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Tropentag 2023

Competing pathways for equitable food systems transformation: trade-offs and synergies

Book of abstracts

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Preface

Tropentag is the largest interdisciplinary conference in Europe focusing on development-oriented research in the fields of tropical and subtropical agriculture, food security, natural resource management and rural development. The theme of the Tropentag 2023 is "Competing pathways for equitable food systems transformation: trade-offs and synergies", organised by the Leibniz Centre for Agricultural Landscape Research (ZALF) in cooperation with the Humboldt-Universität zu Berlin, Germany, and will take place from 20-22 September 2023. It is clear that a just and sustainable transformation of our food systems is urgently needed: climate change, conflicts, rising food and fuel prices, and growing social and income inequalities are exacerbating the vulnerabilities of our food systems. But what should the transformation of our food systems look like?

The theme invites diverse contributions that explore different pathways for transforming food systems and the trade-offs and synergies involved, ranging from more technical solutions, such as climate-smart agriculture and biofortified crops, to more systematic solutions for changing the underlying relationships of our food systems, such as agroecology and alternative food networks.

This debate will be explored during the conference by internationally renowned keynote speakers. This year's keynotes will discuss policy and technical innovations to increase the resilience of food systems to shocks; the role of data-driven approaches in identifying opportunities for more sustainable and equitable food system outcomes; the role of micro, small and medium enterprises in supporting inclusive value chain transformation; a framework for analysing and addressing inequalities in food systems; and alternative pathways for food system transformation, including livestock systems and agroecology.

This year we have received over 980 submissions, of which 625 will be presented as either oral or poster presentations – these are now available in this book-of-abstracts. We will have 133 oral presentations grouped into 25 scientific sessions, 47 face-to-face poster sessions and 9 online poster sessions. There will also be 22 pre-conference workshops and 8 post-conference workshops, which broadly engage with this year's conference theme.

This year's featured CGIAR centre is the International Food Policy Research Institute (IFPRI), which provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition in developing countries.

We would like to thank all the participants for their scientific contributions and our colleagues on the Scientific Committee for reviewing the abstracts and chairing the oral and poster sessions. But the conference could not be organised without the help of many people behind the scenes. We would like to thank Eric Tielkes and his team for their invaluable support in organising this ever-growing event. Special thanks 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 the Humboldt-Universität zu Berlin for helping to organise this conference. Special thanks to our long-standing donors (listed on the back cover) for their unwavering financial and in-kind support, which allows us to keep conference fees at a modest level, especially for early career researchers. Thank you all for attending – you have made it possible once again.

We welcome you to Berlin from so many different parts of the world and wish you an inspiring and enriching conference.

On behalf of the Tropentag 2023 Organising Team:

Stefan Sieber, Dagmar Mithöfer, Caroline Hambloch, Wolfgang Bokelmann, Heike Schobert, Lisa Brandt, Eric Tielkes

Berlin, September 2023

Contents

Plenary speeches

Achieving resilient food systems

Johan Swinnen

International Food Policy Research Institute (IFPRI), United States

For nearly a decade now, global progress against hunger and malnutrition has stagnated and begun to reverse. Countries around the world now grapple not only with rising food and nutrition insecurity but also with the three C's: Climate Change, COVID-19, and Conflict. While food and commodity prices have come down from their peak, they remain historically high. In fact, price shocks and other shocks may be the new normal. In his presentation, Dr. Johan Swinnen will discuss the impacts of climate change, the global pandemic, and the food and fertiliser crisis, as exacerbated by Russia's invasion of Ukraine. Different regions, countries, and segments of the population remain more vulnerable than others to these types of shocks. Dr. Swinnen will draw from IFPRI's latest research and modelling tools, to identify policy and technical innovations that can help policymakers transform food systems so they are resilient against shocks, inclusive of marginalised populations, and environmentally sustainable.

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The interplay of agriculture, land use, climate change, and food security

Catherine Nakalembe
University of Maryland, Dept. of Geographical Sciences, United States

Food security in sub-Saharan Africa is a critical issue, with approximately 140 million people facing acute food insecurity, according to the 2022 Global Report on Food Crises. To address this challenge effectively, understanding the dynamics of land use, climate change impacts on agricultural productivity, and factors influencing food access and resource distribution is crucial. This talk delves into the complex interplay between agriculture, food security, land use, and climate change in sub-Saharan Africa, exploring sustainable pathways and the role of remote sensing and machine learning technologies in enhancing decision-making. We can identify opportunities for more sustainable and equitable solutions by utilising data-driven approaches, especially concerning regional food security. The talk emphasises the potential for these technologies to drive positive change on a large scale.

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Food system transformation through the lenses of nutrition and equity

Jody Harris
World Vegetable Center, Food Systems East and Southeast Asia, Thailand

Food systems are currently not delivering food security and good nutrition for all. Classically, it is the most marginalised groups in a given society who are most malnourished and least able to engage with food systems to obtain a healthy diet. So we need to acknowledge this, and understand who is marginalised and why and how, in order to transform food systems to leave no-one behind.

Marginalisation is the key concept that underpins inequity. We know that much food systems and nutrition research concerns itself with aspects of marginalisation, for instance the disempowerment of women, or disparities in income. But other axes of marginalisation, such as age, ethnicity, disability, sexuality, and geographic marginalisation come up far less often in the food systems literature, when looking at who has these different outcomes. The interactions between these different aspects of marginalisation – intersectionality – are studied even less often. And the structural determinants of marginalisation – inequitable access to basic services, resources and political redressal; and power relations and social norms – are also under-explored in our field.

This keynote will present the Nutrition Equity Framework, to provide a logic for how researchers and practitioners can acknowledge, assess and address inequity in food systems; and offer insights from the new UN-CFS High Level Panel of Experts report on addressing inequality and inequity in food systems for food security and nutrition. The talk will argue not for a specific transformation approach, but rather for considering nutrition among key food system outcomes; and equity as key to the process of negotiating transformation and change.

Keywords: Food systems

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Rethinking agricultural strategies for Africa: Moving beyond the green revolution to embrace agroecology

Million Belay

General Coordinator, Alliance for food sovereignty in Africa and Panel Member IPES Food, Uganda

This presentation advocates for a fundamental shift in African agricultural strategies, urging a departure from the conventional Green Revolution approach and a move towards embracing agroecology. The limitations of the Green Revolution, including environmental degradation, high production costs, and vulnerability to pests and diseases, are discussed, highlighting the need for a more sustainable and inclusive alternative. Agroecology, grounded in ecological principles and local knowledge, offers a context-specific and climate-resilient pathway to transform African agriculture. By prioritising biodiversity, sustainable resource management, and farmer empowerment, agroecology can address food security challenges while promoting environmental sustainability and social equity. The speech presents successful examples and research findings that underscore the positive impacts of agroecology on food security, biodiversity conservation, climate adaptation, and rural livelihoods in diverse African contexts. Embracing agroecology enables Africa to create resilient and equitable agricultural systems that tackle climate change and resource constraints while safeguarding community well-being and ecological integrity.

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The roles and potentials of micro, small and medium scale enterprises for inclusive value chains in developing regions

Lenis Saweda Liverpool-Tasie
Michigan State University, College of Agriculture & Natural Resources, United States

In the last three decades, agri-food value chains (AVCs) have been growing and transforming rapidly in developing regions. This transformation is driven in part by urbanisation, population & income growth, and market deregulation. These have caused shifts in consumption patterns which have stimulated significant supply response; largely domestic. This transformation has been facilitated by enormous aggregate investment on the part of the many micro, small, and medium enterprises (MSMEs) in the "midstream" and "downstream" of AVCs, comprising the wholesale, logistics, processing, and retail segments of value chains. Despite their critical role in making nutritious and safe foods available to consumers, limited attention in research and national or international policy discussions has been directed toward these value chain segments. In this talk, I will draw from several research projects to reflect on the potential roles of these MSMEs (particularly in the midstream and downstream of food supply chains) in making the transformation of these value chains more inclusive and the associated implications for policy and research.

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Competing narratives for livestock development and policy

Ian Scoones
PASTRES, Institute of Development Studies, University of Sussex, United Kingdom

This presentation will offer a new narrative for livestock development and policy, focusing on extensive livestock and pastoral systems from across the world. Making use of half the world's land surface, rangelands are an important site for the production of animal-source foods and other products, generating livelihoods for millions. Yet extensive livestock systems are poorly understood, with herders and their livestock frequently cast as the villains of climate change and environmental destruction. The new narrative challenges these assumptions and suggests alternative pathways for development and policy around five intersecting themes: mobility, land and environment, climate, diets and markets. The new narrative highlights the potentials for livestock systems to enhance the environment and biodiversity, while limiting impacts on the climate. The narrative in turn means development pathways that recognise pastoralism and extensive livestock production as productive, modern systems based on mobility, flexibility and adaptability, and embedded in local social relationships and collective networks.

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Crops and cropping systems

Crop production and management

Oral Presentations

Posters

Irrigation alone cannot counteract adverse climatic effects on macadamia yields in South Africa

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Macadamia is a high value tree nut crop experiencing a considerable rise in global demand. South Africa is the world largest producer of macadamia nuts, with production areas rapidly expanding in the country. However, yields are highly variable and have been declining in recent years, in conjunction with increasingly severe climate change impacts in the region. Therefore, to sustainably increase the productivity and climate-resilience of macadamia orchards, the effect of environmental factors on the trees' vegetative and reproductive cycles needs to be better understood. To this end, we quantified the extent to which climatic and soil factors drive macadamia yields in Levubu (South Africa) along an altitudinal gradient (600–950 m a.s.l.), for irrigated and rainfed orchards, separately. For this we applied mixed-effects models on historical production data for the years 2010–2021 from 247 orchards. On this background, the role of irrigation in counteracting the impact of abiotic stresses on macadamia phenology and productivity was evaluated.

We found a pronounced interannual variability of macadamia yields (from 1.2 to 4.0 tons dry nut-in-shell ha^{-1}). Higher yields were found at elevations >700 m a.s.l. and in micro-sprinkler irrigated orchards. Orchard characteristics and environmental variables jointly explained 49 % of the yield variability. Cultivar, presence of irrigation, tree age and planting density were found to affect yield, while no significant effect was found for soil variables. High temperatures and low global radiation during the nut development stages, alongside poor rainfall amounts in the dry season, were the climatic factors more severely affecting yields. In particular, low irradiance was the main yield limiting factor in irrigated orchards, while extremely high temperatures and poor rainy seasons were most limiting in the rainfed ones. Increased irrigation amounts, although beneficial, were not fully compensating the impact

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of climatic factors on productivity. Our findings suggest that irrigation alone cannot counteract adverse climatic effects on macadamia yields. To sustainably increase macadamia productivity and resilience to climate change, abiotic stress impacts will have to be reduced through a combination of improved orchard management and breeding for stress tolerance.

Keywords: Abiotic stress impact, altitudinal gradient, climate change, irrigation systems, *Macadamia* spp., yield limiting factors

Change along the way? Balancing systems approach and comparability when adapting long-term experiments

Eva Goldmann, Akanksha Singh, David Bautze, Laura Armengot, Johanna Rüegg, Marc Cotter, Noah Adamtey, Amritbir Riar, Beate Huber
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SysCom was initiated to provide evidence for the performance and viability of organic agricultural cropping systems in the tropics. While case studies and long term studies were available for temperate zones, little scientifically backed-up evidence was available to assess the potential of organic agriculture in sustainable development in countries within the tropical climate. Thus in 2007 long term trials in India, Bolivia and Kenya were established, comparing in each country two organic systems with two conventional systems based on locally relevant cropping systems and main crops (cotton, cocoa, maize). Combining the existing practical examples and recommendations from local agricultural institutions organic and conventional treatment were designed, putting high emphasis on the local relevancy and prevalent practices. After the systems established it became clear that organic systems in our long-term experiments (LTEs) were lacking behind in profitability and productivity, not offering a valuable approach for local farmers to sustain their livelihoods. In our analysis we had to realise that often a mere copy of conventional practices, substituting conventional with organic inputs would not suffice to provide solid evidence on the potential of organic agriculture in the tropics.
Using the example of the SysCom program, we want to discuss the challenges and opportunities of adapting LTEs, confronting questions on how to adapt the three LTEs implemented in different countries to still be in nexus to each other, how to balance systems approaches to optimise the different compared treatments while still being comparable to each other and finally how to meet the golden mean of innovative and optimised farming approaches while being realistic and relevant to local contexts. The adaptations realised in the annual cropping system LTEs, such as changing input levels and seed material, introducing more complex intercropping patterns and crop rotations are proving to be valuable additions to our experiments. The positive impacts on productivity and profitability, especially on the organic systems can serve as a examples of sustainable locally adapted production systems, allowing also smallholder farmers to sustain their livelihood also in the future on farming.

Keywords: Annual cropping systems, cotton, India, Kenya, long-term trial

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Improving the productivity of the sorghum-cowpea intercropping systems through varietal diversity in Sudano-Sahelian zone of Burkina Faso

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Cereal-legume intercropping systems are one of the most commonly practised cropping systems in Sub-Saharan Africa. Despite their multiple agroecological, crop yields remain low in the Sudano-sahelian zone of Burkina Faso. Our study aims to improve the productivity of this intercropping system through the use of varietal diversity. Specifically, it aims to (i) characterise the type of sorghum-cowpea intercropping most commonly practised by farmers, (ii) identify the most productive sorghum and cowpea varieties, and (iii) identify the agro-morphological traits of varieties that influence productivity in this system. Surveys of 170 farmers and monitoring of 80 farmers' plots were carried out in the Centre-Nord region of Burkina Faso. Sorghum (13) and cowpea (11) varieties, selected in a participatory manner, were evaluated in intercropping systems during the 2018 and 2019 seasons, at Saria research station. The results showed that intercropping in the same seed hole is the most practised cropping system with 98 % of respondents. It is mainly practised with local varieties (92 % for sorghum and 67 % for cowpea). Yields measured on farmer' fields were highly variable (CV □ 40 %) and low (average □ 500 kg.ha^{-1}) for both crops. Intercrops were relatively more productive than the corresponding sole crops for all varieties with land equivalent ratios (LER) ranged between 1.00 and 1.79. Optimal productivity combinations were obtained with the sorghum varieties CSM 63E, Pisnou and PSE08 G1/21–1G1, and the cowpea varieties Kvx396–4-5–2D, Yiisyande, Niizwe and Tiligré. Sorghum cycle duration (r=-0.49), plant height (r=+0.60), and chlorophyll content in sorghum leaves (r=+0.66) were traits that most influenced grain yields of sorghum when intercropped. Cowpea cycle duration (r=-0.25), branching length (r=+0.30), and competitiveness ratio (r=-0.31) were the most influential cowpea traits on sorghum grain yield. The varieties identified could be proposed to farmers for improved productivity.

