

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



Tropentag

2020

Food and nutrition security
and its resilience to global
crises

Book of abstracts

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Tropentag 2020

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





Tropentag 2020

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

Food and nutrition security and its resilience to global crises

Book of abstracts

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Preface

Tropentag is the largest interdisciplinary conference in Europe on development oriented research in the fields of sub-/tropical agriculture, food security, natural resource management and rural development. Taking place annually, *Tropentag* 2020 turned out to be a special challenge. Originally planned to take place in Prague, the Corona pandemic did not allow presence in or travel to Prague for prospective participants. ATSAF took on the challenge to organise a virtual *Tropentag* based on Zoom meetings being streamed on YouTube channels using the Whova as online conference platform from September 7 to 9, 2020.

Since *Tropentag* normally is a whirling pool of people interacting and listening to each other, learning new things, building and refreshing networks, and enjoying science and coffee, the question arises if a virtual *Tropentag* can actually provide a similar ambience. Well, the straight answer is: No! So, what happens if such conferences, such scientific networking activities, such exchanges of knowledge are constrained by global crises? Will people and science suffer? Will project activities have to be abandoned, projects to be terminated and where does it leave the efforts of the last decades in fighting hunger and malnutrition?

We thought this to be an interesting discussion topic for a virtual *Tropentag* and chose "*Food and nutrition security and its resilience to global crises*" as the overarching theme for the *Tropentag* 2020.

We received 460 contributions related to the theme of which 318 were presented in the virtual conference and are now available in these proceedings. The five plenary keynote contributions to this years' *Tropentag* gave us a very good overview of the disciplinary understanding of crises and how resilience or responses to crises are detected and evaluated in the different disciplines. Prof. Dr. Reiner Sauerborn, a paediatrician from Heidelberg University, showed us how children are affected by all kinds of crises ranging from the lean season nutritional crises to exceptional droughts and climate change. Dr. Helen Young, a nutritionist of the Feinstein International Center at Tufts University, was driving home the point that persistent global acute malnutrition is still a major problem for children not only in times of crises, but enforced through any crisis. Dr. Petra Schmitter, an agronomist from IWMI, introduced us to the effects of the global water crisis on food and nutrition security. Dr. Bjoern Ole Sander, a climate change specialist from IRRI, showed us how climate change and rice production influence each other and enhance the crises in global climate change and food security. Finally, Dr. Michael Bruentrup, an economist from the German Development Institute DIE, concluded the plenary keynote by asking: "Which of these crises matters?" and presenting us a clear case of multi-risk management as the way to go forward.

The plenary sessions and the fiat panis award session were the only *Tropentag* 2020 events that were moderated and held physically under strict COVID-19 hygiene regulations at the University of Hohenheim - with an allowance of 66 individually numbered attendees in a lecture hall seating 450 in normal times. The foundation *fiat panis* split its 2020 Hans-H. Ruthenberg award among Sina Bierkamp (Leibniz University Hannover), Franziska Steinhübel (Passau University) and Roberto Villalba (University of Hohenheim) for three outstanding accomplished Masters theses. This years Josef G. Knoll award winners for outstanding PhD achievements in connection with the improvement of the nutritional situation in developing countries were Dr. Addisu Fekadu Andeta (KU Leuven, Belgium), Dr. Thomas Daum (University of Hohenheim) and Dr. Arndt Feuerbacher (Humboldt University Berlin).

The plenary and award session was then followed by 109 virtual oral presentations in 23 sessions from places around the world and in time zones as different as Peru and Vietnam □ as always in parallel sessions. The 209 poster presentations where held as 3-5 min audio/video clips in 28 moderated poster sessions and the discussion was held via zoom meetings with the presenters interfaced with the youtube audience via the whova platform. All these contributions are still available online via the Whova conference tool and accessible to all participants for review.

Tropentag 2020 has clearly shown that the scientific exchange and also the discussions needed to keep the science alive are possible and fruitful even in a virtual conference. A better understanding as to how crises affect food and nutrition security was clearly achieved by the 738 people from 67 countries during this years' *Tropentag*. We have learned some lessons on online conferencing that are particularly suitable to increase *Tropentag*'s outreach and that might spill over also into coming non-virtual *Tropentag* conferences. In the absence of the team of student reporters, Ralph Dickerhof, freelance reporter, ATSAF member and student reporter media trainer of the first hour, fed the *Tropentag* blog with his impressions of the web-based scientific exchange. Likewise, we fed the flickr foto-stream with impressions of the plenary and with behind the scenes images from Eric Tielkes and the IT support team.

Special thanks go to Eric Tielkes and his team for his very valuable support in organising this first ever virtual *Tropentag*, getting the IT setup sorted and distributing the scientific debates to the likewise decentral *Tropentag* family around the globe. Particular thanks are due also to our longstanding donors (listed on the back cover) for their unwaning financial in-kind support, which permitted us to do a 2020 *Tropentag* at all, to go virtual and to keep conference fees at a modest level, especially for junior scientists.

On behalf of ATSAF as the organiser of *Tropentag* 2020:

Folkard Asch and Christian Hülsebusch

Internet, September 2020



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Assessing farming systems at different scales

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Modelling Land Suitability for Expansion of Irrigated Rice and Dissemination of Alternate Wetting and Drying Water Management in Burkina Faso

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Spatially explicit assessment of land suitability can guide the identification of cropland with the highest potential for irrigated rice development, but for many regions in sub-Saharan Africa, the knowledge is very limited. Besides, reducing water input while maintaining rice yield is important for sustainable rice production in SSA. The objectives of this study were to produce a nation-wide prediction of irrigated rice area and estimate the climatic suitability of the alternative wetting and drying (AWD) technique of irrigation. We applied three environmental niche modelling (ENM) approaches that use machine learning algorithms along with the current distribution of irrigated rice locations in Burkina Faso to determine the extent of the potentially irrigated rice area. We used a simple water balance model to estimate the climatic suitability for AWD for the two main growing seasons: February – June and July – November. The evaluation metrics of the ENMs such as Area Under the Curves (AUC) and Percentage Correctly Classified (PCC) were higher than 90 % and 80 % for both training and testing, respectively. Exchangeable sodium percentage, distance to stream networks, exchangeable potassium, precipitation of the warmest quarter, annual mean temperature, soil depth to bedrock, topographical wetness index, actual evapotranspiration, soil organic carbon stock, and total phosphorous were the top 10 predictors determining a land suitability for irrigated rice development. The modelling predicted that 3 million ha of land are potentially suitable for irrigated rice cultivation in Burkina Faso. Most of these suitable lands are located within the sub-Saharan and north-Sudanese climatic zones while the Sahelian climatic zone only showed marginal suitability for irrigated rice. About 97 % of the suitable lands for irrigated rice cultivation were found to be appropriate for AWD in the first growing season against 57 % in the second growing season. The results of this study can guide investments in irrigated rice development and large-scale dissemination of AWD in SSA.

