Event Summary and Agenda for Action

18th Triennial Symposium of ISTRC

International Society for Tropical Root Crops

CALI, COLOMBIA • 22-25 OCTOBER 2018

18th Triennial Symposium of the ISTRC

22 -25 October 2018

International Center for Tropical Agriculture (CIAT)

Cali, Colombia

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CIAT

Table of Contents

ISTRC
International Society for Tropical Root Crops

CIAT

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Position	Name	Address
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WELCOME TO
#ISTRC2018
18th
Triennial Symposium of ISTRC
International Society for Tropical Root Crops

SUMMARY

The International Society for Tropical Root Crops (ISTRC) convened its 18th Triennial Symposium at CIAT headquarters in Cali, Colombia from 22-25 October 2018. About 200 scientists from around the world participated. The majority were crop scientists representing disciplines in the biological sciences. However, participants also included policy experts, R&D managers, donors, social scientists, economists and industry representatives. Proceedings of the Symposium will be published on the Society's website (www.ISTRC.org).

The purpose of the current summary is to provide a broad overview of the presentations and discussions, and especially to synthesize some of the overarching conclusions and points for future action. Other details about the event, including information about discussion and decisions in the executive session and prize winners can be found at the ISTRC website.

The Society's principal aim is to convene triennial symposia to support and foment interactions and collaboration among the global cadre of scientists, private sector entities, development organizations, policy-makers, and others. The Society has carried out this function since its founding in 1967 in Trinidad. Organizers elaborated a symposium program around the question: 'When, where and how will tropical root and tuber crops lead the next agri-food revolution?'

The Symposium was organized along key themes in individual sessions (details in Annex I): *Scaling*; *Discovery*; *Come Clean go Clean* (pest and disease management); *Seed Systems*; *Biofortification*; *Quality Foods*; and *Building the Data Revolution*. To cover these themes, there were 70 oral presentations and 170 posters. Additionally, CIAT hosted lab and field visits, and multiple events to encourage discussion and networking.

The Symposium was strongly supported by participants from key international root and tuber-focused organizations, e.g. the Global Cassava Partnership for the 21st Century (GCP-21); the Root, Tuber and Banana Crop and Food Systems Program (RTB) of the CGIAR; Centers of the CGIAR (CIAT, CIP, IITA, IFPRI, Bioversity International) and many projects around the world supporting root and tuber research for development.

The root and tuber (RT) crops provide about 20% of global calories for human consumption, along with important contributions to animal agriculture and industry. They share several characteristics that distinguish them from seed propagated crops, and that in turn create special value in the extensive interaction and close collaboration among those who seek to improve any one of these crops. The tropical RT crops, in general, are:

- Vegetatively propagated, with major implications for seed management and for pest and disease management
- Heterozygous, having large impact on breeding approaches
- Mainly crops of the poor, grown on land that is not optimally managed for fertility, water, pests and diseases, weeds and other agronomic practices. Women are often key value chain actors, as producers, processors, marketers and consumers.

- Bulky and perishable, requiring careful post-harvest management to account for high costs of transporting and storing fresh roots or tubers. In many value chains, they are processed to create a less bulky and less perishable product.
- Primarily a calorie source. However, wide variation exists in landraces for key nutrients such as beta carotene, zinc and iron, and aggressive breeding has been undertaken to improve nutritional value.

OBJECTIVES

- Bring together leading root and tuber crops researchers and practitioners from a wide range of disciplines to review the state of the art on research and development activities involving these crops.
- Identify key research and knowledge gaps with the aim of stimulating new research for development that will realize the next agri-food revolution.
- Identify the research outputs that are ready to scale-up/out to contribute to food security, economic growth, poverty reduction and sustainable development.
- Propose appropriate policy interventions that will support the contribution of root and tuber crops translation to development outcomes.
- Propose how to strengthen public-private-partnerships for root and tuber agribusiness innovation and development.
- Assess 50 years of the impact of research and development on roots and tubers for improved livelihoods and nutrition.

EXPECTED OUTPUTS

- Symposium attendees updated on the state-of-the-art scientific developments, innovations and technologies.
- Identification of new areas of investment in research, development, and value chains.
- Advise on strategies to engage on private-public-partnership for capacity building, dissemination and implementation of research and technologies and the impact of roots and tuber crops on smallholder fields.
- Raise awareness on the importance of strengthening national agricultural development policies for sustainable root and tuber production.

Dr Lateef Sanni, incoming President of ISTRC, addresses the audience.

INTRODUCTION

The International Society for Tropical Root Crops (ISTRC), founded in 1967, is the only global forum for all tropical root and tuber crops. The October 2018 meeting was the 18th triennial meeting since the founding. ISTRC complements many other organizations in this role, especially the Root, Tuber and Banana Crop and Food Systems Program of the CGIAR (RTB) and the Global Cassava Partnership for the 21st Century (GCP-21). ISTRC plays a number of roles for the people who work on root and tuber crops:

- Sponsor regional, international meetings, workshops and training courses
- Encourage and support the establishment of regional branches and affiliates to the Society
- Sponsor study groups on subjects of importance to the goals of the Society
- Strengthen cross-linkages between national, regional and international research centers and organizations, including universities, through involvement in jointly planned research and training programs.
- Publish appropriate and informative communications, such as newsletters, summaries of the status of particular crops, lists of research workers and their areas of specialization, proceedings of meetings and other appropriate publications
- Facilitate the exchange of personnel and germplasm materials
- Provide financial assistance if possible to members of the Society from developing countries to attend the Society's meetings.

At the time of the founding of ISTRC, just over half a century ago, the world of agricultural research in developing countries was focused on the strategies that had brought dramatic success to yield improvements for rice and wheat through 'Green Revolution' technologies: varieties responsive to intensified management, and the accompanying agronomy package, usually including water, fertility and pest management for high productivity. At first, many in the R&D world of donors and research organizations felt that the same approaches for wheat and rice could be broadly applied across the basic food crops. However, solutions for improving other crops proved much more diverse and complex. RT crops were usually cultivated on small plots, with few purchased inputs, and with diverse market requirements.

Research got a major boost when three centers of the CGIAR were mandated to work on several RT crops: CIAT (cassava); CIP (potatoes, and later sweet potatoes) and IITA (cassava and yam). These centers soon recognized the unique features of the RT crops, which suggested a different and more complex research agenda as compared to the major grains. While the common features among vegetatively propagated crops were well recognized, there was no broad coordinated effort to exploit the efficiencies and synergies of working together across the crops. Although ISTRC provided a common forum, it did not have the leverage to obtain significant funding across the crops. Not until 2012, with the CGIAR reform, was there a major effort to work across these crops to maximize benefits from the common challenges and common approaches.

There have been major shifts in the regional importance of RT crops since the founding of ISTRC. Most notable of these is the massive increase in production of cassava in Africa, which now accounts for over half of the global supply. Research focus has shifted accordingly, with a large share of donor funding for research in support of Africa. Likewise, publicly funded sweetpotato and yam research has also shifted toward Africa. Development organizations and donors are increasingly recognizing the value of these crops in nutrition and income for the poor.

The symposium organizers specifically chose topics and designed a program for the various RT crops to interact and benefit from cross-crop experiences. The topics reflect the recognition that research needs to be structured along the value chain in order for the customers of the products of research to fully benefit. New tools support achieving goals faster and more efficiently, but usually don't alter the goals. High yield and high quality for product customers often remain the means to support actors along the value chain. But achieving those goals becomes ever more precise with new tools, along with old tools practiced more effectively.

