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Collaborative wheat breeding for durable resistance to stripe rust in China

Breeding of durable resistance to stripe rust —the greatest biotic threat to wheat production in the largest wheat producer and consumer in the world, China— was the major theme of a workshop jointly organized by the CIMMYT-Sichuan office and the Sichuan Academy of Agricultural Sciences (SAAS) at the SAAS Plant Breeding Institute in Chengdu, Sichuan province, China, on 18 May 2013. The workshop aimed to promote the adoption of second-generation parents and slow-rusting breeding strategies in spring wheat-producing areas of China and to facilitate collaborative breeding strategies between SAAS and its sister organizations in neighboring provinces. The workshop consisted of a seminar and a discussion session on germplasm and breeding strategies led by Gary Rosewarne (CIMMYT Global Wheat Program senior scientist) and Bob McIntosh (Emeritus Professor at the University of Sydney), and followed by a field visit to the Southern China Field Station at Xindu.

China has the largest area prone to stripe rust epidemics in the world. Traditionally, the disease has been controlled through genetic strategies focused on incorporating major seedling resistance genes to provide immunity. However, this method places strong pressure on the fungus to evolve and overcome these genes. Since the 1950s, the development of virulent pathotypes to widely used resistance genes has caused numerous serious stripe rust epidemics, with the major ones in 1990 and 2002 resulting in the loss of 2.65 and 1 million tons of grain, respectively. Given China's importance in the world's wheat production and consumption, any threat to the country's wheat production has implications for global food security.

CIMMYT has pioneered breeding of durable resistance to stripe rust through the incorporation of multiple, slow-rusting loci, a breeding strategy well established at SAAS but largely ignored by most other wheat breeders in China who still focus on major seedling resistance. At the beginning of this century, SAAS and CIMMYT established a shuttle breeding system to introduce slow-rusting loci into Sichuan germplasm. Five high-yielding but susceptible Sichuan lines were sent to Mexico each year for three years; Ravi Singh, CIMMYT distinguished scientist and head of Bread Wheat Improvement, then made single backcrosses with several CIMMYT donor lines. The resulting lines were advanced in Toluca and Obregón, Mexico, and large populations of early generation materials were sent back to Sichuan for further advancement and final selection. Fixed lines from these first generation crosses have shown good levels of resistance in China, along with yields comparable to those of the check varieties. There is currently a range of second generation parental lines with slow-rusting loci in Chinese backgrounds; it is expected that with these as donors, researchers should be able to raise yield potential further while maintaining resistance.

The workshop resulted in a proposed collaborative strategy which would allow breeders representing different regions of China to receive several lines of second generation Chinese slow-rusting donors and to conduct single backcrosses with some of their elite germplasm that has become susceptible. Chinese scientists involved in the process will be invited to help select early generation materials using the bulk selection methodology. After selection, large early generation populations will be sent back to the regions for further selection and advancement under local conditions. "We anticipate that through this mentoring process, breeders will feel comfortable adopting new breeding strategies that can increase their efficiencies and ensure that durable stripe rust resistant lines are released throughout China," explained Rosewarne.

High up and hyperspectral

Last week CIMMYT obtained a new hyperspectral camera and thus significantly expanded its remote sensing capabilities. Pablo J. Zarco-Tejada, director of QuantaLab remote sensing laboratory, Instituto de Agricultura Sostenible (IAS), Consejo Superior de Investigaciones Científicas (CSIC), Córdoba, Spain, and his team spent 13-17 May 2013 at the Campo Experimental Norman E. Borlaug (CENEB) in Ciudad Obregon, Mexico, installing the new camera on the remote sensing platform they delivered during their last visit in February 2013.

Zarco-Tejada and his team also trained a pilot and CIMMYT staff on the use of the hyperspectral remote sensing equipment, which was obtained through a capacity building project between CIMMYT's Global Conservation Agriculture Program and QuantaLab-IAS-CSIC, funded by MAIZE and WHEAT CRPs under Strategic Initiative 3.

Members of CIMMYT (Ciudad Obregon), IAS-CSIC (Spain) and the aircraft crew during the flight tests conducted to test the new hyperspectral camera.

