ETH zürich

World Food System Center Research Symposium 2020

10 December 2020: Plant Breeding for Global Food Security Webinar

11 December 2020: Poster Session & Networking Event

World Food System Center

Research for food systems transformation

Overarching all our work in food systems, is the call from the UN Agenda 2030 Sustainable Development Goals (SDGs) to find shared solutions to the world's urgent challenges. For the upcoming UN Food Systems Summit in 2021, five action tracks have been defined that drive food system transformation. Each track is designed to address synergies as well as possible trade-offs with other tracks, and to identify bold new actions, innovative solutions, and strategies that can deliver wide-reaching benefits across all of the SDGs.

This year, as the COVID-19 pandemic threatens the lives and livelihoods of people around the world, it also has exposed dangerous deficiencies in our food systems. Sharing research working towards sustainable food systems is as critical as ever.

These times have also made us all rethink how we share and interact. We are, therefore, excited to present food systems research at ETH Zurich in a different format, namely in two distinct online events. The first is a webinar with presentations and panel discussions focused on plant breeding for global food security. The second is a reimagining of our Networking Poster Session, providing young scientists a platform to share and connect with others in the food systems arena. Both events highlight how work at ETH Zurich contributes to food systems transformation.

Follow us on:

@ethzWFSC @ethzWFSC World Food System Center, ETH Zurich

Program

Plant Breeding for Global Food Security Webinar

Thursday, 10 December 2020: 16:00 - 17:30

	Presented by:
Welcome	**Michael Siegrist (WFSC)**
Presentations	
Pea root rot: Will understanding plant-microbiota interaction support resistance breeding?	**Lukas Wille (FiBL)**
Advancing bean breeding thourgh genomic selection	**Beat Keller (ETH Zurich)**
Panel Discussion with Questions from Audience	**Monika Messner (FiBL), Bruno Studer (ETH), Clare Mugisha Mukankusi (CIAT), Robert Santiago Andrade (CIAT), Martijn Sonenvelt (WFSC), Jeanne Tomaszewski (WFSC)**

Poster Session and Networking Event

Friday, 11 December 2020: 16:00 - 18:00

Welcome	**Michael Siegrist and Martijn Sonnevelt (WFSC)**
Flash Presentations and **Discussion Rounds**	**Selected Poster Presenters**
Open Networking Time	

Plant Breeding for Global Food Security Webinar

Thursday, 10 December, 16:00-17:30 CET

This webinar, with presentations and panel discussion, focuses on plant breeding and the implications for global food security.

Presentations from World Food System Center Research Programs will be featured and give insight into the applications of plant breeding. The panel discussion, with its various perspectives, will further highlight how the research contributes to the future of plant breeding and its implications for global food security and a planetary health diet.

- Welcome: Michael Siegrist, World Food System Center, ETH Zurich

- Presentations
  - Lukas Wille, Research Institute of Organic Agriculture (FiBL): Pea root rot: Will understanding plant-microbiota interaction support resistance breeding?
  - Beat Keller, ETH Zurich: Advancing bean breeding through genomic selection

- Panel Discussion with Questions from Audience
  - Monika Messmer, Research Institute of Organic Agriculture (FiBL)
  - Bruno Studer, ETH Zurich
  - Clare Mugisha Mukankusi, Alliance Bioversity-CIAT (International Center for Tropical Agriculture)
  - Robert Santiago Andrade, Alliance Bioversity-CIAT
  - Martijn Sonnevelt, World Food System Center, ETH Zurich
  - Moderator: Jeanne Tomaszewski, World Food System Center, ETH Zurich

Welcome

Michael Siegrist
ETH Zurich

Presentations

Lukas Wille
FiBL

Beat Keller
ETH Zurich

Panelists

Monika Messner
FiBL

Bruno Studer
ETH Zurich

Clare Mugisha Mukankusi
Alliance Bioversity-CIAT

Robert Santiago Andrare
Alliance Bioversity-CIAT

Martijn Sonnevelt
ETH Zurich

Moderator

Jeanne Tomaszewski
ETH Zurich

Presentations

The Center's Research Programs support new cross-disciplinary and solution oriented research to address food system challenges, with 33 projects totaling nearly 9 million CHF funded to date.

All projects are subject to a rigorous evaluation and an assessment process that takes into account scientific excellence and relevance to the programs. To fund these programs, we established the World Food System Grants Platform, which allows for working with industry and foundation partners in a pre-competitive way that ensures academic independence and industry relevance.

Our two current research programs, the Mercator Research Program on Organic Production Systems for Global Food Security and the Coop Research Program on Sustainability in Food Value Chains, provide support for new projects.

The **Mercator Research Program** on Organic Production Systems, funded by the Mercator Foundation Switzerland, supports research, education, and outreach that explores the role and potential of organic production systems (certified or non- certified) to contribute to global food security.

The **Coop Research Program** on Sustainability in Food Value Chains, supported by the Coop Sustainability Fund, enables research that addresses challenges and opportunities for sustainability in food value chains.

The Center strives to work together with others in partnerships to achieve together what no partner could achieve on their own. We formally develop both strategic and collaborative partnerships, and, in addition, we indirectly foster new partnerships at the project level. This partnership approach, which we developed during our first phase of operations, has been critical to the Center's success.

Title: Advancing bean breeding through genomic selection

Authors: Beat Keller[1, 2], Daniel Ariza-Suarez[2], Ana Elisabeth Portilla-Benavides[2], Hector Fabio Buendia[2], Winnyfred Amongi[3], Julius Mbiu[4], Clare Mukankusi[3], Bodo Raatz[2], Bruno Studer[1]

[1]Molecular Plant Breeding, Institute of Agricultural Sciences, ETH Zurich, 8092 Zurich, Switzerland

[2]Bean Program, International Center for Tropical Agriculture (CIAT), Cali, Colombia

[3]Bean Program, International Center for Tropical Agriculture (CIAT), Kampala, Uganda

[4]Tanzania Agricultural Research Institute (TARI), Maruku, Tanzania

Abstract: Common bean (*Phaseolus vulgaris* L.) is an important protein and iron source, hence a good alternative to meat, produced mainly of smallholder farmers in the tropics. The phenotypic diversity ranges from different seed colors and sizes, to bush and climbing growth types. Climbing beans achieve higher nitrogen fixation rates, seed iron concentration, and yield per area, especially under drought and low input conditions. However, climbing beans are more laborious to cultivate, and therefore, have been largely neglected in breeding programs.