The symposium emphasized what is new in key themes that are all fundamental to successful RT research for development: *Scaling*; *Discovery*; *Come Clean go Clean* (pest and disease management); *Seed Systems*; *Biofortification*; *Quality Foods*; and *Building the Data Revolution*.

SESSION OVERVIEWS

SCALING: Scientific innovations that have impact on root and tuber crop systems and those who depend on them

Ultimately even the most technically successful research has limited value unless its benefits reach intended customers. More people now live in cities than in rural areas around the world, even in Africa which is the most rural among major tropical RT producers. Food systems are often failing, and the RT community asks how it can contribute to improvement.

Scaling theory and practice are receiving increasing attention. Research cannot succeed on the concept of *build it and they will come* as a theory of change to scale technologies for impact. There is no single model, but customer profiles are a critical starting point to successful scaling. A 'scaling readiness approach' used by RTB treats innovation as a flexible package of technological, organizational and institutional components that may include crop varieties, equipment, management practices, legislation and marketing. An innovation may be ready in a technical sense, for example a new crop variety may thrive in the local environment, but if farmers lack funds to buy seed or if the policy environment discourages the uptake of new varieties, it may not be adopted. This approach assesses the potential of technologies and other innovations supported by RTB to be used at scale, and guides researchers and other stakeholders in implementing these innovations in practical contexts.

Too often investment in scaling is linked to specific projects, and begins and ends with a project. Few or no resources are allocated, nor experts involved. Many projects have unrealistic ideas about impact in the short term. However, scaling constraints often cut across multiple value chains, and the institutional, financial and social elements need to be in place to broadly support scaling. The recommended approach to scaling is to plan the process when the project is written – to apply the appropriate theory of scaling from the outset, with an understanding of the science, the process and the expected outcomes. Most of all, scaling needs to meet the demands of the people who will apply the scaling. There is some evidence that scaling is only sustainable through government agencies or the private sector (or public private partnerships), but not through development organizations. Scaling is successful when it is sustainable. Although the model for sustainability will vary widely from one situation to another, situations where customers are paid to adopt a technology cannot be considered successful scaling. Scaling often begins small with each of many users rather than large scale with fewer users. The ‘try and grow’ approach with farmers is a typical scaling strategy that can work when managed well.

Roots and tubers are often stigmatized as a crop of low economic value, a crop of low nutritional value, a crop of the poor. They tend to fall out of favor with urbanization. As such, it is necessary to create an enabling environment for value chain interventions, with scaling through market development, such as culinary innovation. Applying market development principles has a critical role in changing perceptions about food and food products.

Key questions in the planning process are:

- Need to understand the components (technological, social, market, political) of scaling, and know which ones require support and strengthening
- What do we need to overcome the bottleneck(s) for scaling?
- What is our theory of scaling to achieve that?
- Who de we need to partner with (media, lobby group, etc.)?
- What is the best partnership process?
- Where to invest for maximum impact

In answering the question, 'scaling for whom?' there are many, and perhaps a majority, of the situations in RT value chains where women and youth are critical components of a scaling strategy, both as beneficiaries of the technology being scaled, and as key actors in successful scaling activities.

Lessons Learned from scaling (small, medium and large scale) include:

- ensuring profitability is key and drives sustainability;
- end-user concerns are key to investment decisions; quality management and constant supply is key;
- effective partnerships are critical;
- support required is different by country. Advanced technical support may not always be available locally;
- institutionalization of the value chain necessary for sustainability;
- categorization of youth involvement in the cassava value chain helps track employment opportunities.

One of the powerful tools in a scaling strategy can be mechanization. However, mechanization often has strong gender implications, and can be highly disruptive (either beneficial or harmful) to women's interests. Mechanization often transforms women's work into men's work, e.g. planting, weeding, pest management, harvest, and processing. Machines are typically made by male mechanics, and are a symbol of masculine power. Men and women have very different perspectives on what labor saving technologies are available. Adjustments are needed for women and more images of women using machines are needed.. Understanding interests of men and women – power, culture norms, social value – is therefore an essential starting point. For whom is the scaling? Mechanization initiatives need to move beyond production and productivity toward social impact.

As one of the major themes of the symposium, seed systems also played prominently in the discussion on scaling. BASICS is a major project funded by the B&M Gates Foundation to support cassava seed system development in Nigeria. Key scaling strategies include semi-autotrophic hydroponics (SAH) for rapid multiplication of virus-free plantlets to feed into a breeder seed system; and a Village Seed Entrepreneur model to put seed system management into the hands of local entrepreneurs rather than large centralized seed systems. An information system was developed to manage and monitor all aspects of the seed system and to facilitate transactions for both buyer and seller. Information management systems, designed with all value chain actors in mind, are critical to successful scaling. E-certification was launched in Oct. 2018 in Nigeria, a world first.

As with seed systems scaling, the theme of biofortification also gave rise to several examples of scaling challenges and strategy. One of the largest projects on scaling for biofortified RT crops is the example of Provitamin A cassava dissemination in Nigeria, supported primarily by HarvestPlus, along with many local, national and international interests. Scaling has been achieved by multiple actors, whose roles have significantly evolved over time. This evolution will not be fully predictable, but should be broadly planned as part of a long-term scaling strategy. Initially, most planting material was distributed by researchers and other project personnel as part of the project funding. But this has limited reach and low sustainability. Later, extension services and informal exchange among farmers became more prominent in the scaling. Currently, private sector seed services are rising in prominence, and considered the most effective and sustainable basis for scaling. The combination of these strategies has succeeded in two varieties of high beta carotene cassava being adopted by over 60% of farmers in the target regions of Nigeria.

Conclusions were:

- Quality was crucial to market success, which tends to be a challenge for small processors
- Significant opportunities for both commercial and community processors
- Rural markets absorb products slowly and therefore require massive promotion through end user demonstrations
- Market segmentation is critical in developing markets for cassava products
- Knowledge of physico-chemical properties of cassava flour facilitated market development. Future research should focus on characterizing functional properties of cassava varieties
- Quality management of products gave confidence to end users to continue buying cassava flour
- Readily available service provision was critical in creating market opportunities for cassava products

DISCOVERY: How to sustain genetic gains in root and tuber crops

The term 'discovery' was used in this symposium to refer to the exploration and development of advanced science to solve problems more effectively and efficiently than is possible through traditional solutions. Discussions covered technology and information primarily for application to management of genetic resources, breeding (advanced genomics and phenotyping), and pest and disease management.

The Discovery session covered the following broad topics, with examples across crops and regions:

- Development of inbred-hybrid technologies for RT crops
- Genomics for management and use of genetic resources
- Genomics to accelerate genetic gain
- Physiology and high throughput phenotyping, quality traits, and pest and disease management

Inbred-hybrid technologies for RT crops

There are currently no commercial F1 hybrids in the tropical root and tuber crops, i.e. hybrids resulting from the cross between two inbred lines (or variations of this scheme). Breeders have hypothesized for many years that cassava, sweet potatoes and potatoes could benefit in multiple ways from such an approach. In summary, there are four main advantages suggested (the order of importance of these advantages will vary by crop and by each specific application situation).

- Heterotic effects, as seen for many crops, most notably maize
- The ability to 'breed by design' in much more precise ways. There would not be wide segregation for a multitude of traits each time a cross is made. For example, with inbred parents, simple backcross methods could be applied to RT crops

- Varieties could easily be 'cleaned up' from the large majority of pathogens by generating through a true seed generation.
- Seed systems could be made more efficient by use of true seed for easier transport and faster multiplication rates

The symposium presented examples in potato and in sweet potato where inbred-hybrid systems are being developed in advanced stages (potato) or early stages (sweetpotato).