Hyperspectral technology uses the most advanced remote sensing cameras that are sensitive to the visible and near infrared spectral regions. This allows for acquisition of hundreds of images at once, each of them covering a different and narrow spectral region in a continuous mode. While multispectral cameras widely used for crop monitoring through remote sensing methods can acquire only five or six spectral bands at once, the new hyperspectral imager owned and operated by CIMMYT obtains 250 spectral bands at the same time, covering the entire electromagnetic spectrum between the visible and the near infrared regions. This opens up tremendous new and powerful avenues for research on early crop stress detection, physiological assessment, conservation agriculture, plant breeding, disease detection, etc.

The thermal, multispectral, and hyperspectral cameras are installed on the same aircraft which allows researchers to obtain both thermal and multi/hyperspectral images concurrently. With resolutions ranging between 20 and 50 centimeters, it is possible to target single experimental plots as well as within-field spatial variability in commercial fields. The cameras acquire 250 bands of 6.4-nanometer width in the 400-885 nanometer region, scanning swaths of 500 meters at 30-50 centimeter pixel resolution.

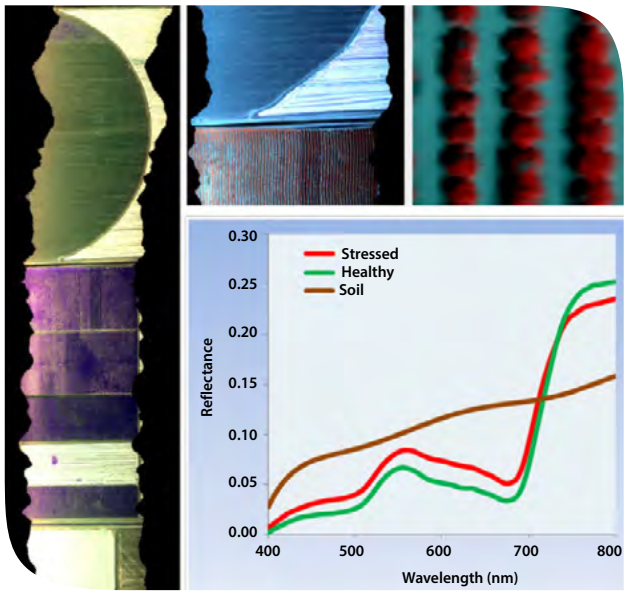
This makes it possible to calculate several new spectral indices related to photosynthetic pigments, such as chlorophyll content, carotenoids, xanthophylls, and anthocyanins, as well as measure physiological and structural indicators, which can be used to map nitrogen status and derive nitrogen recommendations to improve wheat quality. Most importantly, the new hyperspectral

The aircraft operated near CIMMYT station in Ciudad Obregon ready for hyperspectral imagery collection.

imager allows for early detection of stress using narrow-band indices related to light-use efficiency, as well as for quantifying chlorophyll fluorescence emissions by the plant, which is the focus of current cuttingedge international research on canopy photosynthesis. This has proved to be a better physiological indicator than other traditional vegetation indices.

The hyperspectral camera was tested over an area near CENEB and is now fully operational for phenotyping and physiological and agronomic research. Image processing methods and hyperspectral analysis procedures were used for signature extraction from the imagery and observation of the spectral differences between healthy and stressed vegetation pixels.

Configuration of the new hyperspectral camera for different operation modes and the identification of successful remote sensing indices will continue through research collaboration between CIMMYT and QuantaLab-IASCSIC. The algorithms and stateoftheart methods for the processing of the imagery, as well as field instrumentation required for the flights, are now available at CENEB. The same instruments are planned to be used during the upcoming cropping season in El Batán and Toluca.



Hyperspectral flight line acquired near the CIMMYT station at Obregon acquired at 40 cm resolution on May 15, 2013 (left). Areas with dense vegetation and trees orchards are shown in red (top inserts). The graph shows the full hyperspectral signatures extracted from the imagery from healthy and stressed vegetation pixels, and from a soil target after radiometric calibration and atmospheric correction methods are conducted in the laboratory at CIMMYT.