The main goal of our project was to advance climbing bean breeding through genomic selection, a method that uses statistical models to predict the performance of new breeding lines based on genomic data only. Genotypic and phenotypic data was collected in order to establish the models. First, 290 climbing bean lines were sequenced and evaluated in field trials in Colombia, Uganda and Tanzania. Second, models were trained with thousands of molecular markers to best predict the phenotypes. For seed yield and iron content, a predictive accuracy of about 70% and 85% of the heritable genetic variance was reached across all locations, respectively. In a breeding program, this allows to efficiently pre-select superior lines without laborious and expensive field testing.

The established models can be extended to specifically select for resource efficiency and yield stability out of the huge genetic diversity common bean offers. The developed varieties will not only increase food security and nutritional quality but also improve the sustainability of the agricultural production system regarding the environmental impact and income of smallholders.

This research is supported by the WFSC Coop Research Program. Further information is available on **the IncreBean project webpage**.

Title: Plant-microbiota interactions in resistance breeding - The case of pea root rot

Authors: Lukas Wille[1,2], Monika M. Messmer[2], Pierre Hohmann,[2] Bruno Studer[1]
[1] Molecular Plant Breeding, Institute of Agricultural Sciences, ETH Zurich, Zurich, Switzerland
[2] Department of Crop Sciences, Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

Abstract: Pea (*Pisum sativum* L.) is an important protein source for human consumption and animal feed. Through the symbiosis with nitrogen-fixing rhizobacteria, pea cultivation improves soil fertility. The reduced demand for external fertilizers makes pea a valuable element for organic and other sustainable farming practices. In Europe, an increase in pea acreage is expected due to current efforts to promote a local, plant-based protein supply as an alternative to overseas soybean imports. However, pea production is challenged in most temperate zones by a complex of pathogens causing root rot diseases. Despite considerable progress in resistance breeding against individual pathogens, current pea varieties lack resistance against this conjoint occurrence by various root rot pathogens. The plant-associated microbiota as a whole is involved in plant health and disease development. It is known that plants have the ability to modulate its microbial community; recent studies have shown that there is a genetic basis for this modulation that can be exploited in plant breeding.

As part of the project ResPEAct, a screening system was developed that allows testing pea lines for resistance against the root rot complex present in a given soil. Using this system, we identified resistant pea lines, which also performed well in subsequent field trials. This promising selection tool is currently being implement in pea breeding programs.

We also aim at understanding the pea root rot complex and the role of individual microbes therein for plant health. Therefore, a selection of resistant and susceptible pea lines was tested in soils that present different pathogen complexes. PCR-based detection of ten microbial species in diseased pea roots revealed that resistant and susceptible pea lines have distinct microbial communities. Across the tested soils, the amount of the fungal pathogen *Fusarium solani* serves as a predictor of plant disease. On the other hand, the abundance of arbuscular mycorrhizal fungi, known beneficial symbionts of pea, can be used as a predictor for disease resistance.

Our research outlines the potential to integrate information on plant-microbe interactions in plant breeding. In particular, the use of microbial markers for essential plant functions,, for instance disease resistance, holds promise to serve as an additional selection criterion for new crop varieties.

This research is supported by the WFSC Mercator Research Program. Further information is available on the ResPEAct project webpage.

Poster Session and Networking Event

Friday, 11 December, 16:00-18:00 CET

Since 2016, the World Food System Center Research Symposium every autumn show-cases food system relevant research conducted at ETH Zurich and partner institutions. The accompanying networking poster session was an open and appreciated way for researchers from across departments and institutions to come together and exchange. The work of these food system researchers deserves an audience, and thus, this year, we present an Online Poster Session and Networking Event.

For the upcoming UN Food Systems Summit in 2021, five action tracks have been defined that drive food system transformation. The posters and presentations at the Networking Event highlight how work at ETH Zurich contributes to these action tracks.

Program

- Welcome: Michael Siegrist and Martijn Sonnevelt, World Food System Center, ETH Zurich
- Flash Presentations and Discussion Rounds based on the action tracks of UN Food Systems Summit
- Open Networking Time - connect with other food system researchers

In addition to the Networking Event, all posters are displayed on @ethzWFSC Twitter #ETHFoodDays and the Center website from 03 December 2020.

Action Track 1: Ensure access to safe and nutritious food for all

Eating microalgae: How tiny organisms solve big problems

Authors: M. Huelsmann, I. Haberkorn, M. Schäfer, M. Ackermann, A. Mathys, J. A. Vorholt

Iron bioavailability from iron-biofortified orange-fleshed sweetpotato: A stable isotope study in Malawian women

Authors: R. Jongstra, M. Mwangi, C. Zeder, J. Low, G. Mzembe, M. Andrade, K. Phiri, M. B. Zimmermann, R. Wegmüller

A combined approach of oral vaccination and bacterial competition eliminates gut pathogens in a targeted manner

Authors: V. Lentsch , C. Moresi , S. Aslani , W. Hardt, D. Kümmerlen , M. Diard , E. Wetter Slack

Effects of maternal Spirulina supplementation on the meat quality of fattening pigs

Authors: R. Lugarà, M. Kreuzer, K. Giller

Integration of small-scale circular agroecosystems on buildings in a high density urban context

Authors: I. Merz, J. Six

Effect of the supplementation of vitamin B9 and B12 on the human gut microbiota

Authors: P. Morales, P. Kundra, A. Geirnaert, A. Greppi, C. Lacroix

An in vitro continuous fermentation model to investigate horizontal gene transfer in the chicken gut microbiota

Authors: A. Pennacchia, F. Constancias, A. Greppi, B. Pugin, R. Stephan, C. Lacroix

Investigating the potential and safety of nutritional interventions against iron deficiency anemia using a novel African infant gut fermentation model

Authors: C. Rachmühl, N. Stoffel, A. Giorgetti, M. B. Zimmermann, C. Lacroix, A. Geirnaert

Potential and manipulation of intestinal microbiota to produce reuterin and detoxify dietary carcinogens

Authors: A. Ramirez, J. Zhang, F. Constancias, A. Greppi, E. Wortmann, M. Wandres, K. Hurley, A. Pascual-Garcia, S. Sturla, C. Lacroix, C. Schwab

Action Track 2: Shift to sustainable consumption patterns

Temporal differentiation of resource capture and biomass accumulation as a driver for yield advantage in intercropping

Authors: N. Engbersen, R. W. Brooker, L. Stefan, C. Schöb

Food shopping and panic buying in the time of COVID-19 pandemic

Authors: C. Hartmann, M. Siegrist

Measuring dietary iron absorption from mealworms (*Tenebrio molitor*) in young women and assessing the effect of chitin on iron bioavailability: a stable isotope study

Authors: N. Hilaj, V. Galetti, R. Murad Lima, C. Zeder, M. Zimmermann, D. Moretti

