ICRISAT’s holistic approach to agri research appealed to me, says new Deputy Director General-Research

A breeder who started out studying chickpea, pigeonpea and groundnut, and then worked for long on rice, Dr Arvind Kumar is happy to be leading the research on these three and other mandate crops of ICRISAT. We discover interesting aspects of our new Deputy Director General – Research who assumed office on 21 December 2020.

Growing up in a farming family in rural Bihar, India, young Arvind spent some time in a military school but ultimately chose to pursue agricultural research rather than become a soldier.

“Starting out as a research associate at the Indira Gandhi Agricultural University (IGAU), Raipur, Chhattisgarh, the first five years I worked on chickpea, pigeonpea and groundnut, apart from rice,” he reminisced. “It was only later that I moved to rice as my focus crop.” After working at IGAU for 12 years, he moved to the International Rice Research Institute in Manila, Philippines, as a Post-Doctoral Fellow in 2004 and then continued in various capacities. Dr Arvind worked at the ICRISAT Hyderabad campus between 2012 and 2016, setting up IRRI’s South Asia Regional Breeding Hub. After another stint as leader of CGIAR Research Program Rice’s Flagship 5 and as Interim Head, Rice Breeding, at Manila, he moved to Varanasi, India, to set up the IRRI South Asia Regional Center, before joining ICRISAT as Deputy Director General – Research (DDG-R) on 21 December. He took over from Dr Kiran Kumar Sharma.

“When in the 1960s, agriculture in India was all about food security and self-sufficiency, now the whole world is aiming for nutrition security, and therefore, in the next decade or so, the nutrient-dense mandate crops of ICRISAT are going to attain great significance,” said Dr Arvind. “Moreover, I feel that these crops have a lot more potential than they are credited for. We need to work hard to make them as popular as rice, wheat or maize.”

Citing the factors that drew him to ICRISAT, he said, “ICRISAT’s work on crop improvement that combines genetic resources – genomics, trait development and breeding strategies – to develop high-yielding climate-resilient nutritious cultivars, crop-water-soil-nutrient-disease management, developing market linkages to its crops, the agribusiness arm, the watershed interventions, and much more, fascinated me and I saw an opportunity to bring about positive holistic change by integrating these aspects.”

When asked about his immediate and long-term goals as DDG-R, he said that his immediate actions would be to drive enhancement of research programs and breeding programs to align to a rapidly changing world, as well as to prepare to position this work in the best possible way in the One CGIAR setup. He emphasized the importance of effective communication as a great means to engage and enthuse the staff towards any change. He stated long-term goals as a) to improve nutrition security in the drylands, not just for the smallholder farmers but also consumers and b) to elevate and uphold ICRISAT at a position of leadership in agricultural research.

As an accomplished breeder, Dr Arvind aspires to highly effective breeding programs at ICRISAT, saying, “New knowledge is being generated almost every single day. In
our breeding programs, we need to be able to combine breeding experience with the new technologies being discovered and use them to develop comprehensive breeding strategies for different crops. This will enable breeders to develop varieties quickly, accurately and efficiently to obtain significant genetic gains in our crops.” He commended the strides made already towards modernization of our breeding programs, and said that a combination of technology, talent and effort would reap rich rewards.

The staff here – scientists as well as support staff – are the biggest asset of the institution, he said. Their combined knowledge and experience will be the driver that can propel ICRISAT to greater heights. Therefore, he said, there is much to be gained from motivating, supporting and empowering our staff so that they can carry out their work to the best of their ability.

“ICRISAT’s legacy of several decades of life-changing work among the poorest of the poor in the semi-arid tropics – be it watershed management, the genebank or any other aspects – is also a distinct advantage that we have,” he said. “We need to converge our facilities and our staff to get optimum outputs to help our stakeholders.”

Talking about life lessons, Dr Arvind said, “We’re scientists, and science is dynamic. My biggest lesson in life has been to always be ready to learn new things. Being aware of new information will enable us to absorb it and use it to deliver better products to our ‘clients’ – the smallholder farmers.”

To young researchers just beginning their journey in science, his advice is: “Dream big, and follow it up with consistent hard work.”

On the upcoming One CGIAR initiative, Dr Arvind was optimistic that it would contribute towards more cohesive working among different CGIAR centers for greater productivity and efficiency.

“I wish that 2021 be a year of hope, better life and positive environment for all of us at ICRISAT and everywhere else and that we start our research for development activities in 2021 with new energy,” said Dr Arvind.
10 new chickpea varieties released in 2020 in collaboration with NARS

*Market-driven chickpea innovations record many firsts in Africa and Asia*

Desi chickpea variety Phule Vishwaraj (ICCV 15109) released in Maharashtra, India.

To meet the growing global market demand for protein-rich chickpea, scientists have created new varieties that would contribute to greater nutrition security, health and climate resilience and replace existing obsolete varieties. In 2020, despite pandemic constraints, 10 new varieties (6 desi and 4 kabuli) were released through effective collaborations with National Agricultural Research Systems in Africa and Asia. The releases have recorded many firsts in terms of innovations in *South and Southeast Asia* and *Eastern and Southern Africa* – regions that together contribute to 73% of the global chickpea production (http://www.fao.org/faostat/).

In 2020, *Malawi officially released its first chickpea varieties* bred for high yield, climate resilience and nutrition, while an ascochyta blight-resistant, high-yielding *desi* variety was released in *Ethiopia*. In India, *machine-harvestable chickpea made inroads into Central India* as quicker harvest time saved the crop from unseasonal rain, while large-seeded *kabuli* varieties (39-45 g weight of 100 seed) commanding premium prices in global markets were bred to suit agro-ecologies across north, west, central and south India and provide a replacement for old varieties.

ICRISAT’s chickpea improvement research has a major focus in *Eastern and Southern Africa (ESA)* and *South and Southeast Asia*. The regions contribute to 73% and 93% of the total chickpea production in Africa and Asia respectively. Chickpea improvement research in these regions is primarily with public sector organizations. The private sector has shown interest in research and development of chickpea in recent years due to its increasing global demand as a nutritious pulse crop, its climate resilience, expansion and adaptability to new regions, increasing availability of value-added products and emerging opportunities for protein extraction.

ICRISAT has been working closely with research and development organizations, the seed sector and non-profit organizations contributing to the development and promotion of improved chickpea varieties to benefit smallholder farmers by enhancing climate resilience, food and nutrition security, and incomes. The 10 varieties (see table) released in 2020 bring the total number of chickpea releases from improved breeding materials developed by ICRISAT to 117 (73 in *South and Southeast Asia*, 41 in *ESA*, 2 in *Australia* and 1 in *USA*). These varieties have contributed significantly to increasing area, productivity and production of chickpea in central and southern *India, Myanmar, Ethiopia* and *Tanzania*.

The longstanding collaboration between Indian Council of Agricultural Research (ICAR) and ICRISAT has resulted in the development of 50 improved chickpea varieties in India. These varieties have been instrumental in expanding chickpea area in central and southern India.
Chickpea varieties developed through ICAR-ICRISAT collaborations currently account for about 65% of the total demand for chickpea breeder seed in central and southern India. From 1981 to 2018, the chickpea production increased 6 times (from 1.29 million tons to 8.25 million tons) in central and southern India due to a threefold (2.43 million ha to 7.8 million ha) increase in area and doubling of productivity (530 kg/ha to 1058 kg/ha). Central and southern India is now a major chickpea-producing region of the world and, during 2018, contributed to 48% of global chickpea production and 73% of Indian chickpea production.

A high-yielding machine-harvestable desi chickpea variety ‘Eshete’ with high resistance to Ascochyta blight was released in Ethiopia by the Ethiopian Institute of Agricultural Research (EIAR), Debre Zeit Agricultural Research Center (DZARC), Debre Zeit. In Malawi, three chickpea varieties, which included two desi types and one kabuli type were released. These are the first chickpea varieties released

Ascochyta blight-resistant desi chickpea variety ‘Eshete’ (healthy variety in the middle) released in Ethiopia.
in the country (https://www.icrisat.org/malawi-officially-releases-its-first-improved-chickpea-and-finger-millet-varieties/). Dr NVPR Ganga Rao, Product Placement Lead, ICRISAT-Nairobi, played a key role in development of these varieties. The breeding lines supplied from ICRISAT-Hyderabad were first evaluated by him at ICRISAT-Nairobi and then he supplied selected lines to Malawi. Under leadership of Dr Patrick Okori, ICRISAT Country Representative for Malawi, these lines were evaluated by the Department of Agricultural Research Services in partnership with ICRISAT under the Malawi Seed Industry Development Project (MSIDP) for local adaptation and finally released through Agricultural Technology Clearing Committee of the Ministry of Agriculture, Malawi. These new chickpea varieties are expected to have high impacts on production of chickpea in Malawi due to their high yield potential and greater resilience to climate change.

About the authors:
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Dr Pooran Gaur, Director, Research Program Asia, ICRISAT.

Read more about chickpea on EXPLOREit.

Projects and Funders:
1. ICAR-ICRISAT Collaborative Research Project – Indian Council of Agricultural Research (ICAR).
3. Tropical Legumes III – Bill & Melinda Gates Foundation.
4. Malawi Seed Industry Development Project (Phase III) – Irish Aid.
5. CGIAR Research Program on Grain Legumes and Drylands Cereals – Various donors.

Partners:
1. ICAR – All India Coordinated Research Project on Chickpea.
2. Acharya NG Ranga Agricultural University (ANGRAU), Regional Agricultural Research Station, Nandyal, India.
3. Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, India.
4. Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, India.
5. Rani Lakshmi Bai Central Agricultural University (RLBCAU), Jhansi, India.
6. Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya (RVSKVV) – RAK College of Agriculture, Sehore, India.
7. Ethiopian Institute of Agricultural Research (EIAR), Debre Zeit Agricultural Research Center (DZARC), Debre Zeit, Ethiopia.
8. Department of Agricultural Research Services (DARS) and Department of Agricultural Extension Services (DAES), Ministry of Agriculture, Malawi.
9. ICRISAT.