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CIMMYT supports Wheat Initiative

On 16 May 2013, the Wheat Initiative issued its vision document paving the way for its future actions. Discussed and agreed upon at a meeting of the G20 Agriculture Ministers in Paris in June 2011, the Wheat Initiative was established to coordinate global wheat research to achieve - through international collaborative efforts - the progress needed to increase wheat production, quality, and sustainability, thus contributing to the global efforts towards toward food security and safety under changing climate conditions. Although wheat is a staple crop worldwide, its production has not reached demand in 10 of the 15 past years. To find out more about what the Wheat Initiative's international vision to address this situation is, visit the WHEAT CRP website.

Giving power to African farmers: learning from the Indian experience.

From 29 April to 10 May, 16 agricultural engineers, agronomists, machinery importers, and machinery manufacturers from Ethiopia, Kenya, Tanzania, and Zimbabwe took part in a study tour in India organized by CIMMYT, the Indian Council of Agricultural Research (ICAR), the Australian Centre for International Agricultural Research (ACIAR), and the Australian International Food Security Centre (AIFSC). The tour was organized as part of the "Farm Mechanization and Conservation Agriculture for Sustainable Intensification" (FACASI) project to identify opportunities for exchange of technologies and expertise between India and Africa and strengthen South-South collaborations in the area of farm mechanization. The project is funded by AIFSC and managed by ACIAR.

India is the world's largest producer of pulses, and the second largest producer of wheat, rice, potatoes, and groundnuts. But would India's agricultural performance be that high if the number of tractors in the country was divided by six and the number of draught animals by three? Such a reduction in farm power would bring Indian agriculture close to the current situation of Kenya and Tanzania. In India, most agricultural operations are mechanized, including planting, harvesting, threshing, shelling, and transportation to the market; in Africa, these are generally accomplished manually. Bringing African agriculture closer to the situation in India is the goal of the FACASI project. This tour was designed as the first step in the construction of an enduring trilateral partnership between Africa, India, and Australia, consolidated by CIMMYT, to facilitate exchange of research and development results in the area of farm mechanization.

The study tour was officially opened by S. Ayyapan, ICAR director general, who stressed the importance of farm mechanization for agricultural intensification. He pointed at the commonalities between the circumstances of Indian and African smallholders and invited the group to develop concrete country-specific proposals regarding possible partnerships with India. The participants then spent five days at the Central Institute of Agricultural Engineering (CIAE) in Bhopal, Madhya Pradesh state, where they were exposed to various low-cost gender-friendly technologies for post-harvest operations and weeding; sowing, fertilizing, spraying, and harvesting technologies adapted to animal traction; two-wheel and four-wheel tractors; as well as conservation agriculture based technologies. Through calibration exercises and other field activities, participants gained hands-on experience with these machines. The group also visited the Central Farm Machinery Training and Testing Institute in Budni.

The second part of the study tour took place in the states of Punjab and Haryana, where the group interacted with scientists from the Punjab Agricultural University (PAU) and the Borlaug Institute for South Asia (BISA), and was exposed to various Indian innovations including laser land levelers operated by two-wheel tractors, relay direct seeders, multi-crop planters, crop threshers, and rotary weeders. They also participated in a discussion session organized by a farmer cooperative society at Noorpur-Bet focusing on institutional innovations encouraging farmer access to mechanization, and interacted intensively with Indian agribusinesses such as National Agro-Industry, Dashmesh Mechanical Engineering, Amar Agro Industries, and All India Machinery Manufacturers Association.

The study tour was concluded by a visit of the Central Soil and Salinity Research Institute (CSSRI) in Karnal to observe the role of conservation agriculture in reclaiming degraded land, and a visit to the Indian Wheat Research Centre in Karnal.

The lessons learnt in India will be put in practice in Ethiopia, Kenya, Tanzania, and Zimbabwe through the FACASI project. The study tour has generated several ideas for the development of new machines by African engineers and created contacts between Indian manufacturers and African machinery importers which may materialize into business opportunities.

IRMA and WEMA set standards and procedures for conducting trials

The Insect Resistant Maize for Africa (IRMA) and Water Efficient Maize for Africa (WEMA) projects held their 2013 start-of-season planning meeting in Kiboko, Kenya, during 22-27 April 2013. The meeting had several objectives, ranging from a critical review of past performance; development of standard operating procedures for activities unique to the projects and common understanding of functions; 2013 season preparations; and ensuring that IRMA/WEMA trials are properly planted and managed and that data is taken adequately and in the same way across locations. The meeting-cum-training was attended by 50 participants comprising of scientists, CIMMYT and Kenya Agricultural Research Institute (KARI) technicians, IRMA/WEMA staff and students, KARI staff involved in designing and implementing trials across sites in Kenya, and contracted casuals.