Keywords: Agro-morphological traits, grain yield, intercropping, land productivity

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Water use efficiency and the net ecosystem C balance assessments from rice cultivation in Benin

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The water use efficiency (WUE) and net ecosystem carbon (C) balance (NECB) are key indicators of agroecosystems, used to describe the trade-off between yield on the one hand, and required water and soil C loss/gain on the other hand. Considering the different farming practices, sustaining, or even increasing yields while improving water use and limiting carbon loss is therefore vital for sustainable agriculture. Here, we seek to assess the WUE and the NECB from rice cultivation as affected by different water management and N fertiliser rates in southern Benin. A field experiment was established from November 2022 to March 2023 at Koussin lélé, Cove district, using a split-plot experimental design. The main plots are different water management measures, which include continuous flooding (CF) and two thresholds (at 15 cm and 30 cm below surface) of alternate wetting and drying (AWD) irrigation (AWD15 and AWD25). The subplots are two rates of N fertiliser that include 90 kg ha^{-1} (farmer's practice) and 120 kg ha^{-1} (high amount of fertiliser). WUE and the NECB were assessed based on dynamic, manual closed chamber (A: 0.16 m^2; V: 0.16 m^3) measurements of evapotranspiration (ET), ecosystem respiration (Reco), and net ecosystem exchange (NEE), which were performed biweekly with a novel, low-cost ET, and CO_2 flux logger system. Measured CO_2 and ET fluxes were calculated using modular R scripts. The results showed that the agronomic WUE (yield (g)/ET (mm)) ranged from 1.63 g mm^{-1} to 2.36 g mm^{-1} and was highest under CF and AWD15 with N90 (statistically similar). All the treatments were small C sinks. The highest negative NECB (atmospheric sign convention) was recorded under CF with N120 (-30.98 g C m^{-2}) whereas the NECB was recorded under AWD15 with N120 (6.28 g C m^{-2}). The increase in negative NECB was in the order CFN90 > AWD15N90 > CFN120> AWD25N90 > AWD25N120> AWD15N120. In addition, the grain yield under CF and AWD15 are statistically similar. Therefore, we recommend adopting the AWD15 irrigation regime with an application rate of N 90 kg ha^{-1} for sustainable irrigated rice production.

Keywords: N fertiliser, NECB, rice, water management, water use efficiency

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Environment-specific selection of high-quality cotton cultivars from on-station and on-farm trials

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Selecting qualitatively high cotton cultivars is a critical aspect of cotton breeding programs. However, choosing cultivars is not straightforward. Genotype × environment (G×E) interactions have to be considered when choosing varieties for cultivation. This holds especially true in organic farming where natural stress resistance is crucial in the absence of genetic modifications.
For on-station trials, GGE biplots have become a popular tool for selecting cultivars. We applied the method to data from our on-station trials conducted at five sites in India and for 29 cotton cultivars. The sites included different farming conditions and the cultivars were a mix of hybrids and non-hybrids from the *Gossypium hirsutum* and *Gossypium arboreum* species. Using the PPBstats package in R, we identified suitable varieties for each site. Cultivar performance varied greatly between sites. Varieties bred at a site performed particularly well, showing the importance of environment-specific breeding.
On-farm trials are a participatory breeding approach that enables farmers to participate directly in the decision-making. However, estimating G×E effects is difficult due to the trial design. To analyse our on-farm trials conducted on 102 farms in India, testing 32 *G. hirsutum* and *G. arboreum* varieties, we applied a hierarchical Bayesian G×E model. The analysis was done using the PPBstats package in R. Farm clusters in which the tested cultivars performed similarly were identified. Well-performing varieties for each cluster were found through mean comparisons within each farm. Furthermore, a GGE biplot analysis was performed by pooling farms along agroclimatic zones to identify suitable cultivars on an agroclimatic level. The preliminary results from the GGE biplots have lower precision for the individual farmers that participated in the trials than the hierarchical Bayesian method but can be used for giving recommendations to policymakers and stakeholders for selecting cultivars based on agroclimatic zones. Thus, the combination of the two approaches can be used for decision-making on G×E cultivar selection through on-farm trials while providing participating farmers with tailored recommendations for their own cultivation.

Keywords: Cultivar selection, genotype by environment interaction, on-farm trials, on-station trials, organic cotton, site-specific breeding

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Adapting the CROPGRO model to simulate biomass production and soil organic carbon of *Brachiaia* cv. hybrid Cayman and *Panicum maximum* in East Africa

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Biophysical models are key to inform management activities that can restore degraded soils and ultimately improve biomass production and soil organic carbon (SOC) sequestration. Within East Africa several studies have been conducted to evaluate models in annual cropping systems, and to quantify the impacts of different agronomic management options on soil organic carbon and yields. However, no modelling studies exist on perennial forage grasses, which are important for mixed-crop livestock systems within the region. We evaluate the CROPGRO-Perennial Forage model (CROPGRO-PFM) using harvested biomass and SOC data from several sites across Kenya and Tanzania. The model version initially parametrized for *Brachiaria* cv. Marandu and *Panicum maximum* in Brazil is applied to simulate *Brachiaria* cv. hybrid Cayman and *Panicum maximum* in the two countries. We modify model parameters to improve d-statistic and root mean square error (RMSE) for biomass and SOC. Our results show that the CROPRO-PFM model can simulate biomass of *Brachiaria* cv. Cayman under different soils and weather conditions with an acceptable adjustment of parameters including soil water (lower limit, drained upper limit, saturated water content) and stable soil organic carbon. The d-statistic for harvested biomass across the Tanzania sites ranged between 0.78 to 0.97, while the root means square error ranged between 0.6 to2 t ha^{-1}. Sensitivity simulations with increased manure application rates of 5 t ha^{-1} show an increase in SOC of up 0.833 t ha^{-1} yr^{-1}. These results suggest that the CROPGRO-PFM can be used to simulate growth of *Brachiaria* cv. Cayman adequately under rainfed conditions in the East African highlands.

Keywords: Biomass, *Brachiaria*, Kenya, perennial forage model, soil organic carbon, Tanzania

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Nitrogen fixation and nitrous oxide emissions in tropical silvopastoral systems based on *Urochloa* grasses and *Leucaena* shrub legume

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Cattle production in tropical regions is largely dependent on monoculture pastures, which are characterised by low technology adoption and high land occupation. The introduction of legumes in tropical pastures has been proposed as a potential alternative to increase forage and animal productivity while maintaining soil quality without the use of synthetic inputs. However, the impact of increased nitrogen inputs via symbiotic fixation by legumes on soil nitrogen gaseous losses has received limited attention. To evaluate the potential of shrub legumes to improve nitrogen cycling in pastures of Valle del Cauca, Colombia, we conducted a one-year study from 2021 to 2022. Four pasture treatments, including *Urochloa* hybrid cv. Cayman and *U. brizantha* cv. Toledo alone and in association with the shrub legume *Leucaena diversifolia*, were evaluated. We measured plant biomass production, forage nitrogen uptake, nitrogen fixation of *L. diversifolia*, and nitrous oxide emissions from soil after the application of urine patches in the pastures. Pasture treatments associated with *L. diversifolia* produced up to 36 % more forage biomass and showed up to 50 % higher nitrogen concentration in leaf tissue than the Cayman and Toledo grasses growing alone. Furthermore, the proportion of nitrogen derived from the atmosphere in *L. diversifolia* was estimated to be around 50 %. Although absolute nitrous oxide emissions after the application of urine patches were higher in pastures associated with *L. diversifolia*, the increase in forage production per unit area led to up to 18 % lower intensity of emissions than in grass alone pastures. Our findings suggest that integrating *Urochloa* grasses with legumes such as *L. diversifolia* is a promising alternative to sustainably intensify animal production without increasing gaseous N losses.

Keywords: Forage quality, livestock, nitrogen losses, pasture productivity

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Do groundnut haulm quality influence farmers decision on variety adoption? An explorative study from an eastern Indian state

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Crop residue contributes major shares (61 %) of total dry matter intake in mixed crop-livestock systems, while dual-purpose crops play an important role-grain provides feed for human and crop residue used as feed for the livestock and will continue as available land is declining due to urbanisation and population growth. Groundnut is one of the important dual-purpose crops, where its haulm provides high-protein to ruminants especially in low-rainfall/dry land agro-economy system. Identifying the improved variety having both high pod yield and better haulm quality and disseminating will have high positive impact on the livestock productivity. Having importance of groundnut for both food and feed, ICRISAT and ILRI embarked on selecting superior varieties of groundnut in India having better pod yield and nutritive quality of their haulms since 2006. As a result, a new improved variety namely ICGV91114 was identified and released nationwide in 2007 including Odisha. This variety (local name 'devi') was successfully adopted by the government system and also widely adopted by farmers in Odisha.

In this context, the study aimed to provide both qualitative and quantitative insights into the adoption of 'devi' variety by the farmers through focus group discussion covering 439 villages from 9 districts. Two stage sampling methods were followed to identify the villages.

Farmers' choice of adopting groundnut variety depends on various factors like grain yield, availability of seed, availability on time, haulm quality, haulm yield and such others. We observed that adoption of particular groundnut variety is depending upon the grain yield followed by seed availability in particular time (especially during planting period) and haulm quality. Though, farmers prefer to grow 'devi' variety as it has high pod yield and better haulm quality, due to non-availability of seed, farmers plant other varieties that are available during the planting period (January-February). While disseminating the devi variety, stakeholders involved in the releasing process did not consider the haulm quality, only focused pod yield. Therefore, to improve the adoption of improved dual-purpose groundnut or any other crop, there needs to disseminate the information on benefits of dual-purpose crops among farmers, improve the seed value chain system and marketing.

Keywords: Adoption, dual-purpose crop, groundnut, haulm quality

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Alternative agricultural approaches for the South: All the same or clear distinctions?

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The objective of this study is to assess alternative agricultural approaches that have the potential to cope with the multiple crises smallholder farmers in the South are confronted with.

Agri-food systems have been identified to contribute to soil degradation, loss of biodiversity, and greenhouse gas emissions at least substantially. Meanwhile, the threat particularly to livelihoods in areas of the global south intensifies but the challenges go beyond environmental aspects. The mineral fertiliser crisis – high prices, accessibility, and lack of delivery in time –, while alternative approaches to fill the gap are lacking, is further increasing food insecurity. Equally, the role of socioeconomic and political disturbances becomes more and more apparent and necessitates addressing contemporary and future crises of agri-food systems.

Today, we are confronted with a plethora of approaches that aim at transforming agricultural systems towards a more sustainable relationship between humankind and the environment. Consequently, many of these introduce innovations in the composition of crops, technology, and applied practices but likewise address the social and ethical dimensions of agriculture. The manyfold approaches lead to a lack of clarity for all actors coping with agriculture.

Addressing this complexity, we selected six agricultural approaches for further analysis based on their agroecological potential, their transformative claims, the variety of their methods/practices, and their current distribution: Conservation tillage, evergreen agriculture, holistic management, regenerative agriculture, syntropic agriculture, and organic agriculture are all approaches that have shown promise in improving sustainability in agriculture. As they focus on different ways to tackle environmental and social issues and employ different practices, we argue that there is no one-fits-all solution to every/each future challenge and trade-offs are necessary.

We differentiated these systems according to their ecological, cultural, economical, and market potentials, and assessed their strengths and weaknesses against a set of ecological and socio-economic criteria, to provide a comprehensive overview and subsequently identify merging potential and possible synergies. Doing so, we refer to scientific literature defining and assessing these agricultural approaches.

We finally examined the applicability of those approaches to smallholder farms in (sub-)tropical surroundings and conclude with policy recommendations.

Keywords: Agri-food systems, conservation tillage, evergreen agriculture

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Life cycle inventory of soybean production systems in Minas Gerais and Paraná states, in Brazil

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Soybean (*Glycine max* L.) is among the major grains produced globally as it is an efficient source of proteins and lipids, mainly used as animal feed, food, oil and biofuel. Brazil is the current global leader in production, with soybean grown in all its biomes. Soybean system is facing multiple sustainability crisis as its intensive production is driving environmental crises such as deforestation, biodiversity loss, soil degradation, water scarcity and pollution, and thus climate change. Alternative systems such as organic or the claimed 'sustainable' production are emerging. There is, therefore, a need for a comprehensive understanding of environmental impacts of different soybean productions systems. While many Life Cycle Inventory (LCI) studies of soybean AFVCs have emphasised on intensive production systems, often with carbon footprint as the main impact category, there is still a research need to cover alternative production systems, with more relevant impact categories. The aim of this research is to provide a detailed LCI of soybean production systems in Paraná and Minas Gerais states in the Atlantic Forest biome. Data has been collected through surveys, interviews, and observations, and will be complemented with scientific literature data and the Ecoinvent 3.9 database. The inventory from cradle to farm gate has revealed four soybean production systems: conventional, organic, transgenic, and 'sustainable'. The direct planting, weed control, biofertilisers and bioinputs production on farms were found to be among the factors hindering sustainable and organic soybean intensification. Intercropped soybean with coffee seemed to use smaller machinery but more fuel as huge machines seem to save fuel but at a high ecological cost of soil compaction and biodiversity loss. The inventory analysis is ongoing and will be followed by impact assessment using brightway2. By the end of this and subsequent research objectives, we will have provided evidence on where environmental loads and savings take place in different production systems of soybean, consumed, and wasted. With the broad range of impacts quantified, this work will raise awareness and show environmental trade-offs on the level of soybean footprints in Brazil, for improvement of sustainability research and decisions in soybean food system.