Keywords: Alternate wetting and drying, climate change, ecological niche modelling, land suitability, rice

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Potentials and Risks of Alternate Wetting and Drying in Rice Production of the Dry Savannah Zone of West Africa

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Irrigated rice farming plays a vital role in global food security but also requires more water than any other staple crop. Meeting the high demand for rice to feed the growing population under increasing water scarcity is one of the major challenges of the twenty-first century. Alternate wetting and drying (AWD) is one of the most widely advocated water-saving irrigation technologies. The technology was introduced only recently in the dry Savannah zone of West Africa, where it is still largely unknown by farmers. We assessed the effect of AWD on grain yield and irrigation water productivity against the backdrop of possible N losses. Participatory on-farm trials compared AWD to farmers' irrigation practice in four irrigation schemes of Burkina Faso during both the dry and the wet seasons of 2018 and 2019. AWD was compared to farmer' irrigation practice (FP) in 156 pairwise comparisons of AWD and FP plots. In addition, soil nitrate-N dynamics in relation to soil water content was assessed in dry season 2019. Compared to farmers' practice (FP), irrigation water input with AWD technology was reduced by 32 % in the dry and by 25 % in the wet season. With no significant effects on grain yields (mean of 4.9 Mg ha⁻¹) AWD increased the irrigation water productivity by 64 %. However, each AWD cycle resulted in soil N mineralisation of about 3 kg N ha⁻¹ and the loss of this nitrate-N upon rewetting. Total N losses increased with soil drying intensity and the number of AWD cycles and reached up to 30 kg ha⁻¹. While AWD appears to be an effective strategy to save irrigation water with no rice yield penalty, the observed nitrate losses point towards possible negative longer-term impacts on soil fertility and productivity in rice irrigation schemes of the dry Savannah zone.

Keywords: AWD, Burkina Faso, *Oryza sativa*, water productivity, water-saving technology

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Reviving Seed Sharing for Biodiversity Conservation Food Security and Ground Water Recharge

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Ground water protection and recharge is a major concern in West Africa, since water demand is likely to double in next thirty years with the growing population. Climate projections indicate that West Africa will be subjected to increased variability combined with a decline in rainfall. The GIZ Water Program ProSEHA investigated how ground water recharge can be improved alongside improvements of food security.

ProSEHA decided to test the improvement of rice production by increasing rice biodiversity and by encouraging site specific cultivation of old traditional rice varieties. ProSEHA collected a total of 25 varieties with different local names and the farmer-led testing and genetic tests validated 15 well distinguished varieties. Among these varieties were some with very good abilities to grow in deeper water and varieties with very low water needs for upland cultivation. Due to this wider adoption range, farmers were able to cultivate a larger proportion of their traditional watersheds. This increase in production area, helped that less land in the watershed banks remains idle, and thus prone to erosion, and consequently water recharge is enhanced.

167 farmer managed rice testing plots were evaluated. In the first year the plots were very small (<100 sqm) and increased over time as more seeds become available to plot sizes of up to 1 ha. All farmers tested various old varieties against a modern variety (mainly IR841). Farmers were invited to rate the relative performance of cultivars by observation and in addition precise yield measurements were taken. The trials were done without chemical fertilisers or other chemical plant protection measures.

The 4-years results showed local varieties performed at least equal (22 %) or even better (52 %) than modern varieties. Average yield for local rice varieties was 2.35 t ha⁻¹ against 1.94 t ha⁻¹ for modern varieties (+21 %). Farmer observation revealed that the local varieties offer a broader variation in crop cycle length, flooding and drought and pest resistance. Information and seed were diffused by annual seed sharing fares. The encouraging results led to an increase in participating farmers from below 20 in 2016 to 538 in 2019.

Keywords: Biodiversity, food security, seed exchange, water recharge

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Water Availability and its Interaction with Cropping Intensity Patterns of Rice-Based Systems in Southeast Asia

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Agricultural changes in cultivation patterns of rice-based systems in Southeast Asia have been investigated in the frame of the BMBF funded project “RICH-3P” coordinated by the University of Bonn. Six sites were considered, two in each of the listed countries: Cambodia, Myanmar and the Philippines. Alongside other changes, a shift from (rainy season) single rice cultivation to double rice cultivation (rainy and dry season) per year was observed at five out of six locations. For example, in the Central Dry Zone in Meiktila-Myanmar, 108 farmers (out of 160 respondents) indicated that they were producing rice twice a year in the present (2018), whereas about 20 years ago none of them were cultivating rice in both seasons. This development was made possible by the improved access to water in the respective regions. The present study aims to evaluate the external pressures and the (farming system) internal drivers leading to the change of single to double rice cropping. On the one hand, factors such as the improvement or installation of public irrigation infrastructure, cooperative work on municipal irrigation systems, advisory campaigns and assistance in the implementation of pumps, etc. are taken into consideration to explain the increase in water availability for farmers. On the other hand, we are investigating the thresholds of water quantity and availability that would lead farmers to definitely establish a second rice crop. For these purposes, apart from the evaluation of secondary sources, our work focuses on the acquisition and evaluation of optical satellite data (Landsat, Sentinel-2) from 1990 onwards in the corresponding study areas. A field-wise evaluation (polygon- and pixel-wise) of spatial and temporal water cover patterns during the flooding and transplanting status in the study areas will serve as proxy for the assessment of water availability and the determination of thresholds that induce farmers to shift from single to double rice cropping in the regions. The current state of research is taken into account and already implemented algorithms for the recognition of rice fields are applied using the data basis of the project, which also includes georeferenced boundaries of the farmers fields.

Keywords: Agricultural change, cropping patterns, irrigation, remote sensing, rice, water

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Introducing Sustainable Farming Practices in Rice Production to Myanmar's Transitioning Agriculture Sector

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Myanmar has experienced considerable economic and social changes since its political transition in 2011/2012. Its agriculture sector has demonstrated rapid intensification and modernisation. However, rice yield gaps remain an important issue with regard to food security. Reducing rice yield gaps in Myanmar could increase annual production and support efforts to establish food security. Therefore, agricultural best management practices (BMPs) were introduced to rice farmers in the Bago Region from 2012 on to increase sustainable rice production, reduce rice yield gaps, and counteract negative environmental impacts of agricultural intensification. The objective of this study was to determine rice farmers' agronomic development, socioeconomic situation, and livelihood changes due to the adoption of BMPs. Using a digital survey questionnaire application to collect household data, 160 farmers in eight villages were interviewed in 2012 and 2017. Data were analysed using uni- and multivariate statistics. Results showed that farmers who adopted BMPs such as improved rice varieties and optimised fertiliser application demonstrated significantly higher yields, income, and profitability while reducing inputs and labour. Furthermore, after five years significant socioeconomic differences were found between BMP adopters and non-adopters. The study showed that BMP adopters improved their livelihoods due to increased agricultural efficiency. However, yield productivity remains low in Myanmar compared to neighbouring countries. Poor access to inputs, high input prices, and little risk management are factors impeding improved agricultural profitability, and hence rural development. Furthermore, natural conditions as well as economic and social constraints play an important role in the way farmers are able to manage their land. Therefore, further development research and dissemination strategies for the implementation of appropriate sustainable technologies are needed to improve rice farming.

