International Conference on Research on Food Security, Natural Resource Management and Rural Development

Tropentag 2022

Can agroecological farming feed the world?

Farmers' and Academia's view

Book of abstracts

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Tropentag 2022

International Research on Food Security, Natural Resource Management and Rural Development

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Preface

Tropentag is the largest interdisciplinary conference in Europe, focused on development-oriented research in the fields of tropical and subtropical agriculture, food security, natural resource management and rural development. *Tropentag* takes place annually, even though the past two years were particularly challenging, while the conference had to be organised as an online only event. One of the lessons that we learnt from the virtual conferences is that yes, it is possible to organise it that way, but that it is much better to meet and talk in person. We are thus very happy that this year (two years after what was initially planned), we are able to organise the *Tropentag* 2022 conference at the campus of the Czech University of Life Sciences Prague, Czech Republic, and thrilled that we will again meet all face-to-face, during the 14-16 September venue. However, some of you, due to various reasons, who could not come to Prague, you can still participate at this year *Tropentag*, as all plenary and oral scientific sessions are streamed via the Whova platform, and we also organise several online poster sessions.

This year's *Tropentag*'s confederating theme is: 'Can agroecological farming feed the world? Farmers' and academia's views'. The debates on global food production challenges have become polarised among both scientists and farmers, widening the gap between the advocates of industrial agriculture and global commerce, and the supporters of local food systems and organic farming. While the former claim it is only possible to meet the high production demands through conventional agriculture, the latter are convinced that the world's small farmers can increase yields and final production by adopting techniques that respect natural equilibria and processes and maintain or improve soil health without synthetic inputs. *Tropentag* 2022 will review recent research results that address these challenges from various points of view, with various methodological approaches. Discussions in plenary and thematic sessions, guided poster tours, and workshops will provide participants with new ideas to enhance our understanding of the potential capacity of the agroecological approaches to maintain and restore soil health, conserve biodiversity and adapt to climate changes, and help us face future crises, together with meeting the challenge of feeding global populations.

These aspects will be addressed during the conference by internationally renowned keynote speakers, as well as, by a plenary panel discussion, where you will be able to hear, discuss and confront the ideas of farmers, scientists, and businessmen. Further on, we received $>$ 800 contributions related to the theme of which some 500 will be presented either as oral or poster presentations and are now available in this book-of-abstracts. Apart from 105 oral presentations, clustered in 24 scientific sessions, there

are 36 guided and 14 online poster sessions. Moreover, you can join some of 20 pre- and post-conference workshops and numbers of side events, such as a film festival on pastoralism.

The featured CGIAR centre of this year is AfricaRice, a pan-African Centre of Excellence for rice research, development, and capacity building. It contributes to reducing poverty, achieving food and nutrition security, and improving livelihoods of farmers and other rice value-chain actors in Africa by increasing the productivity and profitability of rice-based agri-food systems, while ensuring the sustainability of natural resources.

We wish to thank all participants for their scientific contributions and our colleagues of the scientific committee for reviewing all abstracts and acting as chairs for oral and poster sessions, but the conference could not be organised without the help of large number of people behind the scenes. We express our gratitude to Eric Tielkes and his team for his very valuable support in organising this ever-growing event. Special thanks go to the student reporters for keeping the blog and reports 'alive'. Thanks also to ATSAF for all the guidance, and to the staff and student volunteers from CZU Prague for helping to organize this venue. Particular thanks to our long-standing donors (listed on the back cover) for their unwaning financial and in-kind support, which allow us to keep conference fees at a modest level, especially for junior scientists. Thank you all for participating - you made it happen again.

We welcome you coming from the many different parts of the world to Prague and wish you an inspiring and enriching conference. Indeed, *Tropentag* is again a whirling pool of people interacting and listening to each other, learning new things, building and refreshing networks, and enjoying science, discussions, food and drink. As of now, let us wish you all the best and enjoy this magnificent event.

On behalf of *Tropentag* 2022's organising team.

Bohdan Lojka, Olga Leuner, Jan Banout, Vladimír Verner, Lucie Ackermann-Blažková, and Patrick Van Damme

Prague, September 2022

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Plenary speeches

Agroecological transformation of tropical livestock production through improved forages and silvopastoral systems

Jacobo Arango

International Center for Tropical Agriculture (CIAT), Colombia

Livestock production and consumption of animal foods around the globe are currently under scrutiny, as consumers usually associate these activities to the environmental damage largely caused by extensive cattle ranching and deforestation. However, a change in the narrative is gaining track among key stakeholders giving more visibility to the how livestock foods are produced, differentiating extensive and sustainable cattle raising. Using examples from the tropical belt it can be demonstrated that sustainably managed forages with different strata (e.g., silvopastoral systems) can contribute to all the agroecological principles, mainly recycling, input reduction, soil health, animal health, biodiversity, synergy, social values, and economic diversification. Silvopastoral systems, based in improved forages, have been largely acknowledged for the potential to contribute to climate change mitigation and adaptation. Improved feeds based on mixtures of grasses and legumes (usually local genetic resources) influence modulating the ruminants' digestive microbiota, and hence reduce enteric methane emissions per unit product (kg meat/L milk). Moreover, in a global N fertiliser shortage, agroecological livestock production through silvopastoral systems benefit from the legumes capacity to fix N, with estimates ranging from 80 to 600 kg N per hectare per year, which avoids about 4.5 kg CO_2eq per kg N than if applied via fertiliser. Currently, diverse technologies have been proposed pointing for sustainable livestock production, however, silvopastoral systems stand out among them for the potential contribution to all agroecological principles, increasing livestock productivity while providing ecosystem services, including reduction of the carbon balance of the system.

Contact Address: Jacobo Arango, International Center for Tropical Agriculture (CIAT), A A 6713, Cali, Colombia, e-mail: j.arango@cgiar.org

Agroecology as a path in the face of chemical dependent agriculture

Larissa Mies Bombardi
University of São Paulo, Department of Geography, Brazil

With the worldwide economy, particularly after World War II, agriculture started to take on a global scale, not only in the sense that a significant part of the agricultural production started to be globally commercialised, becoming a commodity, but also because it began to become dependent on chemical industries of fertilisers and pesticides and, more recently, on patented seeds. The industrialisation of agriculture – which allowed agricultural production to be carried out on a very large scale and in a homogeneous way – became known as the "Green Revolution" and had, as a justification for its implementation, the promise of overcoming hunger, through the use of technology.

However, more than half a century has passed and, even so, the only constant still is hunger. Currently, the number of hungry people in the world has increased. In 2020, from 9.2 % to 10.4 % of the worldwide population faced hunger.

Not only has hunger increased, but, in addition, the environment and human health have been intensely contaminated by chemical substances used in agriculture.

To look at the human and environmental tragedy resulting from this agricultural model, let us focus on Brazil, the country that is the largest worldwide exporter of soy, beef, sugar, coffee and orange juice, among other products.

In Brazil, the emblematic expansion of soy – which currently covers an area equivalent to the entire territory of Germany and whose production has grown exponentially – shows us how devastating the monoculture expansion scenario for exportation is.

Between 2010 and 2020, the use of pesticides in Brazil substantially increased by 78.3 %. As a consequence of this increase, we are witnessing chemical violence, oftentimes indirect, silent and subtle, which arises as an unfolding of the aforementioned Green Revolution.

Facing the model imposed by the Green Revolution, which reveals itself to be external, homogenizing, dangerous and colonialist, agroecology appears as an alternative, proposing changes to the way economic processes unfold.

The need for a progressive transition to the path of agroecology is urgent. Otherwise, we will continue on a route that will result in a collision against ourselves.

Contact Address: Larissa Mies Bombardi, University of São Paulo, Department of Geography, São Paulo, Brazil, e-mail: larissab@usp.br

"It's the economy, stupid": Why a 1980s American political slogan is a perfect illustration of the drivers for restoration in the Sahel

Patrick Worms
World Agroforestry (ICRAF), Belgium

The vast drylands of Africa's Sahel region stretch from Mauritania and Senegal in the west to Eritrea and Djibouti in the East and are home to hundreds of millions of people, mostly farmers and pastoralists. Land use systems appear to have been adequate and sustainable for many centuries but were profoundly damaged by colonialism and the subsequent rise of the regulatory state, which emasculated evolved natural resource governance systems. Rapid population growth, serious droughts in the 1970s and 1980s, and maladapted regulatory systems and development priorities have led to a rapid degradation of land and ecosystem health indicators, the progressive worsening of rural livelihoods and a concomitant rise in outmigration and banditry. We propose a number of conceptual principles to apply in the effort to restore these landscapes to high ecosystemic productivity at scale, taking into account the range of modelled changes to local climates. Informed by decades of research and partnerships with development efforts across the region, these principles ask practitioners, regulators, donors and researchers to consider contexts, incentives and drivers, land, tree and livestock management strategies, scale, and nested regulatory and economic governance systems.

Contact Address: Patrick Worms, World Agroforestry (ICRAF), Brussels, Belgium, e-mail: p.worms@cgiar.org

Crops and cropping systems

Crops and cropping systems I

Oral Presentations

Posters

Crop diversification under climate change: a comparative assessment in Ghana, Burkina Faso, Ethiopia and Niger

Abel Chemura[1], Lisa Murken[1], Gloy Nele[1], Paula Aschenbrenner[1], Sophie von Loeben[1], Christoph Gornott[2]

[1]*Potsdam Institute for Climate Impact Research (PIK), Climate Resilience, Germany*

[2]*University of Kassel & Potsdam Institute for Climate Impact Research (PIK), Fac. of Organic Agricultural Sciences, Germany*

Diversified farming systems as an agroecological measure maintain functional biodiversity at multiple spatial and temporal scales in order to be productive, resilient and efficient. However, the potential for transforming or maintaining diversified agricultural systems depends on the ability of the selected crops to be sustained under the climate of the specific areas they are grown. Climate change can affect the ability of one or more crops to grow within specific niches and thereby reducing their potential to be part of a crop diversification strategy. In this study, we assessed the agro-climatic suitability of four major food crops in Ghana (maize, sorghum, cassava and peanut), Ethiopia (maize, sorghum, teff and wheat), Burkina Faso (maize, sorghum, cowpea and peanut) and Niger (maize, sorghum, cowpea and peanut) under current and projected climatic conditions using the ECOCROP crop suitability model. We find that suitability for four crops will decrease in Burkina, Ghana and Niger, while it will increase only in Ethiopia with the magnitude dependent on the climatic scenario. Positive changes in suitability are also projected for three crops in Ghana (up to 26.3 %) and for Ethiopia (up to 7.7 %), while in Burkina Faso area suitable for three crops will decrease (up to -36.8 %) and remain relatively unchanged in Niger(≈ 1 %). Instead, areas that are suitable for only one crop will increase in Burkina Faso, Ghana and Niger, while it will decrease only in Ethiopia. We therefore conclude that the potential for higher crop diversification will be negatively impacted by climate change. The impacts will vary within and across countries and thus, will influence planning for scaling up diversification as an agroecological measure.

Keywords: Climate impacts, crop suitability, farming systems, food crops, multiple cropping

Contact Address: Abel Chemura, Potsdam Institute for Climate Impact Research (PIK), Adaptation in Agricultural Systems, Potsdam, Germany, e-mail: chemura@pik-potsdam.de

Crop species richness in homegardens increased in a homestead food production cluster-randomised trial in Bangladesh

Katja Kehlenbeck[1], Jillian Waid[2], Abdul Kader[3], Amanda S. Wendt[2], Sabine Gabrysch[2]

[1]*Charité - Universitätsmedizin Berlin, Institute of Public Health, Germany*

[2]*Potsdam Institute for Climate Impact Research, Research Dept. II: Climate Resilience, Germany*

[3]*Helen Keller International, Bangladesh Country Office, Bangladesh*

Homegardening can contribute to both food security and dietary diversity of households by increasing availability of and access to nutrient-dense foods, particularly fruits and vegetables. We examined the impact of a Homestead Food Production programme on crop species richness in homegardens as implemented by the NGO Helen Keller International. Around 2700 women in 96 settlements of rural Habiganj, Sylhet, Bangladesh were enrolled in the 'Food and Agricultural Approaches to Reducing Malnutrition' (FAARM) cluster-randomised controlled trial. The Homestead Food Production programme was implemented in the 48 intervention settlements from mid 2015 to late 2018. Over the study period, trained data collectors interviewed women regularly on the number of crop species harvested in their homegardens by season (hot-dry, monsoon, and winter). During the baseline survey in early 2015, we collected annual data on crop species richness for the previous year. Over the ten seasons considered for analysis (from hot-dry 2016 to hot-dry 2019), we collected 31,639 observations of 2,699 women. We estimated the intervention's impact on crop species richness comparing means and using multilevel regression controlling for baseline levels of crop species richness.

At baseline, respondents reported harvesting 6.1 crop species in their homegardens in the previous year, with a slightly higher crop species number in gardens of women later assigned to intervention than to control (6.5 versus 5.8), including 3.7 and 3.3 vegetable as well as 2.6 and 2.3 fruit species, respectively. Comparing the hot-dry seasons from 2016 to 2019, mean total crop species richness was consistently higher in the intervention than in the control group, peaking in 2018 and slightly decreasing in 2019, the year after the intervention ended (all $p < 0.001$): 7.8 vs. 4.0 (2016); 9.2 vs. 5.0 (2017); 12.4 vs. 6.5 (2018); 10.1 vs. 6.1 (2019). The multilevel regression analysis also showed that more crop species – mostly vegetables – were harvested in gardens of intervention than control women in 2016, 2017, 2018 and 2019 (all $p < 0.001$). In summary, the intervention had a positive impact on crop species richness in homegardens, particularly vegetables, not only during the intervention period, but also in the year after the programme ended.