Keywords: Agroecology, Brazil, footprint, soybean production systems, sustainability

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Perception of smallholder farmers on efficacy of ecological farming in Chiradzulu district, southern Malawi

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The majority of sub-Saharan countries, including Malawi, heavily rely on cereals such as maize as their staple food. However, climate change and poor farming practices have led to soil degradation, hindering smallholder farmers' ability to increase maize production. This problem is compounded by the escalating costs of inorganic fertilisers, which smallholders are forced to use. This practice also leads to high transaction costs within the value chain system, and increases food prices. Malawi, like many other sub-Saharan countries, is dependent on inorganic fertiliser imports from the global North. Any supply chain disruption, such as the Russian-Ukrainian war, creates a bottleneck that makes fertiliser scarce and expensive, exacerbating food insecurity in the region. To address this issue, there is an urgent need for a radical sustainable option for the farmers. Ecological farming has been proposed as a cost-effective and sustainable alternative to conventional farming that can improve soil health and reduce the dependence on increasingly expensive inorganic fertilisers. However, despite the potential benefits, smallholder farmers in many sub-Saharan African countries, including Malawi, have been slow to adopt ecological farming practices. To understand why this is the case, we examined the perception of smallholder farmers on the efficacy of ecological farming in Traditional Authority Mpama, Chiradzulu district in Malawi. Our study involved five focus group discussions and structured interviews with 120 smallholder households, and we analysed the data using qualitative approaches and the principle of weighted average index. Our findings indicate that at least 60 % of smallholders perceive ecological farming technologies as retrogressive and non-productive. Furthermore, we identified a significant association between socio-economic characteristics of respondents and community perceptions on efficacy of ecological farming. To overcome these barriers, we suggest implementing interventions that improve knowledge levels, attitudes, and behaviours of farmers through capacity building, sensitisation, and mobilisation. We believe that these interventions can effectively promote the adoption of ecological farming among smallholders, leading to increased food security and reduced dependence on expensive and lethal technologies.

Keywords: Capacity building, ecological farming, food security, land optimisation, perceptions, smallholder farmers

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Assessment of duplicates in perennial soybean (*Neonotonia wightii*) collection

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Perennial soybean (*Neonotonia wightii* Wight & Arn.) is a herbaceous perennial forage legume that is mainly used as pasture or hay for animals. It is a nitrogen fixing legume that can be grown as a cover or fallow crop and contributes to improved soil fertility and productivity of crops. It is a drought tolerant climate adaptive species with an annual productivity of up to 10 tons DM/ha. The ILRI Genebank holds over 400 accessions with little information on the collection. Generating information and understanding the collection through genotyping and phenotypic characterisation is necessary to promote greater use and to rationalize and efficiently curate the collection. Preliminary passport data assessment showed some potential duplicates in the collection. In line with this finding, we used a molecular approach to study the identified potential duplicates. Genomic DNA was extracted from young leaves collected from healthy growing seedlings in the greenhouse and sent for genotyping at SEQART, ILRI Nairobi, Kenya. The generated genotyping data were used to assess the genetic distance/similarity among the accessions. Visualisation of the hierarchical clustering, principal component analysis, genetic relationship matrix and genetic distance were used to assess the genetic relationship of the accessions. The result showed the accessions are differentiated from each other with varying level of genetic distance (0.123–0.370 Roger distance and 0.4687–0.9136 Hamming distance). Thus, the result from this study demonstrates that genotyping data can be used to complement the passport and phenotypic data to assess potential duplicates and for efficient curation of germplasm in the genebank.

Keywords: Duplicates, genebank, genetic distance, germplasm, perennial soybean

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Assessment of slow-growth treatments to develop an efficient *in vitro* medium-term conservation method for garlic (*Allium sativum* L.)

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The study aimed at assessing various osmotic agents and plant growth regulators at varying concentrations to determine their effect on growth reduction to develop an efficient slow-growth storage protocol for the medium-term conservation of garlic (*Allium sativum* L.). Osmotic agents, sorbitol (20–60 g l^{-1}), mannitol (20–60 g l^{-1}), and sucrose (30–150 g l^{-1}) and plant growth inhibitors chlorcholinchlorid (CCC) 200–600 mg l^{-1} and abscisic acid (ABA) at 1–5 mg l^{-1} were tested as media supplements in combination with 18±1°C cultivation temperature to determine their effect on growth reduction. Full-strength and ½ concentrated MS were used as basal culture media and control. Preliminary findings after a 5-month treatment time duration show that MS medium is more effective in reducing plant growth in combination with the tested media supplements, while ½ MS is not effective in further reducing plant growth, demonstrating a stimulating effect on growth even in combination with the tested media treatments. Overall, MS media +ABA treatments (1, 3 and 5 mg l^{-1}) proved to be the most efficient in inducing slow-growth, with plantlets reaching an average height of just 2.1 cm, 1.4 cm and 1.0 cm, respectively, almost 3 times lower growth compared to the control MS medium (4.7 cm) after the 5-month storage. However, the mannitol treatments proved ineffective and induced hyperhydration (HH) as a form of morphological abnormality. The other treatments also induced slow-growth but were less effective than the ABA treatments. Further research is being conducted to push the boundaries and assess the effect of the tested treatments in reducing the growth of garlic in time. This research will contribute to the development of an efficient medium-term *in vitro* conservation protocol for garlic, the second most important *Allium* species.

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Keywords: Osmotic agents, plant growth regulators

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Genotypic variation and associated loci for lateral root density and length in rice (*Oryza sativa* L.)

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Many abiotic stresses associated with climate change will be most acutely perceived by the plant at the root-soil interface where fluctuations in soil moisture affect water and nutrient uptake. As rainfall patterns change water supply is becoming less predictable and that has caused shifts in rice production systems away from transplanting into flooded fields towards direct sowing into drier soil. The rice root system consists of two lateral root types, indeterminate larger L-types capable of further branching, and determinate, short, unbranched S-types. L-types correspond to the typical lateral roots of cereals whereas S-types are unique to rice. Both types contribute to nutrient and water uptake and our objectives were to assess whether genotypic variation for density and length of these laterals could be exploited in rice improvement to enhance adaptations to nutrient and water-limited environments. A QTL mapping population developed from parents contrasting for lateral root traits was grown in a non-flooded low-P field, roots were sampled, scanned and density and length of lateral roots measured. One QTL each was detected for L-type density (LDC), S-type density on crown root (SDC), S-type density on L-type (SDL), S-type length on L-type (SLL), and crown root number (RNO). The major-effect QTL for LDC on chromosome 5 accounted for 46 % of the phenotypic variation and additional field experiments confirmed that lines with the donor parent allele at qLDC5 had 50 % higher LDC. Simulating effects of allelic differences of main QTL in a P uptake model indicated that qLDC5 was most effective in improving P uptake followed by qRNO9 for RNO and qSDL9 for S-type lateral density on L-type laterals. Pyramiding qLDC5 with qRNO9 and qSDL9 is possible given that trade-offs between traits were not detected. Phenotypic selection for the RNO trait during variety development would be feasible, however, the costs of doing so reliably for lateral root density traits is prohibitive and markers identified here therefore provide the first opportunity to incorporate such traits into a breeding program. Breeding lines combining above QTL are currently being tested without supplementary irrigation in farmers' fields in Madagascar.

Keywords: Crown root, L-type lateral roots, P uptake simulation

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Survey and collection of solanaceous indigenous plants in central Vietnam

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In Vietnam is a visible erosion of genetic resources and a decline in biodiversity, especially solanaceous plants are seriously threatened in Vietnam. Therefore, one aim was to conduct an inventory of the distribution of solanaceous species in farms and local households in central Vietnam in order to understand the level of cultivation. In this study were conducted investigations and surveys in central Vietnam, searching for regions and communities with high cultivation of non-indigenous and indigenous solanaceous plants. Furthermore, an aim was to collect wild solanaceous species in the nature having a value as food or as medicinal plants. In general the aim of the research was focused on the collection of various accessions of solanaceous species in different regions and creation of germplasm database based on morphological characterisation in order to restrict the loss of solanaceous genetic diversity. One of the studies focused on very economically important species, cultivars and landraces for example the genus - eggplants. Indigenous solanaceous genetic resources often lack information on agricultural characteristics, genotypes and phenotypes because they have not been evaluated in detail. The existing database for genetic resources of indigenous Solanaceae plants in Vietnam is underdeveloped because collection, classification and evaluation are not done systematically. This study tried to contribute knowledge in this regard. There are many taxonomic problems with the important indigenous species of the family Solanaceae in Vietnam, particularly as the Solanum genus is highly variable and contain a large number of hybrids. Therefore, identification based on morphological characters is quite difficult. Overall, under-utilised indigenous solanaceous species should be collected, evaluated and conserved. In addition, developing of strategies for germplasm conservation for indigenous genetic resources is necessary.

Keywords: Eggplant cultivars and landraces, genetic resources of solanaceous plants, germplasm conservation, wild solanaceous species

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Participatory bread wheat variety evaluation through seed producer cooperatives in Amhara region, Ethiopia

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Adoption rate of improved crop varieties in Ethiopia is very low. The absence of engaging farmers and their community agents such as cooperatives in the process of variety testing is one of the main factors for lower rates of variety adoption, which resulted in the lower crop productivity and contributes to weak food systems. Participatory bread wheat variety evaluation (PVE) was conducted by breeders, seed producer cooperative (SPC) and development practitioners with the objectives to identify farmers' selection criteria, to assess farmers' preferred varieties and to increase the SPC's variety portfolios. Role, responsibility and contribution of each actor were defined with prior to the experiment. Researchers were responsible for trial management (design, layout, data collection, analysis, reporting and seed provision), SPC was accountable for land allocation, practice all agronomic practices as per the research recommendations and cover local costs. Local practitioners were responsible in capacity building, field days organisation and follow-up. Eleven released varieties (Wane, Abora, Lemu, Tay, Danda'a, Kakaba, Alidoro, Denbel, Ogolcho, Liben, Buluk) were evaluated during 2020 in Amhara region, Ethiopia. Pair-Wise Ranking Matrix was used to identify farmers' selection criteria and Direct Matrix Ranking to prioritise those selected criteria. Randomised complete block design with two replications was used to evaluate the performance of the varieties both with and without lime applications. Seed yield was identified the first preferred trait by farmers followed by early maturity, disease tolerance, tillering capacity, spike length and biomass yield. Combined mean values showed that higher yield was recorded with the lime application than without. Lemu (6.4 t ha^{-1}), Alidor (6.3 t ha^{-1}), Denbel (6.3 t ha^{-1}), Aboro (6.1 t ha^{-1}) and Liben (6.1 t ha^{-1}) were found the highest yielding bread what varieties with lime application. The t-test results confirmed the significant variations between with lime application and without lime for the number of tillers per plant (0.005), spike length per plant (0.001), plant height (0.000), 1000 seed weight (0.003), and hectoliter weight (0.018), but non-significant variation for grain yield (0.121). The selected varieties should be included in the production plan of the cooperatives for large scale production to increase the variety portfolios and to address the demand of the farming community.

Keywords: Cooperatives, Ethiopia, food systems, participatory variety evaluation

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The lateral root architecture of the aus-panel

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Drought reduces the grain yield of rice with different intensities in various developmental stages, indicating a need to find well-performing root phenotypes for specific drought scenarios. The aus-panel is known for being stress-tolerant and has a different genetic background from the indica and japonica panel. This makes it a new genetic source for breeding programs under climate change aspects.
To understand and screen the lateral root formation and the variation within the aus-lines, field experiments were conducted during the dry season of 2022 at the International Rice Research Institute (IRRI). In two locations, 206 lines mainly from the aus-panel were sown. Besides measurements like yield and tiller number, crown root samples from the topsoil area were scanned and analyzed. Surface area and length of the main root and lateral root types, number of S-type lateral roots, and the average distance between two S-type lateral roots were measured from this dataset, to serve as an overview of the phenotypic variation within the aus-panel. We found that the lateral root surface area did not increase with the nodal root diameter, but the correlation between these traits was weak ($R^2 < 0.5$). In conclusion, root phenotype variation within the aus-panel can be determined by measuring multiple root traits with a focus on lateral roots and testing their correlation and variation. These root phenotypes will be tested in future experimental and modeling work, to test for beneficial root trait combinations and investigate the role of lateral roots under drought stress and rewatering conditions to contribute to stable food crop security.

Keywords: Aus-panel, drought, lateral roots, rice

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Performance of integrated climate smart push-pull system with pigeon pea as an intensification pathway

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African farming systems are increasingly being intensified to address need for food and challenge on diminishing arable land. Push-pull technology is promoted in western Kenya to sustainably intensify farms and for the management of stem borer, fall armyworm and *Striga* weed. Integration of push-pull systems with other sustainable intensification practices has potential to advance its acceptability and adaptability among smallholders. Push-pull is currently limited in diversity of utility mainly because the companion crops, *Desmodium* (push crop) and *Brachiaria* (pull crop) are not edible. Participatory research carried out among smallholder farmers in western Kenya revealed intercropping, agroforestry and crop-livestock integration as priorities for further intensification of push-pull farming systems. The aim of the study was to determine the effectiveness of push-pull system integrated with pigeon pea (*Cajanas cajan*) on productivity and soil fertility. Field experiments consisting of four treatments (climate smart push-pull (maize + *Desmodium* + *Brachiaria*), push-pull + pigeon pea, maize + pigeon pea, and maize monocrop) were established on fifteen farms in three counties of western Kenya. A section of the plot was demarcated and used for data collection on growth, grain and stover yield. Preliminary results show that growth and yield vary across counties, seasons and treatments. Overall productivity of the intensified system was best in Siaya, followed by Kisumu and Vihiga counties respectively. Push-pull + pigeon pea and maize + pigeon pea were superior in performance based on maize growth and stover yield for season one. Maize + pigeon pea and push-pull performed better in grain yield than push-pull+ pigeon pea and maize monocrop for both seasons. Reduction in yield per unit area resulting from intensification of push-pull with pigeon pea is leveraged by alternative products such as fodder, firewood and diversified diets. Intensification with pigeon pea resulted in better stover and grain yield in the long rain season further it provided additional products such as alternative diets in the dry season of 2022, firewood from twigs and stems, fodder from leaves and pods, soil organic matter from litter and overall system resilience. Diversification of push-pull can guarantee its successful upscaling in East Africa for synergy in sustainable food production and environmental conservation.

