union delegation to Mali, during a visit to a sorghum field.

Photo: ICRISAT

Inside the Svalbard Global Seed Vault, where 91% of ICRISAT's genebank collection has been safely duplicated.

OUR GLOBAL REACH

The impact of ICRISAT's work transcends Asia and Africa to many countries across continents that benefit from the International Public Goods that are developed. Sharing of plant genetic resources and cutting-edge technologies is critical to global food security and agriculture.

Sharing germplasm

- Safety duplication of 3,700 accessions in Svalbard Global Seed Vault
- 4,984 accessions of ICRISAT mandate crops distributed in 11 countries

Genomic technologies

- *Cicer* pangenome studies and quality control panel for mandate crops to serve as public goods
- Nutritional genomics focus on high-iron and zinc pearl millet and quality sorghum stover

Digital apps and tools

- Modern analytics facilitate quicker decisions in breeding programs
- ICRISAT's Weekly Data Clinics facilitate quick adoption of technology
- Dashboards provide real-time data on ICRISAT operations
- New methods for crop monitoring using machine learning

Pandemic response

- Supported COVID-19 policy response through various studies and publications

Facilities upgraded

- Genebank facilities upgraded in India and Africa

Genebank activities

Genebank at India

Safety duplication and public goods: ICRISAT safety duplicated an additional 3,700 accessions in Svalbard Global Seed Vault and distributed 4,984 accessions to 11 countries.

Seed lab activities: Despite the lab closing down for many months during the pandemic, more than 2,800 accessions were tested for viability, 3,289 were health tested and 1,333 were disease cleaned. A total of 6,812 accessions were regenerated and 1,906 characterized to different descriptors and traits.

Chickpea Mission launched: In partnership with the National Institute of Plant Genome Research, Delhi, and many other Indian institutes, 5,000 genebank accessions of chickpea will be characterized to different biotic and abiotic stresses and genotyped.

Diversity of accessions assessed: The level of diversity within and among 108 diverse landraces and wild accessions of sorghum, pearl millet and pigeonpea using both phenotypic and genotypic characterization data was assessed. This study will support genebank curators in understanding the dynamics of populations within and among accessions in devising appropriate germplasm conservation strategies and their utilization for crop improvement.

Reference: Frontiers in Plant Science (2020; 11:1878; doi: 10.3389/fpls.2020.587426)

Niamey regional genebank

Activities: Accessions of pearl millet, sorghum, groundnut and pigeonpea were characterized (2,924), regenerated (3,819), health status tested (6,032) and viability tested (6,059).

Acquisitions: The genebank received 364 accessions of sorghum, pearl millet, pigeonpea and finger millet from the Royal Botanic Gardens, Kew (UK) and 3,082 accessions of sorghum, pearl millet, groundnut and some non-mandate crops from Ghana, Burkina Faso, Nigeria and Niger.

Distribution: About 2,213 seed samples of pearl millet, sorghum, groundnut and pigeonpea accessions were distributed in several countries, 283 of sorghum, 274 of pearl millet and 2 of groundnut were sent to ICRISAT headquarters for long-term storage.

Facility upgraded: The Niamey genebank was upgraded by implementing a barcoding system for field activities and the development of 11 Standard Operating Procedures. Prior to collection missions in Chad and Niger, NARS (25 in Niger, 30 in Chad) were trained on germplasm collection, conservation, management, sample handling, international treaty, farmer rights and benefit sharing. Passport data of 15,388 accessions are now available online.

New equipment was purchased for better seed storage and testing. CCTV and access card systems were set up for enhancing the security in the cold rooms.

Key achievement: A workshop was held in Dakar in December 2020 to integrate the ICRISAT genebank, CGIAR genebanks in WCA and WCA NARS working on plant genetic resources.

Bulawayo regional genebank

Activities: A total of 1,077 accessions (427 finger millet, 446 sorghum and 204 pearl millet) were characterized/ regenerated and 954 accessions were distributed (148 pearl millet, 357 finger millet and 449 sorghum).