Keywords: Diversity, fruits, healthy food, impact, intervention, vegetables

Contact Address: Katja Kehlenbeck, Charité - Universitätsmedizin Berlin, Institute of Public Health, Charitéplatz 1, 10117 Berlin, Germany, e-mail: katja@kehlenbeck.org

Climate change impact on mixed-crop livestock systems in sub-Saharan Africa

Amit Kumar Srivastava, Thomas Gaiser, Frank Ewert, Andreas Enders, Alparslan Demircan

University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany

Sub-Saharan Africa (SSA) is particularly exposed and vulnerable to climate risks and therefore warrants a profound estimate of the effects of current and future climate on crop and livestock production to inform policies that may counteract the adverse effects. Therefore, the current study attempts to develop an integrated modelling framework at a farm-scale (IFM-FARM) for simulating the impact of climate change scenarios on the potential productivity of the mixed crop-livestock production systems in SSA. Dominant crops such as millet, sorghum, and maize and total livestock units (TLUs) based on one Representative Concentration Pathways (i.e., RCP 4.5) from the four General Circulation Models (GCMs) namely mbc-cclm-mpiesm, mbc-wrf-gfdlesm, mbc-wrf-hadgem2, and mbc-wrf-mpiesm in Sudan and Savannah zone of SSA were chosen in the study. The time-horizon 1981–2005 and 2020–2050 were considered to represent the baseline and near-future climate conditions respectively.

There was an average decline in the yield of millet, maize, and sorghum by 33.9 %, 28.7 %, and 26.3 % respectively across all the GCMs in 2050 compared to the baseline period. The highest yield loss was estimated for millet and Sorghum to the tune of 65.5 % and 53.2 % respectively under mbc-cclm-mpiesm in the Sahelian savannah zone.

Total livestock Units (TLUs) per hectare increased on average by 81 % in time horizon 2050 compared to the baseline across the two zones and GCMs which could be attributed to the more availability of grass biomass for feed. The results indicate the necessity of tailored management options and agricultural policies promoting the development of short cycled, heat, and drought-tolerant crop varieties and promoting the irrigation schemes in the affected areas.

Keywords: Climate change, integrated modelling framework, livestock, sub-Saharan Africa

Contact Address: Amit Kumar Srivastava, University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Katzenburgweg 5, 53115 Bonn, Germany, e-mail: amit@uni-bonn.de

Can low-input agriculture in semi-arid Burkina Faso feed its soil, livestock and people?

Gildas Assogba[1], Myriam Adam[2], David Berre[2], Katrien Descheemaeker[1]
[1]*Wageningen University and Research, Plant Production Systems, The Netherlands*
[2]*CIRAD, UMR/AGAP, Burkina Faso*

Agriculture in semi-arid Burkina Faso is dominated by mixed crop-livestock smallholder farms with limited investment capacity in production factors (e.g. improved seeds, fertiliser and equipment). Hence, to maintain production, farmers try to make the best use of available resources based on principles of agro-ecology, including crop diversity and nutrient and biomass recycling). We investigated farm-level management of resources (soil, crops, manure, fertiliser and livestock) through time to assess whether the current management options were able to sustain crop and livestock production and fulfil household food requirements. We ran a one-year detailed farm monitoring campaign in collaboration with 22 volunteer farms representing the diversity of the farming system in our study area. We quantified inputs and outputs in the cropping system (244 plots) for one rainy season. In addition, the weekly dynamics of crop residues left on field was quantified up to 12 weeks after harvest. Moreover, inflow and outflow of resources at farm-level were quantified weekly. The cropping system was characterised by a negative nitrogen balance of about 10 kg N ha^{-1} at the farm level. At the field level, cereal-legume intercropping significantly reduced the nitrogen deficit from -23.7 kg N ha^{-1} (sole cereals) to -4.8 kg N ha^{-1}. Dry season livestock grazing caused the amount of crop residue left on the soil after harvest (739 kg DM ha^{-1} on average) to quickly reduce at a rate of 26–76 kg DM ha^{-1} per week, leaving very little mulch as organic amendment. Livestock protein requirements were rarely met from farm-produced feed with average feed gaps ranging between 22 and 94 % of the requirements for small herd and large keepers respectively. Large livestock (cattle) owners relied on transhumance during the rainy season, grazing and frequent purchase of crop residues and concentrates to feed their livestock. Concerning food availability in the household, the amount of grain produced (89–175 % of food required) was generally enough to fulfil household requirements. Our detailed farm data indicates that a better integration of legume crops in the cropping system associated to improved manure and forage management is needed to sustain crop and livestock production.

Keywords: Agro-ecology, crop-livestock, efficiency, farming system

Contact Address: Gildas Assogba, Wageningen University and Research, Plant Production Systems, Bornsesteeg 48, 6700 AK Wageningen, The Netherlands, e-mail: gildas.assogba@wur.nl

Urban household vegetable production through the use of a developed vertical garden

Selorm Y. Dorvlo[1], Helena A. Nyanteh[1], Edmond K. S. Aziato[1], Beatrice Adjei[1], Belinda N. S. Djabeng[2], Ibrahim Sakibu[1], Lisa Desbordes[1], Daniel Ninson[3]

[1]*University of Ghana, Dept. of Agricultural Engineering, Ghana*
[2]*University of Ghana, Dept. of Geography and Resource Development, Ghana*
[3]*University of Ghana, Dept. of Agricultural Economics and Agribusiness, Ghana*

Rice is a major stable in Ghana and there are constant efforts to increase its production locally. As of 2020, local rice production figures were 987,000 tons, an increase of about two hundred tons from 721,465 tons in 2017. This shows a very promising trend in ensuring local production of rice. However, the major rice producers are smallholder farmers whose processes are riddled with drudgery. In addition to ensuring continued production, the smallholder farmers are being introduced to conservation agriculture farming methods. Though they are gradually adopting conservation agriculture methods of production, the level of drudgery in their production still poses major problems for their agenda to increase production sustainably. This study was formulated on the premise that if smallholder rice farmers can own/access machinery easily, it will increase their productivity. As such the study aims at providing a machinery ownership model for smallholder farmers that is economically feasible and sustainable. This was done by first evaluating the level of mechanization through a survey of 150 rice farmers in both the southern and northern sectors of the country. The field data collected from rice production centres in the northern and southern parts of Ghana showed that aside from the major issues with rice production mechanization, only specific processes along the value chain receive attention regarding mechanization. Based on technical specifications, the study provided the full set of equipment (13hp power tiller, drum seeder, knapsack sprayer, mini combine harvester) required to mechanize smallholder rice farming and then further developed economic models around ownership of the machinery. The net present value and cost-benefit-ratio analysis of the business models developed show that the best model is where farmer cooperatives own machinery and hire it out to members.

Keywords: Affordable, growthmedium, low technology, self-watering, vertical garden

Contact Address: Selorm Y. Dorvlo, University of Ghana, Dept. of Agricultural Engineering, Legon, Accra, Ghana, e-mail: sydorvlo@ug.edu.gh

Selection of varieties of deep-water rice for the *cuvelai* system of seasonal wetlands in Namibia

Mark Spoelstra

Agricola cc., Germany

In the communal area of north-central Namibia, most residents are subsistence farmers. Pearl millet, the main food crop, provides only low yields, causing frequent famine in Namibia. In the wet season, flood waters flow from the Angolan Plateau through seasonal rivers (*oshanas*), and surface water appears around early January toward the middle of March. The area is utilised by communal farmers as grazing land and the system is called the *Cuvelai* system of seasonal wetlands and covers approximately 800,000 ha, of which 250,000 can realistically be cultivated. The basic idea was not to bring water to the plants, but to bring a suitable plant to the water, i.e., not to redesign the environment with irrigation facilities, but to choose crops that will grow in the given ecosystem. The method chosen was on-site trials carried out at the Ogongo campus of the University of Namibia (UNAM) as well as at the Ministry of Agriculture's Mahenene Research Station, both located in the middle of the wetlands. The National Botanical Research Institute of Namibia (NBRI), located in Windhoek, owns three wild rice species endemic to Namibia. Preselected deep-water varieties from IRRI (International Rice Research Institute) and WARDA (West Africa Rice Development Association) nurseries were tested (n=588). On-farm trials were carried out to see how the rice cultivation fits into existing farm activities. The results are more than promising. The three selected varieties are a short-season, early ripening variety (114–122 days), a late variety (143–158 days) and a variety with awns that defend it against Quelea birds (132–164 days). The selected varieties are reasonably salt resistant. Yields are significantly higher than those of pearl millet. With soil improvement or fertilisation, yields can be increased considerably. So far, there are no rice pests or diseases in Namibia, so its cultivation is purely organic. Wetlands cover 6 % of the earth's land surface and their use is important for food security. Rice cultivation in wetlands can improve farmer's resilience to climatic change by growing an additional crop on underused land, increasing the productivity of agroecological farming by using natural waters.

Keywords: Agriculture, communal areas, *Cuvelai* system of seasonal wetlands, deep-water rice, food security, job-creation, namibia, poverty alleviation , resilience to climatic change, variety selection

Contact Address: Mark Spoelstra, Agricola cc., Po Box 118, 67247 Freinsheim, Germany, e-mail: markspoelstra123@gmail.com

Drivers and pathways of changing rice production systems in Luzon, Philippines

Richelyn Rose Clavero[1], Manuel José C. Regalado[2], Mathias Becker[1], Shyam Pariyar[1]

[1]*University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Plant Nutrition, Germany*

[2]*Philippine Rice Research Inst., Rice Engineering & Mechanization Div., Philippines*

Estimating future production trends and expected changes in land use and crop management requires an understanding of past and present changes in productivity and of pathways of transitions to the emergence of new cropping system configurations. Understanding and forecasting change trends and their determinants can help avoiding undesirable developments and guide policy decisions for a sustained supply of rice. We studied how recently implemented Rice Trade Liberalization Law (Republic Act No. 11203) in the Philippines changed the policy landscape in the rice sector and impacted rice production systems.

Through a diachronic analysis (years 2018 vs. 2022) we assessed changes in production practices and performance attributes in four main rice-producing provinces in Luzon representing either rainfed or irrigated agriculture systems. Structured surveys administered to 600 rice farmers were complemented by focus group discussions and the sampling and analysis of soil attributes and grain yields.

The law caused the Philippines to be flooded with cheap, imported rice that halved the price of palay (freshly harvested rice) increasing the uncertainties on economic revenues of rice farmers. Just after three years of its implementation, we observed major changes in land use and agronomic practices in the main rice-producing provinces. Mean Paddy area decreased in each site (2–20 %), with significant decrease in Aurora ($P = 0.023$). Least decrease in rice cultivation area was observed in Pangasinan (2 %, rainfed & favorable), whereas highest reduction was observed in Nuava Ecija (20 %, irrigated & favorable). Interestingly, the dry season (DS) crop establishment shifted to direct seeding due to high cost of transplanting in Bulacan (81 %), Nueva Ecija (13 %), and Pangasinan (21 %), whereas wet season (WS) direct seeding increased in Aurora (69 %) and Pangasinan (52 %). N application per hectare decreased in DS Aurora ($P = 0.000$) and Nueva Ecija ($P = 0.049$) and WS Bulacan ($P = 0.05$) and Pangasinan ($P = 0.005$). These might have affected decreased yield per hectare in DS Aurora ($P = 0.000$) and Nueva Ecija ($P = 0.000$) and in WS Bulacan ($P = 0.006$), and Nueva Ecija ($P = 0.010$). We identified new trends and likely drivers at both pre-and post-implementation of the rice trade liberalization law, and highlight major pathways of changing rice production in the Philippines.

Keywords: Cropping system shift, DPSIR, food security, *Oryza sativa*, rice tariffication

Contact Address: Richelyn Rose Clavero, University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Plant Nutrition, 53115 Bonn, Germany, e-mail: richelyn.clavero@yahoo.com

Spatial and temporal patterns of agrometeorological indicators in maize producing provinces of South Africa

Christian Simanjuntak[1], Thomas Gaiser[1], Hella Ahrends[2], Amit Kumar Srivastava[1]

[1]*University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany*
[2]*Helsinki University, Dept. of Agricultural Science, Finland*

Climate change impacts on maize production in South Africa, i.e., interannual yield variabilities, are still not well understood. We here present a pioneer study based on a recently released reanalysis of climate observations (AgERA5), such as temperature, precipitation, solar radiation, and wind speed data. We assess climate change effects by quantifying the trend of agrometeorological indicators (Mann-kendall and sens slope), their correlation with maize yield, and analysing their spatiotemporal patterns (EOF analysis). Thus, we derive the main factors that affected yield variability for the last 30 years (1990–2020) in major maize production provinces, namely Free State, KwaZulu-Natal, Mpumalanga, and North West. Results show that there was a significant positive trend in temperature that averages 0.03–0.04 °C per year and 0.02–0.04 °C per growing season. There was a decreasing trend in precipitation in Free State with 0.01 mm per year. Solar radiation did not show a significant trend in all regions. Wind speed in Free State increased at a rate of 0.01 m s^{-1} per growing season. Yield variabilities in Free State, Mpumalanga, and North West show a strong positive correlation (r>0.43) with agrometeorological variables. Yield in KwaZulu-Natal is not influenced by climate factors. The leading mode (50–80 % of total variance) of each agrometeorological variable indicates a homogenous pattern across the regions. The dipole patterns result illustrate that the variabilities of agrometeorological indicators are linked to South Indian high pressure and the warm Agulhas stream. Its corresponding temporal pattern demonstrates extreme events with strong positive and negative anomalies. Results form this study could be used to assist South Afria's government in favour of policy development to prevent famine due to climate change impact.