CGIAR Research Program: Grain Legumes and Dryland Cereals

This work contributes to UN Sustainable Development Goals
Innovations

New sorghum hybrid with preferred market traits developed in partnership with Zimbabwean seed company

A new disease-resistant sorghum hybrid with 23-34% higher yield, best suited for brewing, food and forage and adaptable to diverse agro-ecologies in Zimbabwe and southern Africa was developed in partnership with Seed Co, a private seed company. The development and use of the new hybrid is a forerunner of the ICRISAT-led Sorghum and Pearl Millet Hybrid Parents Research Consortium that fosters public-private partnerships.

The new hybrid (SCXH102) demonstrated superior and consistent performance during the evaluation period. It outperformed all the check hybrids and open pollinated varieties used in the trials. Its yield potential is 3.5-8 t/ha and comes with a yield advantage of 23-34% compared to the local checks NS5511 and Rakodzi respectively.

It is an early to medium maturing hybrid with an average height of 165 cm, maturing in 92 to 115 days (Table 1). It has a stiff straw that offers good resistance to lodging. In addition, it has good resistance to leaf blight and sooty stripe. It is a brown seeded hybrid and is good for alcoholic and non-alcoholic beverages (opaque beer brewing) as shown in Table 2. ICRISAT and Seed Co collaborated with Delta Corporation, the largest beer brewing company in Zimbabwe on malting quality evaluation. SCXH102 showed acceptable malting quality levels for moisture, Sorghum Diastatic Units (SDU), solubility and malt activity making it ideal for brewing.

ICRISAT supplied sorghum inbreds to Seed Co, a primary and founding member of the said consortium and a leading producer and marketer of certified crop seeds in Zimbabwe and in the Eastern and Southern Africa (ESA) region. The breeding lines were shared by Dr Eric Manyasa, Sorghum Breeder, ICRISAT-ESA. Various hybrid combinations were derived from the inbreds and one of the combinations produced a competitive hybrid named as SCXH102. The hybrid underwent extensive multi-location trials in Lowveld (semi-arid), Middleveld and Highveld ecologies of Zimbabwe for over three consecutive cropping seasons.

As the demand for sorghum and pearl millet grain grows driven by emerging markets and alternative uses in ESA (e.g. brewing) and pragmatic food security policies (e.g. flour blending), greater productivity enhancement opportunities exist from sorghum and pearl hybrids.

### Table 1. Mean values of agronomic characteristics measured over 3 cropping seasons (2017-2020)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>SCXH102</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant height cm</td>
<td>165</td>
</tr>
<tr>
<td><strong>Days to maturity:</strong></td>
<td></td>
</tr>
<tr>
<td>Lowveld (below 800 m)</td>
<td>92</td>
</tr>
<tr>
<td>Middleveld (800 – 1,200 m)</td>
<td>113</td>
</tr>
<tr>
<td>Highveld (over 1,200m)</td>
<td>115</td>
</tr>
<tr>
<td>Leaf Blight Score</td>
<td>2.7</td>
</tr>
<tr>
<td>Sooty Stripe Score</td>
<td>1.0</td>
</tr>
<tr>
<td>Mass/1,000 seed (g)</td>
<td>28</td>
</tr>
<tr>
<td>Grain Colour</td>
<td>Brown</td>
</tr>
<tr>
<td>Principle use</td>
<td>Brew, Food and Feed</td>
</tr>
</tbody>
</table>

**Key:** Disease score: 1 = Resistant and 9 = highly susceptible
### Table 2. Malting Quality Attributes of SCXH102

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture Specification</th>
<th>SDU LSL</th>
<th>Target USL</th>
<th>Solubility LSL</th>
<th>Target USL</th>
<th>Malt Activity LSL</th>
<th>Target USL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCXH 102</td>
<td>7.884</td>
<td>39.46</td>
<td>91</td>
<td>22.25</td>
<td>27-39.6</td>
<td>35.91</td>
<td></td>
</tr>
</tbody>
</table>

Source: Delta Corporation Limited, a beer and soft drink company of Zimbabwe

Key: LSL= Lower specification Level; USL= Upper specification Level; SDU= Sorghum Diastatic Units.

which have shown >30% yield advantage over open pollinated varieties. The Seed companies have realized this potential and opportunity that will guarantee them regular seed sales as opposed to open pollinated varieties where farmers recycle seed. Due to their limited capacity to develop hybrid parents, the seed companies depend on breeding programs like ICRISAT’s to supply these. The development and release of this new sorghum hybrid in partnership with Seed Co is a big step in this direction. ■

Visit EXPLOREit for more on sorghum and work in Zimbabwe.

Reported by Hapson Mushoriwa, Principal Scientist & Regional Breeding Theme Lead Zimbabwe, East & Southern Africa Program.
ICRISAT’s state-of-the-art seed processing facilities begin operations

Efficient production of high-quality seed for research is an important activity for modern breeding and genebank programs. To bolster this activity, ICRISAT has modernized its seed processing, preparation and grain quality data collection facilities with state-of-the-art machinery and equipment which was inaugurated by Dr Jacqueline Hughes, Director General, ICRISAT, on 18 December.

These facilities, set up by the Crop Improvement Operations Team (CIOT) and Genebank, are part of the institute’s efforts to modernize crop breeding and genetic resources conservation. The seeds are threshed, dried, cleaned and graded by size and sorted by color in the facility. Before storing, the seed moisture content is determined and the seeds are mechanically counted and weighed. The seeds can also be fumigated after threshing or before being put into the cold rooms. Mechanization of seed processing can cut down the time required to process the harvest from one hectare from a month to about 10 days.

“Only the best seed has to be made available to breeders in every generation of varietal development for a breeding program to meet its objectives. Likewise, the material conserved in the Genebank needs to be of the highest quality. These facilities will help us to do so at a reduced cost, with less drudgery, in a faster and a more efficient way while allowing us to dedicate our staff to other important areas,” said Dr Hughes while appreciating the efforts of CIOT and the Genebank team for getting the facility set up and operational during the pandemic.

CIOT was launched in September 2019 by merging technical groups of ICRISAT’s mandate crops into one team to harmonize standards across crops and increase efficiency, keeping in view the larger effort to modernize breeding.

“The CIOT seed processing facility will provide many benefits to breeding programs, including increased productivity and better seed quality for research purposes and seed storage. This facility has enhanced our capacity for efficiently collecting seed and grain data with required accuracy resulting in informed breeding decisions. Overall, processing workflow will be complemented with digitization for efficient tracking, tracing and automation,” said Dr Harish Gandhi, Regional Breeding Lead-Asia and Global Head, Breeding (Interim). He further informed that similar facilities are being developed in regional crop improvement hubs in Zimbabwe and Mali.

“Genebanks are often the starting points in the search for existing and novel traits for breeding programs. Thus, it is imperative that only seeds that meet the requirements of genetic resources conservation are conserved, meaning: with high viability, properly cleaned and free of diseases. By reducing the time taken for processing seeds and increasing the quality of seeds conserved, the overall effort of conservation is strengthened,” said Dr Vania Azevedo, Head, Genebank. The ICRISAT Genebank is one of the largest repositories of dryland crops, with almost 130,000 accessions. For genebank operations seed viability, seed health and moisture content are critical for long-term conservation.
Sorghum and millet grow money for the Mariko family

*Use of improved seed triples yields, credit through warrantage system leads to big gains*

Fousseyni Mariko and his wife’s Diala Sangaré choose to grow sorghum and millets on their farm in Mali.

Access to fertilizer is a serious constraint in Sola Bougouda, Mali. Farmers looking for hardy and resilient crops that need less fertilizer than maize have shifted to sorghum and millet. The Mariko family made the shift and reaped big gains. In fact, Fousseyni Mariko, seed producer and President of the Djiguifa cooperative, is a pioneer in his community. In 2014 he enrolled in a [Feed the Future](https://www.feedthefuture.gov/) farmer field school and was one of the pilot farmers trained on seed production, credit systems, storage techniques and marketing.

Seed production business

Fousseyni recalls that there were few seed producers within the community and the yield of old varieties was around 900 kg per hectare. In comparison, the popular new varieties *Grinkan Yerewolo*, *Tiandougoukoura* and *Soubatimi* have more than tripled yield with a potential of three tons per hectare and one ton of seed per hectare.

Producers, including a significant number of women involved in sorghum seed production and marketing, have improved their incomes. Many have built new houses, while others have bought motorcycles or work equipment like threshers and plows.

The strength of cooperatives

From a single grain store for the community in 2017, the Djiguifa cooperative acquired two new warrantage stores to enhance capacity for improved varieties. Eventually with the support of American people, the cooperative also acquired a millet and sorghum thresher and fully equipped its warrantage store.

Credit from warrantage system

The Djiguifa cooperative has managed loans totaling $3,745 since the launch of the warrantage system in 2018. The warrantage system gave producers access to credit and participants were able to invest in new materials and capital assets to expand their production capacity, while others used profits to feed their families.

*Before this project, I was not a millet and sorghum producer. Now, I have five hectares devoted to sorghum. In 2018, I produced 700 kg seed of the Grinkan Yerewolo variety and grew pearl millet on two hectares, harvesting 2500 kg. After allocating grain for home consumption, I sold part of the produce for $ 655.*

— Fousseyni Mariko, Farmer
“Farmers who could barely get credit of $44 before can now access as much as $266,” Mariko observes.

**Gains for the Mariko family**

Fousseyni says he stored a ton of cereal as a guarantee for $500 credit provided by the microfinance institute Soroyiriwaso. This loan helped him branch out into other profitable activities including a small ruminant fattening business. From the profits, he bought a motorcycle and constructed two grain lockers and two stores in an urban center near his village. “I also completed the construction of an urban residence for my mother to relocate her closer to the hospital where she is undergoing medical care,” explains Mariko.

Diala Sangaré, Fousseyni’s wife, is also a seed producer and a member of the cooperative. She bought two goats in 2018 for fattening. With the profit, she was able to meet the costs of plowing and maintained her own seed plot. “I deposited part of my harvest at the warrantage store for credit of $89 in 2019 to buy my daughter’s bridal trousseau,” explains Sangaré.