Facility upgraded: A generator, security door and access control system were installed.

Capacity building: Smallholder farmers were oriented on conservation of plant genetic resources and genebank staff were trained on the use of the Breeding Management System and digitalization of data collection.

Groundnut genetic studies under controlled environment.

Genomic technologies

***Cicer* pangenome:** To decipher the genetic diversity in 3,000 chickpea lines, a detailed map of variations in 3,171 cultivated and 195 wild accessions was developed as a public resource for chickpea genomics research and breeding. Four genomic breeding approaches were optimized to enhance crop productivity for 16 traits while avoiding erosion of genetic diversity.

Quality Control panel for mandate crops: Significant progress has been made in developing and deploying Single nucleotide polymorphisms (SNPs)-based QC panel for global breeding applications by leveraging existing sequencing data in all ICRISAT's mandate crops.

Nutritional genomics: In pearl millet, considerable progress was made towards mapping and mining novel alleles/genes for grain iron (Fe) and zinc (Zn) content. The genes will be useful in designing markers and assay development to breed nutritionally dense cultivars. We also developed, verified and validated 4-SNP panel marker for grain Fe and Zn content. The SNPs were validated in diverse lines from the Indian breeding programs and can be effectively used to reject (negative selection) low Fe and Zn lines in forward breeding programs.

Stover quality studies: Quality of sorghum stover (measured in terms of in vitro organic matter digestibility - IVOMD) attracts equal or a higher price than grain for farmers. A difference of 5 units of IVOMD has shown a price increase of ₹2 per kg of dry matter. A diverse set of 24 sorghum lines was field evaluated over 3 years under irrigated and terminal drought scenarios. No trade-off between grain yield and fodder quality traits was recorded, indicating the possibility of concurrent improvement of these economic traits by breeding. These results can change the breeding strategy for dual-purpose sorghum product development across regional breeding programs of ICRISAT and partners.

Pandemic response

Timely analyses and publications on various topics ranging from the pandemic's impact on food security to leveraging digital tools supported ICRISAT's COVID-19 policy response. An important ICRISAT study and recommendations published in the "Sustainability" journal filled critical gaps in understanding the pandemic's impact on food value chains.

Digitalization of breeding programs

ICRISAT's crop breeding program is entirely digital in terms of field experimental designing, data collection and management, and enabling data to be synced to data servers in real time from research fields. Seed material and its inventory is now digital and accessible globally. ICRISAT is working with several breeding programs of ICAR and enabling digitalization of their breeding programs. Weekly data clinics that ICRISAT organizes for partners across ESA, WCA and Asia have catalysed quick adoption of technology.

Modern data analytics

ICRISAT is expanding its multi-location testing capabilities. Sophisticated algorithms are used to choose locations. Modern methods are being standardized and integrated into breeding decision making. To enhance breeding efficiency, it has developed QC markers for all mandate crops for germplasm identity, purity and checking crossing success. To quickly integrate Genomic Selection in plant breeding, Mid-density Marker panels have been developed.

Open data access & open digital dashboards

Through several data sprints, hackathons and workshops, ICRISAT has facilitated open access of several datasets. An Open Crop Breeding Dashboard provides real time data to stakeholders on ICRISAT's operations.