Keywords: Agrometeorological, maize yield, spatial-temporal trend

Contact Address: Christian Simanjuntak, Bonn University, Agricultural Sciences and Resource Management in the Tropics and Subtropics, Katzenburgweg 5, 53115 Bonn, Germany, e-mail: simanjuntak_christ@yahoo.co.id

Ecological status of the Pitahaya crop of the San Jorge farm, Pastaza, Ecuador

Evelyn Pérez Rodríguez[1], Raymundo Vento Tielves[1], Juan Carlos Cruz Hurtado[2], Reinaldo Demesio Alemán Pérez[3], Roldán Torres-Gutiérrez[4]

[1]*University of Pinar del Río, Center for Environment and Natural Resources Studies, Cuba*

[2]*Technological University of the La Habana, José Antonio Echevarria, Electronic Research Center, Cuba*

[3]*Amazon State University, Earth Science Faculty, Ecuador*

[4]*Regional Amazon University Ikiam, Live Science Faculty, Ecuador*

The research developed inserted in the DiveCropS Project: Diversifying Cropping Systems financed by DAAD of Germany, was carried out in the Pastaza province in Ecuador for the study of agricultural practices used in crops. to diversify the production of exportable resources of timber, medicinal or edible species. Within the edible products of this region is the Pitahaya (*Selenicereus megalanthus*) characteristic of subtropical and Amazonian zones, considered an exotic tropical fruit, with yellow skin, pulp with a bittersweet taste, with high demand in the national and international market. The objective of this study was to diagnose the state of the Pitahaya plantations in the San Jorge farm for the introduction of good agroecological practices. The research was based on the descriptive observational technique, which contemplated the application of observation and interview instruments. As results, the plantations were identified in moist, sandy loam soils, with good drainage due to their sensitivity to flooding, applying the traditional trellis system cultivation technique with a height of up to 2 m exposed to high light, with staggered production, achieving five harvests per year, in addition, environmental problems with the crop were detected, where the loss of biological diversity, the felling of forest ecosystems, the use of agrochemicals in the fertilisation of plantations, as well as the opening of access roads, causing the fragmentation of the ecosystem. This situation shows the need to establish a set of agroecological practices to mitigate the impact of environmental problems detected in the crop as a sustainable and sustainable alternative.

Keywords: Agricultural practices, agroecology, cultivation and environmental problems

Contact Address: Evelyn Pérez Rodríguez, University of Pinar del Río, Center for Environment and Natural Resources Studies, Reparto Hermanos Cruz, Pinar del Río, Cuba, e-mail: evelyn@upr.edu.cu

Participatory research for agronomic salinity management: Experiences from coastal peri-urban vegetable production in Maputo, Mozambique

Jakob Herrmann[1], Matias Siueia Júnior[2], Alberto Luis[3], Sebastião Famba[4]

[1]*Weltweit – Association for the Promotion of Local Initiatives e.V., Germany*

[2]*Municipal Council Maputo, Dept. for Agriculture and Extension, Mozambique*

[3]*ABIODES - Assoc. for Sustainable Developm., Program for Agriculture and Food Security, Mozambique*

[4]*University Eduardo Mondlane, Fac. of Agronomy and Forestry Engin., Mozambique*

Salinisation of agricultural soil resources is an ever increasing problem for global sustainable food production. Often, it results from interplay of climate change impacts and human agronomic mismanagement. The concept of Saline Agriculture (SA) provides a versatile toolbox of agricultural practices which have the potential to sustain agricultural production under saline conditions and partly even reverse salinisation through soil remediation processes. SA combines diverse soil, water and crop management approaches which intend to improve soil health parameters, in order to minimise salinity levels within the crops' root zone and/or mitigate salinity stress for the plants. However, SA practices are not universally applicable. They need to be tested locally and adapted to the particularities of production systems. Especially smallholder vegetable production systems in (sub-)tropical environments are still rather poorly understood in this regard. Addressing this knowledge gap, an ongoing project initiative is implementing a participatory pilot of SA practices in Maputo's peri-urban coastal vegetable production zones, in southern Mozambique. A consortium of research institutions, farmer associations, agricultural extension bodies and non-governmental organisations conducted an exploratory study to understand the local extent, farmers' perception, and agronomic implications of salinisation in the target region. A mixed method approach was applied, building on stakeholder interviews, field observations, and a participatory soil and water survey. Currently, the project evaluates the local adaptability of selected SA practices in participatory field trials. Preliminary results confirm (a) the pertinence of salinisation as a local driver of land degradation, with salinity levels significantly surpassing threshold levels recommended for vegetable production, (b) a considerable but expandable (tacit) knowledge level on salinity management by the local farming community, and (c) the potential of innovative SA practices to be sustainably introduced into the local production system. The latter include different organic manures, selection of tolerant cultivars, improved fallows with salt tolerant green manures like Sesbania spp. and salinity monitoring with portable soil and water sensors. The presented poster shares these technical insights along with reflections on the participatory methodology of the project, in order to provide impulses for further applied research initiatives on SA.

Keywords: Farmer field school, local knowledge, socio-ecological niche

Contact Address: Jakob Herrmann, Weltweit – Association for the Promotion of Local Initiatives e.V., Bad Soden, Germany, e-mail: jakob@welt-weit.org

Cultivation of niger-seeds – a treasure plant to secure availability of edible oil in Ethiopia

Eneyew Tadesse Melaku[1], Michael Henry Böhme[2]

[1]*Addis Ababa Science &Technology University, Biotechnology & Bio-process Centre, Ethiopia*

[2]*Humboldt-Universität zu Berlin, Horticultural Plant Systems, Germany*

The availability of edible oil in Ethiopia is limited typical plants as rape or sun flower are not cultivated. Niger-seed (*Guizotia abyssinica* Cass.) is native to Ethiopia and has a very good quality for edible oil, but underestimated in this regard and exported as birdfeed in industrial countries. In northern Ethiopia as in the highland area of Amhara Region niger-seed was cultivated long time by small holder farmers. The aim of this study was to identify land with favourable soil and climate conditions and sufficient water availability for niger-seed cultivation, as well convenient transportation to oil mills. In the field experiments were investigated cultivation methods using the cultivars Fogera and Kuyu, different nitrogen fertilisation in their effect on seed yield, seed quality and postharvest handling, as well as the oil expression efficiency and the quality parameters for niger-seed. The field experiments were prepared in a randomised block for statistical analyses with three repetitions. Based on field study in the locations, Adet and Koga, three seed rates and three fertiliser rates the highest mean niger-seed yield was 1384.6 kg ha^{-1} at Adet location (rainfed) followed by location Koga (rainfed) with 1064.7 kg ha^{-1} and Koga (irrigation) with 967.0 kg ha^{-1} showing significant difference. The seeds were stored in the laboratory for four weeks before the analysis started. Before further laboratory analysis started was ascertained the seed yield (kg ha^{-1}), moisture content (%) (dry basis), thousand seed mass (gram), and total ash content (%). Oil content determination was done for all the three cultivations for comparison i.e. Adet (rainfed), Koga (rainfed), and Koga (irrigation). Fatty acid and vitamin E determination was only done for the Adet experimental station (rainfed). The oil content by experimental location was 41.54 % for Koga (rainfed) followed by 39.59 and 38.67 % for Koga (irrigation) and Adet (rainfed) respectively showing significant difference whereas the Ash content showed a reverse trend of oil content. Fatty acid composition did not show significant difference in any treatment. Significant mean α-tocopherol of 80 mg/100 g (70 to 89 mg/100 g) was determined for increasing seed and nitrogen rates.

Keywords: oil content, seed quality, seed yield, α-tocopherol, oil expression

Contact Address: Michael Henry Böhme, Humboldt-Universität zu Berlin, Horticultural Plant Systems, Grünfließer Gang 7, 12587 Berlin, Germany, e-mail: michael.boehme@hu-berlin.de

Key physiological mechanisms involved in salt tolerance by comparing quinoa genotypes of various geographical origins

Ali Abd-Elkader[1], Ahmed Zaki[1], Anas Salama[2], Mohamed Aboul Fotouh[3], Mohamed Abdelsattar[4], Emad Abd El-Samad[5], Sayed Hussin[1], Sayed Eisa[1]

[1]*Ain Shams University, Agricultural Botany, Egypt*

[2]*Ain Shams University, Soil Science, Egypt*

[3]*Ain Shams University, Agricultural Biochemistry, Egypt*

[4]*Agricultural Genetic Engineering Research Institute (AGERI), Egypt*

[5]*National Research Centre, Vegetable Crop Research, Egypt*

Salinity is the most common problem that limits agricultural productivity in arid and semi-arid regions. One of the promising approaches to cope with salinity problems is the direct utilise of cash halophyte crops. *Chenopodium quinoa* is regarded as a facultative halophyte with a great potential for cultivation in saline regions. The wide range of geographic distribution of quinoa has resulted in significant genetic diversity in salinity stress tolerance among quinoa cultivars. This study aimed to elucidate the individual mechanisms that confer differences in salt resistance to three quinoa cultivars of different origins, namely, the salaries cultivar "Real", the highland cultivar "CICA-17", and the coastal lowland cultivar "NL-6". The quinoa genotypes, varying in salinity tolerance, were sown in sandy soil and directly irrigated with three water salinity levels (0, 150, and 300 mM NaCl) under greenhouse conditions. Eight weeks after the treatments, Plant growth parameters, leaf Na and K content, and photosynthetic measurements were determined. Seed yield per plant was measured at the end of the experiment. Responses to salinity greatly differed among the three cultivars. Plant seed yield was reduced by 47.1 %, 48.5 %, and 11.7 % in the NL-6, CICA, and Real cultivars respectively, at 150 mM NaCl salinity treatment. The Real plants exhibited distinctly the highest K+/Na^+ ratio compared to both CICA-17, and NL-6 plants, suggesting a more efficient control mechanism for K+ retention in Real cultivar. Net CO_2 assimilation rates were reduced by 42.8 % and 49.0 % of the control values in NL-6 and CICA-17 cultivars, respectively, versus only 11.7 % for Real plants. When plants were exposed to 300 mM NaCl, all cultivars showed a sharp decrease in physiological traits and seed yield, with a decrease of 71.7 %, 70.4 %, and 42.8 % in the potassium/sodium ratio in leaves and a reduction of 66.0%, 71.0% and 48.0% in the rates of Net photosynthesis and 84.3 %, 82.3 %, 66.8 % decrease in seed yield of NL-6, CICA-17 and Real cultivars, respectively, compared with the control. These results revealed that Real cultivar is a promising candidate in terms of salt-resistance and seed yield compared to either the CICA-17 or NL-6 cultivars.

Keywords: Genotypes, photosynthesis, quinoa, salinity, seed yield

Contact Address: Sayed Eisa, Ain Shams University, Agricultural Botany, Shubra Al Kheimah, 11241 Al Qalyubia, Egypt, e-mail: sayed_eisa@agr.asu.edu.eg

Combining mineral fertilisers with compost for sustainable maize production and reduction of greenhouse gas

Gebeyanesh Worku Zerssa, Bettina Eichler-Löbermann

University of Rostock, Agricultural and Environmental Faculty, Germany

Increasing crop production to supply the global food demand without harming the global environment is a major challenge for agricultural sectors in the world. The combined application of organic and inorganic fertilisers has been proposed as a tool for sustainable crop production and reducing greenhouse gas (GHG) emissions. However, interactive effects of fertilisers applied in different ratios on soil nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4) emissions are site specific. The study aimed to analyse the effects of the combined application of compost and inorganic fertiliser (urea or NPS) in different ratios on maize yield and GHG emission from in Nitisol in Ethiopia at two moisture levels (40 % and 75 % water filled pore spaces) in a laboratory incubation experiment and a two-year field trial. The results showed that maize yield can be increase by about 12 to 18 % when combining organic and inorganic fertilisers compared to inorganic fertiliser application alone. The combinations are also suitable to reduce the emission of N_2O by about 22 to 80 % in comparison to the inorganic fertilisers, especially in wet soil, while CO_2 and CH_4 emissions were less affected. Based on our findings compost application accounting for 40 to 70 % of the N supply in the fertiliser mixtures could be a suitable combination to increase maize yield and reduce N_2O emissions in Nitisols in Ethiopia. Further investigations on farm level are recommended in order to cover a broader spectrum of environmental and management effects.

Keywords: Combined application, compost, greenhouse gases, inorganic fertiliser

Contact Address: Gebeyanesh Worku Zerssa, University of Rostock, Crop Production, Erich-Schlesinger-Str. 19, 18059, 123456 Rostock, Germany, e-mail: workugb2010@gmail.com

Crops monitoring and yield estimation using sentinel products in semi-arid informal irrigation systems

Boris Ouattara[1], Gerald Forkuor[2], Michael Thiel[3], Barbara Sponholz[1], Heiko Paeth[1], Claudia Kuenzer[3]

[1]*University of Wuerzburg, Dept. of Physical Geography, Germany*

[2]*Center for Earth Observation and Environmental Research (CEOBER), Ghana*

[3]*University of Wuerzburg, Dept. of Remote Sensing, Germany*

The use of earth observation data for crop mapping and monitoring in West Africa has concentrated on rainfed systems due to their predominance in the sub-region. However, irrigated systems, though to a limited extent, provide critical livelihood support to many. Accurate statistics on irrigated crops are, thus, needed for effective management and decision-making. This study explored the use of Sentinel 1 (S-1) and Sentinel 2 (S-2) data to map the extent and yield of irrigated crops in an informal irrigation scheme in Burkina Faso. Random Forest classification and regression were used together with extensive field data comprising 842 polygons. Four irrigated crops (tomato, onion, green bean and other) were classified while the yield of tomatoes was modelled through regression analysis. Apart from spectral bands, derivatives (e.g. biophysical parameters and vegetation indices) from S-2 were used. Different data configurations of S-1, S-2 and their derivatives were tested to ascertain optimal temporal windows for accurate irrigated crop mapping and yield estimation. Results of the crop classification revealed a greater overall accuracy (76.3 %) for S-2 compared to S-1 (69.4 %), with S-2 biophysical parameters (especially the fraction of absorbed photosynthetic active radiation i.e fAPAR) being prominent. For yield prediction, however, S-1 VV polarisation came up as the most prominent predictor in the regression analysis (Radj2= 0.63), while the addition of S-2 fAPAR marginally improved the fit (Radj2= 0.64). Tomato yield in the study area varies up to 1616 kg $m^{-}2$, although about 83 % of the area have yields of less than 10 kg $m^{-}2$. Our study revealed that early-season images (acquired in December) perform better in classifying irrigated crop compared to mid or late-season. On the other hand, the use of early to mid-season (December to February) images for yield modelling produced reasonable prediction accuracy. This indicates the possibility of using S-1 and S-2 data to predict crop yield prior to harvest season for efficient planning and food security attainment.