Another producer and cooperative member from the family, Sidi Mariko, adds, “I availed a $177 by placing 1,500 kg of cereals in the warrantage store. I added the loan amount to my savings and bought cattle costing $399 in 2018. I also took a second loan and built a new house.”

Summing up the project impact, Mariko says, “The production of improved sorghum and millet varieties, the better management and sale of produce and the success of the warrantage system has greatly contributed to mutual trust between farmers and the microfinance institutions leading to a win-win situation for both.”

Farmer field schools like these are supported by Feed the Future through the United States Agency for International Development (USAID) as part of Africa RISING’s Large-scale Diffusion of Technologies for Sorghum and Millet Systems (ARDT_SMS). Read more about sorghum and millets on EXPLOREit.

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**Project:** Africa RISING’s Large-scale Diffusion of Technologies for Sorghum and Millet Systems (ARDT_SMS)

**Partners:** Aga Khan Foundation (AKF), Association des Organisations Professionnelles Paysannes (AOPP), Catholic Relief Services (CRS), Compagnie Malienne pour le Développement des Textiles Nord-Est, Compagnie Malienne pour le Développement des Textiles, Sud, European Cooperative for Rural Development (EUCORD), Institut d’Economie Rurale (IER), SPROXIL, myAgro, and Malimark.

**Funder:** USAID Feed the Future.

**CGIAR Research Program:** Grain Legumes and Dryland Cereals.

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This work contributes to UN Sustainable Development Goals.

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Left: Fousseyni Mariko is his grain store. Right: Cooperative members show their motorcycles purchased from incomes gained through sorghum production and commercialization via the warrantage system.
Soil atlas and two modern state referral labs launched through ICRISAT-led Bhoochetana project in Odisha, India

The soil movement started in the Indian state of Odisha two-and-half years ago through the ICRISAT-led Bhoochetana project crossed an important milestone with the launch of a soil atlas and two modern soil testing laboratories of international standard. Dr Arun Kumar Sahoo, the State Minister of Agriculture and Farmers’ Empowerment, did the honors virtually.

In keeping with the theme of this year’s World Soil Day – ‘Keep soil alive, protect soil biodiversity’, Dr Sahoo, speaking in Odia, drew attention to the Indian ethos of referring to the earth as ‘mother’ – the progenitor of life and respect towards all living creatures. He gave examples from rural traditions to illustrate the respect to mother earth. He spoke at length on the opportunities and challenges in sustainable management of soil and the various initiatives taken by the government.

Dr Jacqueline Hughes, Director General, ICRISAT, congratulated the state leadership and expressed happiness at the progress made. Referring to Dr Pawan Kumar Agarwal, Vice Chancellor, OUAT, and his thoughts on nano fertilization, pesticide application and use of robotics and artificial intelligence on precision farms, Dr Hughes said that 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. She emphasized on the quantum of work done in all the 30 districts in the state. More than 40,000 samples were analyzed based on which Soil Health Cards were given to farmers, development of Soil Health Maps, publication of the Soil Atlas, distribution of Tablets and the two state soil labs, one each at Bhubaneswar and Sambalpur upgraded with state-of-the-art equipment and trained staff.

Participating in the discussions, Dr Arabinda Kumar Padhee, Director, Country Relations, ICRISAT, commended on the impressive progress made by Odisha in the agriculture sector, nearly doubling its agricultural GDP in real terms between 2000-01 and 2016-17, clocking an annual growth rate of about 4.5 per cent against the national average of 3.1 per cent. Whilst soil nutrients are important, soil carbon is equally critical and it is important to sustain soil biodiversity, he said. Referring to ICRISAT’s expertise in improving soil nutrition by intercropping with legumes, he said that growing short-duration pulses in rice fallows and the many such techniques not only raise the productivity of pulses but also the soil nutrient profile. He spoke of the Odisha Millets Mission and said that it was a successful example with the potential to scale out to other crops. ICRISAT is ready to partner with the Government of Odisha for science-led agricultural development, Dr Padhee said.

Talking of the way forward, Dr Sreenath Dixit, Head of ICRISAT Development Center stressed on the need for policy interventions to bridge the value chain gap to improve farmers’ access to fertilizers and strategize on acid soil amendment as such soils restrict plant nutrient uptake. He said that farmers who have followed the soil health recommendations had seen a yield increase in the range of 20-60% and these benefits need to be sustained.

The web event held on December 5 was marked by forward-looking discussions and had top officials from Odisha’s Department of Agriculture and Farmer’s Empowerment and several academicians in attendance. The participants included Mr Suresh Kumar Vashisht, Special Secretary; Dr Saurabh Garg, Principle Secretary; Mr Raj Kumar Sharma, Agricultural Production Commissioner; Dr M Muthu Kumar, Director of of Agriculture and Food Production and scientists of Odisha University of Agriculture and Technology and National Rice Research Institute, Cuttack, Odisha.

Reported by Jemima Mandapati
Demand for peanut oil in India is increasing and a dependable supply of quality seed of varieties that combine both high oil and high oleic traits are highly desirable for increased shelf life and consumer health benefits, said Mr Tushar Tumar from Kedut Foods and Feeds at a recent virtual industry interface meeting hosted by ICAR - Directorate of Groundnut Research. At the same meet, scientists, traders, seed producers and processors discussed the importance of having seed production guidelines in place to ensure high genetic purity in the high-oleic seed value chain.

Addressing peanut industry, traders, and exporters virtually, Dr T Radhakrishnan, Director, ICAR-DGR sought their feedback on the opportunities and limitations in domestic and export markets to identify researchable issues that can strengthen the peanut value chain in India. Key issues from the feedback include –

- For the confectionery and chocolate industry, high-oleic peanut is high priority and a high standard of genetic purity in seed and commodity value chain, and food safety are critical for businesses.

  - Unlike high-oleic peanuts that have longer shelf life owing to 10-times low oxidation of oleic acid compared to linoleic fatty acid, peanuts with normal oleic content quickly become rancid and have low shelf life. Contamination of high-oleic commodity even with a few kernels of peanuts with normal oleic content results in quality deterioration of the confectionary product.

Two high oleic groundnut varieties: Girnar 4 (ICGV 15083) and Girnar 5 (ICGV 15090)

Salient features:
- High oleic and high-yielding varieties
- Contain 53% oil
- More than 78% oleic acid
- Oleic to linoleic acid ratio of 17
- Produce more than 3 tons of pods per hectare in the rainy (kharif) season

Where and when to cultivate:
- Recommended for cultivation in Gujarat, Rajasthan, Andhra Pradesh, Karnataka and Tamil Nadu
- Suitable for cultivation in the kharif season
- Mature in 110-113 days of sowing
The group identified the need for commercialization of more high-oleic varieties to cater to the specifications of various market segments in India, for example, large-seeded and high-oleic peanuts for the confectionery industry.

High-oleic peanut varieties with good blanchability and uniform kernel size (higher percent of Grade 1 and 2 kernels) were key traits needed by the processors that could be targeted in the Groundnut Product Profiles.

In her presentation on Global Scenario of High-oleic Peanuts, Dr Janila Pasupuleti, Principal Scientist from ICRISAT, emphasized on the need to have ‘high-oleic peanut seed production guidelines’. She noted that the use of cost-effective robust tools such as bench-top or portable Near Infrared Reflectance Spectroscopy (NIRS) is desirable. China, with about 30% of peanut area under high-oleic varieties, extensively uses portable NIRS in the seed production chain to ensure genetic purity. Her presentation was in line with the proceedings of the workshop on Seed Production Guidelines held in October under the chairpersonship of Dr K Yadav, Additional Director General (Seeds), ICAR that had participants from public seed producing agencies, State Agricultural Universities (SAUs), ICAR-DGR and ICRISAT.

It may be recalled that in response to the demand for high-oleic peanuts, ICRISAT in collaboration with ICAR-DGR and SAUs lead the development of high-oleic peanut cultivars, resulting in notification of first two high-oleic varieties, Girnar 4 (ICGV 15083) and Girnar 5 (ICGV 15090) in 2020.

Enhancing the capacities of all the stakeholders engaged along the high-oleic seed and commodity value chain was seen as critical for sustaining a high-oleic value chain in the country. The immense potential of high-oleic peanuts for processing renewed the interest of the domestic and export peanut industry in India.

Read more about groundnut on EXPLOREit

This work contributes to UN Sustainable Development Goals
Ambitious food value-chain initiatives pursue multiple development objectives of reducing poverty, malnutrition and environmental footprint by increasing smallholders’ productivity and incomes with the help of new technologies and market links.

Scientists from World Agroforestry (ICRAF), Australia’s Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) are questioning the ability of business-led value chain approaches to solve complex social issues, such as malnutrition.

They advise adopting a ‘systems perspective’ when designing value-chain interventions to consider all trade-offs and synergies between farmers, the corporate food industry, public institutions and consumers in order to build more sustainable food systems.

A business-led agricultural transformation agenda

Investing in smallholders’ agricultural innovation remains important to boost the productivity of millions of farms in the Global South and reduce rural poverty. Major food-security initiatives like the African Development Bank’s Feed Africa claim recent successes, such as Sudan’s record wheat harvest. They envision an agricultural transformation of Sub-Saharan Africa to become the breadbasket of the world by modernizing priority food value-chains ranging from maize through cassava to horticulture and cocoa.

By analysing how these important food commodities are produced, transported, processed and marketed from field to plate, value-chain assessments and interventions address bottlenecks, such as access to inputs and finance, strengthening market links, and identifying opportunities for upgrading, particularly for smallholders. New technical solutions, such as climate-resilient seeds or digital extension services, are tested to help farmers increase productivity and incomes. Further along food value-chains, interventions have, for example, aimed to improve quality standards and traceability from the farm to consumers.

But could such interventions respond to multiple development objectives while leaving no-one behind, from improving smallholders’ livelihoods (‘pro-poor’ value-chain approaches like Afrinut, a farmers’ cooperative groundnut-processing unit in Malawi) through to eradicating malnutrition (‘nutrition-sensitive’ value-chain approaches) whilst ensuring a low environmental footprint (‘green’ value-chain approaches with low water or carbon footprints)?