Geo-spatial studies

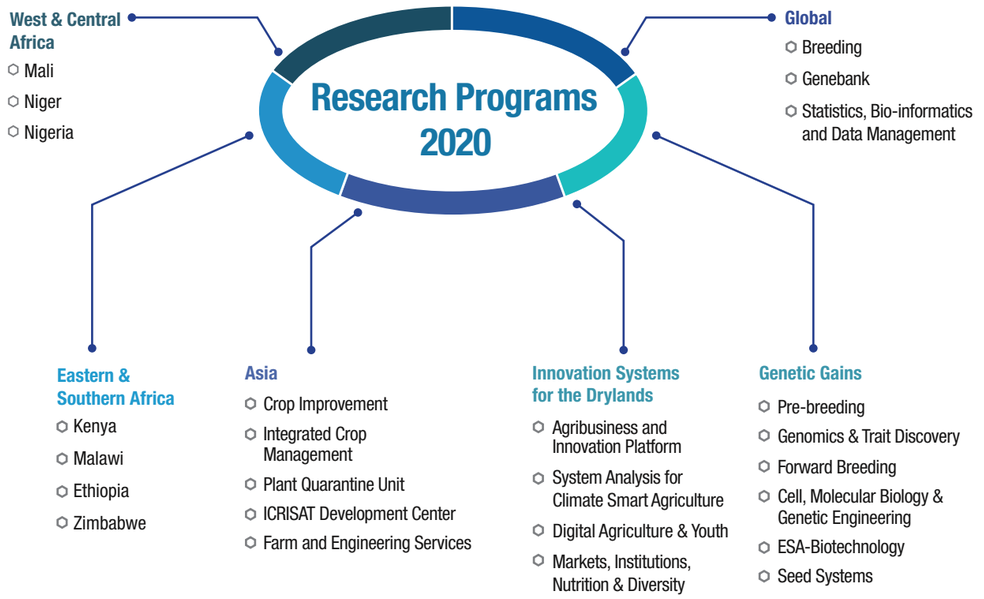
Crop monitoring using machine learning algorithms: Studies were published on Mapping Cropland in South Asia using Landsat data on Google Earth Engine and Mapping Crop Types using Sentinel-2 Satellite Data. A remote sensing method for estimating bare soil moisture has been developed.

Drones for crop monitoring.

Vision
A prosperous, food-secure and resilient dryland tropics

Mission
To reduce poverty, hunger, malnutrition and environmental degradation in the dryland tropics

Approach
Inclusive Market-Oriented Development (IMOD)



ICRISAT leads ▶ CGIAR RESEARCH PROGRAM ON Grain Legumes and Dryland Cereals

ICRISAT is a partner in ▶
CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security (CCAFS)
CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems
CGIAR RESEARCH PROGRAM ON Agriculture for Nutrition and Health
CGIAR RESEARCH PROGRAM ON Livestock and Fish
CGIAR RESEARCH PROGRAM ON Policies, Institutions, and Markets
CGIAR Genebank Platform
CGIAR Platform for Big Data in Agriculture

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

RESEARCH PROGRAM ON Grain Legumes and Dryland Cereals

HIGHLIGHTS

KEY RESULTS:

Common bean helps reduce poverty in 2.5 M families in Ethiopia

- 4 M smallholder farmers derive nutrition and income
- Adopted by approximately 2.5 M farmers
- Yield increase from 0.5 t/ha (2004) to 1.6 t/ha (2016) fetching thrice the income from maize
- Food and other expenditures go up by US$ 217 person/year

High oleic groundnut varieties commercialized in India, enhanced shelf life for food industry and consumer health benefits

- Girnar 4 (ICGV 15083) and Girnar 5 (ICGV 15090) with over 80% oleic acid dedicated to India
- Confectionery industry-friendly, long shelf life
- Private seed companies take up seed production in India and testing ongoing in Myanmar and Bangladesh for release

High-yielding climate-resilient beans improve food security, kickstart business in Zimbabwe

- Dissemination of four varieties
- 36% more farming households reached by 2019
- 347 kg more beans harvested/ha, resulting in 3.6 kg more beans consumed per capita/year