Keywords: Adoption, best management practices, dissemination, impact, Myanmar, rice production, sustainable agriculture

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Increasing Nutrition Security with Vertical Gardens – Testing Different Systems for Vegetable Production

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Vertical garden systems have been a largely urban phenomenon, used to cultivate food crops as well as ornamental species in areas that would not normally be suitable for plant growth. Vegetables grown in vertical garden systems can provide an important dietary supplement to households. However not much research has been done concerning systems' or varieties' production efficiency. We aimed to construct vertical garden systems that are low-cost, low-labour, and simple to make with materials available to all. The developed systems were tested for their (i) water holding capacity; (ii) produced biomass and yield; and (iii) which vegetable plant families could be suitable. The three systems designed and constructed were: the Second Wall, Planting Tower, and Bucket System, using three irrigation systems, i.e. cotton cloth, plastic tubes, and drip irrigation. The crops used in the systems represented four vegetable families: field peas (*Pisum sativum* L.; Fabaceae), African spinach (*Beta vulgaris* spp.; Amaranthaceae), black nightshade (*Solanum nigrum* L.; Solanaceae) and sukuma (*Brassica oleraceae* L.; Brassicaceae). Soil temperature and moisture were measured through implanted sensors, and yield was recorded. Six systems were constructed at three sites (2 system types per site) in schools located in Kapchorwa, Uganda. The systems and vegetables were compared using a mixed model. The Planting Tower had the highest and most constant water holding capacity, followed by the Second Wall. The soil temperatures of all three systems remained very constant, varying slightly between 18–23°C. The Planting Tower showed the highest yields for all cultivated species, followed by the Second Wall. The Bucket System produced the lowest yield for all vegetables. Both African spinach ($p = 0.020$) and black nightshade ($p = 0.049$) showed significant differences in yield depending on their placement in the system (at the top or the bottom), making them more sensitive to water content than sukuma and field peas. Overall, the systems performed well to produce a mix of nutrient-dense vegetables under different conditions in the field. We consider vertical gardens a promising option to increase surface area to produce a higher amount of diverse vegetables for the household, hence improving their food and nutrition security.

Keywords: Food and nutrition security, home garden, vegetables, vertical garden

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Opportunistic Adaptation of Conserved Moisture for Food Sustainability in Arid Zone

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Climate change coupled with multiple stressors have compelled subsistence farmers to develop location specific adaptation strategies to sustain their livelihoods in risk-prone ecosystems. A study on the opportunity of using conserved soil moisture for food and livelihood security and its adaptation in rural areas was carried out in Hemawas check dam with its catchment area in Pali district of Rajasthan, India. In arid zone (study zone) farmers are exposed to a set of multiple stressors making their subsistence vulnerable and to sustain their livelihood under these conditions, farmers have adopted specific options to diversify their livelihood options. In recent years as the consequence of climate change the terminal heat and rising temperature in the winter season have diverted farmers in Pali to adapt muskmelon in late winters. This is a short duration crop, cultivated with very least external inputs and moderate vulnerability. As the water dry up in the dam the land is first sown with short duration varieties of wheat, barley, oats, mustard and vegetables. The standing water is utilised for irrigation and as the land becomes devoid of water, muskmelon is grown in the conserved moisture. Normal ploughing is done to open up the soil and then manual sowing is done in the open spaces using local variety of muskmelon. Local plants are used as windbreaks to protect the small plants from cold winds in initial period and from hot winds in later period. Due to surplus moisture on top layer the seed germinates and as the plant grows its long root system draws water from the deeper layers of soil profile. After 15–20 days planking is done on the germinated seed and vines to close the open soil strata and this practice kills insects and parasites hiding in the crevices besides conserving the moisture in the soil layers. The soil is very rich in organic matter and nutrients thus on getting favourable conditions the vines yield ample fruits to sustain farmers livelihood. As no chemicals and fertilisers are used the crop is purely organic and the entire produce is sold at farm gate.

Keywords: Arid zone, moisture conservation, muskmelon, opportunistic adaptation, organic

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Smallholder Farms Characterisation and their Use of Productive Resources in the Mt. Elgon Region, Uganda

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Smallholder farming systems in Uganda are diverse and this diversity relates to the farm structures and production strategies employed by the smallholders. The behaviour of these smallholders regarding resource allocation has implications on their overall farm output and on their contribution to the local food system. They are faced with various challenges and therefore to increase farm production in small rural farming systems through targeting of interventions needs an understanding of the diversity in these farm systems. This study explores the relation between production diversity and the socio-economic characteristics (including resource endowment) of 108 farming systems in the Mt. Elgon region, Uganda by creating a farm typology. Using a multivariate analytic technique of principal components and cluster analysis based on the socio-economic characteristics of the farm, we identified three farm types strongly differing in terms of assets. Farm type 3 had high resource endowment in terms of productive assets such as land, livestock and labour resources compared to households that belonged to farm types 1 and 2. Generally, household production decisions were linked to larger farm sizes, access to a greater number of fields, availability of labour resources, ownership of livestock and off-farm income sources. Farm households that were less endowed on the other hand had low production diversity and were less involved in the sale of crop output. The farm types identified in the study area are a basis for identifying representative farms from which farm models can be constructed. Therefore, identifying homogeneous groups of farms may contribute to target policy recommendations through developing feasible farm strategies and estimation of production potential to realistic farms.