Keywords: Biomass, *Brachiaria*, intercropping, pigeon pea, push-pull system, sustainable intensification

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Effects of *Tithonia diversifolia* on the growth, secondary metabolites and anticandida activity of *Cymbopogon citratus*

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Tithonia diversifolia is a plant advantice with good content in basic minerals including nitrogen, phosphorus and potassium, and has been experienced as an organic fertiliser in some studies. *Cymbopogon citratus* is an aromatic and medicinal plant, well known for its medicinal values such as antifungal and antimalarial properties. This study aimed at evaluating the effect of *T. diversifolia* powder and compost on the growth parameters, total phenolic and flavonoid contents and anticandida activity of *C. citratus*. The plants were cultivated for 8 months in an experimental farm designed as a split plot into 4 blocks. Each block was treated either with *T. diversifolia* compost ($150\,g\,plant^{-1}$), powder ($40\,g\,plant^{-1}$) or the synthetic fertiliser (NPK 20–10-10; $10\,g\,plant^{-1}$) respectively, followed by sprays with same fertiliser treatment on each block every two weeks after transplantation. The control block received no amendment and was sprayed with water. Plant growth parameters (fresh and dry leaves weight, tillers and plant height) were evaluated at four and eight months after transplantation. The harvested fresh leaves were hydro-distillated for essential oil and the hot aqueous extract. Both extracts were used for the evaluation of the anti-candida activity while the latter was submitted to total flavonoids and phenolic analyses. At 4 and 8 months after transplantation, the synthetic fertiliser and *T. diversifolia* compost significantly increased plant growth parameters as compared to other treatments. The plants treated with *T. diversifolia* compost showed higher total phenolic ($61.13 \pm 5.19\ \mu g\ GAE\,mg^{-1}$), flavonoid ($41.17 \pm 10.195\ \mu g\ GAE\,mg^{-1}$), and essential oil content as compared to the plants from other fertilisers. The essential oil from *C. citratus* treated with *T. diversifolia* compost showed the best inhibitory activity on *C. albicans* NR-29451. In conclusion, this study showed that *T. diversifolia* compost was a promising organic fertiliser in optimising the growth, secondary metabolites and anticandida activity of *C. citratus*.

Keywords: Anticandida bioactivity, *Cymbopogon citratus*, plant growth parameters, secondary metabolites, *Tithonia diversifolia*

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Biochar and bioslurry production using water hyacinth from Lake Tana / Ethiopia – methodological issues and impact on crop yields

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Water hyacinth (*Eichhornia crassipes*) (WH) is an invasive species in Lake Tana, Ethiopia, which infestation increases over the last decade and became a serious issue for fishery and biodiversity of flora and fauna. Furthermore, the WH mats are hosting mosquitos as well as bilharziasis.

Several strategies are discussed to reduce WH infestation: (a) reduction of nutrient flow int the Lake via household and agricultural nutrient input that are the drivers of WH growth; and end of pipe solutions including (b) chemical reduction of the plant population, and (c) technical reduction via harvest strategies combined with the transformation of WH biomass towards products for agricultural purposes. This project focus is on strategy (c). The overall aim of this research is to analyse the whole chain of harvesting, drying, storing, transporting, and preparing the biomass for transforming towards biochar and bioslurry and related residues for composting and biogas production, up to the impact of these fertilisers on crops, using tef (*Eragrostis tef*) as a reference crop.

Findings inform about nutrient content of the diverse parts of WH, the processing characteristics, preparation of the material and logistics and methodological aspects. Furthermore, we inform about the impact on crop yield via different amounts of applications of biochar and bioslurry applications, their combination, additional mineral fertilisers, compared with a non-fertiliser control and farmer's practice.

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A first rough calculation clarifies the relation between WH productivity in the Lake in comparison to the need of nutrients for agricultural production in smallholder communities along the Lake shore, technical challenges logistics, labour, economy and acceptance by the local farmers.
Against the backdrop of the mineral fertiliser crisis - shortages, unavailability, delivery not in time, quality deficiencies, and high prices - alternative organic nutrient fertilisers are of great importance.

Keywords: Biochar, bioslurry, crop yield, fertiliser, Lake Tana, smallholder farmers, water hyacinth

Invasive alien plants and the future of agriculture: Reviewing control approaches in western Serengeti, Tanzania

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Despite its remarkable contribution to ecosystem sustainability and economic development, Serengeti and its surrounding communities are highly affected by invasive alien plants (IAPs). Although some IAPs may have beneficial applications for some communities, such as providing building materials or decoration, they are nonetheless known to be damaging. These plants have extended enormously into farmlands interfering with agricultural production in western Serengeti, the main economic activity in the region and considered the backbone of the country's economy. This study assesses the impacts of IAPs on agriculture and potential control methods in the Bunda and Serengeti Districts of western Serengeti, Tanzania. Data was collected through questionnaires, key informant interviews, and focus group discussions with randomly selected respondents. The study found that while the control of IAPs has been successful in protected areas, it remains a challenge in adjacent community lands. The results indicate that IAPs cause significant threats to local agriculture, soil quality, and biodiversity. Failure to manage IAPs will result in decreased agricultural production, hampering food security and livelihoods in the affected communities. The study recommends early detection and rapid response to new invasions and highlights the need for improved management approaches to address the problem. However, managing IAPs is an expensive initiative that requires significant investment. The study's findings are valuable to farmers, protected area authorities, policymakers, and other stakeholders interested in managing IAPs.

Keywords: Agriculture, biodiversity, control methods, ecosystem, invasive alien plants

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Contrasting accessions of tropical forage *Urochloa*: Pioneering tool for the prediction of carbon-soil sequestration

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Soil carbon deposition through biomass production as well as plant-soil interface exchange in tropical forage systems may represent huge contribution to ameliorate the increase of carbon dioxide concentration in the atmosphere and thus the climate change. Cattle farming in the tropics is predominantly dependent on pastures with tropical forages. Different accessions of tropical forages, such as *Urochloa humidicola* and its hybrids, display a variety of rooting strategies, root biomass production and suberin deposition, which is hypothesised to contribute to soil carbon deposition. Root morphological traits, such as secondary metabolite deposition in hypodermis and/or endodermis, may represent a versatile phenotyping tool to assess soil-carbon sequestration capacity of tropical forages. We used *Urochloa humidicola*, accession nr. 679, and *U. humidicola* hybrid Bh08 – nr. 1149 to assess root morphology. Root cross sections made from defined relative length revealed less secondary metabolite deposition in hypodermal layers and epidermis, which is coherent with decreased rooting depth, frequent branching, less soil compaction resistance, and thus may coincide with less soil-carbon deposition in 1149 hybrid compared to 679. Further, 1149 roots displayed lower parenchyma cell files number, lower main root thickness, poor aerenchyma development, increased lateral root thickness relative to the main root thickness when compared to 679. In conclusion, we have found two contrasting root morphology phenotypes that perform different rooting strategies. These contrasting genotypes are currently planted under field conditions in Colombia to test their impact upon soil carbon sequestration. Further, an extensive phenotyping will be performed with other numerous accessions, first from hydroponics and later on from natural soil conditions.

Keywords: Carbon sequestration, forage, phenotyping, root morphology

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Relay intercropping of durum wheat and lentil enhances mycorrhizal functionality, weed control and crop productivity

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Complementary and inter-specific plant-plant associations, like the case of cereal-legume intercrops, drive the recruitment of rhizosphere microbial communities such as the arbuscular mycorrhizal fungi (AMF) important in the provision of ecosystem services that stabilise crop yields and restore soil health. Attempts to assess the impact of intercropping on the functional presence of native AMF communities and their agronomic potential in rain-fed fields remain inconclusive, more so in intercropping systems involving winter-spring crops such as durum wheat and lentils. We carried out a 3-year (2019, 2020, and 2021) field experiment in Central Italy to assess the agronomic performance and mycorrhizal selection of relay intercropped winter durum wheat (*Triticum durum* Desf. cv. Minosse) and spring lentil (*Lens culinaris* Medik. cv. Elsa) under a low-input management system, comparing different crop stand types (monocrop vs intercrop) and intercrop densities (350 plants m^2–100 % wheat dose vs 116 plants m^2–33 % wheat dose). Relay intercropping enhanced lentil grain yield, durum wheat grain protein concentration and P uptake but marginally reduced durum wheat grain yield and lentil grain protein concentration. Both intercropping strategies were effective in controlling weeds and proved beneficial in stabilising the overall yield productivity (LER 164–648 %) compared to sole cropping. Intercropping enhanced soil mycorrhizal activity but differentially influenced mycorrhizal root colonisation compared to sole cropping. Root mycorrhizal analyses via Illumina Miseq sequencing generated a total of 234 amplicon sequence variants belonging to Glomeromycota, which were assigned to 31 virtual taxa using the MaarjAM reference database. Glomeraceae and Claroideoglomeraceae were the most abundant AMF taxa but had contrasting abundances in 2020 and 2021. The overall changes in AMF diversity and community structure were affected by the interaction between crop species and year, and not by intercropping. Claroideoglomus and Septoglomus showed a strong association with lentil roots while Rhizophagus and Paraglomus were associated with durum wheat roots in 2020, affirming a strong host genotype-AMF preference. PCA analysis showed that grain protein concentration was associated with mycorrhizal parameters such as community richness and AMF root colonisation. This study reveals the importance of relay intercropping winter-spring crops in stabilising crop productivity and maintaining soil functionality.

Keywords: AMF community structure, relay intercropping, weed control

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The influence of endophytic actinomycetes inoculation in rhizosphere soil on growth and yield quality of tomato

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The study aims to determine the influence of endophytic actinomycetes inoculation in rhizosphere soil on growth and yield quality of tomato. The experiment was conducted in a net greenhouse at the Agricultural Resource System Research Center, Faculty of Agriculture, Chiang Mai University, Thailand. The randomised completely block design (RCBD) was arranged for 4 treatments with 3 replications, which were (T1) Control (Growing material), (T2) Growing material inoculated with TGsR-03–04 (*Streptomyces violaceorectus*), (T3) Growing material inoculated with TGsL-02–05 (*Nocardiopsis alba*), and (T4) Growing material inoculated with TGsR-03–04 (*Streptomyces violaceorectus*) and TGsL-02–05 (*Nocardiopsis alba*) in tomato. Prior to the experiment, growing material properties analysis and microbial isolation were performed. Isolated actinomycetes of each treatment were inoculated into the root zone of tomato seedlings. Colonisation of actinomycetes into the root of tomato was analysed by Scanning Electron Microscopy (SEM). The height of tomato was measured at 14, 28, 56, and 112 days after transplanting (DAT) and final yield and yield quality of tomato was assessed at the maturity phase. The SEM result illustrated that the root of tomato seedling of all treatments were colonized by endophytic actinomycetes. It contributed to plant height at 14 DAT increased significantly as found in T2 (19.40 cm) compared to the control. Besides, all inoculated treatments enhanced yield and yield quality of tomato. The highest fruit width (42.05 mm), fruit length (53.73 mm), and fruit weight (48.98 g) were obtained by inoculation with the TGsR-03–04 (*Streptomyces violaceorectus*) (T2). There was no statistically difference in the number of fruits per plant and yield per plant when various inoculations of endophytic actinomycete were applied. Therefore, endophytic actinomycete especially TGsR-03–04 could be considerably used to improve the growth, yield and yield quality of tomato.

Keywords: *Lycopersicon esculentum*, *Nocardiopsis alba*, root colonisation, *Streptomyces violaceorectus*

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Azolla compost as an alternative source of nitrogen for organic vegetable cultivation

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The spread of organic farming in Asia has led to the need to find alternative sources of high quality organic fertiliser. *Azolla* is a genus of floating water ferns that is high in nitrogen and organic matter due to its rapid growth and symbiotic relationship with nitrogen-fixing bacteria (*Anabeana azollae*). It is grown as a green manure in rice fields in many Asian countries. However, little research has been done on the use of *Azolla* as an organic fertiliser for vegetable production. The objective of this study was to evaluate the effects of different levels of *Azolla* compost fertiliser on the growth and yield of Malabar spinach (*Basella alba*) - a popular vegetable crop in the tropics and subtropics - to improve the process of using *Azolla* as an organic fertiliser in vegetable production. The experiment included 6 treatments: Without application-as control (T1); 1 t ha^{-1} soybean meal (T2); 16 t ha^{-1} cow manure (T3); 12 t ha^{-1} *Azolla* fertiliser (T4); 16 t ha^{-1} *Azolla* fertiliser (T5); and 20 t ha^{-1} *Azolla* fertiliser (T6). Our results showed that *Azolla* fertiliser application significantly increased shoot length, number of leaves, leaf size, dry matter, leaf area index (LAI) and SPAD of Malabar spinach compared to control or cow manure. Application of *Azolla* fertiliser at rates of 12, 16, and 20 t^{-1} ha significantly increased the yield of Malabar spinach by 150, 192, and 205 %, respectively, compared to the control and by 37, 60, and 67 %, respectively, compared to the cow manure treatment. Our results suggest that *Azolla* fertiliser can be used as an alternative organic nitrogen source in organic vegetable production. However, genotype selection and rapid multiplication of *Azolla* are necessary to develop it as a nitrogen source that meets the requirements of fast-growing organic agriculture.

Keywords: *Azolla* fertiliser, *Basella alba*, manure, organic vegetable

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Title characterisation of the Mayan Milpa system: Maintenance of crop diversity

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The Milpa system is a traditional Mayan intercropping system used by small scale farmers in Mesoamerica, which plays a vital role in ensuring food sovereignty and maintaining crop diversity. Despite its importance, small scale farmers are among the poorest in the world and are subject to economic, political, and cultural forces that shape their livelihood strategies and threaten Mayan culture. This study aims to characterise the present Milpa system in El Tablón, Sololá, Guatemala, and examine the farmers' criteria for selecting and conserving seeds and crops within the system. Based on household surveys and participatory observation, the study found that El Tablón, Sololá, Guatemala, had many characteristics of traditional Milpa, including intercropping of local landraces of maize (*Zea mays* L.), beans (*Phaseolus* spp.) and squash (*Cucurbita spp.*). The seeds are saved for generations and are usually not shared among neighbours, giving rise to high landrace diversity among the families. Fertiliser management includes the use of compost and manure. However, there was a widespread use of chemical fertilisers in the milpa system. The findings suggest that the Milpa system in El Tablón is dynamic and that farmers seek to conserve traditional landrace diversity while also adopting modern practices. The study shows that the Milpa system has an important cultural and personal value for smallholder farmers, who select seeds and crops based on both agronomic traits, and personal preferences. This highlights the need for further research and to promote *in situ* conservation, to secure agroecology and food sovereignty in Guatemala, and support long-term sustainability of the Milpa system.