Flagship Program 1: Priority Setting and Impact Acceleration

- Over 21.9 M smallholder farmers adopt improved GLDC varieties on over 20.5 M ha: Adoption study
- Lentil in Bangladesh: 40% increase in yields, 47% in gross margins (US$ 501/ha), 657,600 people exit poverty (Yigezu et al. 2020)
- Improved groundnut varieties in Nigeria: about 1.5 M people exit poverty (Melesse et al. 2020)
- Chickpea in Ethiopia: Adopted by 585,000 households; 58.5% increase in yields; 5% increase in household dietary diversity (Murendo et al. 2020)
- Ex-ante impact evaluations, adoption and impact studies define gender-sensitive prioritization of varietal attributes in target countries
- TOPSIS_ShinyApp: New multicriteria method developed to rank GLDC research and technologies
- End-user demand for GLDC food crops and technology demand by rural farming households studied
- Studies on rural aspirations focus on the drivers of technology adoption (Mausch and Harris, 2020a; Mausch and Harris, 2020b)
- Critical trade-offs in value chain approaches identified (Mausch et al. 2020)
- Interventions to mainstream nutritious orphan crops into African food systems reviewed (McMullin et al. 2021)
- GLDC crops meet 9% of energy and 21% of protein requirements – Study

For more: http://gldc.cgiar.org/progress-in-fp1-priority-setting-and-impact-acceleration-2020/

Flagship Program 3: Integrated Farm and Household Management

- Framework developed and piloted to assess farming systems sustainability
- High-yielding and early-maturing soybean and cowpea genotypes identified
- Sustainable intensification systems with diversified crop mixes developed
- 476,591 individuals benefit from GLDC-based practices in Malawi and Mozambique
- Sweet sorghum bagasse compost enhances plant growth and yields in sorghum
- High-yielding, drought-tolerant legume varieties (cowpea, groundnut, pigeonpea and soybean) with farmer preferred traits and input combinations identified through participatory cropping system management trials
- 309,558 farmers apply improved technologies on 440,743 ha in Mozambique in the last five years (41% improved varieties; 59% improved crop management practices)
- Agronomic packages developed across Northern Nigeria, Malawi, Tanzania, and India using systems tools and modelling
- Multi-locational datasets and models support product profile development: optimum sowing for millet and early-to-medium-maturing groundnut varieties in semi-arid Nigeria
- Nutrition targeting and consumption behavior change: 1,227 pregnant women and lactating and young mothers, 876 adolescents reached in India
- Household diet diversity in Mali and Burkina Faso: 14 improved biofortified cultivars (sorghum, millet, cowpea, and groundnut) piloted with 160 households
- COVID-19 lockdown effects on agricultural systems and rural livelihoods in South Asia assessed

For more: http://gldc.cgiar.org/progress-in-fp3-integrated-farm-and-household-management-2020/

Smallholder farmers in Mali.

Flagship Program 4: Variety and Hybrid Development

- 30 GLDC crop cultivars commercialized: chickpea (10), lentil (5), groundnut (5), sorghum (2), pearl millet (5), soybean (1) and finger millet (2) in Africa (Burkina Faso, Ethiopia, Malawi, Kenya) and Asia (India)
- Machine-harvestable, wilt-resistant, and drought-tolerant chickpea cultivars released in Ethiopia and India [Eshete (ICCV 10102), RVG 209 (ICCV 08108), and Phule Vishwaraj (ICCV 15109)]
- Chhattisgarh Mungfali-1 (ICGV 06420) and ICGV 06189 meeting oil and confectionery industry needs for groundnut released in India, besides new chickpea cultivars (ICCVs 97105 and 97114) in Malawi, and early-maturing soybean variety (TGx1991-2F) in Malawi
- First dual-purpose pearl millet hybrid IKMH 18001 released in Burkina Faso
- Yellow grain sorghum variety Telangana Jonna 1 (ICSR 89064) released in India
- Fertilizer-responsive, erect, and blast-resistant finger millet varieties Katope and Kambulanje released in Kenya and Malawi
- Multi-cut forage sorghum cultivar Jaicar Nutrigraze released in India
- Automated seed processing, data collection and seed inventory facility set up at ICRISAT headquarters
- 70% of both female and male value chain actors in Mali prefer sorghum and millet cultivars with improved grain and food quality: Study

For more: http://gldc.cgiar.org/progress-in-fp4-variety-and-hybrid-development-2020/