Stephen Mugo, CIMMYT Global Maize Program principal scientist and maize breeder and IRMA and WEMA coordinator, emphasized the three production constraints faced by farmers in Eastern and Southern Africa: drought stress particularly at flowering and grain filling stage; stem borers (*Chilo partellus* and *Bussela fusca*); and maize weevils (*Sitophilus zeamais*) and larger grain borer (*Prostephanus trancatus*). "Farmers harvest only a fraction of what they expect due to these constraints," said Mugo. "However, good interventions can help farmers save up to 50% of their harvests."

To address the above constraints, IRMA and WEMA work to develop drought tolerant, stem borer and storage insect pests resistant maize inbred lines, hybrids, and open pollinated varieties. They test and evaluate drought tolerant, stem borer and storage pest resistant maize germplasm; transfer the germplasm to partners; and generate, share, and transfer new knowledge on this germplasm.

"The success of our work," stressed Mugo, "depends on how well we execute the trials at every stage: designing and planting trials and nurseries; plot management; basic trial information; imposing major treatment; data collection, processing, and reporting; and breeding gains." Generation of high quality data must be at the heart of these activities. Consequently, participants were trained on proper data collection during which they were reminded that every data collection process must be preceded by a clear agreement on how the process will be done.

Accurate and high-quality data were also the topic of the closing remarks of William Mnene, director of KARI-Kiboko Rangeland Research Station: "You should capture data as accurately as possible for data is the most important output of an experiment. Imagine a paper published based on inaccurate data. Other scientists, without knowing that the paper is based on false data, will continue to be citing the information in their publications, perpetuating the fallacy for years before it is corrected, if it will ever be identified and corrected." CIMMYT maize breeder Lewis Machida added that harmonization and standardization of data collection will go a long way in improving the quality of data generated.

The meeting was facilitated by Yoseph Beyene, Tadele Tefera, Andrew Chavangi, John Gakunga, Lewis Machida, and Charles Marangu from CIMMYT; Regina Tende, Paddy Likhayo, and Murenga Mwimali from KARI; and James Mwololo from Pwani University, Kenya. Thank you to all facilitators and participants!

WEMA reaches out to local communities in Kenya

On 02 May 2013, the Water Efficient Maize for Africa (WEMA) project organized a sensitization workshop for local community leaders, provincial administration members, agricultural extension workers, farmers, and representatives of farmer groups. The meeting was held at the Kenya Agricultural Research Institute (KARI) in Kiboko and attracted over 40 participants from the neighboring maize growing areas in the Makueni and Machakos counties in eastern Kenya, along with representatives from CIMMYT, Monsanto, African Biotechnology Stakeholders Forum, and the Ministry of Agriculture. It aimed to explain WEMA's work on development of drought-tolerant and insect-resistant maize varieties using both conventional and genetic engineering techniques. It was also an opportunity for WEMA to demystify myths, allay fears, and enlighten participants on genetically modified organisms (GMOs) and confined field trials.

In his opening remarks, E.O. Mungabe, KARI-Katumani center deputy director, noted that the use of genetic engineering in crop breeding still triggers panic among some Kenyans. However, the emerging challenges of climate change, diseases such as maize lethal necrosis, and pests like the larger grain borer call for new approaches, as conventional ways of breeding alone might not overcome or solve these problems. "It is necessary that we combine our conventional breeding techniques with genetic engineering to effectively respond to these emerging challenges. Think positively of genetic engineering as a technology that has the potential to address them," Mungabe explained the situation to the participants.

"Africa is a drought-prone continent with approximately 300 million people depending on agriculture for their livelihood," said Murenga Mwimali, WEMA-Kenya national project coordinator, reminding participants that due to climate change, the incidences and severity of droughts will increase. Combined with insect and pest attacks, this could make maize farming an unrewarding enterprise if these issues are not addressed. Mwimali then briefed the participants on the progress to-date in developing drought-tolerant and insect-resistant maize varieties using biotechnology and conventional breeding techniques. "Trials show that these new varieties," Mwimali added, "will yield 25% more than commercial hybrids."