The case of potato was presented by the private company Solynta from the Netherlands. The company is aiming primarily at penetrating the 10 billion dollar potato seed industry. The project is based on inbred diploid lines and aims for a 30% productivity increase over current commercial varieties in five years. A major challenge, and where large progress has already been made, is to increase the vigor and yield of the haploid clones. Within 2 years the company expects to introduce two effective resistance genes to Phytophthora (vs 45 years previously spent on resistance breeding). The company will make lines available to the scientific community for further research.

True potato seeds are:

- Clean
- Easy to transport and store
- Fast multiplication – millions of seeds in one season
- 25g TPS instead of 2500 kg seed tubers per hectare

In the case of sweetpotato, CIP is working toward hybrid sweetpotato to exploit high heterosis, to more easily stack simply inherited traits, and to achieve more stable yield as compared to traditionally developed breeding lines. The project is carrying out recurrent selection in two gene pools and selecting parents with high general combining ability. In published results, the project has demonstrated a heterosis increment and genetic gain in crosses among various populations.

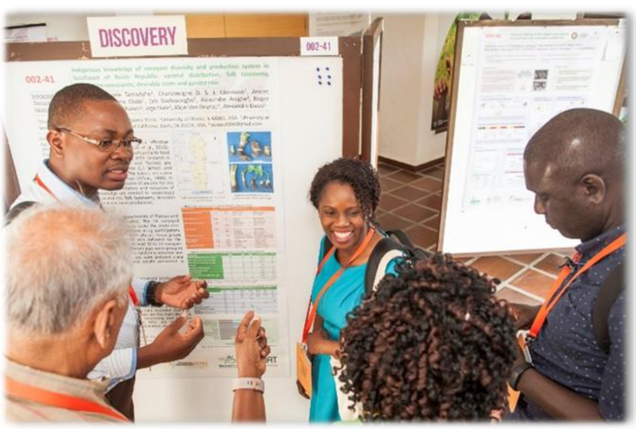
The private sector potato hybrid case demonstrates the level of planning and funding that needs to go into a successful RT inbred-hybrid system. To date, the efforts in cassava and sweet potato have been more at the level of developing the theory and the rationale for such a system, but this has not attracted the significant funding to put into place a comprehensive, long-term inbred and hybrid development scheme. The next steps may be to develop well-founded business plans that demonstrate the investments required for success, and the expected returns on these investments.

Genomics for management and use of genetic resources and to accelerate genetic gains in breeding

Genomics work was described for cassava and yam in the oral sessions, with many posters also addressing these and other crops. Genomics research is supporting both germplasm management (e.g. genebanks) and breeding systems to increase efficiency and efficacy.

Yams are one of the most complicated crops for the study and application of genomics-assisted breeding. In spite of these challenges, significant progress is reported:

- Whole genome sequencing and resequencing of *D. rotunda, D. alata. D. dumetorum* and other species ongoing
- Genotyping by sequencing of guinea yam
- DArTseq of *D. rotundata* and *D. alata* for diversity and population structure; linkage mapping and QTL analysis
- High throughput phenotyping
- Considerable progress in genomics assisted breeding
- Application of MAS implemented but still needs to be extended to other traits
- Finalizing HTPG marker selection process for routine activities in yam breeding program
- GWAS tested on several traits
- Develop comprehensive marker linked to key traits in yam
- Marker assisted selection for anthracnose disease in *D. alata*
- Establish yam genome hub for breeding community



Cassava has been the beneficiary of a large B&M Gates-funded project. The primary goal of this project is to put in place methods and infrastructure that will dramatically increase the rate of genetic improvement of cassava varieties in sub-Saharan Africa, starting with programs in Nigeria and Uganda"

The first 5-year phase of the project was strongly focused on proof of concept for genomic selection, and attacking some of the intransigent challenges of cassava as a target of breeding, such as sparse flowering and introduction of new gene sources into the program. The efficacy of genomic selection is still a matter of focus of the project, but initial results showing that some traits, such as CMD resistance, are highly amenable to more rapid improvement through genomic selection.

Pest and disease management, especially resistance, is one of the strongest investment areas for genomics. As the vectors of two of cassava's most devastating diseases (cassava mosaic disease and cassava brownstreak disease), the whiteflies are justifiably a prime target for better understanding through genomics research. CIAT presented progress and future plans on QTL mapping for whitefly resistance, based on resistance found in Ecuadorian germplasm in the 1980s. Although the resistance has been successfully transferred to commercial varieties, accelerating gains in the future, and especially transferring resistance to key environments in Africa and Asia, will require genomic approaches.

The use of genotyping for breeding relies on robust genome assemblies. While the RT crops had lagged for many years compared to the major grain crops, these gaps are being filled in recent work. The symposium presented research results on improved cassava and water yam (*D. alata*) and the white yam (*D. rotunda*). Clonally propagated crops are a challenge because of heterozygocity. In the case of cassava, availability of an inbred line (94% homozygous – AM560-2) simplified developing the genome assembly.

Physiology and high throughput phenotyping

Understanding of RT growth and development is crucial to the design of selection schemes to accelerate genetic gain. Combined with significant advances in sensors and data management, crop improvement teams have powerful new tools to select superior genotypes more accurately and more quickly, including root, stem and foliage growth and development, root and tuber quality traits, and pest and disease management

Research at Penn State University is looking at root system architectural traits under phosphorous deficiency in sweet potato. The main issue of phosphorous is availability to plants, and yields are far below potential due to P deficiency. The proposed approach is to visualize the system through a 'phene to gene' concept, focused on understanding the pathway toward selecting for higher plant efficiency, and especially root systems. Precise imagery of lengths, angles and numbers of roots is helping physiologists provide recommendations to breeders about best root architecture for yield under varying environmental conditions, such as low P. In addition, laser ablation tomography allows detailed 3D visualization of internal root structure and the changes that occur under different treatments and for different genotypes. While these techniques are most advanced for maize, the facilities at Penn State are open to the possibility of further work with the RT crops.

Some important fundamentals emerged in the discussion on discovery research for RT crops:

- Discovery research in RT crops should generally be driven by the need to find better solutions to research questions with known practical application. 'Blue sky' research, or basic research for the sake solely of advancing knowledge, is usually more appropriate for basic and more broad-looking institutions.
  The advanced knowledge and tools for RT discovery research often derive from work initially aimed at the better-funded grain crops.

- There is a need to adopt tools from the crops that have much more public and private sector investment (i.e. to take advantage of *spillover* effects) but at the same time recognize the unique approaches required for some of the unique features of the RT crops.
- Systems that support interaction, collaboration and coordination among crops will benefit RT crops. A good example is the Excellence in Breeding Platform of the CGIAR.
- The tools from discovery research, when successful, typically become a routine part of research, such as pipeline (or stage-gate) breeding, and discovery moves on to other challenges.
- Advanced science is high risk. Many initiatives will fail, but the successes can have huge impact.
- Projects need to have a basis in a business plan that will demonstrate return on investment (social, economic) over the long term. Hybrid potato a good example. Can it be done for other R&T crops?
- Market diversification is one of the important drivers of demand-led discovery research.

COME CLEAN go CLEAN: How epidemiology, pest and disease management, molecular diagnostics, and disease monitoring will shield our crops

Pest and disease management are critical in RT crops for all the reasons that it is important in seed crops – managing losses that cut into farm profitability and put food security at risk. However, the added dimension of vegetative propagation for the RT crops means that pests and diseases are even more challenging. Many, and especially the viruses, are easily transmitted from one generation to the next. Breeding for resistance, fast reliable detection methods, precise monitoring systems, and regulatory effectiveness are key components of protecting the RT crops.