Flagship Program 5: Pre-breeding and Trait Discovery

- Quality control, mid-density panels developed for five GLDC crops
- Molecular breeding lines in groundnut (3), chickpea (3) and pearl millet released and advanced
- More than 2.5 M marker data points generated by High Throughput Genotyping Platform and 19.81 M genome-wide SNPs identified in groundnut for further analysis
- 10 trait-linked SNP panels for breeder preferred traits in sorghum, pearl millet, chickpea, pigeonpea, finger millet, soybean and cowpea validated for forward breeding
- Accessions from 8 annual wild species of *Cicer* and 7 wild species of *Cajanus* sequenced using Illumina platform to identify haplotypes
- Hi-C approach deployed to develop new de novo assemblies in chickpea, pigeonpea and groundnut
- Protocols for proof of concept in genome editing, second-generation transformation, systematic mutant population, and phenotypic screening established
- Molecular and biochemical mechanisms for rancidity in pearl millet deciphered
- QuickCrop expression constructs for gene editing developed to target primary strigolactone pathway genes in two sorghum and one pearl millet lines.
- Protocols for rapid generation advancement in lentil and cowpea developed
- Diversity in virulence studied among 10 isolates of *grisea* (blast disease)

For more: http://gldc.cgiar.org/progress-in-fp5-pre-breeding-and-trait-discovery-2020/

Flagship Program 6: Common Bean for Markets and Nutrition

- Multiparent advanced generation intercross (MAGIC) population of common bean generated from eight Mesoamerican breeding lines
- Root capacitance potential studied using a novel phenotyping tool
- Parental lines from the tertiary gene pool improve crop synchronization, grain filling under drought, plant habit and higher iron
- Genetic gains enhanced on station and on farm with bean varieties with greater yield potential
- 2.8 M households (58.5% women) benefit from PABRA-promoted varieties and integrated crop management
- 25 new bean varieties released: stress-tolerant (16), high iron (8) beans (HIB), 5,905.7 t seed produced for partners
- New biofortified varieties: 5,905.7 tons of certified, quality declared seed distributed in Tanzania, Uganda, Kenya, Burundi, and Zimbabwe
- Women and youth (148 male, 372 female) trained in entrepreneurship, business skills and value addition to generate bean-based products
- MasterCard Farmer Network (MFN) model deployed in Tanzania and Uganda

For more: http://gldc.cgiar.org/progress-in-fp6-common-bean-for-markets-and-nutrition-2020/

Gender and youth

- Two studies from ICRISAT and ICARDA contribute to gender integration in breeding programs
- Effects of outmigration of men on the role of women in agriculture studied
- Women's access to and control over assets in SAT India studied
- Women trained as model farmers to promote climate-smart technologies
- 19,213 (42.4%; 8,143 women) model farmers trained as change agents across PABRA members (PABRA20_Bean_Corridors_BRIEF.pdf (cgiar.org)
- 9 gender-responsive seed delivery systems for dry bean and GAPs technologies promoted by putting digital agro-climatic services in the hands of bean value chain actors – (pabra-africa.org)
- Youth studies in Mali and Nigeria identify opportunities in agri-food value chains
- Youth studies conducted in the drylands of Ethiopia, Uganda and Tanzania and Youth strategy paper developed

Climate change

- Framework to quantify vulnerability and resilience to climate change developed
- Systems modelling tools to co-design resilient farming systems tested and validated
- Profiling of promising and acceptable Integrated Crop Management (ICM) technologies for bean production continued
- PABRA developed a Digital Agro Climate Advisory for bean farmers

Capacity development

- In short-term programs: 2925 male, 2464 female
- In long-term programs: 19 male, 20 female
- PhDs: 12 male, 13 female
- E-Learning portal set up with 180 registered users

Publications

- 137 peer-reviewed journal articles
- 112 International Scientific Indexing
- 110 open access