Keywords: Biophysical parameter, Burkina Faso, random forest, Sentinel, yield modelling

Contact Address: Boris Ouattara, University of Wuerzburg, Dept. of Physical Geography, Wuerzburg, Germany, e-mail: blou.ouattara@uni-wuerzburg.de

The potential of integrated soil fertility management for closing the yield gap in Ethiopia

Julia Doldt[1], Kidist Yilma[1], Jim Ellis-Jones[2], Steffen Schulz[1]
[1]*Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Integrated Soil Fertility Management Project (ISFM+), Ethiopia*
[2]*Agriculture-4-Development, United Kingdom*

The dominant farming systems across the Ethiopian highlands includes cereals, notably wheat, maize, teff, sorghum and barley with faba bean being a widely grown legume. Key constraints limiting yields are soil degradation and low soil fertility. The Integrated Soil Fertility Management (ISFM+) Project has collected and analysed data from hundreds of farmer-managed demonstration plots over a 5-year period. These compare farmers' practices (control) with demonstrations using at least three ISFM practices. They included the use of agricultural lime on acidic soils, improved seed, organic fertiliser, rhizobia on legumes, green manure and some inorganic fertiliser. The yields of 1,878 one-year short-term demonstrations, maintained for one season and 103 long-term demonstrations, maintained for five years were measured. The results were used to evaluate the effect of ISFM on grain yields. The mean yield across the short-term control plots was 2.88 Mg ha^{-1} while the ISFM plots yielded 4.81 Mg ha^{-1}, a yield increase of 67 %. Continuous use of ISFM for five consecutive years increased yields by 154 %.Soil acidity had a significant negative impact on control yields, while lime used in the demonstration plots alleviated these effects. It was found that almost all plots would benefit from liming especially in the long-term as acidification increased across the control plots. Comparing control yields to the national average showed no marked discrepancies while ISFM yields were considerably (69 %) higher. With increasing mineral fertiliser prices and a need for more sustainable farming systems, ISFM can pay a key role in agroecological transformation, in alleviating food insecurity, increasing farmers' income and reducing food imports. The 3.5 million ha of acidic soils in Ethiopia could be made highly productive by applying lime and ISFM practices. Scaling up will however require significant private and public investment to ensure access to lime, fertiliser, rhizobia and improved seed. A system of private agrodealers supplying inputs to farmers seems the most likely option to achieve this. Hence the environment for private sector sales of agricultural inputs needs to be improved.

Keywords: Ethiopian highlands, lime, soil acidity, yields

Contact Address: Kidist Yilma, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Integrated Soil Fertility Management Project (ISFM+), Addis Ababa, Ethiopia, e-mail: kidist.yilma@giz.de

Phenotyping the banana biodiversity to identify climate smart varieties with optimal market potential in Africa and Europe

Elyeza Bakaze, Rockefeller Erima, Priver Namanya Bwesigye

National Agricultural Research Organization (NARO), National Banana Research Program, Uganda

Banana (*Musa* spp.) is the fourth most important crop in the Least Developed Countries, providing staple food for more than 400 million people (www.fao.org.faostat). It is an important source of income for many small and medium-scale producers that needs only limited inputs to ensure a harvest. However, yield and the value chain are far below their potential for many smallholder farmers in the cattle corridor areas (drought-prone) of Uganda. Intensifying banana production in a sustainable way (without expanding land use and considering biotic and abiotic pressure) means introducing suitable varieties that are resilient to the effects of climate change and remain high-yielding. The project, therefore, aims to sustainably improve banana production and productivity with climate-smart bananas. This would be achieved through the diversity search in the already existing banana varieties preferred by farmers. Also through consultations with stakeholders of the banana value chain. But also needed to do is the drought evaluation of recently released elite banana hybrids that are high yielding and also resistant to pests and disease. This would guide the selection and introduction of climate-smart banana varieties that are tolerant to climate change. Introducing diverse banana varieties that are high-yielding with acceptable sensory attributes, resistant to pests and diseases, but also tolerant to prolonged droughts is equivalent to climate-smart bananas. A baseline survey was conducted in Sembabule, Ntungamo, and Isingiro districts. More than 18 % of respondents suffered food and income insecurity, and loss of livestock during drought. The coping strategy reported was a reduction in the number of meals per day and the sale of animals. Also, not all preferred banana varieties were drought tolerant. Intervention; four banana hybrids: Kabana-6H, NAROban^{-3}, NAROban-4, and NAROban-5, identified on the basis of robustness and resilience to erratic rainfall, pest, and disease were established and being evaluated for drought tolerance. The successful banana varieties with tolerance traits to drought will later be promoted to farmers in the drought-prone areas

Keywords: Climate smart banana, high yielding, pest and disease resistant

Contact Address: Elyeza Bakaze, National Agricultural Research Organization (NARO), National Banana Research Program, National agricultural research laboratories (NARL) kawanda P.O Box 7065, +256 Kampala, Uganda, e-mail: ebakaze@gmail.com

Certified seeds or certified bags? Using genotyping-by-sequencing to validate the identity of maize in Ghana

Lilli Scheiterle[1], Vinay Kumar Reddy Nannuru[2], Regina Birner[1], Karl Schmid[3]

[1]*University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany*

[2]*Norwegian University of Life Sciences, Dept. of Plant Sciences, Norway*

[3]*University of Hohenheim, Inst. of Plant Breeding, Seed Science and Population Genetics, Germany*

Since the green revolution in Asia, the adoption of improved varieties is recognised as one of the most important contributions to agricultural productivity and as a critical measure to reduce poverty. Maize contributes largely to food security in sub-Saharan Africa despite persistently high yield gaps. In Ghana, the commercial maize seed market is dominated, for almost twenty years, by one high yielding variety called 'Obatanpa'. The average maize yield is about $1.7\,\mathrm{t\,ha^{-1}}$ whereas its potential is about $4.3\,\mathrm{t\,ha^{-1}}$. As seed quality plays a crucial role in yield performance, in this study, we investigate whether samples sourced from certified Opatanpa seed bags were actually containing the claimed genetic material. Genetic fingerprinting is increasingly used to assess the genetic purity of crop varieties found in farmers' fields, however, this method has been barely applied to commercial seeds so far. In the present study, we used genotyping-by-sequencing (GBS) to compare the collected seed samples (56) from agro-input shops (34) in the north of Ghana, against the reference obtained from the gene bank at CIMMYT in Mexico. Different methods of population structure were performed using the SNP markers, which revealed high variation among the samples and about 11 % of the samples are not relatable to Obatanpa. This study does not explain the reasons for the poor quality of the certified Obatanpa seeds available in the market, however, entry points can be assumed along the entire production chain of the certified seeds and further analysis is needed to identify these shortcomings. Nevertheless, the study stresses the need to sustainably increase the purity of the genetic material available to small-scale farmers in the region, as it is one lever to improve yields.

Keywords: Generic fingerprinting, Ghana, maize, seed system, yield gap

Contact Address: Lilli Scheiterle, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), 70599 Stuttgart, Germany, e-mail: lilli.scheiterle@uni-hohenheim.de

Does land demarcation affect improved seed uptake? Evidence from farmers' mental models in eastern Uganda

Lisa Murken[1], John Adriko[2], Karlijn van den Broek[3], Kati Kraehnert[1], Christoph Gornott[4,1]

[1]*Potsdam Institute for Climate Impact Research (PIK), Germany*

[2]*National Agricultural Research Organization, Uganda*

[3]*Copernicus Institute of Sustainable Development, Utrecht University, The Netherlands*

[4]*University of Kassel, Fac. of Organic Agricultural Sciences, Germany*

Do secure land rights incentivize farmers to invest more in their land and adapt their agricultural production to climate change? Many studies investigate this question but come to different results that are highly context-dependent. We evaluate the effect of a pro-poor land mapping and registration project in Eastern Uganda, which supported smallholder farmers in resolving land disputes, demarcating their land and applying for customary certificates of ownership. Specifically, we compare households in a sub-county that benefited from the programme with households in a neighbouring sub-county that did not receive such support. Next to a structured survey, we ask households to draw mental models of their decision process to either use or not use improved seeds, such as drought resistant, high-yielding or early maturing seeds. Mental models capture an individual's perception and understanding of a state or process, allowing to uncover divergences between the observed world and an individual's behaviour. By eliciting mental models, we investigate if and how households that benefited from the land mapping project differ in their adaptation decisions, namely with regard to using improved seeds. Results from 253 mental models show that the decision to use improved seeds involves many different factors. The complexity of the mental models drawn goes beyond frequently advanced explanations of (low) improved seed uptake, which centre on high cost of- and low access to improved seeds. Households who benefitted from the land mapping project more often list secure land rights as component of their decision process, compared to the control group. On average, they also draw more positive connections between secure land rights and the uptake of improved seeds, compared to households who were not part of the land mapping project. In contrast, few households see an influence of land certificates on improved seed uptake, both in the treatment and in the control group. The results lend support to the hypothesis that secure land rights are relevant for increased investment.

Keywords: Improved seeds, mental models, tenure

Contact Address: Lisa Murken, Potsdam Institute for Climate Impact Research (PIK), Telegraphenberg A31, 14473 Potsdam, Germany, e-mail: murken@pik-potsdam.de

Detecting cocoa plantations in Côte d'Ivoire and Ghana and their implications on protected areas

Itohan-Osa Abu[1], Zoltan Szantoi[2], Andreas Bernhard Brink[3], Marine Robuchon[3], Michael Thiel[1]

[1]*University of Würzburg, Dept. of Remote Sensing, Germany*

[2]*European Space Agency, France*

[3]*European Commission - Joint Research Center, Italy*

Côte d'Ivoire and Ghana are the largest producers of cocoa in the world. In recent decades the cultivation of this crop has led to the loss of vast tracts of forest areas in both countries. Efficient and accurate methods for remotely identifying cocoa plantations are essential to the implementation of sustainable cocoa practices and for the periodic and effective monitoring of forests. In this study, a method for cocoa plantation identification was developed based on a multi-temporal stack of Sentinel^{-1} and Sentinel^{-2} images and a multi-feature Random Forest (RF) algorithm. The Normalized Difference Vegetation Index (NDVI) and second-order texture features were assessed for their importance in the Random Forest classification, and their optimal combination was used as input variables for the RF model to identify cocoa plantations in both countries. The Random Forest model based cocoa map achieved 82.89 % producer's and 62.22 % user's accuracy, detecting 3.69 million hectares (Mha) and 2.15 Mha of cocoa plantations for Côte d'Ivoire and Ghana, respectively. The results demonstrate that a combination of an RF model and multi-feature classification can distinguish cocoa plantations from other land cover/use, effectively reducing feature dimensions and improving classification efficiency. The results also highlight that cocoa farms largely encroach into protected areas (PAs), as 20 % of the detected cocoa plantation area is located in PAs and almost 70 % of the PAs in the study area house cocoa plantations. These findings highlight the urgent need for governments and buyers to address both the distal and the proximal causes of cocoa-related deforestation.

Keywords: Cash crops, cocoa mapping, encroachment, protected areas, West Africa

Contact Address: Itohan-Osa Abu, University of Würzburg, Dept. of Remote Sensing, 97218 Würzburg Gebrunn, Germany, e-mail: itohan-osa.abu@uni-wuerzburg.de

Assessment the impact of dikes on economic efficiency of models for rice farming in Dongthap, Vietnam

Huong Thi Thu Truong[1], Binh Vu Thai[2]

[1]*Humboldt-Universität zu Berlin, Environmental Resources, Germany*

[2]*University of Nation Ho Chi Minh City, Inst. for Environment and Resources, Vietnam*

The study was carried out in four districts Hongngu, Tamnong and Thanhbinh, which are located in the northern area of Tiengiang river of Dongthap. This is a province in South-Vietnam, with strong flooding by the Mekong River. Because flooding has a large influence on the farms and food production, policy tried already since long time to find solutions to solve this problem. One solution is to set up a branched canal system and a high-density dyke system, in this region important for rice and many other crops. Two main types of dike has been researched, are: (1) the mezzanine dike, a short low dike system, can receive floods to build up alluvium for fields; and (2) the thorough embankment, a high dike system which can completely protect the cultivated crops and farmers from floods. In this region, diking is a good possibility to exploit fully the arable land, for example rice could be grown 3–4 crops per year, vegetables could be grown 6–7 crops per year. However, in a long term it cause the land to be exhausted. However, in a long term it can cause the land to be exhausted. The area inside the embankment is often over-exploited, the concentration of chemical fertilisers in the soil is high and the soil fertility is reducing because floods were reduced for many years and the field cannot receive fertile alluvium soil. This is the main reason for the significant reduction in crop yield and impact to the economic efficiency. The aim of study was to determine the positive and negative aspects of dike system in order to propose a reasonable and profitable agricultural production complex model, which consider the valuable crops, the season and the consumer market. It has to consider, the influence on productivity and cultivated effect depend on the operation of the dike, floods and the environmental quality inner area of dikes. The economic efficiency of production models was evaluated by several parameters, including: Production value GO (Gross Output); Basic investment; Intermediate expenditure (IE); Value Added (VA); Mixed Income (MI) and Profit (Pr). The estimation based on the questionnaires and model monitoring datum.