Consumers' perception of meat alternatives containing pea or algae protein

Authors: F. Michel, A. Knaapila, C. Hartmann, M. Siegrist

The true cost of food in Switzerland

Authors: A. Perotti, J. Six, M. Sonnevelt

Diet-related compensatory behavior and its influence on healthy weight management and diet quality

Authors: C. Sob, M. Siegrist, D. Hagmann, C. Hartmann

Correlates of the willingness to consume insects: A meta-analysis

Authors: B. Wassmann, M. Siegrist, C. Hartmann

The comparability of consumers' behavior in virtual reality and real life based on a cereal ranking task

Authors: C. Xu, Y. Demir-Kaymaz, C. Hartmann, M. Menozzi, M. Siegrist

Action Track 3: Boosting nature-positive production

Improving yam cropping systems in West Africa - YamSys

Authors: Allemann, L. Diby, V. Hgaza, D. Kiba, A. Kangah, E. Frossard

Pesticide load and agricultural productivity: the case of Swiss winter wheat producers

Authors: K. H. Dakpo, N. Möhring, R. Finger

European Union membership and agricultural land use intensity: Evidence from changes in border discontinuities

Authors: D. Engist, R. Finger, D. Wüpper

Can Black Soldier Fly larvae meal replace soybean meal as a protein source in broilers?

Authors: M. Heuel, C. Sandrock, F. Leiber, A. Mathys, M. Gold, C. Zurbrügg, I. D.M. Gangnat, M. Kreuzer M. Terranova

Reducing feed-food competition by using elevated proportions of grass silage in intensive beef production: effects of complementation with maize silage or corn-cob mix

Authors: M. Keller, M. Kreuzer, B. Reidy, A. Scheurer, K. Giller

PestiFreeWheat – adoption of a large-scale pesticide-free wheat production standard in Switzerland

Authors: N. Möhring, R. Finger

Biological Control: Fighting below ground insect pests with entomopathogenic *Pseudomonas* bacteria, nematodes and fungi

Authors: A. Spescha, M. Brunner, J. Weibel, F. Scheibler, F. Gillieron, S. Müller, A. Guyer, R. Campos-Herrera, G. Grabenweger, M. Maurhofer

Spatio-temporal dynamics of land use intensity in Swiss grassland systems

Authors: M. Spörri, N. El Benni, G. Mack, R. Finger

Contractors in precision farming uptake – A spatial economic analysis

Authors: Y. Wang, R. Huber, R. Finger

Action Track 4: Advance equitable livelihoods

Ancient grain Kabog millet: Empowering farmers through food science research

Authors: J. O. Narciso, L. Nystrom

The World Food System Center Alumni Network (WFSCAN)

Authors: M. Wiget, V. Loaiza, N. Bartolome

RUNRES: Establishing a circular economy for resilient city region food systems

Authors: B. Wilde, L. Späth, M. Surchat, L. Messmer

Action Track 5: Build resilience to vulnerabilities, shocks and stress

Elucidating the genetic control of southern anthracnose resistance in a diverse set of red clover accessions

Authors: L. Frey, F. X. Schubiger, B. Studer, R. Kölliker

Using PhenoCams for tracking phenology and estimating yields of different cropping systems

Authors: Y. Liu, C. Bachofen, V. Klaus, G. S. Duarte, Q. Sun, A. K. Gilgen, E. Oliveira Hagen, R. Wittwer, M: G.A. van der Heijden, N. Buchmann

Exploring funding options to forest landscape restoration in the global tropics

Authors: S. Löfqvist, R. Garrett, J. Ghazoul

Building resilience of food value chain to droughts

Authors: E. Monastyrnaya, P. Krütli, J. Six

Irrigation and climate change: implications for water resources in the semi-arid region of Valencia, Spain

Authors: S. Pool, F. Frances, A.Garcia-Prats, M. Pulido-Velazquez, C. Sanchis-Ibor, M. Schirmer, H. Yang, J. Jimenez-Martinez

How can digital twins reduce food loss in postharvest supply chains?

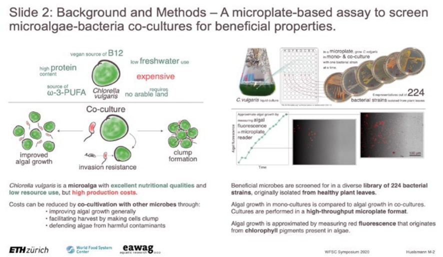
Authors: C. Shrivastava, T. Berry, P. Cronje, T. Defraeye

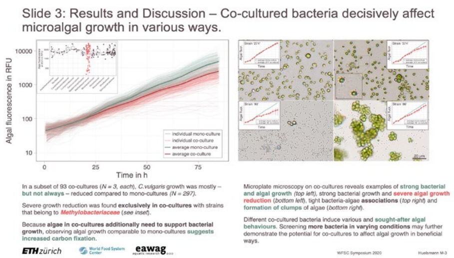
Title: Eating microalgae: How tiny organisms solve big problems

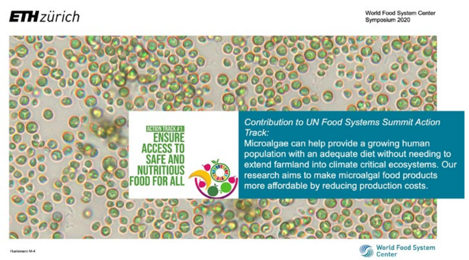
Authors: M. Huelsmann, I. Haberkorn, M. Schäfer, M. Ackermann, A. Mathys, J. A. Vorholt
Affiliations: Microbial Systems Ecology, ETH Zurich; Sustainable Food Processing, ETH Zurich; Molecular Health Sciences, ETH Zurich

Contribution to Action Track 1: Microalgae can help provide a growing human population with an adequate diet without needing to extend farmland into climate critical ecosystems. Our research aims to make microalgal food products more affordable by reducing production costs.

Abstract: The human population is growing and adequately feeding everyone becomes increasingly challenging. Especially since the looming climate crisis does not allow us to extend farmland for our traditional crops. Microalgae, tiny photosynthetic organisms, are highly nutritious and can grow in places that are unsuitable for traditional crops. Yet, growing traditional crops for food is currently much cheaper than growing microalgae. Here, we propose that co-cultivating microalgae with supporting bacteria can bring down costs by e.g. improving microalgal growth, reducing harvesting efforts or fending off harmful contaminations. To find supporting bacteria, we determine how well the microalga *Chlorella vulgaris* grows in co-culture with more than 200 bacteria isolated from healthy plants. Eventually we want to find out how supporting bacteria improve *C. vulgaris* growth and test whether co-cultures with multiple bacteria improve microalgal growth even further.