High reliability in virus indexing technically allows safety of movement of germplasm across political boundaries at levels of safety much higher than before. However, regulatory agencies frequently lag in their regulations, resulting in suboptimal exchange. At the same time, there is increasing demand for seed movement, which is met by under-regulated and under-monitored systems of cross-boundary transport.

An example from the Peruvian potato virome illustrated the massive complexity of viruses in the RT crops. A study from 994 georeferenced samples showed 15 different known viruses, plus 839 unknown viruses. They showed mostly a regional grouping, but also a history of movement within the country.

As noted in the example of potato viruses in Peru, identification of new viruses in the RT crops is common. A study on cassava in Colombia showed that a Torrado-like virus is common, and has been implicated in symptoms of the cassava frogskin disease. In addition, three different species of potex virus were found (CsCMV, CsNAV,CsVX).

Most viruses apparently do not have significant effects on production, but can present significant challenges to regulatory authorities. One of the critical aspects of this management is to have up-to-date reliable and accessible databases so that scientists, extension personnel and regulatory agencies are sharing information. To this end, CIAT has developed, and currently curates, the PestDisPlace database (plantdisplace.org).

Global warming represents a potential risk that new/exotic viral disease on potato may (re)appear. Both viruses and host plants will be affected, causing changes in: magnitude of disease expression, geographical distribution of particular viral diseases, economic importance of particular diseases in a given location, and the set of diseases that challenge potato production. Generally speaking, global warming might cause changes in the impact of diseases on crops by affecting pathogen development and survival rates, modifying host susceptibility, and changes in vector abundance or prevalence

In vitro and other controlled propagation systems have been used for several decades to manage pests and diseases in RT crops. However, there is increasing interest as well on simpler systems that rely on 'positive selection' at the field level. The hypothesis is that plants with fewer visible symptoms, verified by virus testing, might have a lower pathogen load, and therefore provide a means to reduce disease in the next generation if preferentially used for seed.

Positive selection – using only plants with no or few disease symptoms as sources of planting material -- was tested across 50 sites in Abuja State of Nigeria for yam mosaic virus, a potyvirus, which causes up to 40% yield reduction, and robust resistance is not available in commercial varieties. By selecting plants based on symptom severity and virus testing, mean incidence of the virus was reduced by 40% without infusing clean seed from in vitro sources. The study concluded that positive selection is useful to maintain healthy seed stock, but that infusion of virus-free seed is still important to further reduce virus incidence and increase availability of virus-free yam.

At the same time, it should be understood that in the case of cassava mosaic disease (CMD), plants without symptoms do not necessarily indicate plants without the virus. Nigerian data showed that whole fields that looked clean had CMD viruses. Tolerance can be a high risk factor for spreading virus if unsupported by good certification. A molecular test is impractical at the certified seed level (logistics, volume of seed, cost) but can be considered at the level of breeder's seed. Using LAMP, a breeder's seed standard will established in 2018/19 in the BASICS project in Nigeria. BASICS will soon be introducing new high-volume multiplication practices for breeder's seed, based on commercial principles.

One of the most challenging of cassava viruses is the causal agent of cassava brown streak disease, estimated to cause losses of more than US$726 million per year. Phytosanitation and resistant varieties are the key approaches, supported by regulation on cross-boundary movement. RNA-seq studies at NRI showed 19 genes in common to all resistant varieties. In summary: phytosanitation can minimize the spread of CBSD effectively; several resistant varieties are currently being identified and using them is the best way to control CBSD; and there are a dozen + candidate R genes that NRI is investigating further to confirm their role in CBSD resistance

While much of the session on pest and disease management focused on viruses, a team from Costa Rica reported on attempts to manage root rot disease, caused by soil-borne Pythium, in Cocoyam through a search for resistance in wild Xanthosoma. The problem is especially acute because once soil is infested, cocoyam cannot be grown for more than 15 years, and IPM has not been very successful. Among 77 accessions tested for resistance (wild and cultivated), 16 wild accessions showed tolerance/resistance. These will be further evaluated and conventional crossing done to transfer resistance to commercially acceptable varieties.

Crowd sourcing and artificial intelligence (AI) are coming together in new research on pest and disease surveillance systems. A mobile-based AI Assistant called *Nuru* (*light* in Swahili) is being developed and managed under PlantVillage (https://plantvillage.psu.edu). The system is based on analysis by AI of thousands of images which have been confirmed representations of specific diseases, and comparing them to images from 3 upper and 3 lower leaves from a plant of interest. The smart phone app identifies the disease and provides follow-up advice on management. Next steps are to: Broaden coverage to other RTBs; link with other CGIAR apps; connect to molecular diagnostics; add a feature phone module; build a complete 3-step solution (identify problem, access solution, and control problem); and discuss next steps with scaling experts.

CIAT presented an update on the situation of the Sri Lankan cassava mosaic disease in SE Asia, first reported in Cambodia in late 2015. In spite of multiple attempts to motivate action toward eradication, the disease has now spread to Vietnam and Thailand as well. This represents a major threat to cassava in the region. GCP21 supported a regional conference in September of 2018 to bring together research programs and regulatory agencies of the region to promote joint action to control the disease. Long term, breeding for resistance, clean seed systems, and more stringent quarantine systems will be needed. Already, CIAT has introduced crosses between locally adapted materials and sources of CMD resistance to the region, and IITA is also planning to introduce their best resistant materials.

As an overall conclusion from the session, presenters proposed that in most cases, at least for the major RT viruses, host plant resistance is the best long-term solution. While starting with clean planting material is key, susceptible material will sooner or later become reinfected. Reinfection can be slowed but is not a final solution. Regulations must be supportive. Regulators and other non-research partners are typically not a part of our technical meetings, and need to be brought in for integrated solutions.

SEEDs or NO SEEDS: How to create root and tuber seed systems

Seed systems in tropical RT crops typically focus on the main challenges as compared with seed propagated crops:

- Formal seed systems are rare (more common for potato than the other crops) since farmers are able maintain varieties true-to-type through vegetative propagation.
- Multiplication rates are low, and often some form of rapid propagation needs to be introduced into the system for scaling
- Pests and pathogens, and especially viruses, are easily passed from one generation to the next via vegetative propagation material (stems, roots, tubers, corms, etc.)

- Regulations on seed movement across boundaries are often insufficiently developed and not adequately enforced.
- Seed certification systems may be non-existent or inadequately executed

Good data on seed quality in informal systems, and its impact on yield and quality, are scarce. Losses due to poor quality seed are often extrapolated from worst-case scenarios, based on experimental comparisons of clean vs highly infected materials. In the real world, fully clean materials may rarely be available even under 'clean seed' systems, and actual losses in farmers' fields may often not reach the levels of worst case. Losses are usually cited as 'up to' a certain level, but this does not necessarily reflect what the large majority of producers may experience.

One of the main constraints to formal seed systems is the high year-to-year variability of demand. Farmers typically are able to produce adequate supply in some years but not in others. If a new variety is introduced, initial demand may be high, but then declines after farmers are able to produce their own supply. Drought, pests and diseases, or early harvest (where seed cannot be stored until next planting season) all impact demand and the viability of a system that depends on predictable sales in order to be sustainable. These challenges were addressed through various approaches by the presenters in this session.

Modeling based on data from many systems, and projecting future technology advances, can help describe current systems and design new ones.

In the RT crops, because seed systems are largely informal, policy has typically not been well-developed with regard to seed certification, control or support. This is changing somewhat as a result of some major events and initiatives.