Joseph Bii of KARI-Kiboko Rangeland Research Station stressed that 80% of Kenya's land is classified as arid or semi-arid. It is therefore important to develop maize varieties that can tolerate the little and erratic rainfall experienced in these areas to enable farmers to continue the production of Kenya's main staple crop and an important fodder crop for livestock, maize.

The meeting then focused on the topics of GMOs and confined field trials within the scope of WEMA. The project has so far conducted four confined field trials for genetically modified drought tolerant maize variety MON87460 with promising results; another currently conducted confined field trial with genetically modified maize variety resistant to stem borers (MON810) is progressing well. It might take a few more years before farmers can plant the genetically modified maize varieties, but the drought-tolerant CKH110078 conventional variety developed from the Drought Tolerant Maize for Africa (DTMA) materials is likely to be available this year, according to Mwimali. In addition, 14 water efficient WEMA hybrids are already in national performance trials in Kenya and could, therefore, be released as early as next year.

The participants welcomed the opportunity to exchange ideas and get clarifications on many GMO issues: sources of seed and price implications; implications of recycling seed; cross-pollination of GMOs with their local varieties; as well as the reasons why WEMA has not improved local varieties such as Kinyanya. The farmers were also advised on sources of seed and appropriate varieties for their region, particularly the Ministry of Agriculture and the Kenya Plant Health Inspectorate Service through their SMS service, and warned against relying on agro-dealers for information as they are in the business to sell.

The stakeholders toured the MON810 trial and the WEMA confined field trial facility, where they had a chance to observe a genetically modified crop for the first time. It was heartening for the meeting organizers to hear most of the farmers speak positively of the technology and the varieties in the trial, with many expressing their eagerness to try out the genetically modified varieties.

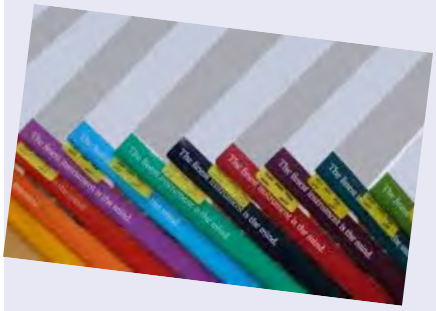
Strengthening capacity of maize technicians in Malawi

Maize technicians in Malawi are responsible for many day-to-day field activities, agronomic management of field trials in the absence of plant breeders, and germplasm development and selection. Their training is therefore crucial for strengthening the capacity of national programs, which is why CIMMYT in collaboration with the Malawian Department of Agricultural Research Services organized a training course for 40 maize technicians from private seed companies and agricultural research stations in Malawi. The course took place during 13-17 May 2013 at the Chitedze Research Station in Lilongwe, Malawi, and was conducted under the auspices of the Drought Tolerant Maize for Africa (DTMA), Sustainable Intensification of Maize-Legume Systems for Food Security in Eastern and Southern Africa (SIMLESA) and USAID-funded heat stress projects to whose success maize technicians contribute. The objective of the course was to update maize technical staff on implementing on-station and on-farm trials, seed production, the use of secondary traits in selecting superior varieties under low nitrogen, heat, and drought trials, and the principles of conservation agriculture.

The course paid special attention to the projects' specific needs. Under the DTMA project, the focus was on genotype selection under managed drought stress, development of a seed production strategy for hybrids and open pollinated varieties, and identification of maize traits preferred by farmers. The SIMLESA project emphasized on-farm testing using mother-baby trials and the principles of conservation agriculture. The USAID project highlighted the importance of trial uniformity and selecting genotypes under heat stress. "The course was very informative and precise," said Sara Bota, one of the course participants.

CIMMYT would like to thank Kesbell Kaonga and Cyprian Mwale from the Department of Agricultural Research Services, Chitedze Research Station; and CIMMYT's Peter Setimela, Zaman-Allah Mainassara, John MacRobert, Amsal Tarekegne, Girma T. Kassie, and Isaiah Nyagumbo, who served as the course organizers and resource persons.