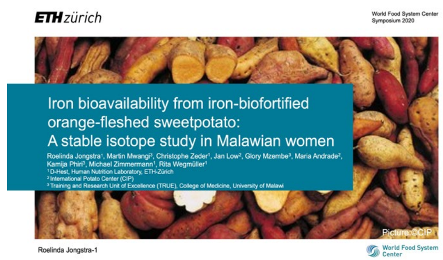


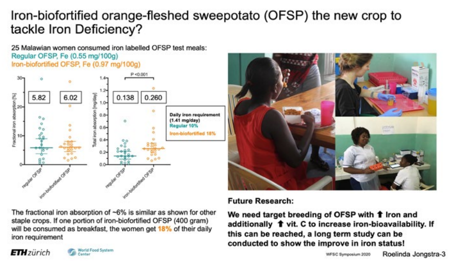
Title: Iron bioavailability from iron-biofortified orange-fleshed sweetpotato: A stable isotope study in Malawian women

Authors: R. Jongstra, M. Mwangi, C. Zeder, J. Low, G. Mzembe, M. Andrade, K. Phiri, M.B. Zimmermann, R. Wegmüller
Affiliations: Human Nutrition Laboratory, ETH Zurich

Contribution to Action Track 1: With climate change the search for crops that are resistant to strong weather conditions and provide the needed nutrients in populations suffering from micronutrient deficiencies due to a monotonous plant-based diet is essential. Biofortification can help ensuring better local access to more nutritious staple foods.

Abstract: Iron-biofortification of sweetpotato could improve iron intakes in populations where sweetpotato is a staple crop. Iron absorption from sweetpotato is unknown. The objective of this project was to assess iron absorption from a regular and iron-biofortified orange-fleshed sweetpotato (OFSP) meal.
A randomized cross-over study in generally healthy Malawian women of reproductive age was completed. The women (n=24) consumed 400g of regular or iron-biofortified OFSP together with labelled iron over 10 consecutive days per meal type. Results showed the regular and iron-biofortified OFSP meals contained 0.55 and 0.97 mg Fe/100g. Fractional iron absorption between meals did not differ (~6%), resulting in a 1.9 fold higher total iron absorption from the iron-biofortified sweetpotato meal (P < 0.001). In conclusion, the absorbed iron per day from iron-biofortified OFSP would cover 18% of the iron requirement for women of reproductive age. More studies are needed to estimate how OFSP could improve iron status when integrated in a daily diet.





Title: A combined approach of oral vaccination and bacterial competition eliminates gut pathogens in a targeted manner

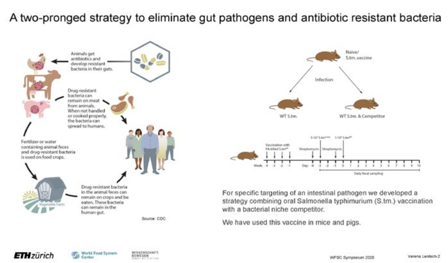
Authors: V. Lentsch, C. Moresi, S. Aslani, W. Hardt, D. Kümmerlen, M. Diard, E. Wetter Slack

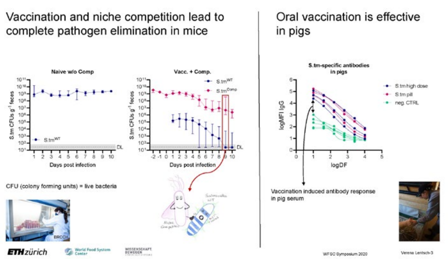
Affiliations: Institute of Food, Nutrition and Health, ETH Zurich; Institute of Microbiology, ETH; Vetsuisse-Faculty, University of Zurich; Biozentrum, University of Basel

Contribution to Action Track 1: Our goal is to specifically clear antibiotic resistant bacteria from the gut of livestock. By this we do not only increase the safety of meat but also that of plants and crops.

Abstract: Antibiotic resistance poses an existential threat to global health, and correspondingly there is a major effort to reduce antibiotic usage in farming. However, removing prophylactic antibiotic usage is associated with major disease outbreaks in herds, and we now know that solitary reduction of antibiotic usage has little impact on the carriage rates of antimicrobial resistant (AMR) strains, that are abundant in the livestock gut microbiome.

Therefore we developed a strategy that both prevents AMR bacteria from causing disease and aims to drive local extinction of these strains. To achieve this, we combine inactivated oral vaccines with engineered bacterial competitors. The antibody response raised by vaccination blocks pathogenicity, and suppresses competitive fitness of the targeted strain against a niche competitor. This robustly protects from non-Typhoidal *Salmonellosis* in murine models. Moreover, our oral *Salmonella* vaccines induce robust immunity in French Landrace pigs. The next targets will be AMR *E.coli*. This will sustainably and robustly improve welfare and increase the safety of food production.





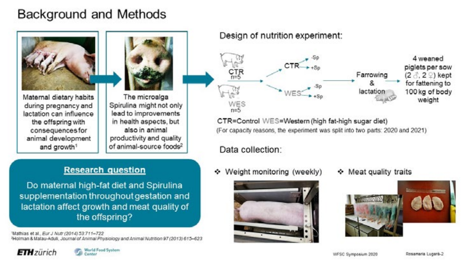
Title: Effects of maternal Spirulina supplementation on the meat quality of fattening pigs

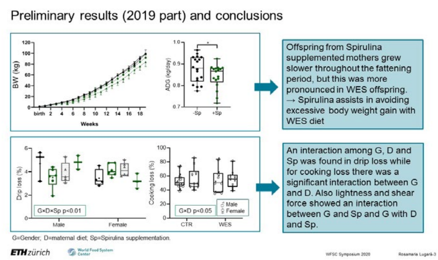
Authors: R. Lugarà, M. Kreuzer, K. Giller

Affiliations: Animal Nutrition, ETH Zurich

Contribution to Action Track 1: Spirulina is a novel algal food and feed, which can be produced sustainably. It is a rich source of nutrients, which is believed to lead to improvements in productivity, but also in health aspects and product quality of livestock.

Abstract: *Arthrospira platensis* (Spirulina) is a filamentous, blue-green microalga, considered a 'superfood' in human nutrition because of its richness in nutrients, particularly proteins (60-70% of its dry weight), and bioactive compounds, which likely mediate its numerous postulated metabolic health effects. When fed to livestock, Spirulina is suggested to not only lead to improvements in animal productivity, but also in health aspects and quality of animal-source foods. This may even happen across generations. The aim of the study was to investigate any potential transgenerational effects of supplementation of 20 g Spirulina/day to gestating and lactating sows with common or high fat-high sugar intake on performance and meat quality of their piglets during a fattening period of five months. Indeed, maternal Spirulina supplementation showed effects. It slowed growth and changed lightness, drip and cooking loss, and shear force. These were also influenced by diet type of the sows and gender of the piglets.