Keywords: Dike systems, farming system, flooding, Mekong delta, multi factoral models

Contact Address: Huong Thi Thu Truong, Humboldt-Universität zu Berlin, Environmental Resources, Grünfließer Gang 7, 12587 Berlin, Germany, e-mail: truonghuong5980@gmail.com

Synthesis of field experiments for the assessment of yield response to different management options in diverse agro-ecological zones in Kenya using the CERES-Maize model

Harison Kipkulei[1], Sonoko Dorothea Bellingrath-Kimura[1], Stefan Sieber[1], Marcos Lana[2]

[1]*Humboldt-Universität zu Berlin, Fac. of Life Sciences, Germany*

[2]*Swedish University of Agric. Sci., Dept. of Plant Production Ecology, Sweden*

Maize production important in sustaining the livelihoods of approximately 98 % of smallholder farmers in Kenya. The production, however, has been declining as a result of periodic climate shocks, pests, diseases, declining soil fertility, and poor agronomic practices. Aligning maize production to feasible management strategies is important for low production regions of sub-Saharan Africa.

In this study, therefore, we synthesized field experiments conducted in the 2014 and 2021 growing seasons in the Endebess region in Kenya and three other well-calibrated and evaluated experiments conducted in Embu, Juja, and Naivasha during different maize growing seasons. Subsequently, we determined yield responses to strategies that include three fertilisation rates (N = 50 kg ha^{-1}, N = 75 kg ha^{-1}, and N = 100 kg ha^{-1}), two irrigation management (rainfed and supplementary irrigation of 80 mm), and three sowing dates (15th March, 1st April, and 15th April) using the DSSAT model (CERES-Maize). In total, we simulated 18 treatment combinations using long-term (1984–2021) weather data and computed the average yield.

Results show a varied response of the different strategies to maize production based on the agro-ecological zone. Under rainfed production and the recommended fertilisation rate of 75 kg N ha^{-1}, CERES-Maize simulated yields of 5835 kg ha^{-1} and 4389 kg ha^{-1} for Endebess and Embu, respectively. However, simulated yields in Juja and Naivasha were 3105 kg ha^{-1} and 2899 kg ha^{-1}, respectively. The yields, however, increased by 27 % and 36 %, under supplementary irrigation and the recommended fertilisation rate. The relatively humid regions of Endebess and Embu showed little effect on supplementary irrigation (+5 % and +4 % yield increase), while a high fertilisation level of 100 kg N ha^{-1} improved yields by 15 % and 19 %, respectively. This shows that in the upper midland agro-ecological zones in Kenya, nitrogen is the limiting factor for maize production, whereas moisture stress is attributed to low production in the lowland regions. Evaluation of the sowing dates shows that early planting (15th March) combined with supplementary irrigation is beneficial only to the lowland regions. The results imply that accounting for site-specific conditions is necessary for improving maize yield in Kenya.

Keywords: CERES-Maize model, management strategies

Contact Address: Harison Kipkulei, Humboldt-Universität zu Berlin, Fac. of Life Sciences, Eberswalder straße 86, 15374 Müncheberg, Germany, e-mail: harison.kipkulei@zalf.de

Patterns and drivers of medium-term agricultural landscape transformation in Kyunsu township, southern Myanmar

Phyu Thaw Tun, Thanh Thi Nguyen, Andreas Buerkert

University of Kassel, Organic Plant Production and Agroecosyst. Res. in the Tropics and Subtropics, Germany

Kyunsu township in southern Myanmar comprises coastal regions and a multitude of small islands covered by vast tropical evergreen forests, mangrove forests, and a large water body in the Adman Sea. Due to population growth, residents are increasingly expanding their agricultural areas. Understanding the patterns and drivers of medium-term agricultural landscape transformation in this area is crucial for local policy making to foster sustainable crop production. Landsat datasets were used in a comparative post-classification approach to investigate agricultural landscape transformation over 40 years. Iso-cluster unsupervised classification, supervised random forest classification, compilation of classified data, and digitisation of Landsat datasets from 1978, 1989, 2000, 2011, and 2020 were performed using ArcGIS software and GEE platform. A minimum of 58 training points and 65 training polygons for each class were used for supervised classification. The overall accuracies of the classification were 96 % (1978), 97 % (1989), 97 % (2000), 97 % (2011), and 97 % (2020). As expected, the results did not indicate notable changes in water bodies (+0.11 %) within the last 40 years. However, major changes were noted in lowland rice fields (+90 %), open forests (+81 %), settlement areas (+115 %), aquaculture (+1594 %), and other land uses (+188 %) while closed forests shrunk by 45 %. Also, minor changes occurred in mangrove forests (-9 %) and in plantation areas (+11 %). Change detection showed that 54.56 km^2 of lowland rice areas were expanded to open forests, mangrove forests and plantation areas and 229.26 km^2 of open forests, closed forests, and mangrove forests were turned to plantation areas. A large proportion of closed forests (405.23 km^2) transformed to open forests. Population growth with settlement areas expansion could be the major driver of agricultural landscape transformation and consequent deforestation in this area. Local land-use planners and extension services should foster agroecological cropping practices to improve crop productivity per unit land area for livelihood security of the local people while making the policy to maintain natural forests for ecosystem services.

Keywords: Crop land expansion, deforestation, ecosystem protection

Contact Address: Phyu Thaw Tun, University of Kassel, Organic Plant Production and Agroecosyst. Res. in the Tropics and Subtropics, Steinstrasse 19, 37213 Witzenhausen, Germany, e-mail: phyuthaw25@gmail.com

Agro-ecological water and crop management practices' effect on rice yield and water productivity in lowlands: a meta-analysis

Bio Zime Sounon Orou[1], André Adjogboto[1], Zakari Sissou[1], Pierre B. Irénikatché Akponikpe[1], Marnik Vanclooster[2]

[1]*University of Parakou, Hydraulics and Environmental Modelling Laboratory, Benin*

[2]*Université Catholique de Louvain, Earth and Life Institute, Belgium*

Climate variability frequently leads to water scarcity in agriculture in general and rice growing in particular. There are many adaptation techniques developed for rice cultivation by diversifying production environments and increasing water management practices. Nevertheless, little is known about their performances. This meta-analysis aims to evaluate the crop management performances of various water management practices in lowland rice cultivation worldwide. We conducted research using Scopus and web of science databases with the keywords << irrigation AND "water productivity" OR "water use efficiency" AND rice* or paddy AND lowlands OR plains OR "Inland valley" >>. The criteria applied are essentially the language (English or French), the year (2000–2021), and the type of document (peer-reviewed papers). A total of 56 articles out of 441 met these criteria, from which 573 Observations were collected. Five (05) water management practices were identified in lowland rice as follows: Continuous Flooding (CF), Saturated Soil (SS), moderate Alternative Wetting and Dry (AWDm), severe Alternative Wetting and Dry (AWDs), and Aerobic rice (AR). We compared SS, AWDm, AWDs, and AR practices to CF. The response ratio of the yield and water productivity (RR) were used as measures of the effect sizes of the response of water stress on rice yield and water productivity. Our study revealed that yields decreased by 11.1 % and 37.5 % respectively in the AWDs and Aerobic systems compared to CF. While on saturated and AWDm practices, the differences in performance compared to CF are not significant ($p > 0.05$). Water productivity increased by 25.7 %, 32.9 %, and 25.6 % under AWDm, AWDs, and Aerobic systems, respectively. Findings also showed that rice yield and water productivity were significantly improved with rice short genotype cycle, in' direct sowing under AR practices and higher plant density (]75;100]). Meanwhile, the best water productivity (49 %) was observed under AWDs system when rice is transplanted with plant density 25 plants m^{-2} The implementation of the AWDm practices allowed to improve water productivity by 25.7 %, while maintaining rice yield.

Keywords: Aerobic rice, agroecological water management practices, alternative wetting, and dry, continuous flooding, rice, soil saturation

Contact Address: Bio Zime Sounon Orou, University of Parakou, Hydraulics and Environmental Modelling Laboratory (HydroModE-Lab), Parakou, Benin, e-mail: biozimsounon@yahoo.com

Comparative characterisation of humic substances obtained from anaerobic digestate of horticultural residues

Yanelis Avilés-Tamayo[1], Yans Guardia-Puebla[2], Lázaro Valdes-Izaguirre[2], Quirino Arias[2], Raul Lopez[3], Gert Morscheck[4], Bettina Eichler-Löbermann[4]

[1]*University of Veracruz, Fac. of Agricultural Sciences, Cuba*
[2]*University of Granma, Chemistry, Cuba*
[3]*University of Granma, Plant Biotechnology Study Center, Cuba*
[4]*University of Rostock, Agricultural and Environmental Faculty, Germany*

Currently, agriculture has as one of its main objectives the reduction of the use of agrochemicals, since their constant application causes damage to the environment and human health. Among the products that have been used to increase crop yields are bio-stimulant products. Humic substances have been recognised for their bio-stimulant action and direct impact on plant physiology. One of the ways of obtaining humic substances is from the anaerobic digestate obtained by anaerobic digestion. Compared to commercial products, humic substances from anaerobic digestate contain a wider variety of organic substances, more lipids, more nitrogen and a lower degree of oxidation. In this study, the humic substances obtained from anaerobic digestate of horticultural crop residues for their use in agriculture were characterised. Anaerobic digestate samples were subjected to a basic treatment with sodium hydroxide (NaOH) at concentrations of 0.1 mol, 0.5 mol and 1.0 mol that allowed the separation of humic and humin substances. For this purpose, three solid/liquid fraction ratios (1/8; 1/10; 1/12) were used. Then, the separation of humic acid and fulvic acid by acid extraction with hydrochloric acid (HCl) was performed. The physical-chemical characterisation of the humic substances showed the high potential fertiliser value due to their contents of N, P, K, and micronutrients. However, the proportions of N-P-K in both humic substances were widely variable; meanwhile, the micronutrients were below the recommended limits for the concentrations of potentially toxic elements. In conclusion, the humic substances obtained from the anaerobic digestate showed substantial differences in terms of nutrients and physicochemical characteristics. Future perspectives indicate that nutrient variability in bio-based fertilisers will be one of the greatest challenges to address in the future utilisation of these products.

Keywords: Anaerobic digestate, horticultural residues, humic substances

Contact Address: Yans Guardia-Puebla, University of Granma, Chemistry, Bayamo, Cuba, e-mail: yguardiapuebla@gmail.com

Do agro-ecological practices improve water productivity in irrigated vegetables crops?

Gbègnidaho Mègnissè Bignon Inès Justine Zohoun[1], André Adjogboto[1], Sissou Zakari[1], Pierre B. Irénikatché Akponikpe[1], Joost Wellens[2]
[1]*University of Parakou, Hydraulics and Environmental Modelling Laboratory, Benin*
[2]*Université de Liège, Department of Environmental Science and Management, Belgium*

Performance of irrigation systems are suggested better crop yield and irrigation water use efficiency (IWUE) when combined with agroecological practices. These practices aim at a sustainable soil, water, and crop management by improving soil root zone environment and increasing crop water and nutrient absorption. However, the effects of agroecological practices on crop yield and IWUE are variables. This study presents the results of meta-analysis of 25 peer reviewed scientific publications on irrigated vegetables that met eligibility criteria. A total of 282 observations extracted was used with random-effects model to compute response ratio (RR) of vegetable yields and IWUE. It aims to assess whether irrigation application methods, relative irrigation amount, season, and crop types significantly improve crop yields and IWUE under deficit irrigation (DI) and over full irrigation (OFI) compared to full crop water requirement (100%ETc) as the control. Both gravity and pressurized irrigation have a negative impact on vegetable yields under DI or OFI. IWUE is improved when DI is applied under pressurized irrigation compared to gravity application while in OFI, both water application methods lead to a significant decrease of IWUE by 240 %. Over full and deficit irrigation have a significant negative impact on vegetable yield (RR DI=-0.1388, $p<.0001$; RR OFI=-0.0437, $p<.0001$). The effect is 200 % more severe when DI is applied compared to OFI and under 50 % of ETc. Among the different irrigation amount applied, only an application between 50 and 80 % of ETc resulted in the best IWUE. Yield is negatively affected as opposed to IWUE regardless the fertiliser source used under DI and OFI. Indeed, IWUE is most improved when organic fertiliser is applied alone or in combination with mineral fertilisers. Crop types and production season also negatively impacted yield under DI or OFI, but water productivity is improved under fruit vegetables and spring-summer season. Our findings highlight the potential of agroecological practices under irrigated vegetable to increase yield and WUE and identify in which conditions these results can be achieved. These practices can be used successfully around the world.

Keywords: Agroecological practices, irrigation methods, relative irrigation amount, vegetable, water use efficiency

Contact Address: Gbègnidaho Mègnissè Bignon Inès Justine Zohoun, University of Parakou, Hydraulics and Environmental Modelling Laboratory (HydroModE-Lab), Parakou, Benin, e-mail: inozohoun@gmail.com

Identification and characterisation of salt stress-responsive NHX gene family in chickpea

Kauser Parveen, Muhammad Abu Bakar Saddique, Shoaib Ur Rehman

MNS University of Agriculture, Inst. of Plant Breeding and Biotechnology, Pakistan

Chickpea (*Cicer arietinum* L.) is commonly recognised as a garbanzo bean. It has a nut-like flavour and is a most valuable and nutritious food crop for the globally increasing population. The annual production of chickpea is 11.5 million tons and has the third rank after common beans. Salinity has an adverse influence on chickpea germination, vegetative growth, and reproductive activities. Plant adapts the strategies to cope with the salinity stress. Na^+/H^+ exchanger (NHX) is one of the gene families which has been well known to improve salt tolerance in plants. NHXs are membrane transporters that catalyze the electroneutral exchange of K^+ or Na^+ for the accumulation of H^+ and are important for pH and ion homeostasis and salt tolerance. The aim of this study was the identification and characterisation of the NHX gene family to identify the salt stress-responsive NHX genes in chickpea. We identified the eight salt stress-responsive NHX genes from chickpea on a genome-wide scale. The phylogenetic analysis represented the evolutionary relationship of CaNHXs with other species, and the intron-exon organisations analysed by gene structure analysis revealed that CaNHX7 and CaNHX8 have a high number of introns and exons. Subcellular localisation, protein-conserved motifs, and domains were examined. In silico gene expression analysis revealed that out of eight members of the NHX gene family, two members CaNHX3 (Ca_19073) and CaNHX7 (Ca_02050) have shown high expression under salt stress. Overall, this study provides the specific targets for further comprehensive functional study and identified that CaNHXs may be explored further as potential gene candidates for the improvement of chickpea.