Keywords: Farm household, multivariate analysis, production diversity, typology

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Assessment of Wastewater-Irrigated Urban Vegetable Production and Market Systems in Ethiopia: The Case of Akaki River in Addis Ababa

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Ethiopia, urban vegetable production using wastewater from Akaki River in the capital city Addis Ababa is a common practice. In a wider sense, the potential of urban agriculture in the area has not been realised due to subsistence agriculture, insufficient land, underdeveloped marketing structure and the state of water used for irrigation. Apart from these, little is known about the production system, opportunities, and challenges. In cognizant of the fact, the study attempts to comprehensively address the issues of production, marketing value chain, challenges and health related implications of urban vegetable production through wastewater irrigation. The study was based on a household survey of 115 respondents (75 producers and 40 consumers) around Akaki River while review of secondary documents supplements the study with evidences. Mixed approaches of quantitative and qualitative data analysis methodologies including descriptive statistics with simple tests coupled with narrative of qualitative findings were employed. In this study, the production system and the perception of the people about the system has been analyzed. The results indicated that this vegetable production system produce mainly cabbage, lettuce, cucumber, and green pepper while the average frequency of production per year is about five cycles. The irrigation practice using wastewater from Akaki River is dominated by furrow irrigation and traditional features which impact the efficiency of water use as manifested in the dry seasons. Moreover, industrial and household wastes released into the river increase health risks as result of contamination added to the low level of safety standards followed by producers. Despite the problems, the wastewater irrigation practice resulted in higher vegetable productivity as compared to the national average. This makes producers profitable although marketing of products directly on the farm could also have a significant impact. Apart

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from the negative implications, vegetable production using wastewater from Akaki River found to improve plant growth, household vegetable consumption, and create job opportunities. Hence, synergy between local authorities, NGOs, Universities and Research centres for multidimensional interventions is expected to enhance the safe production system with increased benefit from the practice.

Keywords: Akaki River, irrigation, urban agriculture, vegetable, wastewater

Effect of Saffron-Mallow Intercropping Patterns in the Third Year on Possible Cooling of Corms for Climate Change Adaptation

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Intercropping is a traditional agricultural approach which is the growing of multiple plant species at the same time in the same location. Traditionally, intercropping has been used to enhance plant yield and the efficiency of the resource as well decrease risk. Intercropping has been shown to decline the risk of plant failure by increasing the plant yield stability over time. Intercropping creates biodiversity in the agroecosystems, and it is considered to make the ecosystems more resilient against environmental perturbations, thus improving food security. The current study was aimed to investigate the effects of intercropping patterns of mallow as a perennial medicinal plant on stigma yield and quality characteristics of saffron affected as possible cooling of corms for climate change and global warming mitigation. The experiment was carried out at Faculty of Agriculture, Ferdowsi University of Mashhad, Iran. Treatments were 15, 30, 45 and 60-cm row spacings for saffron from mallow planting rows and sole saffron and mallow cultivations. The results revealed that the impact of intercropping patterns with mallow was significant on yield indicators of flower indicators of saffron. In comparison between sole cultivation and intercropped saffron revealed that the highest values for flower number, dried stigma yield and yield of daughter corms were recorded for sole saffron cultivation with 81 flowers m⁻², 0.2115 g m⁻² and 26.51 g m⁻², respectively. In comparisons amongst intercropping patterns, the highest value for dried stigma weight was related to 30-cm row spacings from mallow with 13.39 g m⁻². However, corcin, picrocrocin and safranal contents were not significantly affected by mallow intercropping patterns. The maximum land equivalent ratio was calculated for 15-cm row spacing with 1.77.

Keywords: Crocin, land equivalent ratio, stigma yield

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Ethnobotanical Study of Medicinal Plants Used by Mocho Community in the State of Chiapa, Mexico

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Ethnomedicine is still used as primary health care resource by several indigenous communities and people who live in rural areas over the world. In Mexico, most of the indigenous population live in rural areas (61.1 % in communities with less than 2,500 inhabitants). The State of Chiapas is inhabited by 11 ethnic groups with valuable ancestral knowledge in the management, and use of medicinal plants that are transmitted orally from generation to generation. The aim of this study was the documentation of traditional knowledge about medical plants and its usage in traditional medicine by the locals of the Mocho community, located in the state of Chiapas. Ethnobotanical and socio-demographical data were collected using a questionnaire from 43 local informants from Motozintla municipality, the state of Chiapas. In addition, quantitative approaches were used to determine medicinal use value (MUV), use report (UR), frequency of citation (ICF), the relative frequency of citation (RFC), and informant consensus factor (ICF). A total of 83 medicinal plant species belonging to 44 botanical families were documented. Asteraceae was the most dominant family by number of species (6 species) followed by Lamiaceae and Rutaceae (5 species each). The most often used parts are leaves (46%) and the decoction is the most common method of preparation. Diseases of the digestive and gastrointestinal system were dominated with 102 use-reports (27.6%) and diseases of the reproductive system had the highest ICF index (0.76) among other aliment categories. According to RFC and MUV index the most important species were *Verbena litoralis* Kunth., *Matricaria chamomilla* L., *Bursera simaruba* (L.) Sarg., *Dysphania ambrosiodes* (L.) Mosyakin & Clemants, and *Ruta graveolens* L. The collected information represents a base of knowledge for future research in the ethnobotanical field in the state, and it will contribute to the understanding of proper usage of medicinal plants. When knowledge is transformed in goods, culture, income and health it can be promoted through the demand of tourists that visit the place searching better options to treat their ailments.

Keywords: Lamiaceae, traditional medicine, *Verbena litoralis*, Asteraceae, ethnobotany

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Agroecology and Organic Coffee: Where Does the Organic Matter Come From? A Resource Accounting Approach

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The adjectives organic and agroecological are often used synonymously. Yet, the current certification for organic products does not consider several aspects that make up agroecology, and especially misses out on systemic dynamics and cycling issues on the farm. In other words, an agroecological agricultural system is potentially more tightly closed than an organic agricultural system. From a metabolic point of view, organic systems may therefore be just as dependent as conventional systems on the input of matter. The matter being not synthetic but rather organic matter, the enrichment of an organic system can be coupled with the depleting of another resource. To the least, the maintenance of the organic system may be dependent on the existence of an external but coupled source of organic matter. The paper analyses farming systems from a metabolic perspective and evaluates their sustainability but also their agroecological character. Our study characterises the metabolism of 5 farms producing coffee in intercrop with banana, chosen among a large sample of farms known from previous research in the Mount Elgon, Uganda. The 5 farms are representative of 3 groups: organic coffee producers, conventional coffee producers and low-input coffee producers. The accounting of material, energy and financial flows through the different production systems provides answers the following questions, all strongly related to agroecological characteristics: How dependent are the farms on material and energy inputs from outside? How related are these with financial flows and funds? How efficient are the farms? And how regenerative are they to their environment? Our findings suggest that through its maintained reliance on external inputs, the organic system shows some metabolic similarities with the conventional system. Much of the organic material needed to obtain good organic coffee yields is imported from distantly accessible savannahs. The reliance on external inputs rather than cycling also has social implications as access to external inputs seem conditional to the wealth of the farm. Our ability to assess agroecological features of farming systems and their relationship to the embedded ecological and institutional landscape, via the metabolic perspective, will increase our capacity to design sustainable farming systems in the future.