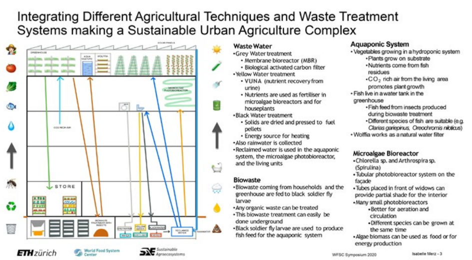


Title: Integration of small-scale circular agroecosystems on buildings in a high density urban context

Authors: I. Merz, J. Six
Affiliations: Sustainable Agroecosystems Group, ETH Zurich

Contribution to Action Track 1: Growing urban populations demand increasing amounts of food and clean water. Integrated and efficient urban farming systems in buildings can provide safe and nutritious food for residents. Those food producing systems create an independent source of food in the city.

Abstract: Cities are facing many challenges such as pollution, limited space and a high demand for food, energy and water. Urban agriculture contributes to meet those demands. Current urban farming projects are often not designed in an integrated and holistic way and thus lack efficiency and sustainability. Here, highly technical implementations can offer innovative solutions. An integrated design of an urban agriculture system on buildings could transform urban food production and offer a sustainable solution for urban living. In the designed system, food production systems, including aquaponic systems, microalgae photobioreactors, insect production, and sustainable building components have been combined with building services such as decentralised wastewater treatment and biowaste treatment. Thus, this system is an example for optimised utilisation of urban space and shows that integrated food production systems and recycling of resources in buildings can be a potential approach to sustainable living.

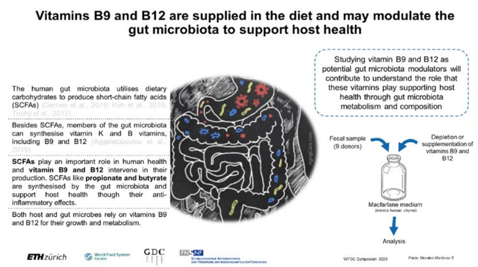


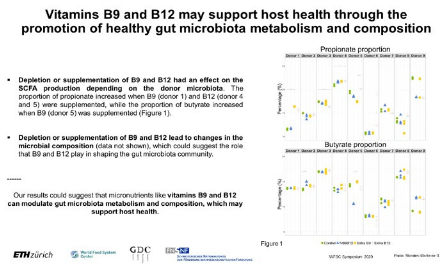
Title: Effect of the supplementation of vitamin B9 and B12 on the human gut microbiota

Authors: P. Morales, P. Kundra, A. Geirnaert, A. Greppi, C. Lacroix
Affiliations: Laboratory of Food Biotechnology, ETH Zurich

Contribution to Action Track 1: Vitamins B9 and B12 are essential micronutrients for both humans and microbes and their intake depends on the diet. However, gut microbiota seems to contribute to B9 and B12 homeostasis of the human gut and the host can potentially benefit from B-vitamins microbiota biosynthesis in the colon.

Abstract: Humans rely on dietary vitamin B9 and B12, but the gut microbiota can also synthesize them. However, it is still unknown whether B9 and B12 impact the production of beneficial short-chain fatty acids (SCFA) by gut microbes.
The effect of B9 and B12 supplementation and depletion on gut microbiota was investigated in vitro using fecal batch fermentations of nine adult donors. B9 and B12 supplementation increased the proportion of propionate (by 4.40%), butyrate (by 3.73%), and total SCFA (by 12.83%). Abundance of *Ruminococcaceae* (by 2.84%), *Erysipelotrichaceae* (by 3.90%), and *Lachnoclostridium* (by 2.70%) increased when B9 was supplemented, while *Ruminococcaceae* (by 3.30%), *Lachnospiraceae* (by 2.40%), *Paraprevotella* (by 7%), and *Sutterella* (by 6.70%) increased when B12 was supplemented. *Dorea* increased when vitamins were depleted (by 3.30%).
Although donor-dependent, our data suggest the potential of B9 and B12 supplementation to modulate the gut microbiota, which may influence gut health via SCFA production.



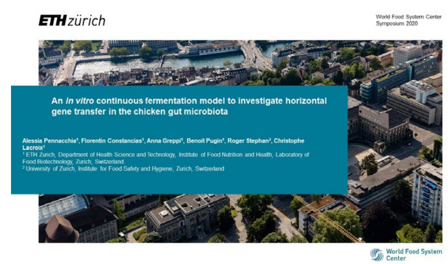


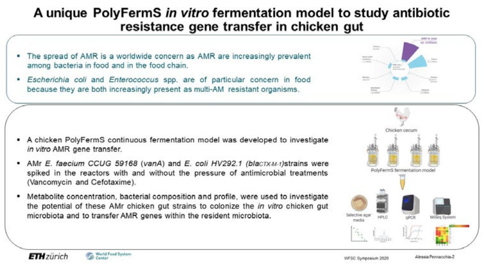
Title: An *in vitro* continuous fermentation model to investigate horizontal gene transfer in the chicken gut microbiota

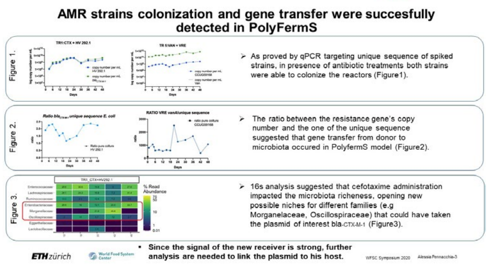
Authors: A. Pennacchia, F. Constancias, A. Greppi, B. Pugin, R. Stephan, C. Lacroix
Affiliations: Laboratory of Food Biotechnology, ETH Zurich; Institute for Food Safety and Hygiene, University of Zurich

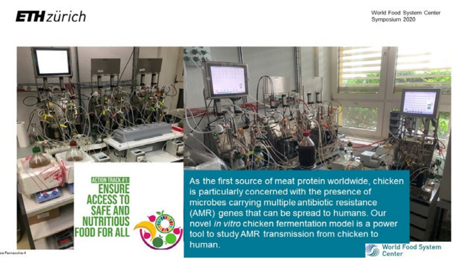
Contribution to Action Track 1: As the first source of meat protein worldwide, chicken is particularly concerned with the presence of microbes carrying multiple antibiotic resistance (AMR) genes that can be spread to humans.