Keywords: Chickpea, expression analysis, gene family, Na^+/H^+ exchanger (NHX), salt stress

Contact Address: Muhammad Abu Bakar Saddique, MNS University of Agriculture, Inst. of Plant Breeding and Biotechnology, Multan, Pakistan, e-mail: abubakar.siddique@mnsuam.edu.pk

Optimum planting dates and season length for maize in Kano, Nigeria

Siyabusa Mkuhlani, Eduardo Garcia Bendito
International Institute of Tropical Agriculture, Natural Resources Management, Kenya

Maize is a staple food crop in Northern Nigeria and most of the cropping is under rainfed farming. Rainfed farming is susceptible to climate change. Climate change has impacts on rainfall and temperature variability which has a significant impact on maize yields. There is therefore need for continued research on strategies to improve climate change adaptation in maize. One such strategy involves the use of low-cost strategies such as planting dates and variety choice. The study was based in Northern Kano, which is the maize belt of Nigeria and used historical climate data (1980-2020) from NASA as input data. Using the DSSAT 4.7 crop model planting series were undertaken every 10 days from 1 May to 31 August each year. Simulations for yields were undertaken at each planting date each year across the Kano State, Nigeria. The planting date with the highest yields each season was considered the optimum planting date. The study also assessed season length at scale by computing the difference in season commencement and termination of effective rainfall (1980-2020). The DSSAT model simulations were undertaken at scale of 10 km^2across the state. Generally, in northern Kano the optimal planting dates range from 20-May to 29-June. This was more notable in the years 1985, 1990, 1995, 2010, 2015 and 2020. In 2000 and 2005 the optimal planting dates were generally delayed across the state and ranged from 29-June to 8-August. The season length is generally shorter in northern Kano compared to southern Kano. The season length in northern Kano ranged from 80-110 days. Northern Kano is therefore suitable for short to medium season length varieties. In contrast the season length was 110 to 130 days in southern Kano. Southern Kano is therefore suitable for medium to long seasoned varieties. The study concludes that there is need for use of different varieties in different areas of Kano to ensure considerable yields across the state. Similarly, use of optimum planting dates by farmers will lead to relatively high yields. There is need to include seasonal forecast data for use in determination of the optimum date and season length.

Keywords: Crop model, planting date, season length, variety

Contact Address: Siyabusa Mkuhlani, International Institute of Tropical Agriculture, Natural Resources Management, c/o International Centre of Insect Physiology and Ecology (ICIPE) , Nairobi, Kenya, e-mail: siyabusa@gmail.com

Potential use of sago (*Metroxylon sagu*) for feed and agro-industry

Regina Magaña Vázquez[1], Fetriyuna Fetriyuna[1], Ratna Chrismiari Purwestri[2,1]

[1]*University of Hohenheim, Inst. of Nutritional Sciences, Germany*

[2]*Czech University of Life Sciences Prague, Fac. of Forestry and Wood Sci., Czech Republic*

Innovation in our way of thinking can create new models that adapt to current conditions and use consciously local resources to their full capacity.
Therefore, making the most of a resource like sago (*Metroxylon sagu*) can be a solution to many problems faced in modern agriculture. Its importance lies not only in its wide distribution throughout Southeast Asia, and thus its proximity to the lifestyle of consumers but also in its multifunctionality. Among its most important uses are as livestock feed, as a natural fertiliser, and for bioethanol. Unfortunately, the sago habitat has been decreasing over time due to the land use change into estate crops that can bring more income. This study aims to review the potential use of sago to support the sustainability of food systems and forest ecosystem services.
Besides its uses in the food sector, sago *hampas* (the fibrous residue of the starch production) can act as livestock feed, due to the fact that it entails a high fiber content of 65.7 % starch, 21 % lignin and 20 % cellulose. It can be further used as an absorbent for heavy metals like chromium and mercury and waste spillage in the sea, as well as in the bioethanol production, with the benefit that the higher octane facilitates a smoother glide in combustion engines. Furthermore, the wastes of the sago consuming animals, mixed with the leftover remains of the palm can be used as fertiliser. These are mixed with poultry waste to introduce something called "*co-composting*". The sago starch can be further fermented using *Lactococcus lactis* to create L-lactic acid, which can be used to create biodegradable thermoplastics and skin care, toiletries, and hair care products.
In conclusion, sago is not only a product that grows in abundance and adapts easily to swampy ecosystems, which could help to conserve the biodiversity of the area, but it also has countless uses as a biodegradable material in agro-industry, pharmaceuticals and the automotive industry.

Keywords: Agro-industry, *Metroxylon sagu*, Southeast Asia, sustainability

Contact Address: Regina Magaña Vázquez, University of Hohenheim, Inst. of Nutritional Sciences, Egilolfstrasse 51, 70599 Stuttgart, Germany, e-mail: regina.magavaz@yahoo.com

Crops and cropping systems II

Oral Presentations

Posters

Online posters

The effect of alternate-wetting-and-drying irrigation (AWD) on rice phenology and yield

Kristian Johnson, Thi Bach Thuong Vo, Folkard Asch
University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany

In the Vietnamese Mekong Delta, an alternative water management strategy is needed to maintain the productivity and sustainability of triple cropping rice (*Oryza sativa*) systems. During the dry season, water saving irrigation technologies, such as alternate wetting and drying (AWD), reduce methane (CH_4) and nitrous oxide (N_2O) emissions due to periodic soil aeration while reducing freshwater use. To evaluate potential yield penalties caused by AWD, field trials were established over two years in the Mekong Delta, Vietnam, in which 20 rice varieties were grown under fully irrigated and 'safe' AWD conditions and yield and yield components were determined. The varieties comprised a selection of twenty commonly cultivated and soon to be released Vietnamese rice varieties and were grown for two successive dry seasons at the Loc Troi agricultural research station in collaboration with the BMBF project, RiSaWa. During both seasons we measured yield components, yield, and water level. We observed a slight, but significant ($p > 0.001$), yield reduction, 7 % on average, across all varieties grown under AWD. Analysis of yield components showed that across all varieties under AWD, rice plants grew more tillers, produced fewer panicles and spikelets, suffered greater sterility, and had a lower 1000 grain weight. Varietal difference could in part be attributed to varying development rates, which exposed certain varieties to a more severe water deficit during key phenological stages. Based on the number of days that overlapped with a phenological stage of a variety, we found that there was a significant ($p > 0.05$) relationship between the number of days exposed to the dry down period during panicle initiation and the spikelet number. Considering the field is already kept flooded during flowering, practitioners of AWD should take other phenological stages into account when scheduling irrigation events. Potentially under 'safe' AWD', the start of AWD could be delayed until after panicle initiation, and the field could be allowed to dry during flowering.

Keywords: Alternate wetting and drying, Vietnamese Mekong Delta, yield component compensation

Contact Address: Kristian Johnson, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Garbenstr.13, 70593 Stuttgart, Germany, e-mail: k.johnson@uni-hohenheim.de

Experimental development of a hydroponic nutrient solution based on organic residues

Sebastian Heintze, Jörn Germer, Folkard Asch
University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany

Bioponics have a great potential to replace mineral fertilisers and offer a strategy for reutilising nutrient-rich organic residues. This study aimed at developing a balanced organic nutrient solution for lettuce, based on different organic waste materials with known N, P, K contents with minimal technical effort. Two different recipes were prepared: (1) containing animal bone meal and goat manure (R1), and (2) based on R1, augmented with potato- and banana peel (R2). To extract the nutrients ingredients were mixed with water according to recipe and digested over 25 days. The experiment comprised aerated (aerobic) and non-aerated (anaerobic) digestion either pH uncontrolled or pH manually kept at pH 6.5, with three replicates.
Samples of the digestate were taken every third day, and NH_4^+, NO_3, K, and PO_4^{3-} concentrations were analysed. For the pH-controlled samples, pH was adjusted at the same interval.
Mineralisation rates differed strongly between digestion method, pH treatment, and the minerals N, P, and K. Anaerobic treatment showed a higher N mineralisation. The mineralisation was promoted by the lower pH in anaerobic conditions since NH_4^+ mineralisation negatively correlated to the pH with correlation factors r = - 0,6 (R2) respectively - 0,79 (R1). Although highest N mineralisation was observed for R1 under anaerobic, pH-controlled digestion, only 11 % of the N contained in the organic substrates was converted into NH_4^+.
P was mineralised slowly over the entire time of observation. Again, a negative correlation to the pH was observed. Mineralisation was highest for the anaerobic and the pH-controlled aerobic treatments. The highest conversion of the organically bound P into PO_4^{3-} with 23 % was measured for R1, anaerobic, pH-controlled digestion at day 22.
Almost all K was mineralised within a short time for both recipes and treatments. The pH value did not influence K mineralisation. Neither recipes nor digestion treatments resulted in well-balanced nutrient solutions for hydroponics.
This study provides, however, relevant information on the mobilisation of main plant nutrients, the role of the pH, and digestion treatments. The findings serve as the basis for subsequent research to increase mineralisation rates and optimise the nutrient ratios of the mixtures.

Keywords: Bioponics, hydroponics, nutrient mineralisation, plant nutrition, reutilisation

Contact Address: Sebastian Heintze, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Garbenstr. 13, 70599 Stuttgart, Germany, e-mail: sebastian.heintze@uni-hohenheim.de

Increasing rice yield and profitability through salt-tolerant rice varieties and nutrient management practices under salt-affected soils in irrigated rice systems in the Sahel

Ali Ibrahim, Kazuki Saito

Africa Rice Center (AfricaRice), Senegal

Soil salinity is one of the major constraints to irrigated rice production in the Senegal River Valley. Several technologies including salt-tolerant varieties and nutrient management practices have been developed but have not been widely adopted due to a lack of farmers' participation in their development, testing, and dissemination efforts. The objective of this study was to assess the agronomic and economic viability of improved salinity management options compared to recommended management practice and farmers' practices. A series of experiments were conducted in both Research Station and farmers' fields using Farmer Participatory Approach over two years (2020–2021) in dry and wet seasons in the Senegal River Valley. There were five treatments including T1: Typical practices (Sahel 108, broadcasting and NP); T1 + potassium input (T2); T2 + Gypsum + Zinc (T3); NPK + Salt-tolerant variety (T4), and T4 + Gypsum + Zinc (T5) in on-station trials in saline soils with EC value 2 dS m^{-1}. Additionally, a total of 170 on-farm trials were conducted. Farmers were asked to choose the treatment (s) among those evaluated on-station, and these treatments were compared with their current practice. On-station results showed that improved management options T3, T4, and T5 outperformed T1 by an average of 1.1 t ha^{-1} (31 %), 0.7 t ha^{-1} (20 %), and 1.8 t ha^{-1} (49 %), respectively. Compared with the current farmers' practice (4.5 t ha^{-1}), average grain yield increased by 0.8 t ha^{-1} (16 %) in on-farm trials. The net profit was about 107 USD ha^{-1} greater with improved salinity management option compared to farmers' practice. These results suggest that there is a great opportunity for increasing rice yield and profitability under salt-affected soils through integrated management options.

Keywords: Farmer participatory approach, management options, productivity, rice, salinity

Contact Address: Ali Ibrahim, Africa Rice Center (AfricaRice), BP 96, Saint Louis, Senegal, e-mail: i.ali@cgiar.org

Effects of mixed cropping on weeds and crop yield – a meta-analysis

Shem Kuyah[1], Charles Midega[2], Mattias Jonsson[3]
[1]*Jomo Kenyatta University of Agriculture and Technology, Botany, Kenya*
[2]*Poverty and Health Integrated Solutions (PHIS), Kenya*
[3]*Swedish University of Agricultural Sciences (SLU), Sweden*

Mixed cropping is one of the strategies proposed for weed control, with potential to increase crop yield. However, there is a knowledge gap about the overall effect of mixed cropping on weeds and crop yield, and the conditions during which the system is likely to deliver a win-win solution. We conducted separate meta-analyses on 446 data points (227 on weed density, 98 on weed biomass and 225 on crop yield) from 38 different papers meeting the selection criteria. Across all studies, mixed cropping strongly reduced weeds but this did not translate into increased crop yield. We tested if type of companion crop used in trials, whether trials were conducted in temperate or tropical regions and if companion crops were arranged as intercrops of companion crops moderated the effects of mixed cropping. Both weeds and crop yield were strongly affected by type of companion crop with a large reduction in weed density and an accompanying large increase in crop yield evident when desmodium was used as a companion plant against striga-weeds. Furthermore, even though companion plants that were non-legumes reduced weeds more strongly than legumes other than desmodium, in contrast to legumes, they tended to be associated with reduced crop yield. The effects of mixed cropping on weed biomass were stronger in trials conducted in tropical compared to temperate regions. Differences in results of mixed cropping with desmodium, other legumes and non-legumes suggest that additional environmental benefits of the companion crop, and the knowledge of specific weed flora are critical for creating a win-win solution in mixed cropping systems.