Keywords: Comparison, farming systems, material and energy flow analysis

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Crop Productivity and Contributing Factors in Organic and Conventional Farming Systems in Kenya - Evidence from a Long-Term Experiment (SysCom)

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Contributing to the global debate if organic can feed the world, the Research Institute of Organic Agriculture (FiBL) has started two long-term trials in Kenya. The Trial sites at Chuka and Thika are situated in the subhumid zones of the Central Highlands. At each site, conventional farming (Conv) and organic farming (Org) were compared at two input levels: high inputs (High) representing export-oriented, large scale production and low inputs (Low) representing smallholder production mainly for domestic use. The conventional system received mostly synthetic fertiliser and used synthetic pesticides. The organic system only used organic fertiliser and bio-pesticides. The differences between input levels were the amount of nutrients supplied and supplementary irrigation. The crop rotation included maize (*Zea mays*), different leafy vegetables (*Brassica oleracea*, *Beta vulgaris*), leguminous crops (*Phaseolus vulgaris*, *Glycine max*) and potatoes (*Solanum tuberosum*). After twelve years of continuous cropping, we encountered some trends with regards to productivity in organic and conventional systems: Grain maize, baby corn and common bean were able to achieve similar yield in organic and conventional, whereas cole crops, French beans and potatoes showed significant lower yields in organic. For example, cabbage showed 40 % higher yields in conventional high input system compared to organic high input system. However, our results showed that productivity often depends on the crop and the chosen management practice within a system. Some crops like grain maize were able to achieve similar yields because crop nutrient supply in organic systems was sufficient and pest and disease were of minor importance to the crop development. On the contrary, we experienced that the organic systems were less productive if management practices were guided by conventional mindsets - substitution of synthetic products by biological ones was not sufficient and other more system-based approaches like mixed cropping or pest resistance varieties need to be incorporated to achieve better outputs. Additionally, it must be mentioned that high productivity might not be enough to declare a farming system sustainable or not. Organic farming systems in our trials were also able to show positive effects on soil fertility, human health and biodiversity.

Keywords: Crop productivity, farming system research, organic farming

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How Do Organic and Conventional Production Systems Perform: Evidence from Long-Term Study in India

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Organic agriculture has gained a reputation for being ecologically sustainable, however sometimes it faces criticism for productivity and profitability aspects in comparison to conventional farming production. This is specifically a matter of concern when aiming at finding solutions to agricultural challenges of smallholder farmers in the developing countries. Through the 'long-term farming systems comparison (SysCom) program', FiBL together with local partners, runs a network of field experiments in the tropics, which aims at obtaining solid scientific evidence on the performance of organic and conventional production systems.

Here we present the findings from the SysCom long-term experiment located in (Madhya Pradesh State) the Central Indian cotton belt. The climate of the project area is semi-arid and cotton, soybean and wheat are the major crops grown in this region. Four management systems (treatments) namely (a) organic, (b) biodynamic, (c) conventional and (d) conventional farming with genetically modified (GM) cotton, are being tested in the field trial on bioRe research station since 2007. After analysis of twelve years of data, we found that for cotton crop, total production cost was highest in Bt-conventional system followed by conventional system and organic systems (org + bio-dynamic) respectively. On an average, there was a yield gap (Seed yield of Conventional systems – Seed yield of organic systems) of nearly 20 % for cotton and main wheat crop. Average yield of second wheat crop following cotton in rotation was above 50 % for organic systems than conventional systems. However, Soybean crop performed consistently equal in organic and conventional systems. However, the profitability – being the output function of input costs – was not consistent with the productivity outcomes. The detailed analysis of productivity and profitability of different systems, with and without premium prices for cash crop, will be presented.

Keywords: Farming systems, organic vs. conventional, productivity, profitability

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Bt Cotton Technology Impacts on Agricultural Land Use Dynamics of Nagpur District of Maharashtra in India

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Sustainable land management is now recognised as a major policy instrument due to severe land degradation problem in India. Understanding the temporal dynamics and trends of agricultural land use will help in planning suitable efforts to materialise the long term sustainable land management goals and improvement in life quality standards of the farmers of the region. In this perspective we analyse the temporal dynamics of agricultural land use change in Nagpur district of Maharashtra in the perspective of Bt cotton adoption since the year 2002. This study finds that a 3.84 percent growth in area under cotton cultivation in Nagpur district for the period 2000–20001 to 2017–18 and a 9.27 percent growth in production for the period studied. Cotton area, production and its yield has shown a significant improvement in the state since year 2000–2001. The study finds negative growth in area and production in case of then major crops of the district viz Black gram, Soybean, Green gram and Sorghum. The increase in the area of cotton finds to be at the cost of other competing crops like millets and other pulses, given inelastic supply nature of land. Cotton got an utmost importance in Nagpur district over the study period as revealed by the compound growth rate (CAGR) analysis. Growth performance of the cotton sector of Nagpur district is examined with a break up into two sub-periods viz; 2000–01 to 2008–09 , 2009–10 to 2017–18 and 2000–01 to 2017–18. The significant and positive growth trends in cultivated area for few crops such as cotton, rice and red gram in the studied district clearly show that there is shifting from diversified cultivation to intensive monoculture which adversely affect the sustainable land management in the area.

Keywords: Bt Cotton, compound agricultural growth rate, sustainable land management, temporal land use dynamics

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Economic Performance and GHG Emissions of Traditional and Organic Cocoa Farms in the Peruvian Amazon

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Organic certification for agricultural commodities has been promoted as a way to reduce the environmental impacts of food production and improving the welfare of smallholder farmers. Nevertheless, per capita net incomes in both conventional and certified farms appear insufficient to cover the average household basic needs and the share of the profits reaching smallholders from the chocolate industry remains marginal, raising governance questions regarding the effectiveness and fairness of the cocoa value chain and the certification schemes. On the other hand, while the environmental benefits of organic production are well documented, the effect of changing low-input cocoa systems in the Amazon to organic production systems on profitability and GHG emissions is unclear. In this study, we assess the profitability and carbon footprint of cocoa production under traditional (low input) and organic systems in the Amazonian region of Ucayali, Peru. For this, we used the Typical Farm Approach, combining participatory farmer workshops and expert guidance to define farms' typologies and obtaining a detailed quantification of all activities, processes, as well as input and output flows of both production systems. Subsequently, we calculated economic indicators and carbon footprint under different scenarios to assess their performance and trade-offs. Our results show that organic production allows higher yields and farm gate prices compared to traditional production systems, yet current price premiums and yield gains are insufficient to cover the additional costs of engaging in organic certification. Both systems require more than 4 hectares to provide the household with two monthly minimum wages, which is above the average of household cultivated area in the region, and could imply increasing pressure on the forests. Additionally, GHG emission increases with the inclusion of organic fertiliser are not offset by the declared yield gains when compared to traditional farming. Based on our results, we do not discourage organic cocoa production, but raise questions on adequate farm gate prices and fair share of the final product value reaching the producer, as well as on the need for tying production to zero deforestation commitments and compensating the aggregate environmental and social benefits when promoting more sustainable cacao production systems.