Keywords: Agroecology, traditional agriculture, crop diversity, Guatemala, *in situ* conservation, intercropping, landrace diversity, maize-bean-squash, milpa

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Impact of maize plant residue on soil temperature dynamics in a dryland environment in Kenya

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Soil temperatures are often high in dryland conditions. In cleared and tilled soils, increased temperatures contribute to accelerated rate of soil organic matter (SOM) decomposition, leading to increased CO_2 emissions and loss of soil fertility, and evaporation. Soil temperature behaviour depends on several dynamic parameters i.e. air temperature, precipitation, short wave radiation, soil moisture, and soil cover. Therefore, continuous measurements may be considered necessary to evaluate soil temperature dynamics under various treatments. Excluding growth of plants, the modification of soil thermal properties is reached through mulching, tillage practices and irrigation.
The recorded continuous soil and meteorological data were used to assess the impact of mulching on soil temperature in a dryland environment. Measurements were performed at the edge of a smallholder field in dry lowlands of Maktau, Kenya (3°25'33 S, 38°8'22, 1060 m asl). Soil temperature (Ts) and volumetric water content (θ) were measured continuously as vertical profiles (0–50 cm) during a two-year period (28/02/2016–26/02/2018). Meteorological parameters were recorded continuously on-site. The mulch was 1 cm thick maize stover corresponding to a mulching rate 5 t ha^{-1} (density 50 kg m^{-3}). The mulched period covered 28/02/2016–06/06/2016 (100 days). The mulch decomposed naturally. Initially, there was no vegetation on the soil surface and new vegetation growth was negligible during the experimental period.
Mulch reduced the diurnal fluctuation of measured Ts compared to bare soil. Daytime Ts peaks decreased below the mulch. The mulch also prevented nocturnal cooling of the soil. Ts decreasing effect was observed down to 30 cm. Reduced Ts fluctuation below mulch is suggested to be due to reduced shortwave radiation interception and increased heat capacity and conductance of soil due to conserved θ.
Plant residues find competing uses as forage and fuel among smallholder farmers in the study area, our results however, demonstrated that even a 1 cm thick maize stover layer clearly reduced the fluctuation of Ts down to 30 cm depth. Plant residue mulching can be recommended for dryland conditions similar to the studied site to reduce effects introduced by high Ts as well as conserve θ.

Keywords: Cooling effect, drought, mulch, smallholder

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In Iran's semi-arid regions, planting primed seeds is an efficient way to provide fodder under severe climatic conditions

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Due to the problems caused by the effects of climate change and excessive exploitation in the past, Iran's rangelands cannot provide enough animal fodder. Studies show that, in many regions of Iran, especially in arid and semi-arid regions, poor seed establishment is one of the common causes of low fodder plant yields. However, the need to use various techniques for improving and restoring rangeland species is now increasingly apparent due to the fact that a sizeable portion of ranchers in Iran's arid and semi-arid regions depend on rangeland feed.
Astragalus squarrosus Bunge is one of the native and adapted species in the sand fields of Iran, which is of great importance in terms of tolerance to severe climatic conditions and the value of fodder production for livestock, especially camels.
In order to investigate the effects of priming on seed germination and seedling growth, the experiment was conducted in split plots based on a randomised complete block design with five replications at Torud Research Farm in Semnan Province, Iran. This research was done on three ecotypes of *Astragalus squarrosus* and nine treatments. The distilled water was considered as the control treatment. So, seeds of different ecotypes, including Yazd, Kashan, and Semnan ecotypes of *A. squarrosus*, were primed separately under different treatments, including hydropriming, hormone priming (gibberellin hormone: 125 and 250 ppm, salicylic hormone: 100 and 200 mg L^{-1}, ascorbic hormone: 100 and 200 mM and osmopriming: potassium nitrate: 0.3 and 0.2 %). According to the findings of the current study, priming significantly affected *A. squarrosus* seed germination and yield. The Yazd ecotype under salicylic acid hormone 100 mg L^{-1} had the maximum performance in terms of yield and seed germination. In general, seed priming improves the yield and fodder production of *A. quarrosu*s. Therefore, further research under farmer conditions in Iran's semi-arid regions is necessary.

Keywords: Arid and semi-arid regions, *Astragalus squarrosus*

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Exploring the potential for improving crop water productivity to sustain future crop production in Egypt

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Egypt is facing the challenge of sustaining food production for its ever-growing population, a situation that is likely to be exacerbated by climate change as well as by future water-related developments upstream the Nile. Most recent research suggests that Egypt's water deficit, the gap between renewable water resources and actual water use, as well as virtual water embedded in food imports will increase to sustain future food supply. Thus, this research investigates the potential of increasing productivity of major crops in Egypt, namely rice, maize, wheat, and clover (berseem), and consequently estimates future water and land resources needed to sustain supply of these crops by 2050. The study developed an approach using open-access gridded datasets to estimate three productivity indicators for the selected crops: (1) yield (= production/harvested area), (2) crop water productivity (CWP = yield/actual evapotranspiration), and (3) transpiration efficiency (TE = transpiration/actual evapotranspiration). Productivity indicators were analyzed, and potential improvements were estimated and used to develop scenarios for future demand for water and land to sustain production of the selected crops by 2050.

Based on the key findings of the current research, Egypt is expected to face challenges in satisfying its future demand for the four crops by 2050 given the substantial water and land required resources to produce sufficient quantities, following the average recent values of productivity indicators. However, based on the spatial-temporal analysis of yield, CWP, and TE, there are opportunities to increase productivity for all selected crops. Thus, quantities of required water and land by 2050 can be reduced by following high production efficiency. In light of these findings, the study proposes a few development strategies that could potentially enable the country to sustain crop supply for its future population. Challenges and opportunities towards realising these strategies are discussed. The methodological approach proposed herein can act as an operational tool for evidence-based policy development in water and agriculture.

Keywords: Development strategies, food security, remote sensing, scenario building, sustainable intensification, water management, water productivity, water-food nexus

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Alternate wetting and severe drying: A sustainable irrigation strategy for rice production in Burkina Faso?

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In the context of water scarcity and increasing fertiliser prices, reducing water input, while maintaining yield and nutrient use efficiency are of critical importance for sustainable production of irrigated rice. Alternate wetting and moderate drying irrigation (AWD15) (i.e., re-irrigation when the water level reaches 15 cm below the soil surface) proved to be an efficient water-saving technology in semi-arid zones of sub-Saharan Africa (SSA) as it allows for the reduction of water input without yield penalty. Alternate wetting and severe drying (AWD30) (i.e., re-irrigation when the water level reaches 30 cm below the soil surface) could further reduce the water input in comparison with farmers' irrigation practices (FP). However, the acute drying phases during its implementation may cause NO_3^-N losses through nitrification and denitrification and reduce the bio-availability of some key nutrients. What are the main potentials and risks of this technology for smallholder rice farmers in semi-arid zones of SSA? To answer this question, from 2019 to 2020, we conducted 33 on-farm field trials in Kou Valley, Burkina Faso, over three seasons and assessed yield, water productivity, nutrients use efficiency, and uptake under two different water management practices: AWD30 and FP. Compared with FP, AWD30 reduced irrigation water input by 37 % with no significant effects on grain yields (mean of 4.8 Mg ha^{-1}), thus increasing water productivity by 45 %. FP and AWD30 were comparable in terms of agronomic N, P, and K use efficiency and apparent N recovery, N, K uptakes, and Mn, Fe, and Zn tissue concentration. However, N content in straw, P and K contents in grain, and total P uptake were 11–16 % lower in AWD30 than in FP plots. In conclusion, AWD30 appears to be an effective strategy to save irrigation water without significant yield and N, P, and K use efficiency reduction. Therefore, AWD30 could be promoted as a substitute for farmers' irrigation practices in semi-arid zones of SSA. However, the observed P and K content reduction in grain points towards possible negative hidden impacts on grain quality and yield under certain conditions. Further studies could unravel the suitable domains for the implementation of AWD30.

Keywords: Agronomic use efficiency, drought, *Oryza* spp., water saving technology, West Africa, yield

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Assessment of cover crops implementation in mango and longan orchards in Battambang province, Cambodia

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After years of mono-cropping and farmland expansion, Cambodia is facing soil degradation, deforestation, and biodiversity loss. Conservation Agriculture (CA) could improve the Cambodian situation. Among the CA approaches, permanent soil organic cover, like cover crops, decreases soil erosion, suppresses pests and diseases, and increases yields. This study investigates about cover crops' opportunities and constraints in mango and longan orchards and farmers' knowledge and attitude towards this practice. A combination of qualitative and quantitative data collection was conducted in 2022 in Battambang province. Thirty-nine semi-structured household interviews were led in nine villages of Rattanak Mondoul and Banan districts, with CA-, CT- (conventional) and CT (CA*)- (previous CA, now CT) farmers. Two Focus Group Discussions were led in Sangha and Borun villages of Rattanak Mondoul districts. Key informant interviews and literature review completed the data gathering. The results showed that 21 out of 39 farmers does not know the definition of CA. Eighteen out of 18 CA- and CT (CA*)-farmers are satisfied with the application of cover crops and recommend CT-farmers to grow them. Thirteen out of 21 CT-farmers are willing to start growing cover crops in their orchards. The main reasons for farmers to start growing cover crops are weed presence, low soil fertility and high soil erosion in the orchards. Farmers have been noticing an improvement on their orchard and an increase in fruit yield since they started growing cover crops. According to farmers' perspective, more trainings and technical support about CA and cover crops are needed, which might also attract more farmers to these approaches.

Keywords: Cambodia, conservation agriculture, cover crops, extension, farm management, farmers' adoption, fruit trees, soil health

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Trade-offs between nitrogen fixation and heavy metal(loid)s accumulation in a cassava-legume intercropping system on post-tin mining soils amended with local organic amendments

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Mining activities severely affect local ecosystems and threaten food security. In particular soils after tin mining on Bangka Island are highly nutrient deficient and characterised by low pH value. Remediation practices, however, are a viable way of reducing the negative impacts on post-mining lands.

In this study, we aimed to investigate the effect of locally available resources on heavy metal(loid)s (HMs) concentrations in crops and soil on a post-tin-mining site located on Bangka Island, Indonesia. Plots with five different soil amendments: (1) dolomite; (2) compost; (3) charcoal; combinations of (4) charcoal + compost; and (5) charcoal + sawdust; and control were established. An intercropping system with cassava and centrosema was employed, and HM concentrations in crops and soils were determined. In addition, the effects of different locally available soil amendments on the percentage of nitrogen derived from the atmosphere (%NDFA) and the amount of nitrogen fixation (N_2-fixation) in the cassava-legume intercropping system were investigated.

The highest amounts of N_2-fixation in centrosema were observed in combined treatment (charcoal + compost), which was influenced more by high shoot biomass production than %NDFA. Improved soil physicochemical properties had a positive impact on the shoot biomass of centrosema, resulting in a higher amount of N_2-fixation and N uptake values. Crop Pb, As, and Cd concentrations exceeded the international standard for maximum levels in food. The edible parts of cassava showed the highest Pb and As concentrations in the charcoal-only treatment. Furthermore, high Pb, As, and Cd concentrations in centrosema vegetative organs indicate a high risk for contamination

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of the human food supply chain, as these are used as cattle fodder.
Locally available organic soil amendments offer a potential solution for remediating post-tin mining soils by increasing N_2-fixation in centrosema when intercropped with cassava. However, due to the inherent high HM concentrations from their local origin, crop HMs can become accumulated in the edible parts of crops. In this study, the combined treatment of charcoal and compost showed the best compromise between improved nitrogen fixation and HMs concentration in a cassava-centrosema intercropping system on remediated post-tin mining soils.

Keywords: Bioaccumulation, crop, local resources, nutrient, remediation, soil

Effect of irrigation efficiency enhancement on crop productivity and irrigation water availability under climate change in Nepal

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Crop production is predicted to be affected by climate change in terms of drought. That is the reason Nepal is expanding its irrigation facilities as adaptive measure in terms of water availability. However, water-efficient irrigation methods need to be used in the irrigation expansion due to the increasing water scarcity in Nepal. Therefore, in this study we assess the influence of three different irrigation efficiencies on potential crop productivity of rice, maize and wheat and on irrigation water savings under three climate change scenarios. The scenarios are based on SSP1–2.6 (low emissions due to strong mitigation), SSP3–7.0 (high emissions), and SSP5– 8.5 (extreme emissions/unmitigated) and are run with three general circulation models (GCMS) GFDL-ESM4, IPSL-CM6A-LR and MPI-ESM1–2-HR. The data are bias adjusted as part of the Coupled Model Intercomparison Project phase 6 (CMIP6) and acquired from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP3b) database. District and province level comparison of yields are carried out for the current time (2015 to 2022), near future (2023 to 2050), mid-century (2050 to 2075), and end century (2075 to 2100). The management scenarios are: (1) current management with an average irrigation efficiency of 30 %, (2) stress-triggered irrigation with efficiency 70 %, (3) stress-triggered irrigation with efficiency 50 %, and (4) stress-triggered irrigation with efficiency 30 %. For scenarios 2, 3 and 4 stress triggered mineral phosphorous and maximum annual 300 kg of mineral nitrogen per hectare is applied. We identified that on national scale yields can be increased by 1 t ha^{-1} for Maize, 0.5 t ha^{-1} for Rice and 1.5 t ha^{-1} for Wheat with an increase of irrigation efficiency from 30 % to 70 %. The results also showed the substantial water savings (up to 200 mm) could be attained if surface irrigation efficiency increases from the current value of 30 % to 70 %. The comparison showed the importance of efficient irrigation as a reliable adaptive measure for future climate change conditions.