Abstract: The transmission of antimicrobial resistant (AMR) strains from chicken to human through food is potentially contributing to the development of the resistome in humans. The high bacterial density of chicken and human gastrointestinal tract (GIT) provides a favorable environment for the transfer of AMR genes between bacteria. *Escherichia coli* and *Enterococcus sp.* are key targets,directly involved in the transfer of AMR to other species. A chicken PolyFermS fermentation model was developed to investigate in vitro AMR gene transfer: AMR *E. faecium* and *E. coli* strains were spiked in the continuous fermentation reactors with and without the pressure of antimicrobial treatments(Cefotaxime and Vancomycin). Metabolite concentration, bacterial composition and profile, were used to investigate the potential of these AMR chicken gut strains to colonize the *in vitro* chicken gut microbiota and to transfer AMR genes within the resident microbiota.
The model provides a unique tool to study the occurrence and mechanism of AMR gene transfers in the chicken GIT.







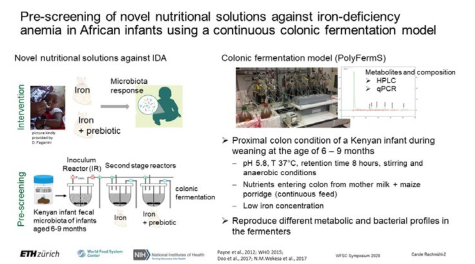


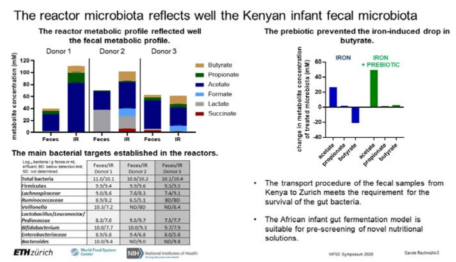
Title: Investigating the potential and safety of nutritional interventions against iron deficiency anemia using a novel African infant gut fermentation model

Authors: C. Rachmühl, N. Stoffel, A. Giorgetti, M. B. Zimmermann, C. Lacroix, A. Geirnaert
Affiliations: Laboratory of Food Biotechnology, ETH Zurich

Contribution to Action Track 1: The availability of an appropriate *in vitro* fermentation model for prescreening of nutritional strategies prior to intervention in African infants will contribute to their safety by elucidating the effect on the infant's gut microbiota in advance.

Abstract: The gut microbiota interacts closely with its host and diet and may influence outcome of nutritional interventions. Therefore, potential and safety of novel nutritional strategies, for example against iron deficiency anemia in African infants, need to be investigated prior to intervention trials. To do so, an appropriate gut microbiota fermentation model is required reflecting that particular host. We developed an African infant gut fermentation model using the advanced PolyFermS platform inoculated with immobilized Kenyan infant fecal microbiota and conditions rationally selected to closely mimic the Kenyan infant's intestine and diet (mother milk and maize porridge). We studied three different donor's aged 6 – 9 months and successfully reproduced the three different metabolic and bacterial profiles in the fermenters. Further, we performed preliminary trials on a novel nutritional strategy containing iron-binding protein and prebiotics. In conclusion, this fermentation model is a suitable model for future pre-screening of nutritional interventions.



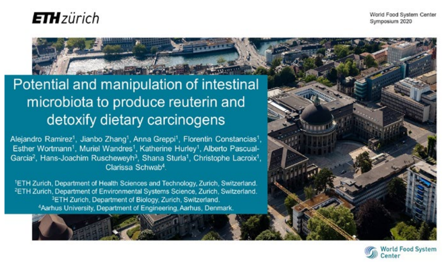


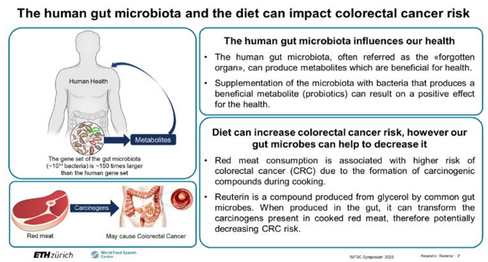
Title: Potential and manipulation of intestinal microbiota to produce reuterin and detoxify dietary carcinogens

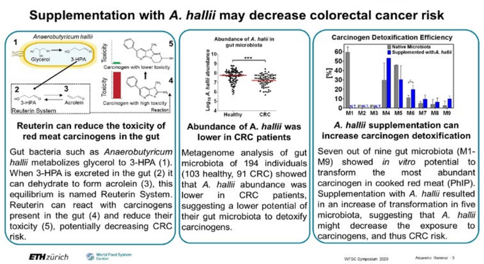
Authors: A. Ramirez, J. Zhang, F. Constancias, A. Greppi, E. Wortmann, M. Wandres, K. Hurley, A. Pascual-Garcia, S. Sturla, C. Lacroix, C. Schwab
Affiliations: Laboratory of Food Biotechnology, ETH Zurich; Theoretical Biology, ETH Zurich; Functional Microbe Technology, Aarhus University, Denmark

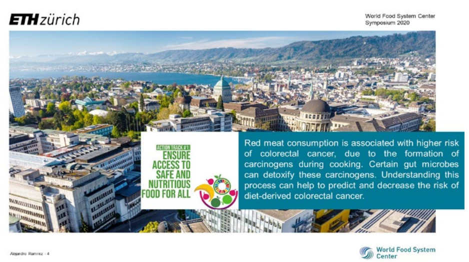
Contribution to Action Track 1: Red meat consumption is associated with higher colorectal cancer risk, due to the formation of carcinogens during cooking. Certain gut microbes can detoxify these carcinogens. Understanding this process can help to predict and decrease the risk of diet-derived colorectal cancer.

Abstract: Reuterin is an antimicrobial produced during glycerol metabolism by gut microbes via glycerol/diol dehydratases (GDH). Reuterin can interact with carcinogens (heterocyclic aromatic amines, HCA) present in cooked red meat and reduce their mutagenicity. Differences in proportions of GDH-active taxa were observed between colorectal cancer (CRC) patients and healthy individuals, suggesting gut microbiota of CRC individuals has lower potential to detoxify HCA. We hypothesized that GDH activity is determined by abundance and distribution of GDH-active taxa, and can be enhanced by supplementing the GDH-active *Anaerobutyricum hallii*. We tested our hypothesis in nine intestinal microbiota using culture-dependent, analytical, and molecular methods. Our results suggest that GDH activity was dependent on *gdh* abundance. *A. hallii* was identified as key taxon in GDH metabolism, and its supplementation increased the rate of reuterin release, which enhanced HCA transformation.
A. hallii supplementation could be beneficial in individuals with reduced GDH abundance, which may reduce carcinogen exposure.