Keywords: Carbon footprint, cost-benefit analysis, organic agriculture, typical farm

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Land Suitability and Socioeconomic Factors for Pigeonpea Cultivation in Uganda

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Pigeonpea (*Cajanus cajan* (L.) Millsp.) is one of Uganda's many traditional pulses and may have an important role to play in helping the country to achieve food and nutritional security, while at the same time protecting and enhancing natural resources. The sustainable cultivation of pigeonpea will require, among other things, identification of suitable regions for cultivation and a better understanding of the factors that influence its adoption by farmers. To offer guidance on production we performed a suitability analysis by matching land characteristics with crop requirements using a GIS weighted overlay technique and gathered related socio-economic data collected with farmers in regions considered suitable. Our findings indicate that a large area of Uganda is suitable for pigeonpea growing and that farmers are likely to adopt, given the right support. The biophysical requirements for cultivation (i.e. rainfall, temperature, slope, soil drainage) were gathered from the available literature. A digital elevation model of the study sites was downloaded from the United States Geological Survey (USGS, <https://earthexplorer.usgs.gov>) to create a data layer for the slope using surface analysis in ArcGIS v10.4 software. We used soil drainage data from the Harmonized World soil database (<http://www.fao.org>) and temperature and rainfall data from the Global Weather Database (<https://globalweather.tamu.edu/>). Suitability analysis revealed that pigeonpea can be grown on 79 % of land in Uganda. Generally, the highly to moderately suitable areas were found in central and western regions whereas the northern and eastern regions were either marginally or not suitable. To determine the factors that influence adoption of pigeonpea we conducted a household survey with 283 randomly selected farmers from three of the sub counties identified by the suitability analysis. Farmers cited pest and disease, lack of market, lack of extension services and lack of improved varieties as the major factors constraining pigeonpea production. Seed distribution is essentially informal, either self-saved, purchased from neighbours/relatives or from local markets. Farmers' preferred traits included resistance to diseases, early maturing, resistance to drought and short cooking times. We recommend promotion of pigeonpea in suitable areas, farmers are likely to adopt the crop if provided with the right materials and support.

Keywords: Cultivation, land suitability, pigeonpea, socioeconomic factors, Uganda

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Can Subsistence Farming Help to Achieve Household Food Security? Evidence from Gurue, Central Mozambique

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In Mozambique, about 70 percent of population live in rural areas and depend directly on ecosystem services for their livelihoods. Subsistence agriculture has been given particular importance by the government of Mozambique as a strategy to fight food insecurity and poverty. Nonetheless, low soil quality, poor and irregular rainfall, low level of synthetic inputs, food losses, inadequate infrastructure and support services are the principal barriers to agricultural productivity. Therefore, the question is can subsistence farmers achieve some level of food security? To answer this question, we collected data from 300 households in Gurue district, central Mozambique, using a semi-structured questionnaire. The results revealed very limited income earning opportunities outside agriculture, therefore, undermining households' ability to buy food. Only 16 % of households had a non-farm income. The number of households with three or more meals a day grows during the harvesting period (March and July), reaching over 60 percent of the households, but this number decreases to 5 percent in January and February when the food reserves are already scarce. Two strategies stand out in alleviating food insecurity, particularly crop diversity and the use of processing and preservation techniques for agricultural products. The more crops a farmer produces, the more likely he/she is to harvest for a longer period throughout the year. The preservation of agricultural products helps to reduce post-harvest losses, while allowing food to be available for a longer period. However, farmers in the study area use traditional preservation techniques, mainly open sun drying, which may have negative impact on food quality, therefore creating a need for the implementation of innovative drying techniques that preserve the quality of food and use sustainable sources of energy.

Keywords: Crop diversity, food processing, food security, rural Mozambique

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Genetic resources and crop improvement

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Pheno-Genetics of Local Apple Varieties in Northern Region of Pakistan: A Hidden Pool of Apple Diversity?

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As a main fruit crop of cold temperate regions, apple (*Malus × domestica*) is traded globally. As a well documented plant cultigen, traditional germplasm in remote regions is still unexplored. In Gilgit Baltistan, Pakistan's increasing market demands for modern varieties and farmers' preference for high yields increasingly lead to the loss of local/indigenous varieties. We therefore studied local apple diversity by assessing varietal richness and diversity, arboricultural activities as well as phenotypic and genotypic characters of apple germplasm. In total, 106 individual apple trees were sampled, and 35 tree owners were interviewed from seven villages of the valleys Ishkoman and Baltistan. Alpha- and beta-diversity, dendrometric parameters, and fruit traits (qualitative and quantitative) in each village were measured. In *Malus*, such alpha- and beta-diversity measurements were conducted for the first time. Alpha diversity was higher in Baltistan, where even a wild apple relative (*Malus baccata* (L.) Borkh.) was discovered. Beta-diversity revealed three compositionally distinct clusters among villages. Calyx depth (cm), fruit weight (g), and axis pit width (cm) showed highest variability among the assessed characters, highlighting those as distinguishable fruit characters for the accessions observed. Arboricultural measures were found to be comparatively low and only a few local varieties were marketed, while most varieties were used for home consumption only. Genetic data revealed a moderate to high diversity. Considering the high varietal, phenotypic, and genetic variability, Gilgit-Baltistan appears a promising source of apple germplasm for future breeding programs. Improved management and product diversification could open up new revenue sources for farmers.

Keywords: Alpha-diversity, beta-diversity, Gilgit-Baltistan, varietal diversity

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Increasing Chickpea (*Cicer arietinum* L.) Tolerance to Soil Acidity: Screening Landraces for Tolerance to Aluminium and Manganese Toxicity in Solution Culture

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Chickpea (*Cicer arietinum* L.) is a nutritious food security crop but its production in many parts of the world is constrained by soil acidity (Aluminium and Manganese toxicity). Selected chickpea landraces (90) from Ethiopia, Bangladesh, Nepal, India, Australia (Striker, Amber) and wild cicer (6) from Turkey were screened for tolerance to Al or Mn toxicity, in a plant growth room, using a hydroponic screening method. In each experiment, replicated thrice, main plots were 0, 15, and 60 μM Al or 2 and 150 μM Mn treatments, subplots were the chickpea accessions. The chickpea accessions were harvested at 10 (Al) and 26 (Mn) days after sowing (DAS). The longest root length (LRL; Al), shoot and root dry weight (Al, Mn) and visual (toxicity) symptom score (Mn), and shoot length (Mn) were measured. Relative Root Elongation index (EI) was derived from the LRL data. Chickpea landraces were classified as Tolerant ($EI > 70$), Moderate ($EI \leq 70$, $EI > 50$) or Sensitive ($EI \leq 50$). In 15 μM Al treatment, wild cicer (wC) (499398 and 50011) were tolerant while landraces (41046, and 42395) were tolerant in 60 μM Al. Most landraces and wC, in addition to Amber and Striker, were tolerant to Mn (150 μM) toxicity. Chickpea landrace (41046) was tolerant to both Al (15 and 60 μM) and Mn toxicity while landrace (42400) was tolerant to Al (60 μM) and Mn toxicity. Striker and wC 49938 were tolerant to Al (15 μM Al) and Mn toxicity. Landraces; 41046 and 42400, and wC 49938 require further investigations in acid soils as they show promising tolerance to both Al and Mn toxicity. Further collection of chickpea landraces and wC grown on acid soils such as eastern Kenya and Ethiopia is recommended to extend the range of acid tolerant germplasm for screening and, to identify candidates for use in breeding programmes to produce acid tolerant chickpea.