‘Tensions between the divergent goals of the many actors along the food chain are not easy to foresee and manage,’ said Kai Mausch, senior economist at ICRAF and lead author of a study Colliding paradigms and trade-offs: agri-food systems and value-chain interventions, published in the journal, Global Food Security.

Unintended consequences of food-security interventions

Maize and groundnut value-chains in Sub-Saharan Africa, for instance, are plagued with aflatoxin contamination, with frequent food scares and loss of export markets. Several countries, including Malawi, Kenya and Nigeria, are addressing this problem by sorting contaminated grain on farms, thanks to low-cost aflatoxin detection kits, field biocontrol and better storage practices, which benefit many smallholders and farmers’ organisations.

However, these interventions are not always the quick wins they appear to be. Poor farmers often incur losses when discarding contaminated produce, posing a substantial income risk to their livelihoods. Unsafe produce may be given to cattle or poultry or diverted to local markets where enforcement of regulations are often weak, with the unintended impact of worsening the contamination level of milk, eggs or local food sold to the poor. Tests of commercial peanut butters sold in Zambian local markets showed that up to 80% of the peanut butters exhibited unsafe levels of aflatoxin contamination.

‘Controlling aflatoxin in the groundnut sector is complex,’ said Caroline Hambloch, ICRISAT’s value-chain specialist.
expert in Malawi. ‘It is not only a technical problem. More importantly, it is critical to understand the local context and the behaviour of different value-chain actors to anticipate possible unintended consequences. You need to offer the right incentives to farmers to prevent contamination, like a premium price for aflatoxin-free supplies, whilst ensuring that consumers are aware of, and demand, safer produce and governments have the capacity to enforce regulations.’

Could we support both poor farmers and consumers at the same time?

Many urban and rural poor cannot afford a healthy, diversified diet because nutritious foods like fruits, vegetables, legumes or milk are too costly. Yet smallholders could provide such nutrient-packed foods to local markets. For instance, tens of thousands of small-scale dairy farmers in Uganda increased their milk production, sales and dairy consumption through agroforestry innovation platforms and adoption of the Calliandra fodder tree. But support for domestic production may not be the most affordable option for poor consumers.

Farming households hold an ambiguous positioning because they are both producers and consumers of food. Farmers may sell their nutritious food and use their incomes to buy less nutritious food, such as convenience and snack foods, worsening household nutrition in the long run, as has been observed with producers of nutrient-rich quinoa or finger millet. In fact, the nutrition transition is well under way in many urban and rural areas in Sub-Saharan Africa, shifting diets towards nutrient-poor staples and cheap, processed foods as observed in Zambia.

‘The value-chain approach often glosses over possible trade-offs between intertwined and sometimes antagonistic objectives,’ said Mausch. ‘It is important to look at broader effects and be open and honest about potential unwanted effects that appear outside the initial target groups. The best way to tackle such trade-offs should be debated among stakeholders in a transparent way.’

Trade-off and foresight analyses required for better food-security interventions

One challenge is to establish the right science--implementation--policy dialogues with a range of stakeholders to proactively debate how to deal with any trade-offs of poverty reduction, nutrition, environment or other development objectives. A societal negotiation may be necessary, asking tough questions about who pays for the complex societal goals of ending malnutrition or push for environmentally friendly food production.

Transparency, systems thinking and a wide range of expertise from agriculture, public health and behavioural sciences are the keys to actionable ‘do no harm’ interventions.

‘All the people engaged in designing a food-security intervention should be open to sometimes conflicting objectives between private strategies and public goods,’ concluded Andy Hall, CSIRO’s agri-food system innovation specialist. ‘With an agri-food systems’ perspective, you can identify alternative scenarios and refine your theory of change. If this is done early on, you can define possible mitigation measures and improve your impact.’

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Originally published in the World Agroforestry blog site

Read the article


This work was undertaken as part of, and funded by, the CGIAR Research Programme on Grains, Legumes and Dryland Cereals, supported by CGIAR Fund Donors. We thank all contributors to the Fund.
Kolar district, in India’s southern state of Karnataka, has been known for centuries as a district of tanks: its landscape is dotted with nearly 3,000 surface reservoirs excavated by successive ancient kingdoms to secure water for household use, livestock, irrigation and groundwater recharge. These tanks, together with shallow open wells, were the predominant sources of irrigation water up until 1985.

Then the flow began to diminish, and farmers started extracting groundwater from deeper aquifers to irrigate fields. By 2000, farmers could no longer rely on Kolar’s mostly dry ancient tanks; irrigation had shifted to borehole wells. Now a district of boreholes, Kolar has also become one of the most water-stressed districts in South India, with the gap between groundwater supply and demand growing by the year.

Why did an age-old system dry up? It’s easy to point to a rising number of people competing for the same water: the district’s population rose from 830,000 in 1972 to 1,540,000 in 2011. But no comprehensive studies investigated the hydrological shifts happening below the surface. Until 2020, that is, when a team led by researchers from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) published the results of a methodologically advanced deep dive into Kolar’s groundwater history in the Journal of Hydrology: Regional Studies. Their research, supported by the CGIAR Research Program on Water, Land and Ecosystems, shows that apparently flourishing agriculture and forestry on the surface can have serious consequences for what lies beneath.

A global groundwater problem in local focus

Granted, Kolar’s water problems are by no means unique. Human enterprise extracts nearly a trillion cubic meters of groundwater annually around the world, with 70% of it flowing to agricultural uses. India ranks first among countries in the use of groundwater, and extraction has gushed ahead from 25 billion cubic meters in 1960 to 250 billion in 2015.

Not coincidentally, assessments suggest that annual groundwater recharge in India has decreased from 447 to 432 billion cubic meters. Today, extraction exceeds recharge in 17% of India, and equals recharge in another 5% of the country. There is an urgent need to understand how rapid economic development has reshaped hydrological processes.

Titled ‘Impact of land use changes and management practices on groundwater resources in Kolar district, Southern India’, the new study aims to identify the reasons and causes of the water gap by analyzing changes extending back to 1970 and connecting these into a water balance model.

More than 40 years of public data sources provided ample evidence. This included monthly observations from wells monitored by Karnataka’s Department of Mines and Geology, weather data from the India Meteorological Department, and records of land and irrigation use from the Directorate of Economics and Statistics. Another powerful input was time series satellite data for the years 1972, 1992 and 2011, which the researchers used to visually analyze historical shifts in land use.

They backed this up with data collected by ICRISAT itself in a study of surface run-off from a 300 ha site in the district, where, for three years starting in 2006, an automatic recorder measured run-off every 30 minutes. The team also collected and analyzed soil samples, performed detailed surveys of some of the district’s ancient tanks, and computed rates of evapotranspiration (how much water is sucked up by the roots of plants and eventually dissipated into the air) for the most widely grown crops.
Tipping the water balance at both ends

The data revealed that between 1972 and 2011 there was a major shift from grassland and rainfed fields, with irrigated crops only growing in patches near tanks, to eucalyptus tree plantations (proliferating to cover 17.7% of the district) and widespread irrigated cultivation (rising to 18% of the district).

The trees and the crops have tipped the water balance at both ends. Eucalyptus trees, adapted to dry landscapes, can develop roots more than 2 meters deep and suck up nearly all water that enters the soil around them. Plantations of the trees produce extreme evapotranspiration that returns the majority of rainfall to the atmosphere and allows next to none to percolate deeper into groundwater reserves.

However, the eucalyptus trees cannot take all of the blame. Another factor is needed to explain the growth of the water gap, which is the growth in borehole irrigation. The irrigated crops included maize, which typically needs three rounds of irrigation to get through a growing season in Kolar; vegetables and fruits under year-round irrigation; and mulberry, used to feed the silkworms that produce Karnataka’s famous Mysore silk. These profitable but thirsty crops have come to replace staples like finger millet, which can easily get by on rainfall alone. As total irrigation demand has increased from 57 mm per year across the district to 140 mm, groundwater abstraction has shot up by 145%.

Towards a deeper awareness of groundwater

The process of agricultural intensification is not likely to reverse, but attending to the water balance can help in deciding permissible thresholds on water use as well as guide land use. This is a crucial concern for a majority of Indian farmers because the water gap is also an equity gap. Smallholder farmers who cannot afford to invest in ever-deeper boreholes are bearing the brunt of declining water tables. In fact, the researchers estimate that fewer than 30% of Kolar district’s farmers are able to invest in groundwater extraction from deep aquifers, leading to harsh inequality in water access.

In the face of land use that is neither equitable nor sustainable, the study’s results can help various stakeholders, including district and national authorities, develop water management strategies that will begin to heal the gap between water supply and demand – in this district, and in many others. It shows that understanding the history of land use changes, together with their hydrological consequences, is key to deciding on the optimum allocation of land uses to protect the shared resources that lie beneath.

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Originally published on Thrive blog facilitated by the CGIAR Research Program on Water, Land and Ecosystems (WLE)
Agriculture remains preferred occupation in rural Nigeria despite pandemic-related challenges

A survey in rural parts of Northern Nigeria shows that in spite of problems in accessing quality seeds and other inputs due to the COVID-19 pandemic, a majority of respondents still want to take up or continue crop farming as their prime source of income generation. Moreover, 40% of the respondents considered crop farming as a source of food security, 34% saw it as an option of diversifying cash income sources, 13% saw it as a profit-making venture and 11% as a pathway to becoming self-reliant.

As in other African countries, the effects of the pandemic have been low in the 19 states of Northern Nigeria where resource-limited farmers live and earn their livelihoods. However, some of the actions taken by the Federal and State Governments to contain the spread of the pandemic have negatively affected agri-food systems and food security. This situation was also acknowledged by African Ministers of Agriculture back in April 2020. Seed production, distribution and marketing was hampered during the lockdown period because seed suppliers could not travel between communities of resource-limited farmers and cities (usually state capitals) where most seed suppliers are based. This aggravated the challenges farmers usually face during the planting season. Further, the supply gap of quality seeds and other farm inputs was rapidly filled by dealers who sourced materials from local markets.