Keywords: Agricultural productivity, agroecology, companion cropping, intercropping, push-pull, weed biomass, weed density

Contact Address: Shem Kuyah, Jomo Kenyatta University of Agriculture and Technology, Botany, Nairobi, Kenya, e-mail: kuyashem@gmail.com

Potential of bacterial and fungal endophytes in promoting growth in finger millet genotypes, Kenya

Beth Wangui Waweru[1], Njira Njira Pili[1], Wim Wesemael[2], Godelieve Gheysen[3]

[1]*Moi University, Biological Sciences, Kenya*

[2]*Flanders Research Institute for Agriculture, Fisheries and Food (ILVO), Plant Sciences Unit, Crop Protection, Belgium*

[3]*Ghent University, Molecular Biotechnology Department, Belgium*

Finger millet (*Eleusine coracana*) is an important crop to subsistence farmers commonly grown in arid and semiarid areas. The crop is highly nutritious making it an excellent crop for infants, elderly, diabetic, AIDs patients as well as poor people who live mainly on starchy foods. In the present study, three fungal (*Trichoderma asperellum, Trichoderma hamatum* and *Purpureocillium lilacinum*) and bacteria (*Bacillus subtilis* and *Paenibacillus polymyxa*) endophytes were used to determine growth promotion potential in four genotypes of finger millet (U-15, P-224, Okhale-1 and Ikhulule) in the greenhouse. Finger millet seeds were surface sterilized with 70 % ethanol for 5 mins followed by 3 % sodium hypochlorite for 20 mins and later germinated in the lab. After six days, finger millet seeds were planted in plastic pots (18 cm diameter and 21 cm depth) filled with 3 kg of sterilised soil. Each pot was drenched with 10^6 spores ml^{-1} after two weeks and boosted with similar inoculum on the third week. Eight replicates were maintained in each finger millet variety and endophytes treatments. Plant shoot height, number of tillers and number of leaves were recorded on weekly basis while fresh & dry shoots weight, fresh and dry root weights, panicle weight and grain yield were measured after four months. *Trichoderma asperellum, Purpureocillium lilacinum* and *Paenibacillus polymyxa* increased dry yield weight in U-15 (P value=0.002), P-224 (P value=0.0001) and Okhale-1 (P value=0.018). There was no significant yield increase in Ikhulule variety (P-value=.0.425). Wet yield weight, number of tillers and shoot & root dry weight increased significantly in all finger millet genotypes apart from Ikhulule.

Keywords: Arid and semiarid areas, endophytes, finger millet, growth promotion

Contact Address: Beth Wangui Waweru, Moi University, Biological Sciences, P. O Box 3900, 30100 Kesses, Kenya, e-mail: bethwwr54@gmail.com

Genotype by environment interactions affecting simulation of rice phenology

Linda Groot Nibbelink[1], Folkard Asch[1], Kazuki Saito[2]

[1]*University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Sweden*

[2]*Africa Rice Center (AfricaRice), Côte d'Ivoire*

Adapting rice production in sub-Saharan Africa to future challenges such as climate change and maintaining food security requires functional crop models to evaluate the potential of a production environment in combination with selected rice varieties. The backbone of such models is accurately simulating phenology across a wide spectrum of environments. Rice garden experiments were conducted at five of AfricaRice's research locations with 25 sowing dates (SD): Cotonou, Benin, 2SD; Mbe, Ivory Coast, 5SD; Ambohibary, Madagascar, 5SD; Fanaye, Senegal, 7SD; Ruvu, Tanzania, 6SD. We simulated days from sowing to flowering (DTF) for 80 varieties across all these environments using cardinal temperatures derived from three existing phenology models developed by Summerfield et al. (1992), Dingkuhn et al. (1995), and Stuerz et al. (2020). The data from this experiment showed that the relationship between development rate (DR) and mean temperature is not linear as assumed in Summerfield's model, but rather stagnates as temperature increases. We therefore developed a model (Asch-Groot Nibbelink; AGN) where this relationship was captured by fitting a second order regression ($DR=a*Tmean^2+b*Tmean+c$) and taking two tangents: one horizontal at the vertex and one sloped with tangency point where DR is half of DR at the vertex. Tbase is where DR=0 while Topt is where the two tangents intersect. Temperature sum is the inverse of the slope of the sloped tangent. When regressing residuals (simulated DTF – observed DTF) against other climatic factors such as photoperiod, radiation, vapour pressure deficit, and relative humidity (RH), we found that RH explained 38,4 % of the residuals. Therefore, AGN was adjusted to include a genotype-specific RH adjustment factor resulting in Topt increasing with increasing RH. With a slope of 0.937, an r^2 of 0.938 and RMSE of 12.3 days when regressing simulated DTF on observed DTF, AGN proofed to simulate genotype by environment effects on phenology better than the three existing rice phenology models. We suggest an RH adjustment factor for optimum temperature to be included into existing rice growth models, e.g. RIDEV and ORYZA2000.

Keywords: *Oryza sativa*, phenology, relative humidity, rice, temperature

Contact Address: Linda Groot Nibbelink, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Spolegatan 24, 22219 Lund, Sweden, e-mail: linda.grootnibbelink@gmail.com

Speed breeding in *Urochloa humidicola*: Changes in photoperiod accelerate flowering and increase seed yield

David Florian Vargas, Rosa Noemi Jauregui, Luis Miguel Hernandez, Paula Espitía, Juan Andrés Cardoso, Valheria Castiblanco

Alliance Bioversity-CIAT, Tropical Forages Program, Colombia

Urochloa humidicola is an economically important tropical forage grass that is being improved through hybridisation techniques to produce genotypes with waterlogging and spittlebug (Hemiptera: Cercopidae) resistance, high nutritional quality and superior agronomic characteristics. Empiric observations suggest that changes in photoperiod and vernalisation induce natural flowering in *U. humidicola* and, consequently, seed production. Under tropical sunlight conditions, a flowering, and therefore crossing, season occurs every 12 to 16 months. As a result, breeding cycles are long and genetic gain is reduced. Little is known about the effect that changes in photoperiod can have on flowering and seed yield in *U. humidicola*. Two trials were carried out at the CIAT experimental station in Palmira, Colombia (3°30'07.1"N 76°21'19.0"W) to determine the response of sexual parental lines to different photoperiod treatments. Two light spectra, red and white, were tested in a factorial design with six photoperiod length treatments: 12/12 hours day/night, 14/10 hs d/n, 16/8 hs d/n, 20/4 hs d/n, 23.5/0.5 hs d/n and 24/0 hs d/n in order to develop a functional tool to accelerate the *U. humidicola* breeding scheme. The first trial carried out during 2019 showed treatments "16/8 hs d/n with white light" and "24/0 hs d/n with red light" as the best to induce flowering, indicated by the increased number of spikes.m^{-1} and seeds/spike (Tukey HSD, $\alpha = 0.05$). In the second trial, a factorial design was used to test the two previous successful light/photoperiod treatments over a larger number of genotypes to evaluate the variability in flowering response. The results showed that while red light triggers a faster development of flowering, white light allows for an increase in the number of inflorescences and a higher seed yield. Once established, the optimised methodology will reduce the time between breeding crossing seasons from 12–16 to 8–12 months. The findings of the study suggest that longer photoperiods can be used as a potential speed-breeding tool in *U. humidicola* breeding programme under tropical conditions.

Keywords: Flowering, photoperiod, seed production, speed breeding, tropical forages, *Urochloa*

Contact Address: Rosa Noemi Jauregui, Alliance Bioversity - CIAT, Tropical Forages, KM 17 RECTA CALI PALMIRA, 763537 Cali, Colombia, e-mail: r.jauregui@cgiar.org

Effect of *Bacillus* spp. on enzyme activity and potassium uptake in lowland rice (*Oryza sativa*) under iron toxicity

Tanja Weinand, Julia Asch, Folkard Asch
University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany

Plant associated bacteria can positively influence the ability of lowland rice to withstand toxic concentrations of soluble iron (FeII) in the soil. This beneficial interaction, however, is dependent on the bacteria strain × rice cultivar combination.

Iron toxicity is a major constraint for irrigated rice production in large parts of Asia, West and Central Africa, Madagascar, and Brazil. While it is known that tolerant rice cultivars deploy different adaptation strategies, the underlying mechanisms are not fully understood. Deciphering the role of both epi- and endophytic bacteria in tolerance mechanisms of local, adapted rice cultivars will be essential to incorporate plant traits mediating beneficial interaction with microorganisms under iron toxic conditions into future breeding efforts and agricultural management practices.

In the present study, three lowland rice cultivars with contrasting levels of tolerance against iron toxicity, namely IR31785–58-1–2-3–3 (sensitive), Sahel 108 (tolerant includer), and Suakoko 8 (tolerant excluder) were inoculated with three *Bacillus* isolates (*B. pumilus* and *B. megaterium*) and, after one week, exposed to excess iron (1,000 ppm) for eight days. The effects of bacteria inoculation were evaluated by leaf symptom scoring and determination of dry weight. Activities of five enzymes involved in reactive oxygen scavenging (ROS) were measured in inoculated and non-inoculated plants under normal and iron toxic growth conditions. Potassium and iron content in roots, sheaths and blades of the same plants were analysed by flame photometer and spectrophotometer, respectively. Enzyme activities and potassium uptake and distribution will be related to the effects of bacteria inoculation on leaf bronzing scores and iron distribution within the plants.

Keywords: Abiotic stress, *Bacillus* spp., iron toxicity, *Oryza sativa*

Contact Address: Tanja Weinand, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Garbenstr. 13, 70599 Stuttgart, Germany, e-mail: tanja.weinand@uni-hohenheim.de

Population hybrid breeding and the use of new statistical tools for sweetpotato

Bert De Boeck[1], Frederico Diaz[1], Raul Eyzaguirre[1], Jan W. Low[2], Jochen C. Reif[3], Hugo Campos[1], Wolfgang J. Grüneberg[1]

[1]*International Potato Center (CIP), GGCI, Peru*

[2]*International Potato Center (CIP), Kenya*

[3]*Leibniz Institute of Plant Genetics and Crop Plant Research (IPK), Germany*

Sweetpotato is a highly heterozygous hybrid, and populations of orange-fleshed sweetpotato (OFSP) have a considerable importance for food security and health. Population hybrid breeding (PHB) has been recently introduced for sweetpotato in the Peruvian, Ugandan, and Mozambican breeding platform by the International Potato Center (CIP). In addition, the transition into PHB was accompanied by intensifying the use of more modern statistical tools for phenotypic data analysis like (generalised) linear mixed models that account for spatial trends in the field. PHB has been studied in the Peruvian breeding platform for a complete reciprocal recurrent selection (RRS) cycle in three OFSP hybrid populations (H1), for which foundation, parents, and hybrids were all evaluated simultaneously at two contrasting locations. The objectives of the study were to estimate heterosis increments and response to selection after one RRS cycle in the three populations. In each H1, the yield and selected quality traits were recorded (for details see Grüneberg et al. (2022); https://doi.org/10.3389/fpls.2022.793904). The data were analysed using modern statistical approaches using mixed models fitted with restricted maximum likelihood (REML), correcting for spatial variation in the field and allowing for heterogeneity of genetic (co)variances in the tested environments. In contrast to previous approaches this leads to unbiased (co)variance estimates and to higher heritabilities because spatial noise is removed from the genetic signal. We observed for storage root yield traits exhibited population average heterosis increments of up to 43.5 %. The storage root yield genetic gain relative to the foundation was remarkably high, ranging from 81.5 % to 132.4 %. In conclusion we argue that PHB is a tool to achieve large genetic gains in sweetpotato yield and most likely other clonally propagated crops, that allows a rapid dissemination of globally true seed that is generated from reproducible elite crosses, thus, avoiding costly and time-consuming virus cleaning of elite clones typically transferred as vegetative plantlets. The transition to more modern statistical tools at CIP was enabled by the Centre for International Migration and Development (CIM), a joint operation of GIZ and the German Federal Employment Agency, by funding the position of plant breeding statistician and resulting capacity building in statistics.

Keywords: Orange-fleshed sweetpotato, population hybrid breeding, reciprocal recurrent selection, restricted maximum likelihood, spatial analysis

Contact Address: Bert De Boeck, International Potato Center (CIP), GGCI, Lima, Peru, e-mail: b.deboeck@cgiar.org

Water uptake does not drive sodium and chlorine uptake in sweet potato genotypes exposed to salt stress

Shimul Mondal[1], Ebna Habib Md Shofiur Rahaman[2], Folkard Asch[1]

[1]*University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany*

[2]*International Potato Center, Sweet Potato Breeding in the Tropics, Bangladesh*

Whereas potassium is taken-up actively to the plant, sodium uptake and distribution often is driven by the transpirational volume flow in the shoots of plants grown under salinity. Thus, reducing transpiration rate is regarded as an adaptation mechanism to reduce tissue salt load. In combination with a high K uptake, plants may be able to maintain growth and are, thus, seen as salt tolerant. Little is known about these mechanisms in sweet potato. Therefore, cuttings of two sweet potato genotypes contrasting in salinity tolerance (CIP 188002.1, tolerant; CIP 189151.8, sensitive) were subjected to 0 and 50 mM NaCl root zone salinity in a hydroponic system and grown under low (40 %) and high (80 %) relative air humidity (rH) to create difference in transpiration. After 18 days of initial hydroponic growth, NaCl was added for another 33 days. Cumulative plant water loss and total ion uptake were determined and related to air humidity and genotypes. Plants subjected to low rH lost twice as much water per unit leaf area compared to high rH but the Na accumulation remained almost the same. In low rH, cumulative water loss per unit leaf area in plants subjected to 50mM salt stress was significantly increased ($p < 0.003$) in the tolerant but decreased ($p < 0.001$) in the sensitive genotype whereas no difference was found under high rH. Independent of genotype, the transpirational history of individual leaves was not correlated with their respective salt load, however, young leaves of the tolerant genotype grown under salt stress in high rH maintained more than twice the amount of K as compared to the sensitive genotype. We conclude that transpirational volume flow is not the main driving force for Na and Cl uptake and distribution within the plant. However, at least at high rH, high levels of K in young leaves may allow a larger accumulation of dry matter. The sodium distributing pattern (Na deposition in older leaves) will be discussed in view of active ion transport linked with ATP trade-offs.