Keywords: Climate change adaptation, irrigation efficiency, irrigation water management

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Dose effect of organic matter on growth and biomass parameters of *Hibiscus sabdariffa* (L.) (Bissap) in the Fatick region

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In Senegal, agriculture is a key sector of the economy, contributing around 8 % of the country's GDP. In addition to being an important economic lever, it makes a strong contribution to the country's social development through job creation, food security, and the fight against poverty. Thus, 60 to 70 % of the working population depends directly or indirectly on agricultural activities *Hibiscus sabdariffa* (L.) plays an important socio-economic role in the Sahel; through its calyxes, leaves and seeds it constitutes an important source of food and brings considerable income to producers. However, its production encounters enormous difficulties, notably due to poor soils and a lack of water, leading to a drop in yields. To alleviate this problem, growers resort to excessive use of chemical fertilisers which, in addition to the ecological and environmental problems they cause, are unable to maintain soil fertility levels. Hence the importance of this study, which aims to promote the use of organic residues to restore soil fertility. The aim is to contribute to sustainable productivity of Hibiscus sabdariffa through the use of horse dung in farming systems. Different doses were used to determine and compare their effects on the growth and fresh biomass of Hibiscus sabdariffa plants. The experimental set-up was a one-factor Fisher block with three treatments: 100 % dose, 50 % dose versus a control. Each fertiliser was applied to 2 kg, 1 kg and 0 kg of soil, respectively. Growth parameters were measured at regular dates and fresh biomass at the end of the trial. The results of this study were non-significant between the different doses. However, growth and biomass of *Hibiscus sabdariffa* were very satisfactory with DF100% followed by DF50% compared with the control (DF0%).

Keywords: Biomass, growth, *Hibiscus sabdariffa*, horse dung, organic fertiliser

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Reusing pineapple residue to promote nutrient cycling and reduce GHG emissions in small-scale pineapple cultivation

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The Philippines is one of the largest producers of pineapples in the world, with an annual production of over 2.8 million metric tons. However, pineapple production can also generate large amounts of pineapple residues (PR) that are usually not further utilised. They are often left to rot or burned mainly because of the high cost and labour needed for further utilisation, especially in small-scale cultivation. This practice creates challenges that are common globally, which include reducing the climate impact of cultivation while maintaining soil fertility and high resource efficiency. To address this, we hypothesise that reusing PR through soil incorporation in small-scale pineapple cultivation can promote nutrient cycling (C/N/P/K) and soil fertility while decreasing GHG emissions, particularly by increasing soil C sequestration. Additionally, we hypothesise that PR reuse can help reduce the use of mineral fertiliser, while still maintaining soil fertility and decreasing CO_2 emissions. To date, longer-term field studies regarding the effects of reusing PR in small-scale pineapple cultivation are still scarce. Using combined field and laboratory experiments, we aim to compare different PR reuse treatments against the common practice of using only mineral fertiliser and their effects on GHG (CO_2 and N_2O) emissions and nutrient cycling (C/N/P/K). Here, we present the results of our one-year field trial experiment on the effects of reusing PR on CO_2 emissions and biomass C/N/P/K performed in Calauan, Laguna, Philippines. We used the developed low-cost CO_2 and ET flux measurement device for manual closed chamber CO_2 exchange measurements of pineapple plants grown under various PR treatments. Additionally, soil and biomass sampling were done every three months to determine C/N/P/K change during the measurement period. This was also supplemented by non-destructive monitoring of biomass development using developed low-cost NDVI sensor. Lastly, the laboratory experiment was performed using developed low-cost incubation system to determine CO_2 and N_2O emissions of soil and PR treatments. Overall, we aim to provide evidence of the potential benefits of reusing PR and contribute to the utilisation of PR as a valuable resource that can help reduce waste and GHG emissions while enhancing nutrient efficiency for more sustainable small-scale cultivation practices.

Keywords: C sequestration, field trial, resource efficiency, soil fertility

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Integration of CERES-maize modelling and remote sensing for crop condition and yield assessment in three agroecological zones in Kenya

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Crop modelling and remote sensing (RS) integration are crucial for understanding crop conditions (CC) and agricultural production. In the present study, the DSSAT-CERES-Maize model was integrated with Sentinel^{-2} and moderate resolution imaging spectroradiometer (MODIS) RS data to analyse maize CC conditions and simulated yield in three agroecological zones (AEZ) in two counties of Kenya (Trans Nzoia and Uasin Gishu), with about 5425 km^2. AEZ I, II, and III correspond to humid, subhumid, and semihumid regions with high, moderate, and low moisture indexes, respectively. Sentinel^{-2} data was used to derive crop type extent maps, whereas MODIS data were used to map crop conditions via the enhanced vegetation index (EVI), normalised difference vegetation index (NDVI), and evaporative stress index (ESI).
The study showed that the RS CC exhibited high positive correlations with the simulated maize yield, especially at the peak season phenological stage. In particular, the ESI index demonstrated strong agreement with yield (r=0.94). Also, NDVI and EVI showed satisfactory performance, with correlations of r=0.89 and r=0.85, respectively. The response of the crop conditions at the AEZ level showed that AEZ I depict a strong relationship with the CC indicators compared to AEZ II and III. The analysis of the growing season influence showed that crop conditions and yield are strongly related between May and August (the vegetative-reproductive period in the study area). The study concludes that crop modelling approaches are important in exemplifying the relationships between crop conditions and maize production, especially in data-scarce landscapes. Integrating the assessment tools is important in monitoring agricultural landscapes, optimising agronomic management, and prior management of crop stressors to minimise/prevent yield losses.

Keywords: Ceres-maize, crop condition, DSSAT, remote sensing

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Model-based climate change adaptational potential and productivity of some cowpea genotypes and its sensitivity to bias adjustment

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Grain legumes are essential for the protein supply to an ever-growing population in Africa. However, little is known about the adaptive capacity of major grain legumes under future climatic change for the evaluation of climate change impact and adaptation. This study assessed the adaptation potential of some cowpea genotypes to future climate change in the moist (Kumasi-Ghana) and dry savannah (Ouagadougou-Burkina Faso) biomes of W-Africa based on a validated process-based cowpea crop model using the output of four GCMs (Global Circulation Models) for two Shared Socio-economic Pathways (SSPs i.e., ssp126 and 585). In addition, it assesses the sensitivity of the cowpea model to bias-corrections of the GCM outputs. In the comparison of future socio-economic pathways with historic time series, the use of bias-corrected climate model output slightly increased the rate of the phenological development of the genotypes in the future period except in Ouagadougou, in the ssp585 scenario. Without bias correction, this increase in the rate of phenological development in the future scenarios was less pronounced. With bias correction, the total aboveground biomass and yield of all genotypes were reduced in both shared socio-economic pathways. The change in the average water stress and phosphorous stress were genotype specific. Despite a general yield decline in both SSPs, the genotypes Asontem and GH6060 exhibited the best adaptational potential to future climate change in the moist and dry savannah biomes by the higher accumulation of total aboveground biomass, and higher yield, tolerance to high temperature as well as high water use and photosynthetic efficiency due to higher atmospheric CO_2 concentrations, despite faster phenological development

Keywords: Bias-correction, climate change, cowpea productivity, crop model, environmental stress

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Impact study of biochar and biomass amendment of *Gliricidia sepium* and shading on the productivity of agroforestry systems

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In recent decades, soils in West Africa have begun to gradually lose their fertility due to their misuse. This has led to a decline in agricultural productivity and yields. In order to achieve successful production, it is necessary to apply fertilisers (mineral or organic) rationally and use good production techniques. However, the economic constraints of households limit their adoption. This study was conducted in Cobly, a commune in the Atacora region of northwestern Benin. The average annual rainfall is 1,000 mm per year and is irregularly distributed during the rainy season. The objective of this study is to evaluate the effect of amendments and shading on millet productivity in agroforestry systems. A split-plot experimental design consisting of three blocks each associated with a species (*Parkia biglobosa*, *Vitellaria paradoxa, Lanea microcarpa*) with three replications. Four amendments (Control, gliricidia, biochar, gliricidia + biochar) are applied in concentric zones under and outside the tree. Analyses were performed with R 4.1.1 software. A linear mixed-effects model was used to identify determinants of growth and determinants of yield and a generalised mixed-effects model was used to assess variation in leaf number. Species, position, and treatment determined millet dry weight and millet grain weight. Biochar+Gliricidia treatment increased millet dry weight ($p < 0.001$). Only *Parkia biglobosa* has a shadow that negatively influences grain and dry weight of millet. The treatments increased millet height when the millet was out of the canopy ($p = 0.033$). Under the canopy, only Biochar+Gliricidia increased height.

Keywords: Amendment, Benin, shading, sorghum bicolor, traditional agroforestry systems

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Root-soil-contact influences on maize root growth, nutrient uptake, and nitrogen-cycling microorganisms in the rhizosphere

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The rhizosphere is enriched with microorganisms, including plant growth promoters and drivers of biogeochemical cycles. Root-soil interactions cover a wide range of biological and physicochemical processes with direct effects on plant growth. Therefore, approaching the rhizosphere in response to root-soil contact is an important strategy to improve crop growth and productivity to fulfil global food demand. Root hairs are an important root trait that ensures root-soil contact. Knowledge of the influence of root-soil contact on plant performance and microbial rhizosphere processes is limited. In this study, we explored the heterogeneity of the maize root system in response to reduced root-soil contact. Contact was modulated by artificial soil pores or the absence of root hairs. We determined the influences on root growth, nutrient uptake, and microbial abundance with a special focus on N-cycling microorganisms. Growth of the *Zea mays root hairless 3* (*rth3*) mutant was comparatively studied with its corresponding wild-type for 21 days in a climate chamber. Root-pore utilisation was characterised by endoscopic analysis. Shoot nutrient contents were quantified by CHNS analyzer and nitric acid digestion followed by flame AAS and ICP-OES analysis. A qPCR analysis targeting the *16S rRNA, amoA*, and *nirK* genes was carried out to quantify the abundance of bacteria, archaea, nitrifiers, and denitrifiers respectively. Root-growth behaviour inside the pores varied depending on the genotype and root type, though both genotypes tended to grow into the pores. Wild-type plants showed significantly higher shoot and root growth than the mutant. Artificial pores did not significantly affect nutrient uptake, suggesting compensation for missing root-soil contact by reducing biomass, while maintaining biomass nutrient levels. The wild-type harbored a higher abundance of bacteria and archaea in the rhizosphere than the root-hairless mutant. Likewise, the abundance of nitrifiers was significantly affected by root-soil contact, resulting in the highest abundance under complete root-soil contact. Both archaea and denitrifiers preferred the pore walls over the bulk soil, suggesting an anaerobic and nitrate-rich environment on the pore walls. Taken together, proper regulation of root-soil contact by reducing soil artificial porosity and selecting genotypes with higher root surface area is worth enhancing plant growth performance.

Keywords: Denitrifiers, microorganisms, nitrifiers, rhizosphere

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Effect of long-term management on yield of dicotyledon plants in cotton systems

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Organic agriculture is a promising solution to sustainably improve crop yields. For several crops, yield from organic farming have been recorded to be lower than yield from conventional farming. However, such data is context dependent and there is very little information on performance of organic systems in the tropics. Particularly, solid data on the benefits and drawbacks of organic agriculture in the tropics is still missing.
In 2007, we set up a long-term farming system comparison trials (LTE) for cotton systems in Madhya Pradesh India. Cotton is the main cash crop in our region and is grown in a two-year crop rotation. The other crops grown with cotton in our region are chickpea, wheat and soybean. In our field trials we are comparing the following treatments: (i) organic, (ii) bio dynamic, (iii) conventional, and (iv) BT conventional (genetically modified) cotton. We have been taking data on multiple parameters such as crop yields, soil nutrients, soil microbial properties and system profitability
Our data indicates that with good management organic systems can become more sustainable than conventional systems both economically and ecologically. Multiple indicators in our trials show this; the performance of crops has improved over the years, reducing the profitability gap between organic and conventional farming systems. In addition, positive impacts on soil fertility indicators (e.g., soil organic carbon) are detectable after 10–12 years in our organic LTE systems. We have also recorded our organic systems to harbour higher biodiversity. Despite our positive results, adaption of best management practices by the farmers remains one of the biggest challenges.
We need more studies on long-term cumulative effect of system approaches on fertility, health and the productive capacity of agricultural lands in conventional and organic farming systems. We need to understand what extent system approaches can enhance the resilience of cotton systems.

Keywords: Chickpea, cotton, crop rotation, dicotyledon, long term system, organic, soybean, treatment, wheat

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Functional biodiversity in organic and conventional cotton farming systems

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Farmland Biodiversity performs a variety of ecosystem services which are directly linked to food production and sustainable agriculture. The crucial role of ecosystem services has been understudied, especially in the tropics. Cotton is one of the most polluting crops in the world, as it requires high inputs of both pesticides and fertilisers. Globally, India is the second-highest producer of cotton, yet it is also the country with one of the lowest yields per hectare. In 2002, India introduced Bt cotton, it holds genes from *Bacillus thuringiensis* that make the plant resistant to the main cotton pest, the American bollworm. Following this introduction, an outbreak of sucking pests such as jassids and aphids has been observed in these systems. On one side, pesticides which were used to fight the bollworms decreased, but on the other side, the use of sprayed pesticides increased. Studies have shown that sprayed pesticides affect pests as well as non-targeting arthropods. In India, the majority of entomological research on cotton systems has been focused on the pest community and the resistance they have built up over time. There is a strong need to be able to compare the impact of these farming systems on functional biodiversity. My study has been exploring biodiversity indicators present in the soil, above ground and on the cotton canopy. The study has been done on a long-term cotton trial in Madhya Pradesh, comparing four different systems: Bt-conventional, conventional, organic and Biodynamic as well as on farmer's fields, comparing Bt-conventional and organic systems. The results have shown a higher diversity in the organic systems above and below ground. The results from the long-term trial have shown no significant difference between the Bt-conventional and non-Bt-conventional. During this presentation, I will outline the long-term effects of pesticides (as well as fertilisers) on the functional biodiversity in the above-mentioned cotton systems.