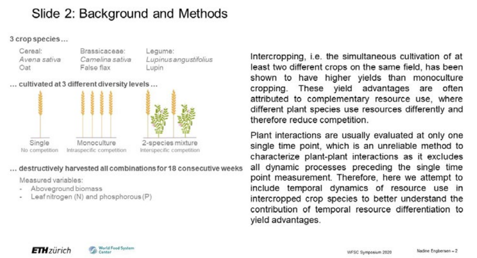


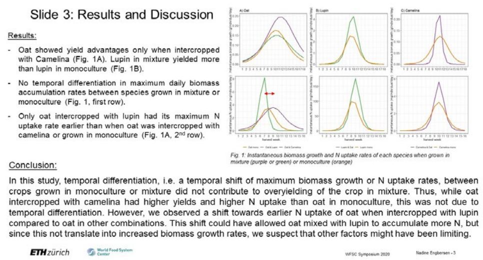
Title: Temporal differentiation of resource capture and biomass accumulation as a driver for yield advantage in intercropping

Authors: N. Engbersen, R. W. Brooker, L. Stefan, C. Schöb
Affiliations: Agroecology Group, ETH Zurich

Contribution to Action Track 2: The results of this study not only contribute to our understanding of the temporal dynamics in competitive plant–plant interactions but also have relevance for improving nutrient-use efficiency and designing species mixtures in sustainable intercropping systems.

Abstract: Intercropping has demonstrated yield advantages compared to monoculture cropping. These yield advantages have often been attributed to complementary resource use, but few studies quantified the temporal complementarity of nutrient acquisition and biomass production as a driver for yield benefits. Our understanding of how nutrient uptake change throughout the growing season and between different neighbors is limited. Here, we measured temporal trajectories of N and P uptake and biomass production by three crop species (oat, lupin and camelina) growing either as isolated plants, in monocultures or in intercropping systems. Additionally, we quantified organic acid exudation in the rhizosphere throughout the growing season. Oat intercropped with camelina accumulated more biomass, N and P than when intercropped with lupin. As this was not due to temporal differentiation of nutrient uptake or biomass growth, we suspect that root exudation of camelina could have improved performance of oat.



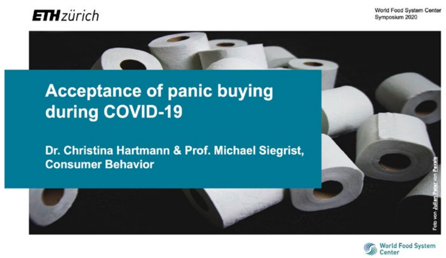


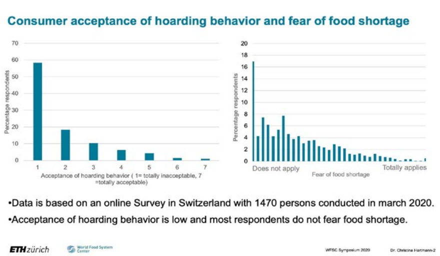
Title: Food shopping and panic buying in the time of COVID-19 pandemic

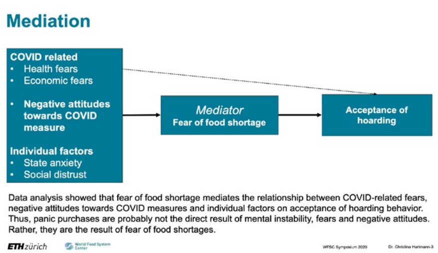
Authors: C. Hartmann, M. Siegrist
Affiliations: Consumer Behavior Group, ETH Zurich

Contribution to Action Track 1: Apart from a potential increase in food waste when people hoard foods, panic shoppers can cause a shortage of goods. This has a negative impact on the consumer behavior of others, puts a strain on the supply system and leads to feelings of insecurity among people.

Abstract: People rapidly change behavior during shock events. Panic buying are the result of such a rapid behavioral adaptation. Times in the past, which were characterized by difficult economic, political or social situations, panic buying was common. So far, however, the underlying psychological factors are largely unexplored. During the first COVID-19 wave in Europe, we conducted an online survey among 1400 Swiss citizens. In addition to socio-demographic factors, we investigated which psychological factors are associated with the fear of food shortages and the acceptance of panic buying. Among other things, economic and health fears, psychological instability, social distrust and the acceptance of governmental measures taken to contain the pandemic were surveyed. The results show that panic purchases are not the result of mental instability, fears and negative attitudes. Rather, they are solely the result of fear of food shortages. The underlying psychological and socio-demographic factors influencing the fear of food shortages were identified.





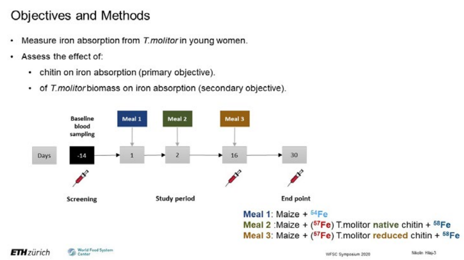


Title: Measuring dietary iron absorption from mealworms (*Tenebrio molitor*) in young women and assessing the effect of chitin on iron bioavailability: a stable isotope study

Authors: N. Hilaj, V. Galetti, R. Murad Lima, C. Zeder, M. Zimmermann, D. Moretti
Affiliations: Human Nutrition Laboratory, ETH Zurich

Contribution to Action Track 2: The projects links innovative nutritional questions (high iron bioavailability from insect foods) with the identification of insect species which have a potentially extremely low environmental footprint, in particular organisms reared on plant by-products such as compost and wood and food products issuing from side streams from the food production system (bran, spent grains).

Abstract: Iron deficiency is estimated to affect up to 1.5-2 billion people worldwide. Edible insects are considered as alternative sources of proteins, but in addition, are also rich sources of minerals and are likely to possess a substantially smaller environmental food print than meat. Mealworm (*Tenebrio molitor*) is recognized as an edible insect worldwide. Chitin, a major component of insect biomass, is a known iron binder. We hypothesize that decreasing chitin could allow the high amounts of iron in insects to be well absorbed, and enhance the absorption of iron from plant-based foods similar to the effect of meat. Our primary objective to measure dietary iron absorption from *T.molitor* with and without chitin in young women (primary objective). Secondly, we aim to assess the effect of the presence of mealworm biomass with and without chitin on iron absorption from iron present in low-phytate maize porridge meal.