Keywords: Ion uptake and salt stress, vapour pressure deficit, water uptake

Contact Address: Shimul Mondal, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Garbenstr.13, 70599 Stuttgart, Germany, e-mail: shimul.mondal@uni-hohenheim.de

Reliability of gridded precipitation products for water management studies: a case study in the Ankavia river basin in Madagascar

Zonirina Ramahaimandimby[1], Alain Randriamaherisoa[2], François Jonard[3,1], Marnik Vanclooster[1], Charles Bielders[1]

[1]*Université Catholique de Louvain, Earth and Life Institute, Belgium*

[2]*Université d'Antananarivo, Génie Civil, Madagascar*

[3]*University of Liège, Earth Observation and Ecosystem Modelling Laboratory, Belgium*

Hydrological modelling for water management in large watersheds requires accurate spatially distributed rainfall time series. In case of low coverage density of ground-based measurements, gridded precipitation products (GPP) from satellite/gauge/model-based merging products constitute an attractive alternative, the quality of which must nevertheless be assessed. The objective of this study was to evaluate at different time scales the reliability of six GPPs against a 2-year record from a network of 14 rainfall gauges located in the Ankavia catchment (Madagascar). The GPPs considered in this study are African rainfall climatology (ARC2), climate hazards groups infra-red precipitation with station data (CHIRPS), the ECMWF Reanalysis (ERA5), integrated multi-satellitE retrievals for global precipitation measurement (IMERG v06 Final), precipitation estimation from remotely sensed information using artificial neural networks- cloud classification system (PERSIANN-CCS), African rainfall estimation (RFEv2) The results suggest that IMERG ($R^2 = 0.63$, slope of linear regression a = 0.96, root mean square error RMSE = 12 mm day^{-1}, mean absolute error MAE = 5.5 mm day^{-1}) outperforms other GPPs at the daily scale, followed by RFEv2 ($R^2 = 0.41$, a = 0.94, RMSE = 15 mm day^{-1}, MAE = 6 mm day^{-1}) and ARC2 ($R^2 = 0.30$, a = 0.88, RMSE = 16 mm day^{-1}, MAE = 6.7 mm day^{-1}). All GPPs, with exception of the ERA5, overestimate the "no rain" class value (0 0.2 mm/day). ARC2, IMERG, PERSIANN, RFEv2 all underestimate rainfall occurrence in the 0.2 150 mm/day, whilst CHIRPS, ERA5 overestimate it. Only CHIRPS and PERSIANN could estimate extreme rainfall (>150 mm day^{-1}) satisfactorily. According to the critical success index (CSI) categorical statistical criteria, IMERG performs quite well in detecting rain events in the range 2 150 mm/day, whereas PERSIANN outperforms IMERG for rain events larger than 150 mm/day. Because it performs best at daily scale, only IMERG was evaluated for time scales other than daily. At the yearly and monthly time scales, the performance is good with $R^2 = 0.97$ and 0.87, respectively. At the event time scale, the probability distribution

Contact Address: Zonirina Ramahaimandimby, Université Catholique de Louvain, Earth and Life Institute, Rue des sports 11/303, 1348 Louvain-la-neuve, Belgium, e-mail: zoramahaimandimby@gmail.com

function PDFof rain gauge values and IMERG data show good agreement. However, at the hourly scale, the correlation between ground-based measurements and IMERG data becomes poor ($R^2 = 0.20$). Overall, IMERG products can be regarded as the most reliable precipitation source at monthly, daily and event time scale for hydrological applications in the study area, but the poor agreement at hourly time scale and the inability to detect extrem rainfall >100 mm/day may nevertheless restrict its use.

Keywords: Ankavia catchment, GIRE SAVA, GPM-IMERG, Madagascar, satellite precipitation products

Specific leaflet mineral concentrations of high-yielding oil palm progenies and their implications for K/Mg management

Olivier Senankpon Dassou[1,2], Adolphe Adjanohoun[1], Wouter Vanhove[2], Reinout Impens[3], Hervé Aholoukpè[1], Xavier Bonneau[4], Albert Flori[5], Bénoît Cochard[6], Sinsin Brice[7], Patrick Van Damme[8,2], Jean Ollivier[4]

[1]*CRA-PP / INRAB, Agricultural Research Centre on Perennial Plants of the National Agricultural Research Institute of Benin, Benin*

[2]*Ghent University, Dept. of Plant and Crops - Lab. for Tropical Agronomy, Belgium*

[3]*SIAT Group / Presco Plc, R&D, Nigeria*

[4]*Agricultural Research Centre for International Development (CIRAD), France*

[5]*CIRAD, UMR ABSys, France*

[6]*PalmElit SAS, France*

[7]*University of Abomey-Calavi, Laboratory of Applied Ecology, Benin*

[8]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Czech Republic*

In oil palm, a similar fertilisation regime can result in leaflet potassium and magnesium concentrations that vary significantly from one progeny to another. This hinders the development of standardised fertiliser recommendations for this crop, as they are usually calculated to reach optimum leaflet nutrient concentrations. We tested the hypothesis that optimum leaflet K and Mg concentrations significantly differ between different oil palm progenies. Four high-yielding oil palm progenies with contrasting leaflet K and Mg concentrations (C1, C2, and C3 of Deli × La Mé origin and C4 of Deli × Yangambi origin) were treated with combinations of three levels of KCl and $MgSO_4$, in a completely randomised split-plot factorial design with six replicates, where progenies were a sub-factor.

For a given level of KCl or $MgSO_4$, different leaflet K and Mg concentrations were found between progenies ($p < 0.0001$). Leaflet K concentration and yield response to KCl applications revealed that the four oil palm progenies have different optimum leaflet K concentrations. In our study period (5–8 YAP), progenies C1 and C3 had highest fresh fruit bunch (FFB) yields (13.62 and 16.54 t ha^{-1} year^{-1}, respectively) at K2, whereas progenies C2 and C4 showed the highest yields (14.62 and 12.39 t ha^{-1} year^{-1}, respectively) at K1.

For the first time in oil palm mineral nutrition research, our study highlighted specific optimum leaflet K and Mg concentrations for different oil palm progenies in a given environment. It paves the way for adopting K and Mg fertiliser application rates adapted to specific requirements of each type of oil palm planting material.

Keywords: Leaflet magnesium (Mg) concentration, leaflet potassium (K) concentration, nutrient diagnosis, nutrient management, oil palm, optimum leaflet mineral concentrations

Contact Address: Olivier Senankpon Dassou, CRA-PP / INRAB, Agricultural Research Centre on Perennial Plants of the National Agricultural Research Institute of Benin, BP 01, Pobè, Benin, e-mail: mandas.oliver@gmail.com

Genotype × environment effects on leaf properties and pigment composition in wheat under water deficit

Ilaria Parente[1], Geckem Dambo[1], Alejandro Pieters[1], Francisco Pinto[2], Folkard Asch[1]

[1]*University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany*
[2]*CIMMYT Mexico, Remote Sensing, Mexico*

Wheat growing environments are increasingly characterised by extreme temperatures and reduced water availability. These conditions can potentially result in photooxidation of pigment-protein complexes and chloroplasts components, which will lead to decreased of photosynthesis and growth. Thus, identification of high-performing and stress resilient wheat germplasms is pivotal. Photoprotection can contribute a large share to achieving such resilience as it is the interface between efficient use of absorbed light in photosynthesis and the safe dissipation of excess light energy. However, a complete understanding of the adaptive response of the wheat photoprotection system to water deficit during crop development is missing. The purpose of this research was to identify changes in leaf hyperspectral reflectance at different crop developmental stages for the youngest fully expanded leaf and the third leaf. Thirteen wheat genotypes from the Best PT panel developed by CIMMYT, were grown in the field at CIMMYT research station in Obregon, Mexico, and exposed to two different environments: water deficit and potential yield. The water deficit environment was irrigated at sowing, 50 % emergency and at the initiation of booting, whereas the potential yield environment was irrigated at sowing, 50 % emergency and every fourteen days but reduced to nine days towards maturity. The lines were selected according to their contrasting evapotranspiration performance, estimated through canopy temperature measurements, and estimation of yield in previous water deficit experiments in the field. Using frequent sensor-based methods, we studied the temporal dynamics of spectral indexes, including NDVI, NPCI, PRI and relative chlorophyll content measured with SPAD. The lines studied showed contrasting patterns for the different physiological indexes at different growth stages. These results will be linked to canopy temperature. These findings can lead to the characterisation of the dynamics of photoprotection mechanisms in wheat, which can be incorporated into a field-based screening tool for high-throughput phenotyping.

Keywords: Photoprotection, reflectance indexes, water deficit, wheat

Contact Address: Ilaria Parente, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Fruwhirtsrasse 11, 70953 Stuttgart, Germany, e-mail: ilaria.parente@uni-hohenheim.de

Impact of drought stress on leaf pigment concentration at different leaf positions in the canopy

Geckem Dambo[1], Ilaria Parente[1], Alejandro Pieters[1], Folkard Asch[1], Francisco Pinto[2], Mathew Reynolds[2], Carlos A. Robles-Zazueta[2]

[1]*University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Germany*

[2]*CIMMYT Mexico, Physiology/Remote Sensing, Mexico*

Wheat productivity is being challenged by increasingly frequent water deficit periods. Under these conditions light induced damage is more likely. Thus, leaf pigments should adjust to mitigate the stress caused by water deficit on the photosynthetic machinery. The aim of this study is to evaluate the impact of water deficit on leaf pigment composition using hyperspectral reflectance and SPAD data. Measurements were taken at initiation of booting on the flag, the second and third leaves using a portable spectroradiometer and handheld SPAD-502 chlorophyll meter. Nine elite bread wheat genotypes from CIMMYT's Best PT panel tolerant to heat and drought stresses were studied in the field at CIMMYT experiment station in NW Mexico during 2021/2022 growing season under drought (D) and yield potential (YP) conditions. The D treatment was irrigated at sowing, 50 % emergency and before initiation of booting, whereas the YP treatment was irrigated at sowing, 50 % emergency and every fourteen days until late grain filling. Spectral reflectance indices related to carotenoids, chlorophyll a and chlorophyll b were used for leaf pigment estimation. Results showed significant differences for treatment effect at flag and third leaves ($p < 0.001$) for carotenoids (Car). Meanwhile chlorophyll a (chl a) showed differences in flag leaf ($p < 0.003$) under YP and differences due to genotype by environment (GxE) ($p < 0.004$), while for chlorophyll b (chl b) differences were found in flag leaf ($p < 0.01$) among treatments and GxE interaction ($p < 0.003$). Low levels of SRI for car, chl a and chl b were observed in D conditions compared to YP. SPAD showed significant differences among genotypes ($p < 0.05$) in YP, and among position in the canopy (flag, second and third leaves ($p < 0.001$). These results show that water deficit has significant effect on hyperspectral reflectance properties related to leaf pigment composition. Spectral indices genotypic variability highlights the potential of this phenotyping approach for identifying water stress tolerant wheat genotypes. Further confirmation will be established by analysis of leaf extracts using HPLC, which will demonstrate relationship between changes in pigment composition and grain yield.

Keywords: Leaf pigments, spectral reflectance indices, water deficit, wheat (*Triticum aestivum* L.)

Contact Address: Geckem Dambo, University of Hohenheim, Inst. of Agric. Sci. in the Tropics (Hans-Ruthenberg-Institute), Stuttgart, Germany, e-mail: geckem.dambo@uni-hohenheim.de

Development of polyploid genotypes in *Mentha spicata* using *in vitro* somatic polyploidisation

Rohit Bharati[1], Eloy Fernández-Cusimamani[1], Pavel Novy[2]

[1]*Czech University of Life Sciences Prague (CZU), Dept. of Crop Sciences and Agroforestry, Czech Republic*

[2]*Czech University of Life Sciences Prague (CZU), Dept. of Food Science, Czech Republic*

Mentha spicata (spearmint) is a widely utilised aromatic herb belonging to the lamiaceae family. It is grown across the globe for its wide range of pharmacological uses. Traditionally, it has been used to treat various respiratory and gastrointestinal conditions. Consequently, numerous research has been done on the breeding of *Mentha* spp. using traditional methods, although very few studies have explored the scope of synthetic polyploidisation in *Mentha* spp. and none in *Mentha spicata*. Hence, the aim of the current study was to obtain polyploids of *Mentha spicata* using oryzalin via *in vitro* somatic polyploidisation. Nodal segments were cultured under *in vitro* conditions on Murashige and Skoog (MS) for 48 hours prior to oryzalin treatment. Thereafter, nodal segments were treated with three oryzalin concentrations (20, 40, and 60 μM) for 24 and 48 hours. Flow cytometry and direct chromosome counting were then used to confirm the ploidy of the treated plant. Obtained polyploids were micro-propagated and transferred to be grown under field conditions. Thereafter, morphological, anatomical, and biochemical data were collected for further statistical analysis. Oryzalin treatment yielded a total of 7 polyploids across all treatments. Oryzalin at 40 μM concentration for 48 h was found to be the most effective treatment with a polyploid induction rate of 8 %. Furthermore, obtained morphological, anatomical, and biochemical data exhibited a significant difference between triploid and hexaploid plants. For instance, the leaf area, and thickness increased by almost 50 percent, and a higher trichome density was achieved in hexaploidy plants compared to the mother triploid plant. Additionally, larger stomata size and higher chlorophyll content indicate a higher photosynthetic capacity in polyploids. The results obtained provide valuable insights into the breeding possibilities in *Mentha spicata* and related species.

Keywords: Autopolyploidy, hexaploidy, *in vitro*, *Mentha spicata*, oryzalin, polyploidisation

Contact Address: Rohit Bharati, Czech University of Life Sciences Prague (CZU), Dept. of Crop Sciences and Agroforestry, Kamýcká 1280, 16521 Prague, Czech Republic, e-mail: bharati@ftz.czu.cz