In order to get an idea of the general feeling about the existing situation among different communities, ICRISAT Nigeria took advantage of two commodity value chain field surveys in five states of Northern Nigeria (Bauchi, Sokoto, Kano, Jigawa and Kebbi) to interview 98 individuals, including 24 women. The surveys were conducted during August-September 2020. A one-page structured questionnaire was used for the interviews with a majority of respondents who had regular cash income-earning activities before the lockdown (this included restrictions on movements and physical/social separation).

Survey results revealed that:
- 48% of the respondents reported crop farming as their principal occupation before the lockdowns while 91% intend to pursue crop farming as an occupation after the lockdown;
- For the 2020 cropping season, 39% of the respondents sourced seeds from the open market, 30% from owned sources and 31% from various other sources;
- 40% of the respondents intend to continue crop farming for food security, while 34% wanted to do so for diversifying their cash income sources;
- 85% reported price increases of several basic commodities and major food items during the lockdown period; the price of rice rose by 40%, pearl millet (reported) by 25%, groundnut by 17% and maize by 18%.

Ms Halima Abbas Salisu, a 27-year-old graduate in agriculture from the Ahmadu Bello University, Zaria, is awaiting deployment for the compulsory one-year National Youth Service Corps. She says, “My engagement in poultry farming during the lockdown period was an opportunity for learning and income generation for me, despite the ever-increasing cost of poultry feed and chicks.”

Similarly, Mr Dalhatu Mohammad, a 60-year-old resident of Bichi Local Government Area of Kano, working as security agent pointed out, “I now have more time to devote to farming. But as I cannot get ADP (Agricultural Development Project) extension agents and good seeds of sorghum and groundnut, I entirely rely on whatever is provided to me by friends and family members.”
While it is heartening to see that agriculture continues to be at the forefront as a preferred activity for people in rural Northern Nigeria, it is all the more critical to develop sustainable supply mechanisms of quality seeds of crops grown by the farmers, so that they can be supported in their efforts, especially during periods of movement restrictions.

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**Project:** Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals (AVISA)  
**Partners:** Institute for Agricultural Research (IAR), Nigeria; and ICRISAT  
**Funding:** Bill & Melinda Gates Foundation  
**CGIAR Research Program:** Grain Legumes and Dryland Cereals

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This work contributes to UN Sustainable Development Goals

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*Ms Halima Abbas Salisu, engaged in poultry farming during the lockdown period.*

*Mr Dalhatu Mohammad, sorghum and groundnut farmer.*

Photos: L Bala, ICRISAT Nigeria
Capacity building

Training on latest technologies and best practices underway in tribal districts of Odisha, India

A series of capacity-building programs, including the use of Plantix – a mobile app to detect pests/diseases in crops, best practices in chickpea and mustard farming, and demonstrations of micronutrient addition to soil, was recently conducted in four districts in Odisha state, India. Despite the prevailing conditions, officials successfully carried out the programs while following all precautions to prevent the spread of COVID-19.

Creating awareness through field demonstrations

During a hands-on training session at Bhonsuli village, Kosagumuda block in Nabarangpur district on 3 December 2020, more than 40 farmers were guided on packages and practices of mustard (Hybrid 7701 variety) and chickpea (JAKI 9218), including the seed rate to be followed, spacing, sowing methods, nipping in chickpea, irrigation scheduling, and humic acid and neem oil for future use activities. Officials demonstrated the use of seed dibbler and easy planter.

On the same day, an exposure visit was conducted for more than 70 project farmers at the Odisha Livelihood Mission (OLM)-funded project sites of ICRISAT, in Muniguda block, Singari village, Rayagada district. At Singari, a crop cutting experiment (CCE) was conducted in the paddy field of Mr Purnima Kashi, a beneficiary farmer of the project, who has adopted micronutrient application as an improved and scientific cultivation practice. The CCE was done in a 25-square meter area, and compared with the same farmer’s conventional practices. While he obtained 15.4 kg grain yield, (6,200 kg/ha) with this method, the yield obtained with the conventional practice was 13.5 kg, (5,400 kg/ha). This showed that the micronutrient application gave significant results over conventional practice.

Training on Plantix

A group of 33 progressive farmers in Mukhubedei village of Semiliguda block in Koraput district learnt to use the mobile application Plantix for real-time detection and identification of pests/diseases. This training, conducted on 2 December 2020, was on the specially developed version of the app that is in Odiya, the local language.

A similar session was conducted on 3 December for 45 farmers in Anukumpa village of R Udayagiri block in Gajapati district; 40 farmers from Bhonsuli village in Nabarangpur district and 70 from Munigada block villages in Rayagada district. The training program was also reported in the ‘Samaja’ a local newspaper.

Under the OLM program, the ICRISAT Development Center (IDC) has been working in a mission mode, following a holistic, scientific approach. Apart from undertaking mass-scale plantation of coconuts saplings in Puri and Khorda districts which were affected by cyclone FANI in 2019, the project also focuses on creating and supplementing agriculture-based livelihoods for resource-poor farmers of the four tribal districts of

Demonstration of seed dibbler and easy planter at Bhonsuli village, Nabarangpur district.

Farmers participate in the CCE in Singari village, Rayagada district.
Koraput, Nabarangpur, Rayagada, and Gajapati. Interventions include integrated nutrient management (soil test-based nutrient application etc.), integrated pest management, best management practices in agricultural crops, scientific vegetable cultivation, and value addition to primary produce.

Progress despite COVID-19
Despite the COVID-19 pandemic, the project has been moving rapidly since its inception, and farmers and staff have been following the required safety guidelines to ensure the program’s progress and success. During *kharif* (rainy) season 2020, altogether 1932 field demonstrations were carried out, with ICRISAT supplying the required inputs.

A consortium of partners including the World Vegetable Center, Odisha University of Agriculture & Technology (OUAT), Bhubaneswar and local organizations supported ICRISAT in these events conducted successfully in the districts of Koraput, Nabarangpur, Rayagada and Gajapati. The District Project Manager, Block Project Manager, Odisha Livelihoods Mission; scientists from Krishi Vigyan Kendra (KVK); scientific officers from ICRISAT; OLM officials; staff from the World Vegetable Center and representatives from the local NGOs were present at the various events.
Chickpea scientists pool their knowhow to train younger scientists in disease management

With newer diseases affecting chickpea crops, it is increasingly important to detect and manage them on time. With a view to develop and disseminate standardized protocols for detection, phenotyping and management of chickpea diseases, a group of chickpea experts came together to share their skills and knowledge in an online workshop recently.

At the outset of the 3-day workshop, Dr Mamta Sharma, Theme Leader, Integrated Crop Management, ICRISAT, said that one of the effects of climate change has been an increased incidence of pest and diseases in chickpea crop and minor diseases becoming major. Dr Pooran Gaur, Research Program Director, Asia, ICRISAT, explained that with chickpea being grown in different regions and climates than earlier prevalent, and at more variable sowing times, it was becoming more vulnerable to certain diseases. Dr Kiran Sharma, Deputy Director General, ICRISAT, emphasized the need to have greater focus on phenotyping with standardized protocols.

Dr SK Rao, Vice Chancellor, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, credited ICRISAT with having contributed significantly towards chickpea disease phenotyping to address the needs of target beneficiaries. Development of multiple disease-resistant varieties and identification of disease-resistant gene is the need of the hour to develop a successful resistant breeding program, he said. According to the co-organizer of this workshop Dr DR Saxena, Principal Scientist, RAK College of Agriculture, Sehore, and Principal Investigator - AICRP Chickpea Plant Pathology, AICRP scientists were looking forward to the workshop for new and rapid disease phenotyping techniques to cope with the changing disease scenario.

The training workshop covered modules related to:
- Surveillance and monitoring of diseases
- Disease diagnosis and identification
- Phenotyping for disease resistance
- Innovative management approaches
- Emerging diseases and the way forward

The virtually held training session, ‘Online International Expert Workshop on Chickpea diseases – Detection, Phenotyping and Management,’ was held during 15-18 December 2020, jointly organized by RAK College of Agriculture, Sehore, ICAR-All India Coordinated Research Project on Chickpea, and ICRISAT.

Of the 250 or more applications that were received from across the world including Bangladesh, Nepal, Myanmar, Egypt, Netherlands, South Africa, Ethiopia, Pakistan, Algeria, Syria, Republic of Morocco and Malawi, about 75 short-listed participants virtually attended the various sessions from different locations over three days.

Reported by:
Rajani Kumar
Sr Communication Officer, ICRISAT

File photo of chickpea rust, an emerging disease.
Upskilling climate change experts in Mali: Training begins with live project synopsis

A training program initiated by the Swedish International Development Cooperation Agency is upskilling climate change professionals in Mali from various streams ranging from agriculture and pastoralism to ecology, meteorology and biochar technology. The launch of the training started with the seven participants presenting a synopsis of the live project that they intend to take up to benefit their institutes.

The participants are from national institutions and agencies such as the Office du Niger, Mali-Météo, Laboratory of the Tropical Ecology (Laboratoire d’Ecologie Tropicale (LET) and the National Agency for Environment and Sustainable Development. They will have access to the latest research and development in their fields of work and network with colleagues from other countries to improve their knowledge of new working methods. Regional experts in home countries and Swedish experts will supervise the trainees.

The Swedish Meteorological and Hydrological Institute (SMHI), an expert agency under the Swedish Ministry of the Environment, is implementing the training program in West Africa. The program focuses on integrating available climate information in a holistic way to facilitate sustainable adaptation measures and therefore places great emphasis on the end-users of climate information.

The ongoing training program is for 10 months including 3 weeks in Sweden. The training consists of 10 training modules including theoretical scientific content and practical tools. The topics include – Climate data, Impact of climate change on water resources, Impact of climate change on agriculture, Vulnerability analysis and risk assessment, Climate change mitigation, Adaptation and preventive actions, Decision making in a situation of uncertainty, Institutional development and Climate information and communication services.

At the workshop launch, each candidate presented the details of a live project that they will work on during the training. Each project caters to the climate change aspect of the program objectives in the participant’s organization.