First, major projects supporting new variety distributions or seed systems per se. *BASICS* for cassava seed in Nigeria; *SASHA* for yellow-fleshed sweet potato in Africa, *NextGen Cassava* to develop new varieties, and HarvestPlus, supporting the dissemination of various RT crops, but especially cassava in Africa, for example are all supporting to some degree the development of better seed systems.

Secondly, new threats from pests and diseases that are disseminated through seed have put an urgent spotlight especially on cassava. The two major issues are the introduction of cassava mosaic disease to SE Asia at the end of 2015, (described in the previous session summary) and the relentless westward march of cassava brown streak disease from East Africa toward West Africa.

In all countries there is a tradeoff between cost and benefits of regulation, and different countries have chosen different seed system regulatory strategies.

Best practices for regulatory policy were suggested as:

- Allow for regulatory autonomy
- Introduce multiple standards
- Introduce flexibility to update standards
- Certify at earliest generations only
- Invest in farmer/entrepreneurial capacity
- Create market opportunities for clean seed

As seed systems in RT crops begin to develop more formally, and even where informal systems continue to predominate, effective information management systems can contribute substantially to access, efficiency, effectiveness and profitability. To that end, IITA has developed a SeedTracker web app for seed value chain and inventory management, monitoring, evaluation and trade (www.seedtracker.org). Seedtracker™ digitally connects seed producers, seed traders and seed quality certifiers. It is a fully featured program for real-time tracking of seed production, including pre-planting, planning, registration of seed fields, crop management, harvesting, quality assessment and quality assertion. It includes a mapping function with full data, including variety name, and allows ordering seed through the web. Seed Tracker is usable on mobile phones, and this model tracker can expand to many other trackers such as yam seed and cassava peels.

One of the most comprehensive seed projects in the history of RT R&D is the BASICS project (Building an Economically Sustainable, Integrated Seed System for Cassava) for cassava seed systems in Nigeria, funded by the B&M Gates Foundation and managed by RTB. The project focuses on overcoming some of the main challenges defined for cassava seed in Nigeria.

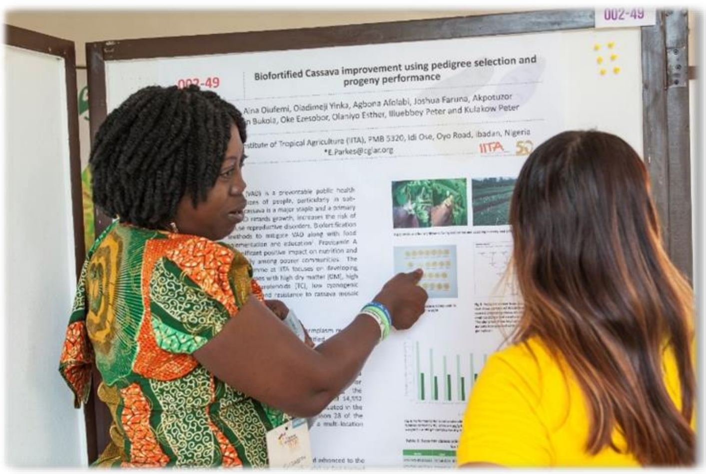
The objective is to develop a sustainable seed system for Nigeria that is based on commercial sale of cassava planting material that is produced with high quality standards, and certified by the National Agricultural Seed Council (NASC). A core of the project is the Village Seed Entrepreneur model (VSE). In pilot cases, there is already evidence of significantly higher profitability for farmers engaged in seed production compared to those who produce roots only ($350/ha profit for stem plus root versus $70/ha for roots only).

RT seed systems have always faced a challenge of sustainability after the project is over. Successful systems will require that farmers see the added value of quality seed, and that in turn they see that value being best provided by trained specialized seed producers.

The presentations and discussions indicated a wide range of experiences in RT seed systems, with a need for linking those experiences to consolidate lessons and apply them to future project design. A common lesson from past projects in seed systems is that too often motivation for seed producers, seed buyers or both, is that the system has functioned on the basis of subsidized elements that have not been designed for sustainability in the absence of such external inputs. Some of the current seed projects are well aware of this challenge and are seeking to address the sustainability issue.

BIOFORTIFICATION: How to improve nutrition and health through roots and tuber biofortification

The 2016 World Food Prize presented to the research team of Drs Maria Andrade, Robert Mwanga and Jan Low, and the HarvestPlus director Howarth Bouis, brought root and tuber crops front and center on the world stage in terms of their potential to contribute to nutrition and health. Certainly RT crops contribute immensely to global nutrition (20% of calorie consumption) even without the added value of micronutrient enhancement (biofortification). But biofortification is now reaching levels of impact that are convincing even the most skeptical, of the value of this research investment for the long term. Most of the RT work has been with cassava (beta carotene), sweetpotato (beta carotene, zinc and iron), and potato (zinc and iron). There are emerging crosscutting lessons as well as lessons that will enable better outcomes for the other RT crops to benefit, such as yam.



Urbanization and higher incomes have played critical roles in human nutrition. The nexus between rural productivity and profitability, and access to nutritious affordable food for urban dwellers is important to our understanding of solutions to both under-nutrition and over-nutrition (obesity). In order to reach urban markets at reasonable cost, food products need to have low perishability and to be shipped at relatively low cost, i.e. high value per unit weight. RT crops tend to be both perishable and of low value per unit weight (high water content). Therefore most RT crops will increasingly be converted into more convenient, higher value products as urbanization progresses and incomes rise. This added value in the marketplace does not equate with higher nutritive value, and in fact is often quite the opposite. RT crops have a special challenge here because the main products (roots or tubers) have mainly calorie content. When processed into snacks or convenience foods, nutritive value may be even lower. Agricultural research scientists alone can't change the course of history in this trend, but nonetheless have the power to make major contributions to better nutrition for both rural and urban poor through biofortification that will have value both in fresh and processed products.

As breeding programs scale up to move more biofortified candidate varieties through the pipeline, it is also essential to improve the efficiency and accuracy of the screening process. For cassava, near infrared spectroscopy (NIRS) has been a fundamental tool, with results at much lower cost and much faster than high-performance liquid chromatography (HPLC). IITA and partners in Africa are now adapting and adopting the technology developed at CIAT. In addition, a range of other traits such as dry matter content, cyanogenic potential, mealiness and poundability are being studied as targets for rapid assessment by NIRS. New miniaturized and less costly machines will drive even greater use among breeding programs and quality labs. For breeders, the work on finding linkage groups for beta carotene expression will support marker assisted selection.

In addition to the genes found within the germplasm of the tropical RT species, work is underway to look at gene editing and transformation. For example, the OR (orange) mutation found in cauliflower and melon has already been overexpressed in potato, sweet potato and other non-RT species. If this avenue proves promising it will be important to have a marker for selection in conventional breeding as well.

A quote from Akinwumi Adesina, President of the African Development Bank and 2017 World Food Prize laureate, sets the stage for the future work of biofortified crops, including RT crops: 'For me, the challenge is no longer the science of biofortification – we know it works; our challenge as policy-makers is to scale up biofortified crops to reach millions of households through institutional, regulatory and financial policy.

QUALITY FOODs: Postharvest loss prevention, storage and processing

Poor infrastructure and transportation systems create massive challenges for perishable crops. Improvements to the system typically need to be through integrated approaches that look both at genetic and management solutions.

Next-users (e.g. processors) and end-users (e.g. household consumers) have always been part of the basis for RT breeders in developing their portfolio of varietal traits, and for processors to manage their machinery, processes and products. However there is a new recognition in the past decade about the complexity of consumer preferences, in general, and the wide variation of these preferences among different customers. Perhaps cassava is most complex in this sense because the roots are boiled or roasted fresh, or processed into a very wide array of products, each with different requirements for quality. Quality is about much more than dry matter content and cyanogenic capacity, which have long been considered at the core of a root quality evaluation for cassava. And although the tools for selection of a wide array of traits have improved, and tools for screening allow better and faster selection, there are still many challenges in addressing consumer preferences, and even more challenges in selecting for better expression of those traits once identified.