Keywords: Acid tolerance, chickpea landraces, hydroponic screening, wild cicer

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Delivery of Clean Planting Material of Orange-Fleshed Sweetpotato to Smallholder Farmers through Decentralised Vine Multipliers in Uganda

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Crop biofortification is one of the most promising approaches being used in recent years to fight hidden hunger among resource-poor communities or persons in fragile environments. Vitamin A rich orange-fleshed sweetpotato (OFSP) has proven to be effective in improving the health of children below five years and pregnant women in many sub-Saharan countries. However, access to improved and clean OFSP varieties has limited realisation of the full benefits of this crop. To increase the availability of disease-free and high yielding planting material of OFSP, CIP together with partners have identified, recruited and trained more farmers in 12 districts of Uganda to start the production of pest and disease-free planting material of selected OFSP to increase its consumption within households in areas with the highest Vitamin A deficiency (VAD) in the country. It is believed that making the planting material of this nutrient-rich crop readily accessible to local communities will go a long way in increasing consumption of OFSP roots hence a reduction in VAD. The training was conducted in December 2019 and January 2020 and involved a total of 81 stakeholders and only 48 farmers were selected to become vine multipliers. During the training, perceptions of the stakeholders on effective ways of increasing OFSP consumption in their communities were also captured. Challenges, opportunities, and experiences of producing, marketing, and consumption of OFSP were also discussed. Community sensitisation, nutritional education, timely availability of improved OFSP varieties, access to irrigation, and market availability were reported to be among the key factors that influence the consumption of OFSP.

Keywords: Biofortified crops, scaling-up, stakeholder perceptions, sweet-potato, vine multiplication

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In vitro Induced Polyploidy in *Celosia argentea* var. *plumosa*

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Celosia argentea L., Amaranthaceae, is an annual herb cultivated for its medicinal, nutritional and horticultural values. It is rich with minerals, proteins, vitamins and several other compounds such as saponins, alkaloids, peptides, glycosides, flavonoids, amino acids and fatty acids. Medicinal properties of this plant are applied in traditional medicine to treat tumors, jaundice, fever, diarrhea, inflammation and various other diseases. As an ornamental plant it is particularly grown for its flowers. Somatic induced polyploidisation *in vitro* is one of the methods used in breeding programs of ornamental plants. Chromosome doubling usually increases plant vigour and enhances morphological traits like flower shape and size.

The aim of this study was to obtain octoploid plants ($2n = 72$) from tetraploid *Celosia argentea* var. *plumosa* ($2n = 36$) by *in vitro* induced polyploidy. In total 320 nodal segments were treated with oryzalin at concentrations of 20, 40, 60 and 80 μM along two time intervals of 24 and 48 hours. The level of ploidy of the affected plants was determined using flow cytometry.

Four octoploid plants were obtained, of which three plants at the concentration of 40 μM for 24 hours and one plant at the concentration of 60 μM for 24 hours. *In vitro* morphological changes such as thicker stems, more compact growth and larger leaf area size were observed in newly acquired genotypes compared to control plants. In the second phase of the research, newly acquired genotypes will be evaluated in *in vivo* conditions for better analysis of morphological and biochemical properties.

Keywords: Amaranthaceae, *Celosia argentea* var. *plumosa*, flowcytometry, oryzalin, polyploidy

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The Origin of Date Palm (*Phoenix dactylifera* L.) – State of the Art and Methods to Distinguish between Putatively Wild and Domesticated Populations

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Date palm (*Phoenix dactylifera* L., Arecaceae) is one of the few extratropical palms and a widely recognised keystone species of arid and semi-arid ecosystems across North Africa, Cape Horn, the Middle East, and the Indus Valley. According to FAO, date palm accounts for roughly 1 % of the global fruit production and is therefore an important agricultural commodity. It belongs to the few perennial and intensively domesticated species, whose wild relative(s) and putative centre(s) of domestication are not yet recognised. Hence, date palm's domestication process is considered one of the most difficult issues in agro-biodiversity contexts, but the search for its wild relative(s) has gained momentum in recent years. It is driven by (i) the need to increase the genetic pool needed for selection and adaptive management to mitigate climate change and (ii) scientific interest in the likely complex evolution of this species. In this study we review current trends in date palm research, consider climatic conditions between 130,000 BCE and today, and use archaeo-botanical (such as phytoliths and pollen) and historic (such as cave paintings and reliefs) records to unravel date palm's evolutionary process. We integrate data obtained from studies of other domesticated plants and propose approaches that allow to better predict putative regions of wild date palm. The data provide evidence for a three domestication centre theory (Persian Gulf as well as East Mediterranean and north-west African regions). The present study underlines the need for a more structured and collaborative research agenda with potential applications for other species of interest.

Keywords: Archaeology, cave painting, domestication, genetic diversity, palynology, phytoliths, private alleles

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Phenotypic Plasticity of Fruits of *Acrocomia aculeata* in Western Minas Gerais, Brazil