Snapshots of the live projects

Building climate resilience of pastoralists: Studying the impact of climate change on pastoralists and the functioning of the family unit can offer a better understanding of the impact of pastoralism on natural resources. “Women and children face major issues related to climate change. We will try to organize them into associations to build infrastructure dedicated to the collection, processing and marketing of milk to build their resilience,” says Mr Amidou Goita, co-author of a working project on the impact of climate change on pastoralism, in Kolokani, Koulikoro region.

Weather alerts: Ms Sow Coumba Kone from the office of Studies and Research for Climate Change at the national meteorological agency of Mali (Mali-Météo) is attending the program on a joint research project with a colleague and looking forward to collaborating with other participants. “Our research project focuses on extreme climate phenomena, their frequency, intensity and impact on the livelihood of populations. Through our project, we want to suggest solutions to alert people
and reduce the consequences of these extreme climate events. We are confident that this program will help us gain experience as well as improve interactions with different stakeholders and it will be very beneficial in reframing our research work for greater efficiency.”

Mr Mamadou Diakité, Meteorological engineer and forecaster at Mali Météo, says, “This program will deepen our knowledge on the subject and enhance the impact of our work. The program offers a great opportunity of interaction with other disciplines to enrich our knowledge. Most of our facilitators are former participants of the same training and therefore are well-equipped to guide us.”

Studying the impact of climate change on transhumance: Mr Boureima Kanambaye and Mr Bouchira Maiga intend to study the impact of climate change on the evolution of the transhumant livestock system in the areas of Nioro and Diéma, Kayes region, Mali. Both, work for the Laboratory of the Tropical Ecology, Faculty of Science and Technology, University of Bamako, and aim to identify the avenues of transhumance and their evolution with climate change. They will also assess the production potential of herbaceous biomass and the pastoral value of rangelands with the aim of reducing human impact on pastoral and forest resources in terms of bush fires and overgrazing by cattle. “A socio-economic survey will be carried out with agro-pastoralists in the project sites in order to identify transhumance tracks and determine their evolution with climate change,” they said.

Biochar for sustainable energy: Mr Mohamed Lamine Sidibe, Head Research and Development, Office du Niger says his working project will focus on the development of organic charcoal by pyrolysis from non-valued local biomass in order to reduce deforestation in the Segou region in Mali. He explains his choice of theme pegging it to the fact that more than 80% of the energy needs of the Malian population are met by firewood or charcoal. The natural resources in the country are under great pressure as more than 100,000 hectares of biomass (forest, bushy savannah) disappear each year, mainly due to human activity (strong demographic growth, excessive cutting wood for fuel, unsustainable agricultural practices and bush fires). “To reduce deforestation while ensuring sustainable energy autonomy, we thought of developing bio-charcoal from non-recovered organic waste such as rice straw, water hyacinth, banana peels, corn husks, peanut shells or bush straw to replace charcoal, thus reducing deforestation and environmental degradation while meeting the energy needs of the population,” said Mr Sidibe.

The seminar ended with the roadmap of program facilitation by ICRISAT in Mali. “As facilitators, we will support participants in the development of their projects through frequent interactions, technical reviews, guidance, progress monitoring and coaching,” said ICRISAT scientist Dr Nadine Worou. “The training will help each participant improve knowledge on climate change related aspects, establish a well-extended network both in the country of origin and in the region and strengthen capacities to induce and lead positive change,” said Mr Tharcisse Ndayizigiye, Project Coordinator for SMHI.

The workshop titled International Advanced Climate Change Training Program on Climate Mitigation and Adaptation was launched at ICRISAT-Mali on December 4. The launch workshop was organized by ICRISAT and facilitated by Dr Nadine Worou in collaboration with Mr Tharcisse Ndayizigiye along with Ms Asa Johnsen, Hydrologist and training officer for SMHI, Dr Abderahim Ahmadou, Food and Nutrition scientist, Institut Polytechnic Rural, Mali and Mr Sékou N ‘Faly Sissoko, Specialist, atmospheric and environmental physics (Mali-Météo).

Partners: SMHI, Mali Meteo, IFRA-IPR Katiboubou and ICRISAT

Reported by Agathe Diama, Head Regional Information, ICRISAT-WCA

Participants working on their live project briefs.
Groundnut innovations with large kernels and high oleic content preferred by the confectionery industry in Bangladesh being developed in partnership with the Bangladesh Agriculture Research Institute was discussed during a training program that deliberated on groundnut value chain innovations.

Researchers and extension staff from government and non-governmental organizations participated in the discussion. ICRISAT principal scientist Dr Janila Pasupuleti participated virtually and shared a presentation on market-preferred peanut varieties for Bangladesh being tested for release. ICRISAT shared advanced breeding lines with the Bangladesh Agriculture Research Institute (BARI) and the evaluation trials conducted by BARI identified early-maturing and drought-tolerant lines ICGVs 00338, 07219, and 02038 and advanced to variety release testing in 2020. High oleic lines are also under testing in Bangladesh, said Dr Janila.

The enormous opportunity for cultivation of groundnuts in the Char area (riverine islands that surface after rainwater recedes post the monsoon season) in Bangladesh was raised by Dr Manjurul Kadir, Principal Scientific Officer, Bangladesh Agriculture Research Institute (BARI). He noted that farmers can reap income benefits from such an intervention that also contributes to sustainability of production systems.

The training program was conducted by BARI, Regional Station, Jamalpur on 25 November. A total of 40 participants from BARI, Bangladesh Institute of Nuclear Agriculture, Soil Resource Development Institute, Bangladesh Sugarcane Research Institute, Bangladesh Maize and Wheat Research Institute, World Vision and Sanga (a local NGO) participated. Dr Manjurul Kadir said that the training session at Bangladesh Agriculture Research Institute (BARI), Jamalpur.

Read more about ICRISAT work on groundnut on EXPLORE it

**Project title:** Enhancing groundnut productivity and profitability for smallholder farmers in Asia through varietal technologies  
**Funder:** Till 2019 OPEC Fund for International Development (OFID). Supported by CRP-Grain Legumes and Dryland Cereals (CRP-GLDC) from 2020 onwards  
**Partners:** Bangladesh Agriculture Research Institute and ICRISAT  
**CRP:** Grain Legumes and Dryland Cereals

This work contributes to UN Sustainable Development Goals

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**Training session at Bangladesh Agriculture Research Institute (BARI), Jamalpur.**

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A national seed systems strategy with special focus on drought tolerant crops such as sorghum and millets is in the making in Kenya. The strategy will leverage existing government initiatives, capitalize on agri-science innovations and use digital technologies for value chain linkage and market intelligence. For the purpose, high-level government officers and USAID’s project staff participated in a workshop to constitute a working group for strategy development and countrywide implementation through annual seed workshops with stakeholders.

Drought Tolerant Crops (DTCs) play a significant role in the food system, particularly in countries like Kenya where 80% of land is arid or semi-arid. For smallholder farmers, investing in quality seeds of improved varieties and other agricultural inputs is a critical step towards increasing crop production, and as a result, improving livelihoods.

However, most smallholder farmers of dryland cereals and grain legumes in Kenya have limited access to high-quality, improved seed at convenient outlets. Many released varieties with superior traits have still not been widely disseminated. The seed systems of the dryland legumes and cereals are highly dominated by the informal sector (farmers producing and exchanging their own seeds) along with an emerging intermediate sector consisting of community-based seed producers, while the formal sector remains relatively weak.

Cognizant of the challenges, strategies were developed for sustainable seed systems of DTCs, mainly sorghum, pearl millet, finger millet, green gram, groundnut and pigeonpea through the Kenya Accelerated Value Chain Development Program (AVCD). These seed strategies as well as seed road maps were developed for three project target counties – Makueni, Kitui and Taita Taveta. Following the successful development of county-level seed strategies, the recent workshop focused on creating a national-level platform.

Highlighting the importance of DTCs and their seed systems at the launch of the two-day workshop, the Government of Kenya’s commitment towards strengthening climate-resilient crops was reiterated by Prof Hamadi Boga, Principal Secretary, State Department for Agricultural Research, Ministry of Agriculture, Livestock and Fisheries.

Dr Romano Kiome, Chief of Party of AVCD, emphasized on the need for a unified platform in the country for DTCs and elicited the government’s support towards increased production and utilization of DTC seeds. “There may be a need for the government to give incentives to seed companies to produce open pollinated DTC seeds,” he said.

“We need to work together to have quality seed of relevant varieties along with associated good agronomic practices reached to as many farmers as possible in the country.”
country,” said Dr Rebbie Harawa, Research Program Director, East and Southern Africa, ICRISAT.

The need to develop a demand-pull strategy for the grain and end products was highlighted as participants agreed that grain markets would stimulate the demand for seed. “Grain utilization is an important factor for strengthening the DTC value chain. If these crops are targeted for prime markets, farmers will invest in high quality seed as it will make economic sense for them,” said Prof Paul Kimurto, Egerton University.

To address these challenges, a set of recommendations were made. Among them, an important decision was that the constituted team would actively push the government’s initiative on flour blending which seeks to roll out a policy requiring millers in the country to blend wheat and maize with sorghum and millets to improve the nutritional value of the products. This will ease pressure from the over-reliance on major staples like maize, wheat and rice and create markets for the more under-utilized DTCs.

Key recommendations for Drought Tolerant Crops seed systems strategy include:

▪ More government focus on research and promotion including access to early generation seed
▪ Align seed systems at the county level with a national level seed system strategy
▪ Link seedbanks to seed companies and Agrovets
▪ Leverage the government initiative on flour blending to enhance demand for DTCs grain and seed
▪ Use the national level seed release database to guide the seed systems strategy
▪ Use of participatory variety selection in identifying suitable varieties
▪ Develop a database of new varieties introduced to farmers along with market share
▪ Maintain a database of stakeholders involved in the DTC seed system as a ready reckoner for building strong seed production and delivery partnerships
▪ Emphasis on seed technology to fully utilize the genetic potential of new varieties and nurture sustainable seed systems
▪ Clear articulation of the national seed demand and supply – both present and future
▪ Appoint a national-level Seed Systems Coordinator to coordinate variety-wise seed demand and supply of various seed classes

▪ Implement the digital seed corridor and effectively use digital applications for real-time seed production, availability, and delivery tracking by organizing capacity building training for all the stakeholders
▪ Increase seed replacement rate and varietal turnover through national-level DTC seed systems platform, annual seed production and delivery planning.
▪ National-level DTC seed systems platform, annual seed production and delivery planning, increase seed replacement rate and varietal turnover.