Keywords: Aboveground, belowground, biodynamic, Bt-conventional, cotton, functional biodiversity, organic

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Effect of conventional and organic practices on cotton quality parameters compared across 15 years

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Cotton is the most widely used fibre crop and quality parameters such as fibre length are crucial for successful processing. These quality parameters can be influenced by a variety of factors, such as nutrient supply to the plant and varieties used. Establishing a correlation between these influential factors and the quality parameters of cotton can help improve the production process and enable farmers to earn more income from their cotton production.
This study aimed to assess product quality data from a long-term farming systems comparison trial under semi-arid conditions in central India in regard to different management regimes. The trial has been running since 2007, comparing biodynamic, organic, and conventional with GM and without GM cotton management. All treatments include a two-year crop rotation which is first-year cotton-wheat/chickpea and second-year soybean-wheat. To assess fibre quality, we took sampled plants for ginning and subsequent lab testing for quality parameters like fibre staple length, fibre fineness, maturity index, micronaire etc.
Results show that no significant difference in quality parameters like fibre length, fibre fineness, short fibre index, maturity index in both the systems even less percentage of nitrogen was provided in an organic system.
The results considering which factors are the most important and which are of lesser importance provide some insight into changes in management effect on lint yield and fibre quality and provide some basis for future investment in research. This bears relevance to stakeholders in the cotton industry including both Indian and international cotton merchants, ginners, spinners, textile mills and commodity exchange.

Keywords: Biodynamic, conventional, cotton, crop rotation, organic, quality parameter, system

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Opportunities of mine reclamation areas for food crops plantation: Case study of coffee plants in former limestone mining

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Reclamation activities must be carried out after mining operations are completed. Mine reclamation areas, such as limestone mines, can be used as food crops plantation e.g. coffee. However, limestone dust affect the soil physical, chemical and biological properties, which will affect the coffee growth. Therefore, to increase the coffee growth, arbuscular mycorrhiza fungi (AMF) was introduced. The purpose of this study was to determine the effect of limestone dust covering former mines and different doses of AMF on coffee growth. The study was conducted using a RCBD method. The study area was divided into several blocks consisting of soil without lime dust, 0–2.5 cm and 0–5 cm dust cover. The blocks were treated with 10 g, 15 g and 20 g AMF with 5 replications each. Inorganic NPK fertiliser was given every month (till 5 month) to all treatments with successive 10 g/seedling, 20 g/seedling, 30 g/seedling, 40 g/seedling and 50 g/seedling for each month. Parameters observed were plant height, plant diameter, and number of leaves. The research results show that limestone dust affects soil conditions such as silt, clay, pH, organic C, bulk density, and C/N ratio. In addition, limestone dust affected plant height and number of leaves of coffee seedlings compared to those grown in areas without dust. The influence of the amount of AMF was significant ($p < 0.05$) and tended to increase the height and diameter parameters of the coffee seedlings. The mean height of coffee seedlings in the 10 g treatment was 23.09 cm, while 15 g = 26.73 cm and 20 g = 25.59 cm. While the mean diameter for the 10 g = 3.78 mm, 15 g = 3.94 mm, and 20 g = 4.53 mm, however, the difference in the doses of AMF was proven to significantly ($p < 0.05$) decrease the number of leaves, namely 10 g = 10 leaves, 15 g = 9.5 leaves, and 20 g = 8 leaves. This study shows that coffee plants can be planted in mine reclamation areas, but further research is needed regarding the quantity and quality of coffee beans produced.

Keywords: Coffee, limestone dust, mine reclamation, mycorrhizal biofertiliser, soil

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Optimisation of micropropagation protocol for mass multiplication of hybrid coffee (*Coffea arabica* L.) cultivars of Ethiopia

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Hybrid technologies were expected to revolutionise the Ethiopian coffee sector through the exploitation of heterosis conserved in the F1 hybrids. However, due to a lack of efficient propagation methods, these high-yielding cultivars were not disseminated to growers. Nevertheless, large quantities of planting materials of elite varieties can be multiplied by tissue culture methods once successful optimisation of conditions is completed *in vitro*. We followed an indirect somatic embryogenesis approach and optimised an efficient and reproducible protocol to propagate F1 hybrid varieties. We also applied a simple and cost-effective approach to sterilizing the leaf and obtained an 80–90 % clean explant that produces a callus. Using various combinations of PGRs, mainly auxin and cytokinin, in addition to MS medium, vitamins, amino acids, carbon sources, and organic supplements, on average 401 somatic embryos per explant (i.e., from a 1 cm^2 leaf disc) were obtained. The result achieved after several years of efforts may be a breakthrough for the coffee sector if existing capacity improves on an industrial scale and smallholder producers have access to high-quality TC-raised planting materials.

Keywords: Coffee, F1 Hybrids, micropropagation, somatic embryogenesis

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Pest, diseases and control options

Oral Presentations

Posters

Online posters

Transformation and intensification of food crop production in Africa in light of increasing threats from pests and diseases

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Pests and diseases present a major constraint to the production of food in Africa, threatening horticultural and agricultural crops alike and causing severe losses of harvest and income. To effectively respond to the increasing demand for food requires a transformation of the food production systems encompassing all components of the systems.

Plant health, starts with healthy and productive propagules. Because in Africa, most of planting materials are traded (exchanged) through informal systems, diseases are spread through human activities. The cassava virus diseases, Fusarium oxysporum TR4, and banana bunchy top virus in banana provide ample evidence for this uncontrolled threat. Seed health, even of commercial seeds, is not given the highest priority and outbreaks of virus diseases in soybean, groundnut and maize can be traced to seed-borne pathogens or, the use of contaminated seed (MLN in maize, ToBRFV in tomato). Pest populations driven by changing weather patterns cause direct damage (Tuta absoluta) or, indirectly, from the spread of virus diseases (Bemisia tabaci) that can destroy cultivation of crops like tomato, cassava or cotton. Healthy seeds and planting materials are the prerequisite for a productive crop and resistant varieties, the main element of disease management in field production systems. However, for many crops resistant, cultivars are not available and crop management in open fields is merely a sequence of chemical control interventions. To mitigate the impact of pests (and the diseases they spread) to horticultural crops, a transition from field production to protective cultivation in screenhouses, as already seen in few African countries, is likely the only option to guarantee a comprehensive crop management following the guiding principles of "good horticulture practices". Under protective cultivation, a framework of measures that include bio-control agents and the sensitive application of pesticides can be applied that, in field production, are not feasible. Challenges and opportunities for African farmers will be highlighted.

Keywords: Crop management, emerging disease threats, plant health

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Distribution, incidence and severity of *Fusarium wilt* on cotton in Benin

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Cotton cultivation contributes 46 % of Benin foreign exchange earnings. It is cultivated by 325,000 farmers and plays a major role in sustaining food security in the country because it serves as a means through which fertilisers are provided to other food crops such as maize, sorghum and rice. However, very little attention has often been paid to diseases and other pests that constitute a limiting factor in cotton production; especially diseases such as fusariosis caused by *Fusarium oxysporu*m f.sp. *vasinfectum* which is one of the most threating factors in large cotton production area. A field survey was conducted in 2022 in 50 sites of 15 districts of all cotton production areas in Benin to access *Fusarium* infestation levels. At least two sites were surveyed per district and on each site, 20 plants were inspected and evaluated randomly along the two diagonals of a cotton field, respectively for the incidence and the severity of the disease. The results showed that *Fusarium wilt* was present in 11 out of 50 sites. The highest means for incidence (31,25 %) and severity (13,25 %) were observed in the agroecological zone four with the maximum incidence in the district of Dassa (48,33 %). The agroecological zone two recorded the lowest incidence (0,27 %) and severity (0,16 %). Across the different cotton varieties in use, the variety OKP 768 was the most susceptible showing the highest incidence (17,03 %) and severity (9,77 %). Finally, the disease is present in Benin with various rate of incidence and severity which are high in the centre part of the country. There is an urgent need of deep understanding of the phenomena as it will contributes to a proper management of the disease that can quickly spread.

Keywords: Benin, cotton, *Fusarium oxysporum*, incidence, severity

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Mobilizing natural enemies for sustainable plant pests and diseases management

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Smallholder farmers contribute approx. 70 % of food supply in Africa. They produce for their subsistence use and sell the surplus in the local market. These farmers make a substantial contribution to sustainable food security in the global south. Their capacity to upscale production is however constrained by shrinking land sizes, high cost of agricultural inputs, impact of climate change as well as damage by pest and disease. Majority of smallholder farmers rely on cultural techniques to keep pests and diseases below economic threshold level. However, persistent use of agricultural chemicals predispose them to risks associated with mishandling and misuse of pesticides. Besides, consumers are exposed to adverse effects of pesticides due to chemical residue in food. To boost food production, there is need for ecologically sustainable pest control methods to minimise agri-pollution, boost productivity and promote biodiversity in Africa. Such methods include use of natural enemies (biocontrol agents) for pests and diseases management. We carried out a survey for potential fungal microbes that parasitize and destroy plant nematode eggs for use as biocontrol agent against potato cyst nematodes (PCN) *Globodera rostochiensis* and *G. pallida* in Kenya. Soil samples were collected from smallholder farms in six leading potato-producing counties of Kenya. The samples were processed in the laboratory and PCN cysts extracted using floatation techniques in Fenwick can. Extracted cysts and eggs were visually examined for fungal infestation. Those showing symptoms of fungal infestation were selected, culture on PDA media and incubated at room temperature, fungal growth were monitored for several days. Fungal colonies were sub-cultured to generate pure culture for further analysis. Ninety-five percent of the soil samples tested positive for PCN infestation. However, the prevalence of PCN in the six counties differed significantly ($p < 0.05$). Fifteen fungal isolates were found associating with PCN cysts and eggs. Characterisation of these fungal isolates is under way. The efficacy of these isolates is being tested *in vitro* and *in vivo* before being processed for use as biocontrol agent again PCN. If successful, the natural enemy will significantly contribute in reduction on use of synthetic chemicals in nematode management besides boosting potato production.

Keywords: Biocontrol, *Globodera* spp., nematophagous fungi

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Screening cassava for resistance against cassava mosaic and cassava brown streak viruses using a precise and rapid high throughput workflow

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Growing cassava in Africa requires resistance against the viruses causing cassava mosaic disease (CMD) and the viruses causing cassava brown streak disease (CBSD). Breeding cassava for resistance against viruses requires the sources of resistance, readily flowering genotypes to produce viable crosses, seeds, and most importantly, a straightforward screening process. Screening for resistance against mosaic viruses can be achieved by planting seedlings into virus hotspots because infections and disease spread with viruliferous whiteflies are guaranteed. Symptoms become readily visible, and scoring for disease incidence and severity allows the selection of resistant candidates already during the first planting season. In contrast, screening for resistance against cassava brown streak viruses is cumbersome because of the unpredictable transmission by whiteflies and the slow plant infection processes that are often not associated with distinct leaf symptoms. Thus, only the assessment of root necrosis which is done at the end of the growing cycle can serve as an indicator for plant resistance/tolerance. The selection of promising candidates thus is associated with high uncertainties from the erratic virus infections. We have developed a high throughput virus screening workflow for cassava resistance screening by which cassava seedlings pass through an intensive and precise virus infection routine after which resistance against mosaic and brown streak viruses can be assessed with high accuracy and, in less than nine months - from seedling infection to a final verdict. Components of the tactics are; effective virus infections, reduced biological repeats, and increased accuracy; susceptible sensitive lines are eliminated early to conduct detailed virus studies with pre-selected lines only. The developed protocol shifts resistance evaluation from the field to the nursery, replacing the erroneous and lengthy infection and screening process with a method of precision and speed.

Keywords: CBSD, CMD, disease tolerance, dual virus resistance, plant immunity, precise virus screening, resistant cassava

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Uncovering the genetic diversity of *Hemileia vastatrix* in three coffee-producing areas in Guatemala and its implications for resistance of coffee varieties

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Coffee rust, caused by the fungus *Hemileia vastatrix*, is the leading disease that attacks the crop worldwide. One of the strategies for controlling the disease is the genetic factor, developed through breeding programmes that result in coffee genotypes resistant to the pathogen. However, to make the best use of this factor, it is essential to know the molecular factor of the pathogen. Despite the importance of coffee cultivation for Guatemala, there is no study of the pathogen's population structure, genetic diversity, and haplotypic diversity. This study evaluated the genetic diversity and population structure of *H. vastatrix* fungal populations in three coffee-producing departments in Guatemala using 17 microsatellite polymorphic markers and ITS. Between 2 and 11 alleles per locus were observed, with a mean of 5.22. The Shannon diversity index, nucleotide, and haplotypic diversity showed values of 0.86, 0.0051, and 0.985, respectively. High within-population variation was observed (92 %). In addition, high levels of gene flow between populations were found, suggesting low genetic differentiation (Fst = 0.024) between populations. The haplotype network showed that *H. vastatrix* isolates behave as a large population without defined differentiation, in which ancient haplotypes were detected from which new variants of the fungus emerged. The Tajima test showed that the populations of *H. vastatrix* are undergoing an expansion process. In general, *H. vastatrix* populations in Guatemala are highly variable, and genetic variation is widely distributed in all the departments studied. It was determined that the haplotypic diversity of *H. vastatrix* may influence the resistance of coffee cultivars. The severity tests of *H. vastatrix* exhibited a statistically significant difference ($p < 0.001$) in the area under the disease progress curve (AUDPC) among the eight varieties evaluated. Still, the interaction between the pathogen and the plant is complex, and other environmental factors may also influence resistance.

Keywords: Coffee leaf rust, genetic diversity, haplotype network, ITS, microsatellites

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Effect of sowing date of faba bean (*Vicia faba* L) cultivars on *Orobanche crenata* seed bank and faba bean production

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The broomrape, *Orobanche crenata* Forsk (Orobanchaceae) is an annual parasitic weed. It is a serious parasitic weed causing considerable losses in many major crops including faba bean (*Vicia faba* L.). In Egypt, losses due to *O. crenata* parasitism may reach 40 to 100 %. Several methods have been used for controlling *O. crenata* but without success. Some of these methods are unfeasible and costly. Little is known about the effect of different control strategies on *O. crenata*. Sowing date seems to be one of the potential solutions for controlling *O. crenata*. In this work we studied the effect of sowing dates on both the degree of infection by *O. crenata* and the pod yield of faba bean using resistant (Giza 843) and susceptible (Nubaria 1) faba bean cultivars in naturally *Orobanche* infested soil. The results demonstrated that, late sowing (3 weeks after normal sowing date) reduced significantly the number of emerged *O. crenata* shoots for both the resistant and the susceptible cultivars . Pod yield increased significantly on late sowing especially for the resistant Giza 843 cultivar (115.2 kg per plot) which produces much higher pod yield than the susceptible Nubaria 1 cultivar (86.4 kg per plot). This can be explained by the reduced number and dry weight of *O. crenata* attachments and a slight decrease in shoot dry weight of the resistant cultivar. So, combining both resistant cultivar with late sowing could be a useful tool as a part of an integrated strategy to control *O. crenata* in faba bean fields.