Full list of publications

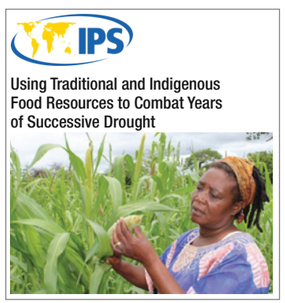
CRP-GLDC Annual Report 2020

CORPORATE SECTION

Photo: L Vidyasagar, ICRISAT

Communications at a glance

▶ In the media



287
Total media mentions

152
High-level mentions

▶ Newsmakers

- 100-year seed longevity experiment
- Launch of women-led food processing units
- RapidGen inaugural
- School feeding trials in Tanzania
- Millets-legume protein study
- TIGR²ESS general assembly

▶ Social media

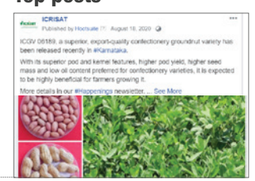
37,795
Followers
(**7,205** new followers in 2020)
305,250 impressions/month
▲ **89%**

Top tweets



24,523
Followers
(**1,575** new followers in 2020)
▲ **7%**

Top posts



51,548
Followers
(**22,691** new followers in 2020)
▲ **78%**

Top posts


▶ Campaigns

- TIGR²ESS first general assembly
- International Day for Women and Girls in Science
- ESA research planning meet
- Open Data Day
- One CGIAR global webinar series on genome editing for agriculture
- COVID-19 updates for India, ESA and WCA regions
- Adaptation Week by World Resources Institute
- HPRC meeting
- RapidGen facility inauguration
- International Women's Day
- World Food Prize digital dialogue
- World Soil Day

Publications

349 Total | **211** ISI publications | **319,731** Publication downloads | **46** Books and book chapters | **2** Policy briefs

816 ICRISAT authors | **850** NARS co-authors | **253** Happenings newsletter articles | **25** Conference proceedings | **51** Articles in other peer reviewed journals | **14** Monographs

Web

Views
1,023,039
▲3.1%

Users
367,525
▲30.9%

Mobile engagement
▲29.5%

Happenings visitors
▲41.2%

Maximum visitor engagement increase in **Zimbabwe - 33%**

Design, photo and video

121
Design outputs

44
Photo and video assignments

Communications for change

FESTIMIL 2nd Edition

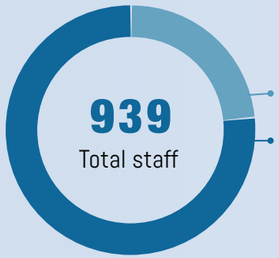
Niger celebrated the second annual International Millet Festival (FESTIMIL) during 3-4 March 2020 at the Academy of Martial Arts in Niamey. Organized by Government of Niger's Ministry of Agriculture and Livestock in partnership with the Tattali Iyali Foundation, Ministry of Cultural Renaissance, Ministry of Health, High Commission for the 3N Initiative, Institut National de la Recherche Agronomique du Niger (INRAN) and ICRISAT, the festival was led by Dr Lalla Malika Issoufou, Niger's First Lady and a Smart Food Ambassador. Smart Food master classes were organized for the President's chefs, in hotels and for students.

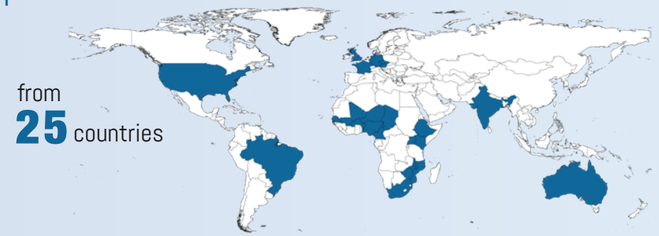
Foodtec Expo 2020

Foodtec Expo, a global virtual expo and webinar on food and food technology, was held during 23-29 November 2020. ICRISAT and the Smart Food initiative were knowledge partners at the 2020 edition of the expo, which was supported by the Republic of Kenya.