As a way forward, the team agreed to form a DTC technical working group that will work to put together a country seed systems strategy to be implemented by organizing countrywide annual seed workshops with various stakeholders.

On 2-3 December, the project held a virtual workshop hosted by the Ministry of Agriculture, Livestock and Fisheries in close collaboration with ICRISAT, Egerton University and Kenya Agriculture and Livestock Research Organization (KALRO). The workshop titled ‘National Workshop on Sustainable and Innovative Seed Systems Strategies for Drought Tolerant Crops (DTCs)’ was attended by 78 stakeholders from the Ministry of Agriculture, Egerton University, KALRO, USAID, FAO, Kenya Plant Health Inspectorate Service (KEPHIS), seed companies, County Governments, and other stakeholders involved along DTCs seed production and delivery.

Read more about ICRISAT’s drought tolerant crops on **EXPLORE it**

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**Project name:** Kenya Accelerated Value Chain Development Program (AVCD)

**Funder:** Feed the Future, USAID

**Partners:** Egerton University, County Departments of Agriculture – Kitui, Makueni and Taita Taveta Counties and ICRISAT

**CGIAR Research Program:** Grain Legumes and Dryland Cereals

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This work contributes to UN Sustainable Development Goals.
Historical socio-economic data critical for research and policy making, say agricultural economists

ICRISAT’s socio-economic data sets for India at the district and village levels, collated over several decades, are vital for researchers, institutions and policy makers, agreed experts in a recent conference. These data sets continue to have great potential to support research and policy making, they said, and made recommendations on further use of the data.

At the conference, Dr Shalander Kumar, Principal Scientist, Agriculture Economist, ICRISAT, presented the Rural Households Panel Data (1975-2014) which has provided insights from the grassroots for informed, need-based and science-led policy making. Due to its open access nature, it is a great boon for students and young researchers; in fact, over 2,800 users (including 576 students) from more than 45 countries have already downloaded the Village Dynamics in South Asia (VDSA) data sets. These data sets have resulted in very highly cited articles in high-impact journals.

Dr S Nedumaran, Senior Economist, ICRISAT, discussed the District-Level Database (DLD) for India, and explained the features and the working of the web tool for the same. Urging all participants to share their own data for their respective states, Dr Nedumaran emphasized the importance of keeping the database up to date.

The comprehensive data gathered by ICRISAT over the years was greatly appreciated by participants, especially the fact that it was easy to access and understand.

Some of the recommendations received in response to the presentations were:

▪ The data could be used to support a district (or a cluster of districts) and one agricultural product.
▪ The data could help identify development gaps and, by comparison with other districts, help find ways to close the gaps.
▪ The data sets could be used to identify development drivers in certain lagging districts.
▪ For locations where district-level data was unavailable, state-level data could be incorporated, with appropriate notifications.

The above presentations were part of a symposium ‘ICRISAT- District level time series and household panel data for agricultural research and development planning’ as part of 28th Annual Conference of Agricultural Economics Research Association (AERA) India on 15 December 2020. Dr PK Joshi, President, AERA, greatly appreciated the quality and scope of data collected by ICRISAT.

This symposium was sponsored by CGIAR Research Program on Grain Legumes and Dryland Cereals.

For more on ICRISAT’s work in this area, click here: Poverty Dynamics| EXPLOREit@ICRISAT

This work contributes to UN Sustainable Development Goals
Shaping policies on sustainable agriculture:
Academicians and scientists talk to policy makers

The Transforming India's Green Revolution by Research and Empowerment for Sustainable food Supplies (TIGR²ESS) team from UK and India had an on-line discussion recently with Mr Anirudh Tewari (top-right corner), Additional Chief Secretary, Government of Punjab, India, on sustainable agriculture and water management among others. This was part of on-going discussion series of TIGR²ESS and the Center for Science and Policy, University of Cambridge with various policy makers in India in shaping policies on sustainable agriculture. ICRISAT was represented by Dr Rajeev Gupta, Principal Scientist & Theme Leader Genomics & Trait Discovery, ICRISAT and Flagship Program 2 leader of TIGR²ESS.
Distant yet together: A poignant celebration of our Annual Day

Reflection, gratitude and anticipation mark the occasion

With the pandemic creating havoc and disrupting lives across the globe in many ways, 2020 has been a turbulent year for ICRISAT and its workforce. Despite the challenges and constraints, the team came together as one to celebrate our 48th Annual Day – from a distance, yet with sensitivity, dignity and gratitude. It was a celebration of hard work and dedication, as much as hope and determination to overcome all hurdles. This year’s celebrations were observed with a difference – with precautions against the pandemic taking utmost priority. Most of our staff joined virtually while the staff receiving the awards were present in person.

In his message, Dr Prabhu Pingali, Chair, ICRISAT Governing Board, was glad that ICRISAT was able, despite the challenges, to celebrate the achievements and the impact that ICRISAT has on the lives of the poor, especially those in the drylands. “I’m delighted that ICRISAT continues to be a leader in science, all the way from genomics to social sciences. The work it is doing in innovative plant breeding – shifting from traditional breeding activities towards modern breeding platforms, looking at product portfolios and breeding innovations – is very significant,” he said.

Addressing all staff, Dr Jacqueline Hughes, Director General, ICRISAT, commended each member of the staff, who, in their own way, had contributed immensely to make it possible for the research and development work to continue uninterrupted – managing work from home, working at odd and extended hours while supporting their loved ones through ill health and other crises.

She also thanked all those who were working hard to make the transition to One CGIAR a reality, “for their support, flexibility and generosity of spirit.” “This turbulent time has shown us that it is a time for doers, makers and risk-takers,” said Dr Jackie, emphasizing that this year has taught many to think out of the box and work together so that “the end result is greater than the sum of the parts,” she said.

On the use of modern tools and technologies she said, “Let’s embrace the possibilities, leapfrog current technology limitations to provide better and new services, develop an enabled vision and move forward with ingenious use of technologies to help us do our work better, more effectively and more intelligently.”

“As an institute not only should we do the right things but also do it in the right manner. Upholding research ethics is the bedrock of ICRISAT’s reputation and the goodwill it enjoys with donors and partners. There are several measures for maintaining the quality of scientific research. Some are preventive (e.g. enhancing the knowledge about scientific methods, proper handling of scientific data, adequate documentation of scientific procedures) and can be overseen by research supervisors. Other measures respond to science quality concerns.”

As is the tradition, long-serving employees of ICRISAT were felicitated for their contribution to the organization on the occasion of the ICRISAT Annual Day. Employees with 10 or more years of service were invited to the
campus and awarded certificates from their respective Research Program Directors amid appreciative applause.

This year a special category of awards was instituted to honor those who had gone ‘Above and Beyond the Call of Duty’ and worked tirelessly to help manage services and operations, secure our campus locations, provide medical help, provide supplies/equipment and much more in the time of the crisis and the lockdowns, particularly during the early phases.

Working virtually has its constraints. While the Annual Day celebrations at ICRISAT Hyderabad were held on 18 December, ICRISAT offices in West and Central Africa (WCA) and Eastern and Southern Africa (ESA) held their Annual Day celebrations on 17 December so that all staff members could view these events as each location livestreamed their celebrations.

Flagging off the celebrations in Bamako, Mali, Dr Ramadjita Tabo, Research Program Director, WCA, commended the long-service awardees and those who put in extra efforts during the COVID crisis. From Niamey, Niger, giving out award certificates to deserving members of his staff, Dr Malick Ba, Country Representative, Niger, praised them for their diligence in the face of challenges. Dr Hakeem Ajeigbe, Country Representative, Nigeria, who himself completed 10 years of serving ICRISAT, applauded his team which went all out to achieve 100% of targets, despite the issues created due to the pandemic.

Dr Rebbie Harawa, Research Program Director, ESA, joined in from Nairobi, Kenya, heartily appreciating and encouraging every member of her team for coping very well with changed circumstances since the pandemic hit in March 2020. Joining the livestream from Addis Ababa, Ethiopia, Dr Tilahun Amede, Country Representative, Ethiopia, reminded the audience about the extremely challenging conditions they were facing currently, with not just the COVID pandemic but also the locust menace.
and security issues in the country. He thanked his team members for going out of their way to ensure that research work continued unhindered. Dr Martin Moyo, Country Representative, Zimbabwe, also felicitated members of his team. Dr Samuel Njoroge joined the event from Lilongwe, Malawi, and felicitated employees who had won awards for their long or outstanding service on behalf of Dr Patrick Okori, Country Representative, Malawi.

Our extraordinary Annual Day celebrations this year infused a sense of confidence and hope in the team, filling us with anticipation of achieving greater successes in the coming year.
Think big, focus on nutrition, gender, climate change research, communication and partnership

Director General of ICRISAT virtually visits West and Central Africa

On a virtual visit to offices and facilities in Mali, Niger and Nigeria, Dr Jacqueline Hughes, Director General, ICRISAT, interacted with staff updating them on the One CGIAR move, the opportunities it presents and the changes it will bring. The overall aim of the move, she said, was to ensure that research is strong with stable funding with the big focus on nutrition, gender, climate change research and strengthening partnership. Dr Hughes commended work in the region and emphasized the need for documenting impacts supported by metrics.

“Things are changing and there will be a huge demand for Agricultural Research for Development,” said Dr Hughes while addressing the staff. Modernization of the breeding program came out as a concern during the interactions. Dr Hughes said that the aim is to make sure we increase the rate of genetic gains. Responding to a query on product profiling as part of modernizing crop breeding she advised staff to think big. She emphasized the need for a broader perspective and focus on big areas including breeding crops for nutrition and forage. “We cannot breed for any small niche markets,” she said. Scientific staff were advised to reach out to Dr Hailemichael Desmae, Regional Breeding Lead-WCA, for issues related to the uniqueness of varieties in different countries.