Recent publications by CIMMYT staff



Heat and drought stress on durum wheat: Responses of genotypes, yield, and quality parameters. 2013. Yun-Fang Li;Yu Wu; Hernandez-Espinosa, N.; Peña-Bautista, R.J. Journal of Cereal Science 57(3):398-404.

QTL analysis of the spring wheat 'Chapio' identifies stable stripe rust resistance despite inter-continental genotype × environment interactions. 2013. Yang, E.-N.; Rosewarne, G.M.; Herrera-Foessel, S.A.; Huerta-Espino, J.; Tang, Z.-X.; Sun, C.-F.; Ren, Z.-L.; Singh, R.P. Theoretical and Applied Genetics Online first

Spatial analysis to support geographic targeting of genotypes to environments. 2013. Hyman, G.; Hodson, D.; Jones, P.Frontiers in Physiology 4 (Art. 40):1-13.

Birthdays 27-31 May

Pawan Singh 27; Velu Govindan 27; Daniel Santiago 28; María del Carmen Corona 28; Agustín Ramírez 28; Nele Verhulst 28; Anant Prasad Regmi 28; Irenie Chakoma 28; Raymundo López 30; Fernando Rodríguez 30; Fernando Valle 30; Fernando Delgado 30; Frédéric Baudron 30; Guillermo Flores 31; Ángel González 31; Jorge Manuel Montoya 31; Virginia Ordóñez 31.

Staving off a new potentially lethal virus

Since April 2013 a number of cases of severe respiratory disease caused by a novel coronavirus have been confirmed in Saudi Arabia, Jordan, and Qatar. Thirty cases had been confirmed by 8 May 2013; 18 of them died. This generated a global alert from the World Health Organization. Since then, additional cases have been reported in the United Kingdom, France, and Germany. The total now stands at 40, of which half have died.

Coronaviruses are a common type of virus that can cause respiratory illnesses, from a simple cold to SARS. Until relatively recently, they were not known to affect humans, and this may be the reason many people show an insufficient immune response. The new pathotype may cause severe pulmonary disease and even death. Patients with underlying medical conditions such as cardiovascular disease, chronic pulmonary disease, and diabetes mellitus are at greater risk of becoming severely ill.

Although the novel coronavirus has been found to spread from human to human, researchers have not been able to identify the original source. The WHO still has not established specific measures to prevent the spread of the disease, but you can reduce your chances of becoming infected by:

- washing your hands often with soap and water,
- not touching your eyes, nose, or mouth, and
- avoiding close contact (e.g., touching and shaking hands) with people who are sick.

The Risk Management Unit has been monitoring this outbreak since early April and has posted more detailed information on the intranet.

Kids celebrate Mothers' Day

In keeping with its goal of promoting and reinforcing family interaction, the After School Program held a Mother's Day celebration on 9 May 2013. To make it fun for the attendees, After School Program staff organized games such as musical chairs and a language ability game, and there was singing and much dancing. Later mothers were serenaded by the children and Andrés Molina on the guitar, who sang John Lennon's song "Woman." After the games, the children gave their mothers gifts they had prepared and wished them a happy Mothers' Day. At the end of the event, refreshments were served. Thank you moms, children, teachers, and Andrés for participating in this event.

Wedding bells

Congrats and best wishes to Jenny Nelson, Global Wheat Program manager, who in the coming week will exchange marriage vows with Chad Grey.

Weekly photo contest...

Weekly photo contest winner: *Just another morning in Obregón...*

This week's winning photos taken by CIMMYT wheat geneticist Marc Ellis show what you're missing if you've never been to the Campo Experimental Norman E. Borlaug (CENEB) near Ciudad Obregon, Sonora.

Don't forget to send us your entries for next week's competition. Pease email them to Barbora Nemcova (b.nemcova@cgiar.org)—or hand them over on a USB stick—and look out for the winners on CIMMYT's flickr, where they are shared under a Creative Commons license. Congratulations to Zahid Mahmood and thank you to all our participants!

Informa is published every Friday by CIMMYT Corporate Communications. We welcome your input, preferably in both English and Spanish. The deadline for submissions is 3:00 p.m. on the Wednesday before publication. We reserve the right to edit all contributions. Please send proposed material to Connie Castro c.castro@cgiar.org.
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