The two-day conference at the expo, Global Food Markets and Trends that are Good for the Consumer, the Planet and the Farmers, brought together policymakers, researchers, entrepreneurs and industry experts to deliberate on: south-south collaboration driving smart foods, food trends in Africa, policies impacting agriculture in Africa, global food trends, millets and sorghum: the new staples and more, and how African and Indian entrepreneurs are building smart food markets and value chains.

ICRISAT staff





ICRISAT Governing Board Members in 2020

Paco Sereme
Board Chair until 1 Oct 2020,
Independent, Burkina Faso

Prabhu Pingali
Board Chair, from 2 Oct 2020,
Independent, USA

Peter Carberry
DG (until 23 April), ex officio,
Australia

Jacqueline Hughes
DG (from 24 April), ex officio,
UK

Trilochan Mohapatra
Vice Chair, ex officio,
Govt of India

Wendy Umberger
Independent
Australia

Sissel Rogne
Independent
Norway

Laurie Tollefson
Independent
Canada

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Independent
Nigeria

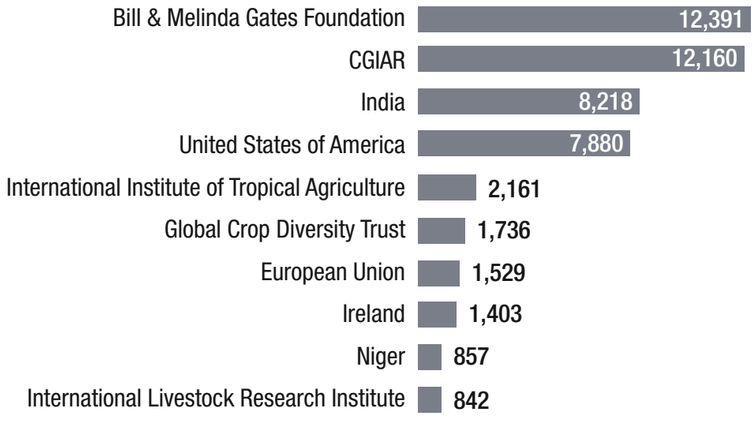
Sanjay Agarwal
Ex officio, Govt of India
India

Somesh Kumar
Ex officio, Govt of Telangana
India

Yilma Kebede
Independent
Ethiopia

Financial summary

Top ten donors for 2020 (in US$ thousands)



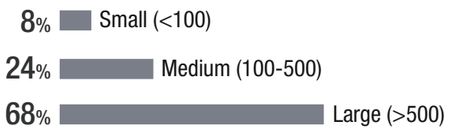
in US$ thousands

Balance Sheet		
	2020	2019
Assets		
Cash and Cash Equivalents	27,437	19,437
Investments	15,064	23,213
Accounts Receivable	22,840	20,160
Inventories	630	844
Prepaid Expenses	127	360
Property, Plant and Equipment	7,024	7,721
Other Assets	960	1,304
Total Assets	**74,082**	**73,039**
Liabilities		
Accounts Payable	11,652	13,154
Accruals and Provisions	1,406	1,442
Payments in advance from donors	22,392	20,751
Long-term Liabilities	261	439
Total Liabilities	**35,711**	**35,786**
Net Assets		
Unrestricted		
- Undesignated	9,728	8,916
- Designated	21,113	21,113
Temporary Net Assets - OCI	1,384	1,078
Permanently Restricted	6,146	6,146
Total Net Assets	**38,371**	**37,253**
Total Liabilities & Net Assets	**74,082**	**73,039**

Projects

Contribution to grant revenue by project size

(in US$ thousands)



128 Partners

26 Academic	11 CGIAR
27 Local NGOs	23 Governments
2 Foundations	2 International NGOs
3 Seed Companies	34 Private Industries

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ICRISAT Locations

About ICRISAT

ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

CGIAR ICRISAT is a member of the CGIAR System Organization

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 agribusiness and linking farmers to markets.

ICRISAT appreciates the support of its 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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