Keywords: Faba been cultivars, *Orobanche crenata* seed bank, Faba bean production, sowing date

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Fatty acids as sustainable biorationals for weed control

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As the global population continues to grow, food production must increase sustainably. This requires enhancing crop yields while reducing the environmental impact of agricultural practices. Weeds are a significant biotic constraint to food production as they compete with crops, reducing agricultural output and increasing external costs. Synthetic herbicides have been the primary method for weed control, but their harmful environmental effects require finding sustainable alternatives. Fatty acid compounds, derived primarily from glyceridic plant oils, are one such alternative. These natural products offer low ecotoxicological side effects and high biodegradability, making them a promising alternative to synthetic herbicides. Pelargonic acid is one fatty acid which is already on the market. This study aimed to evaluate the herbicidal efficacy of an oil-in-water-emulsion preparation containing various fatty acid compounds separately and in mixtures. The greenhouse experiments were conducted on green beans, which are sensitive to herbicides, to determine the phytotoxic potential of the compounds. The results showed that pelargonic acid had high phytotoxic effects on green beans at the level of 1 % and more, while caprylic acid was an effective post-emergence herbicide even at low concentrations of 0.5 %. Even at the lowest concentration of 0.1 %, both compounds exhibited signs of damage, and as the concentration increased, death occurred. Linseed oil (containing linolenic acid as the main fatty acid) also showed potential to exert different levels of phytotoxicity but not as strong as other compounds. The effect strongly depends on the type of fatty acid (chain length). From the experiments it could be shown that the effects of the treatments were dose-dependent, with higher concentrations leading to greater levels of damage and eventual death. Overall, the study's findings highlight the potential of fatty acid compounds as biorational post-emergence herbicides in sustainable weed management strategies. Incorporating these natural products into integrated weed management programmes could contribute to producing crops subjected to less stress in a sustainable manner, promoting sustainable food production to meet the demands of the growing population.

Keywords: Integrated weed management, sustainable agriculture

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Effects of microbial inoculants on growth and salinity tolerance of hydroponically-grown tomatoes

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The relationships of plants with soil-living bacteria and fungi are known to potentiate plants' resistance to diseases, ameliorate plants' stresses and stress responses, and promote plants' growth. Hydroponic production has increased in prevalence all over the world, as a production approach which enables greater control for growers over their plants' environments and more optimal use of scarce resources. The microbial communities with which plants interact in hydroponic environments vary from those in soil in profusion and variety, but microbes are nonetheless present there and can interact with plants, and their effects in these production systems are largely uninvestigated and untapped.

To assess the effect of different microbiota in conferring salinity resistance to tomato (*Solanum lycopersicum*, var. Sweeterno), plants were inoculated with *Bacillus megaterium* Ni-5-SO-11, *Pseudomonas brassicacaerum* 3Re2–7, and *Trichoderma harzianum* DSM 32006 in a basic hydroponic system. Tomato seedlings were treated with each these three inoculants, with and without 60 mM of NaCl, grown for 2 weeks in 2.5 l buckets with 50 % INTEGAR nutrient solution oxygenated via a bubbling air hose, then harvested, measuring biomass, SPAD, leaf area, and tissue ion concentration. Significant differences were found between inoculant treatments and controls in biomass and biomass distribution, SPAD, leaf area, and tissue ion concentrations. Endophytic bacteria were found to induce more consistent and positive responses than fungi, whose mycorrhizae did not thrive in solution and who had widely variable – but generally detrimental – effects on biomass, SPAD, and root length and health. These findings suggest that (certain of) the studied inoculants may boost plant performance in a hydroponic setting.

Growth promotion of hydroponically grown plants by microbes could potentially provide significant benefits. This would occur in a physical and biological environment where the makeup of the microbial community can be directly controlled, e.g. via aqueous inoculation of plants with beneficial inoculation over the full submerged root surface. The plants in this study were harvested at 18 days. Although this makes yield-effect predictions more abstract, this approach could be used as a screening protocol for candidate PGP microbial strains.

Keywords: Hydroponics, microbial innoculant, salinity, *Solanum lycopersicum*

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Inhibitory activity of bacterial lipopeptides against *Fusarium oxysporum* f.sp. *strigae*

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This study investigated the impact of bacterial cyclic lipopeptides (LP; surfactins, iturins, fengycins) on microbial interactions in the plant endosphere. The objective was to investigate whether the presence of bacteria inhibits fungal growth and whether this inhibition is due to the release of bacterial metabolites, particularly LP. The study employed selected endophytic bacterial strains with known plant-growth promoting potential that were cultured in the presence of *Fusarium oxysporum* f.sp. *strigae* (*Fos*), which was applied as the model fungal organism. The extracellular metabolome of tested bacteria, with a focus on LP, was characterised, and the inhibitory effect of bacterial LP on fungal growth was investigated. The results showed that *Bacillus velezensis* GB03 and FZB42, as well as *B. subtilis* BSn5 exhibited the strongest antagonism against *Fos*, while *Paraburkholderia phytofirmans* PsJN had a slight stimulatory effect. Crude LP from strains GB03 and FZB42 had the strongest inhibitory effect on *Fos*, with a significant inhibition of spore germination and damage to the hyphal structure. Liquid chromatography tandem mass spectrometry revealed the production of several variants of iturin, fengycin, and surfactin LP families from strains GB03, FZB42, and BSn5, with varying intensity. Using plate cultures, bacillomycin D fractions were detected in higher abundance in strains GB03, FZB42, and BSn5 in the presence of *Fos*. Additionally, the presence of *Fos* in dual plate culture triggered an increase in bacillomycin D production from the *Bacillus* strains, possibly through activation of signaling molecules. It was also suggested that fungal metabolites produced by *Fos* in dual culture might have triggered LP production by bacteria. The study clearly demonstrated the potent antagonistic effect of certain *Bacillus* strains, including *Bacillus* sp. GB03, FZB42, and BSn5, on *Fos* development. Conversely, we found that *P. phytofirmans* PsJN promoted the development of *Fos*. Our findings emphasise the crucial role of microbial interactions in shaping the co-existence of microbial assemblages in plant endospheres.

Keywords: Bacillomycin D, biological control, co-inoculation, lipopeptide abundance, microbial interaction

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Protecting organic cotton: Biopesticides tested against the American bollworm

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One of the most widely used fiber crops in the world, cotton is utilised in manufacturing clothing and other goods. Its production is highly affected by the American bollworm pest, *Helicoverpa armigera*. To fight off the attacks of *H. armigera*, GMO Bt-cotton was designed, which now dominates India's cotton production. In India, around 90 % of the total cotton production is sourced from Bt Cotton. However, as GMO crops are not allowed in organic farming the attacks of the American bollworm remain a major threat to organic cotton production. At our study site in Madhya Pradesh in central India, we tested different biopesticides on the American bollworm in organic cotton field trials. Three commercially available biopesticides containing the a) Nuclear polyhedrosis virus, b) *Bacillus thuringiensis*, and c) *Metarhizium rileyi* were evaluated and compared with the control, which was not treated against pest attacks. The experiment included four replications in 2021 and 2022. We monitored the pest occurrence and started applying the treatments when the economic threshold level was reached. We counted the number of larvae and eggs of the American bollworm on the cotton plants in regular scouting. In both years, the number of *H. armigera* on the cotton plants was significantly reduced compared to the control. All treated plots had significantly fewer damaged balls when compared to the controls. However, no significant effect on yield could be found. Further research is needed to evaluate the effectiveness of commercially available biopesticide products in laboratory tests. Furthermore, we envisage insect ecology studies to better understand the pest dynamics affecting organic cotton production.

Keywords: Biopesticides on American bollworms

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Reaction of common bean genotypes to plant parasitic nematodes

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Brazil is the world's largest producer of common bean (*Phaseolus vulgaris* L.), a basic dietary protein food source in the diet of the Brazilian. The consumer choice regarding grain colour, grain type, and culinary quality varies regionally, being the carioca grains (pinto bean) the type that dominates 70 % of the common bean market. The use of resistant cultivars is the most efficient strategy to control the nematode population, besides being appropriate to the producer. Nevertheless, few common bean genotypes that could serve as sources of resistance to nematodes have been identified in Brazil. These strategie being frequently the easiest and least expensive approach that can be adopted by farmers. However, in the case of the common bean in Brazil, few sources of resistance have been identified so far. Thus, this study was conducted to assess the reaction of 81 common bean genotypes to the most abundant and harmful plant parasitic nematode species in brazilian crop fields: *Meloidogyne incognita* race 3, *Meloidogyne javanica*, *Pratylenchus brachyurus*, and *Heterodera glycines* race 3. We evaluated the reactions of the genotypes to the nematode species individually, by computing their relative reproduction rates to a susceptibility standard, and collectively by applying the Tukey's multiple comparison test on the means of nematodes recovered.We found genotypes resistant to all tested nematodes: 7 were classified as resistant to *Heterodera glycines* (BRS Esteio, BRS Notável, BRSMG Majestoso, BRSMG Pioneiro, CNFC11954, CNFP10103, Xamego), 15 to *Meloidogyne incognita* (Aporé, BRS Embaixador, BRS Esplendor, BRS Grafite, BRS Notável, BRS Requinte, BRSMG Majestoso, BRSMG Pioneiro, CNFC 10762, CNFC 11954, CNFP 11984, IAC Alvorada, IPR Eldorado, RP 1, Rudá) and 8 to *Meloidogyne javanica* (Aporé, BRS Esteio, BRS Pontal, BRS Requinte, BRSMG Talismã, CNFC 10762, CNFP 10103, CNFP 10794) and 2 found to be resistant to *Pratylenchus brachyurus* (IPR Tangará and Light Red Kidney). The high amount of genotypes evaluated and the uniformity of experimental conditions allowed a solid base for the development of insightful discussions on the aspects involving statistical analysis of nematode data, possible sources of resistance, and the multiplication rates of important nematodes on common bean genotypes.

Keywords: Cyst-nematodes, genetic resistance, *Phaseolus vulgaris*, root-knot nematodes, root-lesion nematodes, soybean

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Enhancing management of invasive fall armyworm under different tillage and cropping systems in Nigeria

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The fall armyworm (FAW; *Spodoptera frugiperda*), is a voracious agricultural pest which cause extensive damage to maize crops. Agroecology is a friendly approach that has been practised by many farmers, but the suitability of agro-ecological measures for reducing FAW densities is largely unexplored. Therefore, we hypothesised the effect of tillage and cropping systems on larval population and damage by FAW across two different landscapes in Ibadan, Nigeria. A land size (48.6 m by 32.2 m) was divided into six equal experimental units, each containing different tillage and cropping systems, namely: maize-celosia intercrop+conventional tillage (AICT), maize-celosia intercrop+minimum tillage-mulch (AIMTM), maize-cowpea intercrop+conventional tillage (CPCT), maize-cowpea intercrop+minimum tillage-mulch (CPMTM), Maize-monocrop+conventional tillage (NICT) and maize-monocrop+minimum tillage-mulch (NIMTM). The set up was replicated in two different landscapes representing areas of high tree cover (HTC) and low tree cover (LTC), with each area, having eight replicated farms. Tillage operations and mulching were carried out based on local practices and maize, cowpea and vegetable seeds were sown following standard procedures. Data on FAW larval population were collected by counting the number of FAW on 'W' point in the core plot (5 m by 5 m area), while data on foliar damage were taken using the CIMMYT pictorial guide, 1–9 (where1 = not infested; 9= heavily infested), at three, six and nine weeks after sowing (WAS). Data were analysed using analysis of variance and means were separated with Duncan's Multiple Range Test at 5 % probability level. The NICT plot had the highest number of FAW larvae in both the HTC and LTC and FAW larval population was significantly ($p \leq 0.05$) lower on minimum tillage-mulch plot than in conventional tillage plot. Foliar damage by FAW was significantly lower in HTC area than in the LTC area. It is apparent from the current study that FAW larval population and foliar damage were reduced on minimum tillage and mulching plot than conventional tillage plot as well as on maize monocrop plot than intercropped plot. The effect of high tree cover was stronger than the low tree cover in reducing fall armyworm larval population in Nigeria.

Keywords: Fall armyworm larval, high tree cover, intercropping, minimum-mulch tillage, monocropping

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Molecular tools to predict resistance-breaking abilities of rice yellow mottle virus isolates

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Rice yellow mottle virus (RYMV, Sobemovirus, Solemoviridae) is a major biotic constraint to rice cultivation in Africa. This icosaedric (+) ssRNA virus has been described in 25 countries. It shows a high and geographically-structured genetic diversity with six major strains distributed in West or East Africa, themselves divided in several sub-lineages. This classification was based on phylogenetic analyses of the coat protein (CP) sequences and confirmed on full-length genomes. Varietal selection is considered as the most efficient and sustainable way to manage RYMV. Sources of high resistance were found mostly in accessions of the African rice species, *Oryza glaberrima*. Two recessive and one dominant resistance genes were identified. Experimental evolution on resistant accessions revealed emergence of resistance-breaking (RB) genotypes in controlled conditions. The RB ability was highly contrasted depending on the RYMV lineages and the resistance sources. We previously demonstrated that the codon 49 of the viral protein genome-linked (VPg) played a major role in the RYMV adaptation to *O. glaberrima* and that the polymorphism at this codon can be used to predict the RB ability of RYMV isolates against several resistance sources. However, sequencing of the VPg gene is required in addition to the CP sequence to determine the RYMV sublineage. Moreover, no molecular marker was available to discriminate an hypervirulent lineage able to overcome all the known resistance sources. Here, we identified a molecular signature in the P1 gene of the RYMV hypervirulent lineage. Then, we designed specific RT-PCR primers in the P1 and VPg genes. These primers were tested and validated on 50 isolates representative of the RYMV genetic diversity. They will contribute to mitigate the risks of RB emergence taking into account the RYMV lineages identified in fields and their adaptability to optimise the deployment strategy of resistant lines at the local scale.

Keywords: Molecular tools, resistance-breaking, rice, RYMV

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