Quality traits include a range of categories:

- Nutritional properties (including retention bioavailability)
- Functional and pasting properties
- Organoleptic and sensory attributes
- Safety
- Stability during storage
- Social and cultural attributes

The first step is to develop a user or a customer profile, to divide the intended users in groups for which a uniform product (variety) can be developed. From this information, variety profiles will be developed that include the full range of traits required or desired by each customer segment that will be targeted in breeding. Not every variation in RT quality indicates that breeding should spend the resources to develop a customer-specific variety. Only customer segments with a certain number of beneficiaries will warrant a directed breeding effort, but this number will vary depending on many local factors.

Breeding teams need to involve the whole value chain, including social perspectives such as gender, from the beginning of the planning process. Breeders cannot employ consumer panels to evaluate every genotype from the earliest stages of selection, so in most cases there needs to be a fast and reliable way to relate end-user traits (complex and difficult to measure) with biophysical traits (broken down into simple components and easy to measure).

OFSP technologies and promotion are quite advanced in East Africa. This suggests that value added products can more readily enter the picture to give producers and processors more income, and provide customers with more choices in nutritious food. One such added value product is OSFP puree, which can be used in breadmaking and other products. Case studies were presented in Kenya, with links to a major supermarket chain, and in Tanzania with a wheat substitution project. Substituting part of wheat with OSFP puree proved beneficial in a number of health issues, including improved starch digestion properties. Although the bioaccessibility of beta carotene was relatively poor (1.5-6.9%), this can be offset by the relatively high content in the OFSP puree. Barriers such as high transaction costs and opportunistic risks were overcome through institutional innovations such as public private partnerships and market competition.

While all the RT crops have relatively shorter storage periods than the cereals or grain legumes, cassava is well-know for its especially short post-harvest storability under ambient conditions. Many methods have been developed to successfully manage this post-harvest physiological deterioration (PPD). On the other hand, studies continue on the feasibility of breeding for lower rates of PPD. As more cassava is processed in more centralized locations, requiring more shipping time and more time in storage prior to processing, it is anticipated that managing PPD will become ever more important. To further understand the GxE interactions that have made the measurement of PPD so complex, CIAT conducted a 5-year study comparing PPD among 40 genotypes across years. Some genotypes were stable and some were very variable, but there was no consistent correlation with environmental factors such as temperature, rainfall, soil conditions. Unlike some previous studies, there was also no clear relation between scopoletin peak and PPD. This study again highlights the frustratingly complex nature of PPD in cassava and the need for further investment.

PPD is also delayed by several management practices, most notably by restricting oxidation by practices such as paraffin coating or sealing in polythene bags. However, up to the present, methods have been developed mainly to handle small quantities, or with relatively labor intensive or expensive processes. NRI reported on a simplified bag approach, using both small and large bags, managed at scale. Scaling up simplified the method, as there was no need to add water; the increased volume of roots naturally raised the humidity. Roots could be stored in quantities of up to 50kg for 8 days with minimum deterioration. Early results show that the big bag technology provided a $10/t return on investment.

Because estimates of losses in RT crops are highly unreliable, RTB and partners carried out studies in Uganda to estimate and compare the extent of postharvest losses (PHL) in the potato, cooking banana and cassava value chains, seen as a good approach to improving food security. In contrast with most non-RT crops, most losses occur at the retail stage rather than during production, processing or transport. Although there were few physical losses for cassava at the market stage, economic losses were high due to deterioration of quality. Overall, potato had the highest economic losses across the value chain at about 35%, followed by banana and cassava at about 11-12%. Reliable estimation of PHL along the chain depends not only on the quality of the data collected (often a big challenge) but also on taking into proper account specific value chain characteristics.

CIAT studied various traits of consumer importance across a wide range of cassava landraces from diverse geographies of the Americas: in the roots -- cyanogenic capacity, post- harvest physiological deterioration, cooking time, dry matter; and in the leaves – trans beta carotene, protein and amino acids and cyanogenic potential. As reflected in the grouping of clones with similar traits in similar geographies, results showed that genetic diversity may reflect different selection criteria for different uses over millennia of cassava domestication. Genetic studies showed that genotypes grouped similarly to the grouping patterns based on phenotype. There was wide variation for each of the traits, including combinations of traits that will be very useful in breeding for current target customer segments.

Cassava has often been touted as a good raw material for ethanol because of its high productivity of carbohydrates. Nonetheless, ethanol production uses only a small percentage of total cassava production. There are several reasons for this, including policies that favor other crops, or that prohibit ethanol production from cassava in order not to compete with food uses. However, there should be strong potential for future growth of a cassava based ethanol industry to meet increasing energy demands. In order to make the process more competitive, CIAT studied a no-cook enzymatic process (simultaneous saccharification and fermentation), and the use of a small starch granule type of starch. The small granule type had significantly higher ethanol yield at 90 hours compared to the normal granule (80% vs 70% theoretical yield, respectively).

Cassava starch or flour must be dried either naturally or artificially. Sun drying has many limitations, and scaling up of operations typically requires a more reliable process. Drying can represent up to 30% of processing cost, even in efficient systems. Small driers are widely used for cassava starch or flour in Africa, but many are not optimally designed. RTB and partners funded research to improve the efficiency of small flash driers, to compete with the efficiency of larger driers. A high energy efficiency pilot flash drier was successfully developed based on a modelling approach, built and tested at CIAT, highlighting promising perspectives to reduce drying costs. Starch can also be dried at lower temperatures, for example at about 135 degrees, vs 180 normal, to further reduce fuel costs.

Building the DATA REVOLUTION in Tropical Root and Tuber Crops

Several trends are impacting data and information management for crop science. Open source databases and publications will greatly enhance access to critical information by scientists. Rapidly declining costs and increasing capacity of many types of sensors means that researchers can monitor and analyze a wide array of plant responses to environmental factors. Keeping the root and tuber crops current in the area of data management is part of several major projects. Key among them is the NextGen Cassava project, which has developed a fully integrated data management system known as Cassavabase.

Better ability to measure through deployment of sensors is greatly accelerating the need to manage information efficiently and precisely. Data storage is generally no longer a problem, as capacity has increased logarithmically at the same time that costs have declined dramatically.

Data management should generally now be part of a *digital ecosystem* – where data never leaves the digital realm. There are many tools to facilitate and support programs to move toward fully digital systems. While Cassavabase was the first of the RT databases, others are under development for other RT crops such as sweetpotato and yam. These RT-bases support comprehensive data management including field design, tablet based fieldbooks, phenotyping workflow, data archiving and sharing and analysis.

RT projects are moving toward streamlined, semi-automated data analysis and reporting, where everything is labeled with barcodes, avoiding unneeded questions and activities. Data curation and analysis is semi-automated. While many programs still use spreadsheets to record and archive data, this practice is discouraged. Data should be linked in fully integrated databases for best access and analysis.

High throughput phenotyping is a key strategy to manage large amounts of data. However, some of the RT crops can be somewhat more complex to manage in high throughput systems as compared to the grain and legume crops, because the plants are very large and have long growing seasons (e.g. cassava), or are large vines (e.g. yam). For cassava, sensor systems are mainly focused at the field level, through drone, satellite and ground penetrating radar. At the screenhouse/greenhouse level, hydroponic and aeroponic systems allow real-time monitoring of root growth. Sensors allow environmental monitoring and crop sensing measurement such as monitoring canopy cover and plant height, predicting biomass with multispectral imaging, stress monitoring with canopy temperature sensors, and others. All these systems generate large amounts of data that need to be managed well in order to achieve expected outputs. Cloud computing will be the next level of managing the large amounts of data generated in crop improvement systems.