Dr Hughes responded to queries on staffing and funding concerns in view of the One CGIAR move. She urged the staff to pursue their resource mobilization efforts and find solutions to overcome setbacks caused by the COVID-19 pandemic.

ICRISAT staff were encouraged to continue COVID-19 preventive measures and to reduce domestic and international travels. The staff appreciated the opportunity to interact with Dr Hughes. ICRISAT staff based in Dakar, Senegal, working under the CGIAR Research Program on Climate Change and Food Security (CCAFS) participated in the sessions.

Videos presented to the Director General showed offices, field stations, laboratories and storage facilities as well as research activities on crop improvement, integrated crop management, systems analysis and policy and impact. “Opportunities in Nigeria, Niger and Mali are similar in terms of funding and impact. I encourage all of you to continue participating and to keep communicating with partners, so as to increase ICRISAT visibility,” Dr Hughes said.

Dr Jacqueline Hughes, Director General, ICRISAT, virtually visited country office stations in West and Central Africa (Niger, Mali and Nigeria) on November 12 and 26.

Read more about West and Central Africa on EXPLOREit

It was like coming back home.
Dr Jacqueline Hughes recollecting her 11-year stay in Nigeria while working for IITA
About the authors:
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- Dr Nadine O Worou, Program Officer, ICRISAT-WCA
- Dr Ramadjita Tabo, Regional and Research Program Director, ICRISAT-WCA

For virtual tour of Niger click here

For virtual tour of Mali click here

For virtual tour of Nigeria click here
In December 2020, using a cutting edge technique known as genomics assisted breeding, Varshney, Research Programme Director – Genetic Gains at the Hyderabad-headquartered International Crop Research Institute for the Semi Arid Tropics (ICRISAT), a publicly-funded global organisation working alongside 49-year-old Chellapilla Bharadwaj, Principal Scientist at Indian Agriculture Research Institute’s (IARI) Chickpea and Molecular breeding programme released a new variety of chickpea called Pusa Manav in double quick time that can not only double the farmer’s yield to nearly 2,400 kg per hectare but is also resistant a fungal disease called fusarium wilt that eats away more than 15 per cent of the output in the major growing regions of central and southern India. Read more...

The Women Farmers Advancement Network (WOFAN) conducted a three-day training on knowledge-enhancing groundnut farming and profitability for extension workers, peer group leaders and marketers from five states of the country.

The WOFAN Executive Director, Hajia Salamatu Garba, disclosed this in an interview with newsmen on Friday in Abuja.

Garba said the training was organised by the group, in collaboration with International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) to expose the trainees to modern approaches in groundnut farming in Read more....

Over 7 000 farmers in Insiza and Matobo districts will benefit from a rangeland mapping exercise that was carried out by the Department of Research and Specialist Services (DR&SS) in collaboration with ICRISAT.

Prof. Wendy Umberger, Executive Director of the Centre for Global Food and Resources and ICRISAT Governing Board member, has been appointed as President to the Policy Advisory Council (PAC) by Australia’s Minister for Foreign Affairs, Senator the Hon Marise Payne.

ICRISAT congratulates her on the well-deserved appointment and wishes her all the best!

Read more on The University of Adelaide site
New publications

Breeding for resistance to diseases and insect pests in grain legumes
Authors: Gaur PM, Samineni S, Hingane A, Sharma M, Jaba J, Varshney RK, Thudi M, Saxena RK, Sharma SS, Bhatnagar PM and Sharma KK
Published: XIX International Plant Protection Congress, 10-14 November 2019, Hyderabad, Telangana, India
http://oar.icrisat.org/11673/

Effect of varied weather parameters and different sowing dates on the incidence of insect pest in chickpea
Authors: Jaba J, Pavani T, Vashisth S, Mishra SP and Sharma HC
Published: XIX International Plant Protection Congress, 10-14 November 2019, Hyderabad, Telangana, India
http://oar.icrisat.org/11674/

Fall armyworm, Spodoptera frugiperda (J E Smith): incidence, host range and its management
Authors: Sharanabasappa S, Kaleshwarawamy CM, Shivanna BK, Hosamani AC, Jaba J and Hanchinal SG
Published: XIX International Plant Protection Congress, 10-14 November 2019, Hyderabad, Telangana, India
http://oar.icrisat.org/11675/

Genetics of diapause in spotted stem borer, Chilo partellus (Swinhoe)
Authors: Dhillon M, Hasan F, Tanwar A and Jaba J
Published: XIX International Plant Protection Congress, 10-14 November 2019, Hyderabad, Telangana, India
http://oar.icrisat.org/11676/

Performance of Three Sorghum Cultivars under Excessive Rainfall and Waterlogged Conditions in the Sudano-Sahelian Zone of West Africa: A Case Study at the Climate-Smart Village of Cinzana in Mali
Authors: Müller M, Dembele S, Zougmore R, Gaiser T and Partey ST
Published: Water (TSI), 12 (10). pp. 1-11. ISSN 2073-4441
http://oar.icrisat.org/11677/

Germplasm Acquisition and Distribution by CGIAR Genebanks
Published: Plants, 9 (10). pp. 1-29. ISSN 2223-7747
http://oar.icrisat.org/11678/

Genome-Wide SNP Discovery and Mapping QTLs for Seed Iron and Zinc Concentrations in Chickpea (Cicer arietinum L.)
Published: Frontiers in Nutrition (TSI), 7 (559120). pp. 1-9. ISSN 2296-861X
http://oar.icrisat.org/11679/

Phylogeography and Symbiotic Effectiveness of Rhizobia Nodulating Chickpea (Cicer arietinum L.) in Ethiopia
Authors: Gunnabo AH, van Heerwaarden J, Geurts R, Wolde-meskel E, Degefu T and Giller KE
Published: Microbial Ecology (TSI). ISSN 0095-3628
http://oar.icrisat.org/11680/

Exploring aflatoxin contamination and household-level exposure risk in diverse Indian food systems
Authors: Audenaert K, Wenndt A, Sudini HK, Pingali P and Nelson R
Published: PLOS ONE (TSI), 15 (10). pp. 1-29. ISSN 1932-6203
http://oar.icrisat.org/11681/

Phenotypic correlation, path coefficient and multivariate analysis for yield and yield-associated traits in groundnut accessions
Published: Cogent Food & Agriculture, 6 (1). pp. 1-22. ISSN 2331-1932
http://oar.icrisat.org/11682/

Exploring the genetic variability and diversity of pearl millet core collection germplasm for grain nutritional traits improvement
Authors: Govindaraj M, Rai KN, Kanatti A, Upadhyaya HD, Shivade H and Rao AS
Published: Scientific Reports (TSI), 10 (1). pp. 1-13. ISSN 2045-2322
http://oar.icrisat.org/11662/

Crop type mapping using high-resolution Sentinel-2 Satellite Data– A case study on Gujarat State
Authors: Murali Krishna G, Panjala P, Ismail M and Pyla V
Published: Project Report. ICRISAT
http://oar.icrisat.org/11663/
Impact of Variegated Temperature, CO₂ and Relative Humidity on Survival and Development of Beet Armyworm Spodoptera exigua (Hubner) under Controlled Growth Chamber

Authors: Jaba J, Mishra SP, Arora N and Munghate R
Published: American Journal of Climate Change, 09 (04). pp. 357-370. ISSN 2167-9495
http://oar.icrisat.org/11664/

Biochemical components of wild relatives of chickpea confer resistance to pod borer, Helicoverpa armigera

Authors: Golla SK, Sharma HC, Rajasekhar P, Mishra SP and Jaba J
Published: Arthropod-Plant Interactions (TSI), 14 (5). pp. 623-639. ISSN 1872-8855
http://oar.icrisat.org/11665/

Development of a dense genetic map and QTL analysis for pod borer Helicoverpa armigera (Hübner) resistance component traits in chickpea (Cicer arietinum L.)

Authors: Barmukh R, Roorkiwal M, Jaba J, Chitikineni A, Mishra SP, Sagurthi SR, Munghate R, Sharma HC and Varshney RK
Published: The Plant Genome (TSI). pp. 1-15. ISSN 1940-3372
http://oar.icrisat.org/11666/

Identification and Characterization of a Streptomyces albus Strain and Its Secondary Metabolite Organophosphate against Charcoal Rot of Sorghum

Authors: Gopalakrishnan S, Sharma R, Srinivas V, Naresh N, Mishra SP, Ankati S, Pratyusha S, Govindaraj M, Gonzalez SV, Nervik S and Simic N
Published: Plants (TSI), 9 (12). pp. 1-14. ISSN 2223-7747
http://oar.icrisat.org/11667/

Effect of plant growth-promoting Streptomyces Sp. on plant growth and yield of Tomato and Chilli

Authors: Srinivas V, Gopalakrishnan S, Kamidi JP and Chander G
Published: Andhra Pradesh J Agril. Sci. pp. 65-70
http://oar.icrisat.org/11668/

Understanding the evolution of plant growth-promoting rhizobacteria

Authors: Sambangi P, Srinivas V and Gopalakrishnan S
Published: In: Symbiotic Soil Microorganisms. Springer, Switzerland, pp. 187-200
http://oar.icrisat.org/11669/

Comparative profiling of volatile compounds in popular South Indian traditional and modern rice varieties by gas chromatography–mass spectrometry analysis

Authors: Ashokkumar K, Govindaraj M, Vellaikumar S, Shobhana VG, Karthikeyan A, Akilan M and Sathishkumar J
Published: Frontiers in Nutrition, 7 (599119). pp. 1-13. ISSN 2296-861X
http://oar.icrisat.org/11670/

Biology of fall army worm Spodoptera frugiperda (JE Smith) on artificial diets

Authors: Jaba J, Sathish K and Mishra SP
Published: Indian Journal of Entomology, 82 (3). p. 543. ISSN 0367-8288
http://oar.icrisat.org/11672/