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Vegetable oils are an important international commodity in today's food and non-food industry. Nowadays, the oil palm (*Elaeis guineensis*) has the biggest share of this commodity. By the next few years, the demand of the cost-competitive palm oil is expected to rise up. An alternative to supply this demand is *Acrocomia aculeata*, an oilseed palm endemic to the Americas which has a productivity and oil composition comparable to *E. guineensis*. *Acrocomia* also shows a variety of agricultural advantages: being fire and drought tolerant, its possible cultivation on degraded soils and its environmental plasticity. Mature fruits of *Acrocomia* have a smooth hard exocarp, a fleshy mesocarp and a very hard, thick endocarp encompassing the endosperm. The mesocarp as the endosperm can be used for oil extraction whereas the endocarp and exocarp are promising for the production of bio-charcoal. This study aims to elaborate the variability in fruit phenotypic characteristics of ecotypes from different regions of Minas Gerais, Brazil, and to assess the difference between plants, originating from dry and humid regions. Mature fruits from different ecotypes were collected at the Macaúba Active Germplasm Bank, of the Universidade Federal de Viçosa in Araponga, MG, Brazil, in February 2020. The layers were separated. Their thickness, proportions, fresh and dry weight were determined. The mesocarp was dried for 48 hours so oil extraction could be done. The fruits are showing natural ecotypic differences. Fruit weight ranged from 20.4 to 41.3 g per fruit, where the predominant fruit mass was situated between 27.4–32.9 g and 32.2–36.5 g for the ecotypes from the dry northern and humid midwestern Minas Gerais, respectively. Fruits from dry regions tend to be smaller than fruits from humid regions. Exocarp thickness is between 0.5–1.5 mm independent of the ecotype. However, a difference between ecotypes can be found in the proportion of the exocarp to the total fruit. The majority of fruits show a proportion from 23.7–25.6 % and 18.5–23.3 % for the northern and midwestern ecotypes, respectively. *Acrocomia* ecotypes show a high fruit phenotypic plasticity, important for further development of the species as a crop.

Keywords: *Acrocomia aculeata*, Brazil, fruit characteristics, oilseed palm, phenotypic plasticity

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Genomic Studies of Myanmar Rice (*Oryza sativa* L.) Varieties Using DArT and SNP Markers

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Two ultra-high-throughput diversity array technology (DArT) markers (silicoDArT and SNP) were employed to investigate the genetic diversity and population structure of rice (*Oryza sativa* L.) varieties of Myanmar. The study was performed using 117 rice genotypes comprising 112 landraces and 5 improved (control) varieties with 4,064 silicoDArT and 7,643 SNPs derived from DArT platform. Quality control parameters included > 95 % call rate, > 95 % reproducibility, and minor allele frequency (MAF) >0.1 for screening. Polymorphic information content (PIC) values for silicoDArT ranged from 0.02 to 0.5 with an average of 0.37. In the case of SNP markers, PIC values ranged from 0 to 0.5 with an average of 0.41. Genetic variance among the genotypes ranged from 0.001 to 0.954 in silicoDArT and 0 to 0.753 in SNP markers. Genetic relationships among the genotypes were identified utilizing weighted neighbor-joining dendrograms. All the genotypes were grouped into two major clusters with both silicoDArT and SNP markers. Population structure were tested using *K* values from 1 to 5, maximum Δk was found at *K* = 2, confirming that the structure analysis also revealed two distinct genetic clusters. Analysis of Molecular Variance (AMOVA) with SNP markers showed that within individuals only 4% diversity existed whereas among individuals it was 22 %. Maximum diversity has been observed at population level (74 %). This study demonstrated that DArT markers are a useful tool for the genomic studies with regard to rice. It will support researchers to identify useful DNA polymorphisms in genes and germplasm of interest and apply that information for rice varietal development and release.

Keywords: DArT markers, genetic diversity, Myanmar, rice landraces, SilicoDArT, SNP

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Characteristics of PBA Profiling Markers in the Analysis of *Arachis hypogaea* L. Genome

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In this study, the PBA technique was utilised to characterise its effectivity to be used for the possible analysis of *Arachis hypogaea* L. genom polymorphism. Three different peanut genotypes were chosen that were characterised previously to have different profiles in iPBS fingerprints. All the genotypes were collected from Chuquisaca Department, Bolivia as original plant sources. The seeds were transferred to the Faculty of Tropical Agrisciences, CULS in Prague, Czech Republic and planted in pots. Young plants were transferred to the AgroBioTech Research Centre; SUA in Nitra, Slovak Republic where biological material was analysed. Three different PBA primer combinations were used in PCRs with the result of generating different PBA fingerprint profiles – CYP1A, CYP2B, and CYP2C. A total of 83 amplicons were generated for the analysed peanut accessions with the highest number of 33 amplicons for marker CYP2C, but for this marker, the lowest percentage of polymorphism was obtained on the level of 60 %. CYP1A marker achieved the polymorphism on the level of 63 % and CYP2B marker on the level of 79 %. CYP1A marker achieved the value of effective number of alleles 1.7634 and the Shannon's Information index 0.6245. CYP2B marker achieved the value of effective number of alleles 1.6500 and the Shannon's Information index 0.5830. CYP2C marker achieved the value of effective number of alleles 1.9780 and the Shannon's Information index 0.6876. None of the markers used in this study has generated the same profile for any of the analysed peanut accessions, that is why all of them should be useful for DNA based profiling of *Arachis hypogaea* L. germplasm, but CYP2B should be used preferably.

Keywords: *Arachis hypogaea*, genome, germplasm, PBA markers, polymorphism

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Zambian Neglected Species: Oils and Cakes Composition of Traditional Oil-Bearing Trees

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Due to the increased contact between disparate human populations and the development of a global trading system, the number of species upon which global food security and agricultural incomes depend narrowed drastically. More than half of today's needs for energy are met by maize, wheat and rice. The impact of the species base narrowing is mostly felt most by the rural communities in marginal areas, where the set of livelihood options is limited. Many neglected/underutilised species occupy important niches, perfectly adapted to the local fragile conditions, contributing to sustainable production with minimal inputs as well as to the diversity and the stability of agro-ecosystems. The scientific community, as well as the food industry, know the only a minimal share of Zambian food plants. Therefore, our study focused on the chemical composition of oils and cakes of three neglected but traditionally important oil-bearing plants, namely: *Parinari curatellifolia*, *Schinziophyton rautanenii* and *Ochna serrulata*, in surroundings of Mongu, Western Province, Zambia. *P. curatellifolia* and *S. rautanenii* oils were chiefly composed of α -eleostearic acid (28.58–55.96 %), linoleic acid (9.78–40.18 %), and oleic acid (15.26–24.07 %), whereas *O. serrulata* contained mainly palmitic (35.62–37.31 %), oleic (37.31–46.80 %), and linoleic acid (10.61–18.66 %). Vitamin E of *S. rautanenii* oil was mainly composed of γ -tocopherol (3236.18 $\mu\text{g/g}$); *O. serrulata* contained similar proportions of α - (287.37 $\mu\text{g g}^{-1}$) and γ -tocopherol (361.11 $\mu\text{g g}^{-1}$), whereas *P. curatellifolia* had negligible levels of vitamin E. All three species can be considered as a good source of essential minerals. The results suggest great potential of the traditional Zambian species to be introduced into food, technical and/or pharmaceutical industry. Especially *O. serrulata* deserves deeper research attention, because of the considerable quantities of α -tocopherol in its oil which exhibits non-rancid properties. Due to the nutrient-rich cakes, the tested species might be also promising for animal fodder fortification.

Keywords: Cooking oils, neglected crops, sustainable diet, underutilised species, Zambia, α -eleostearic acid

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