Human learning is slow and hard to transfer compared to digital processing. Programs are beginning to look at artificial intelligence (AI) -- getting computers to do things better and faster than humans are able to do.

Because investment in data management can time-consuming and costly, it is important that there are good communication and sharing systems so that projects can build on each other rather than 're-inventing the wheel.' For example AgroFIMS is a project for standardizing data collection. PestDisPlace integrates all pest and disease data in one location and is accessible to everyone. Crop ontology systems (www.cropontology.org) allow uniformity in the way traits are described and measured for specific traits among all researchers. This is crucial to clear communication.

There are still many challenges with qualitative data. For example, CGIAR does 180,000 surveys per year, but there are is not broad standardization or understanding of how to make this information available to in the crop databases to support crop management and improvement.

Data privacy is a growing concern as satellite imagery becomes ever more powerful, and data access more open. A first priority for scientists should be to protect private data. Not all data needs to be open access; some should be kept private and this needs to be managed.

KEY TAKE-AWAYS AND KEY ACTION ITEMS RAISED DURING THE SYMPOSIUM

- ISTRC was the leading organization in bringing together the RT crops into a common forum for interchange of results and ideas. This interchange has now been greatly strengthened by the CGIAR initiative to unify the root, tuber and banana research into a coordinated system that exploits the strong synergies among these crops.
- In an era when technology is advancing very quickly and providing continually better opportunities for solutions to challenges, it is also important to keep in mind the users or customers of technologies – who should benefit and how best to target those intended beneficiaries? Will new technologies positively or negatively impact social and economic equity? How well are end-users integrated into the decision-making process about technology development and deployment?
- Women often have a strong involvement in the management of RT crops. In order for women to benefit from new technology, they need to be systematically part of the design and implementation.
- RT crops are highly versatile in their production, processing, product development and consumption. This versatility allows strong options for user demand and other market drivers to *pull* technology solutions, as opposed to the more traditional *push* strategies that make technology itself the driver rather than what customers really need or want.
- Strengthening human capital, development of adapted and efficient business and quality management systems must be incorporated into technology development and scaling.

- RTB Breeders need to access better information to integrate consumer preferences, processing ability and nutritional quality, in addition to the agronomic performance that has traditionally led priorities.
- Seed systems in RT crops have taken on greater importance in recent years. While many begin as short-term project-based initiatives, sustainability needs to be based on government commitment and/or private sector models that do not depend on project-based subsidies.
- Pests and diseases are a *double threat* in in the RT crops. Not only do they affect the current production year, but they are often transmitted to the next cropping season through infested/infected vegetative planting material. Although detection and monitoring systems are continually becoming better and more widely used, long experience indicates that new threats are always going to be a challenge. Technology, communication, education and regulation all need to be advanced toward long-term solutions.
- While the RT crops have generally lagged the cereal and grain legume crops in mechanization technologies, creative options are continually being developed to reduce drudgery, and increase productivity and profitability. There are often strong social consequences of mechanization (e.g. unemployment) and these need to be managed in order to provide equitable benefits
- While RT have generally not been at the forefront of developing new genotyping and phenotyping platforms and technologies, they have been able to quickly adapt and adopt from other crops where there is higher investment. High throughput phenotyping is often a challenge because of large plant size and/or long growing season for the RT crops. Nonetheless advances in use of sensors and imagery to capture both above and below-ground growth and development promise new contributions to genetic gains in breeding as well as better management practices.
- The RT crops are seeing the first applications of the inbred-hybrid system that has transformed other crops, especially maize. Results with potato are very promising and a strong theoretical basis has been established for sweet potato and cassava. While there is a strongly supporting genetic theory, and a growing background of experimental evidence, future investment in inbred-hybrid approaches should be motivated as well by solid cost-benefit projections that will be convincing to donors or investors.
- Digital systems are highly advanced for RT scientists to manage research. Nonetheless, many programs are still using manual data recording, risky data storage systems, and inefficient data analysis, with little sharing outside the immediate project participants. Standardization and more powerful, more user-friendly tools, especially through public access databases, should motivate wider participation in efficient data management systems.
- Genetic resources are more vital than ever to the improvement of RT crops, to provide solutions to new production, processing and use challenges.
- Scientists need to incorporate foresight into research planning in order to preemptively face challenges of urbanization, climate change, cost and scarcity of the inputs to production, among others.

A special congratulations to Dr Hernan Ceballos, Cassava Breeder at CIAT, for receiving the prestigious ISTRC Lifetime Achievement Award.

ANNEX I. PROGRAM.

#ISTRC2018

18th Triennial Symposium of ISTRC
International Society for Tropical Root Crops
CALI, COLOMBIA • 22-25 OCTOBER 2018

DAY 1 AGENDA MONDAY, OCTOBER 22

7:30 - 8:30 am **REGISTRATION**
Area located aoutside Kellogg Auditorium

8:30 - 9:30 am **INAUGURATION -** OPENING CEREMONY AND KEYNOTE ADDRESS
Kellogg Auditorium

9:30 - 10:0 am **GROUP PHOTO**

10:00 - 12:00 m **SCALING:** SCIENTIFIC INNOVATIONS THAT HAVE IMPACT ON ROOT AND TUBER CROP SYSTEMS AND THOSE WHO DEPEND ON THEM
Kellogg Auditorium

12:00 - 1:00 pm Lunch in the CIAT's Arches

1:00 - 3:00 pm MEETING ON THE SCALING MORNING SESSION FOR GENERAL DISCUSSION AND/OR MORE POSTER-ORAL PRESENTATIONS
Latinoamérica y Caribe Room

2:00 - 5:00 pm CASSAVA PROGRAM'S **FIELD** & **LAB VISITS**

4:00 - 4:30 pm Afternoon coffee break

4:00 - 5:00 pm **ISTRC COUNCILLORS MEETING** (CLOSED EVENT)
Trópico Room

5:00 - 7:00 pm Welcome cocktail

7:00 - 7:30 pm DEPARTURE BY BUS FROM CIAT'S MAIN RECEPTION AREA

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DAY 2 AGENDA TUESDAY, OCTOBER 23

8:00 - 10:00 am	**DISCOVERY:** HOW TO SUSTAIN GENETIC GAINS IN ROOT AND TUBER CROPS *Kellogg Auditorium*
10:00 - 10:30 am	Coffee break + **RTBs CULINARY DEMONSTRATION**
10:30 - 12:30 pm	**COME CLEAN** GO **CLEAN:** ARE WE DECLARING WAR TO PEST AND DISEASES: HOW EPIDEMIOLOGY, PEST AND DISEASE MANAGEMENT, MOLECULAR DIAGNOSTICS, AND DISEASE MONITORING WILL SHIELD OUR CROPS *Kellogg Auditorium*
12:30 - 1:30 pm	Lunch in the CIAT's Arches
2:00 - 4:00 pm	GENERAL DISCUSSION ON **COME CLEAN GO CLEAN** SESSION AND/OR MORE ORAL PRESENTATIONS *Latinoamérica y el Caribe Room*
2:00 - 4:00 pm	GENERAL DISCUSSION ON **DISCOVERY** SESSION AND/OR MORE ORAL PRESENTATIONS *Colombia Room*
3:30 - 4:00 pm	Afternoon coffee break + **SP LIQUOR TASTING**
4:00 - 5:30 pm	**POSTER SESSION**
6:00 - 6:15 pm	DEPARTURE BY BUS FROM CIAT'S MAIN RECEPTION AREA

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DAY 3 AGENDA WEDNESDAY, OCTOBER 24

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8:00 - 10:00 am	**SEEDS OR NO SEEDS: WHAT IS THE DILEMA?** HOW TO CREATE ROOT AND TUBER SEED SYSTEMS *Kellogg Auditorium*	
10:00 - 10:30 am	Coffee break	
10:30 - 12:30 pm	**BIOFORTIFICATION: ARE WE SOLVING MALNUTRITION?** HOW TO IMPROVE NUTRITION AND HEALTH THROUGH ROOTS AND TUBER BIOFORTIFICATION *Kellogg Auditorium*	
12:30 - 1:30 pm	Lunch in the CIAT's Arches	
2:00 - 4:00 pm	**POSTER SESSION**	
3:30 - 4:00 pm	Afternoon coffee break	
4:00 - 5:00 pm	**ISTRC GENERAL MEETING** (OPEN EVENT) *Latinoamérica y el Caribe Room*	
5:00 - 6:00 pm	**HOW TO FOSTER MORE DEMAND DRIVEN RESEARCH AND INNOVATIONS IN RTB CROPS?** *Kenya Room*	
5:00 - 6:00 pm	**SEEDS NO SEEDS / BIOFORTIFICATION MORNING SESSIONS' GENERAL DISCUSSIONS** *Colombia Room*	
6:00 - 8:00 pm	Dinner - Networking event	
8:00 - 8:15 pm	DEPARTURE BY BUS FROM CIAT'S MAIN RECEPTION AREA	

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DAY 4 AGENDA THURSDAY, OCTOBER 25

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8:00 - 10:00 am	**QUALITY FOODS:** POSTHARVEST LOSS PREVENTION, STORAGE AND PROCESSING *Kellogg Auditorium*
10:00 - 10:30 am	Coffee break
10:00 - 10:30 am	**POSTER SESSION**
10:30 - 12:30 pm	**BUILDING THE DATA REVOLUTION:** CHALLENGES AND OPPORTUNITIES FOR THE FUTURE *Kellogg Auditorium*
12:30 - 2:00 pm	Lunch in the CIAT's Arches
2:00 - 3:00 pm	**CGIAR RESEARCH PROGRAM ON TUBERS AND BANANAS PARTNERSHIP PLATFORM:** PROGRESS AND PROSPECTS *Trópico Room*
3:00 - 5:00 pm	CASSAVA PROGRAM'S **FIELD** & **LAB VISITS**
3:00 - 5:00 pm	**DEMOS OF AGROFIMS AND THE CASSAVA BASE SYSTEMS/EXAMPLES** *Africa Room*
3:00 - 5:00 pm	**QUALITY FOODS'** MORNING SESSION GENERAL DISCUSSIONS AND/OR Q&A *Asia Room*
3:30 - 4:00 pm	Afternoon coffee break - Parallel to the Quality / Data Revolution
5:00 - 6:30 pm	**CLOSING CEREMONY AND AWARDING OF PRIZES** *Kellogg Auditorium*
7:00 - 7:30 pm	DEPARTURE BY BUS FROM CIAT'S MAIN RECEPTION AREA

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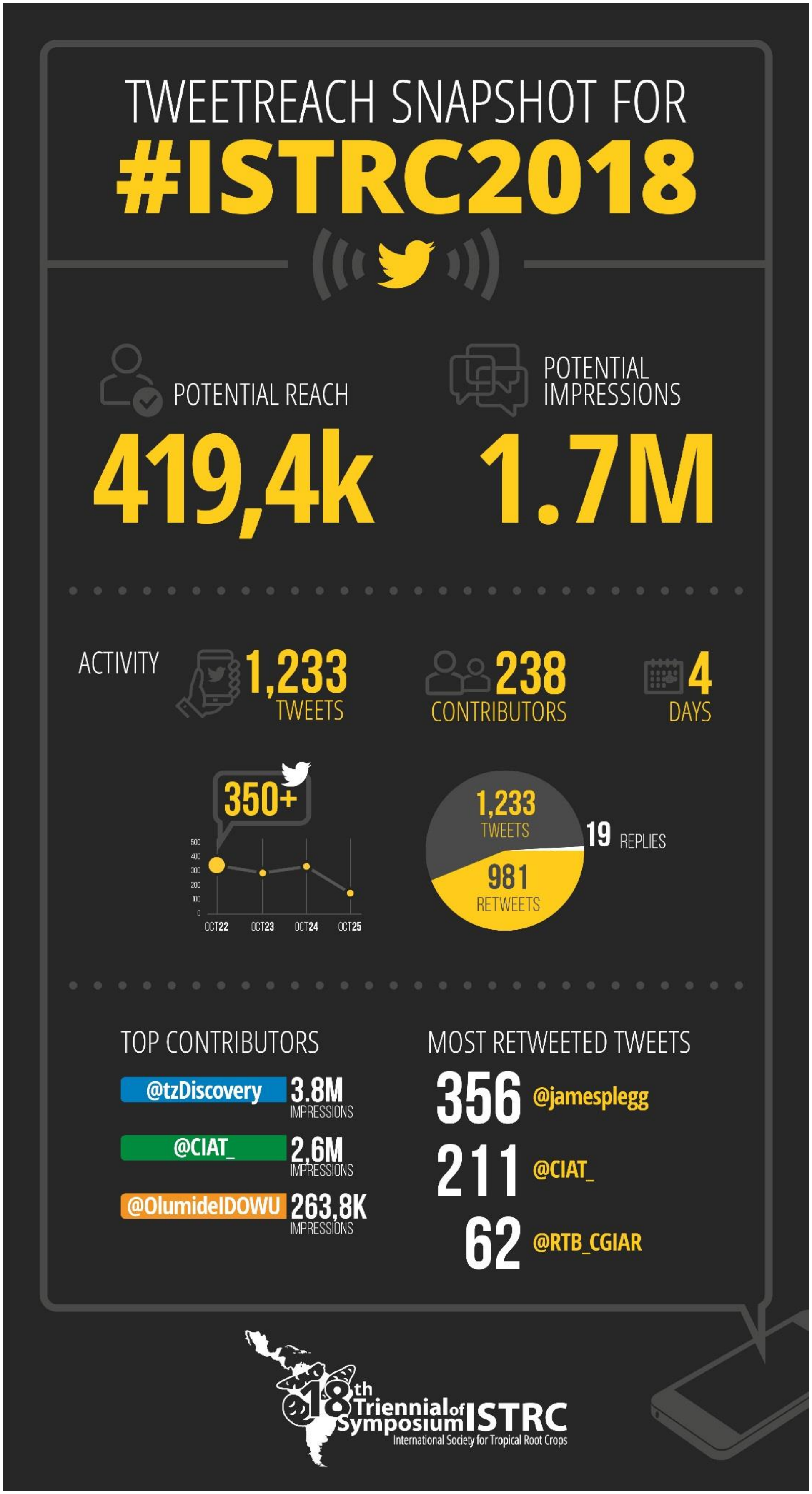
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POTENTIAL REACH
419,4k
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CONTRIBUTORS
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19 REPLIES
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RETWEETS
TOP CONTRIBUTORS
@tzDiscovery 3.8M IMPRESSIONS
@CIAT_ 2,6M IMPRESSIONS
@OlumideIDOWU 263,8K IMPRESSIONS
MOST RETWEETED TWEETS
356 @jamesplegg
211 @CIAT_
62 @RTB_CGIAR
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