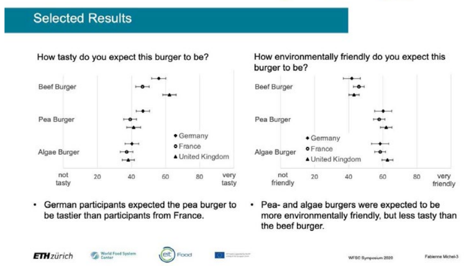


Title: Consumers' perception of meat alternatives containing pea or algae protein

Authors: F. Michel, A. Knaapila, C. Hartmann, M. Siegrist
Affiliations: Consumer Behavior Group, ETH Zurich; Department of Food and Nutrition, University of Helsinki

Contribution to Action Track 2: By examining consumers' perceptions and expectations towards new and sustainable protein sources such as pea and algae, this research contributes to the knowledge that is needed to guide consumers towards more sustainable protein sources compared to the traditional animal-based protein.

Abstract: Within recent years, demand as well as supply of products to replace meat, so called meat alternatives, have increased. For future products, new plant-based protein sources are of high interest. Protein from pea and especially from algae provide huge potential for human nutrition as well as for the environment. To provide insight on consumers' perception for the development of new meat alternatives, this study investigated consumers' opinions of pea and algae burgers compared to the traditional beef burger in terms of taste, health, and environmental friendliness. The online survey was conducted with meat-eating participants from Germany (N=567), France (N=605), and the United Kingdom (N=562). Participants in all three countries expected pea and algae burgers to be less tasty, but healthier and more environmentally friendly compared to the beef burger.

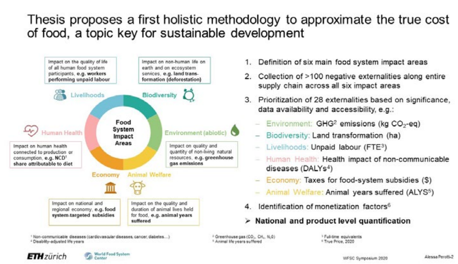


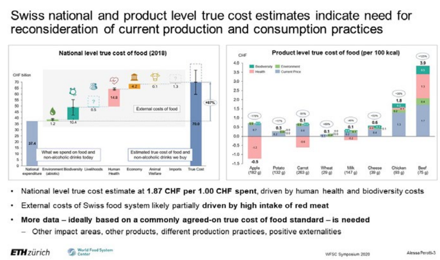
Title: The true cost of food in Switzerland

Authors: A. Perotti, J. Six, M. Sonnevelt
Affiliations: Sustainable Agroecosystems, ETH Zurich

Contribution to Action Track 2: A common understanding of the true cost of food is the basis for the transition to a sustainable food system, where sustainable choices are facilitated along the entire value chain - therefore enabling and supporting sustainable consumption patterns.

Abstract: A standard for identifying food system impacts, their measurement and cost is key for food system transformation. This thesis proposes an initial methodology to calculate the true cost of food. Based on 28 prioritized food system externalities affecting the environment, biodiversity, livelihoods, human health, economy and animal welfare, it then approximates the true cost of the Swiss food system and eight conventionally produced Swiss products. National level external costs are estimated at 0.87 (0.61-1.12) CHF per CHF spent. Beef, chicken and cheese - per 100 kcal and based only on environment, biodiversity and human health costs - cause the highest external costs: 2.14 CHF (125% above retail price), 0.49 CHF (+38%) and 0.20 CHF (+53%). The results illustrate the urgency of (Swiss) food system transformation. As the basis for concrete reduction targets and increased policy coherence, Swiss food system stakeholders are called to co-create a true cost of food standard.



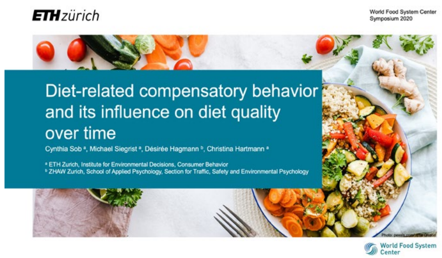


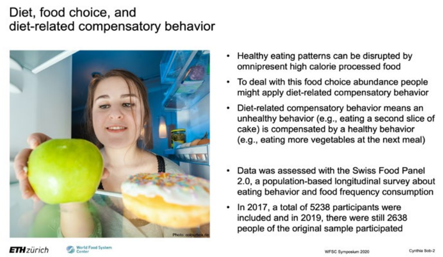
Title: Diet-related compensatory behavior and its influence on healthy weight management and diet quality

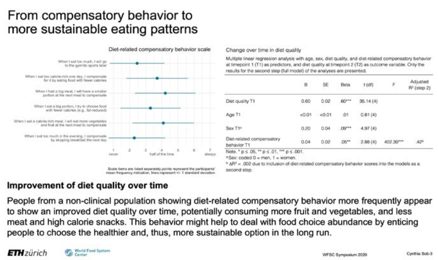
Authors: C. Sob, M. Siegrist, D. Hagmann, C. Hartmann
Affiliations: Consumer Behavior Group, ETH Zurich

Contribution to Action Track 2: By examining how consumers interact with the abundance of food choice, it is possible to detect specific eating habits promoting healthier and more sustainable food choices over time, eventually contributing to a shift to more sustainable consumption patterns.

Abstract: Assessing eating behavior patterns contribute to the examination and promotion of healthier and more sustainable food consumption patterns. The aim of the present study was to examine the role of diet-related compensatory behavior regarding diet quality, physical activity, and body mass index (BMI) over time. The adapted items measuring diet-related compensatory behavior were shown to be valid and reliable. On a longitudinal level, the results show that diet-related compensatory behavior was a significant predictor for change in physical activity and diet quality. With a higher tendency for diet-related compensatory behavior, physical activity and diet quality increased/improved after two years. No effect was found for changes in BMI over time. Therefore, when applied in healthy doses, diet-related compensatory behavior may contribute to the maintenance of a balanced and healthy body weight, and contribute to healthier and more sustainable food choices (more fruit and vegetables, less meat) over time.





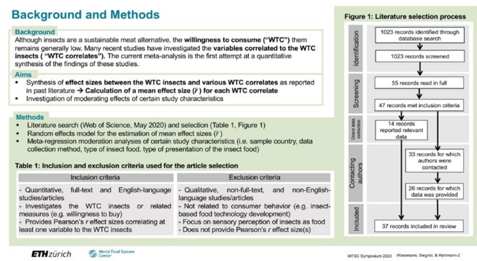


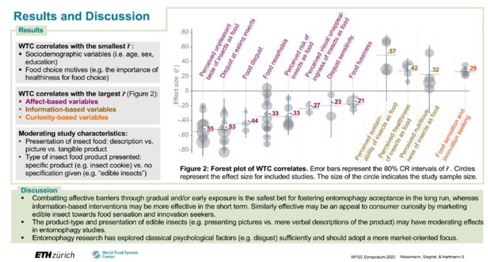
Title: Correlates of the willingness to consume insects: A meta-analysis

Authors: B. Wassmann, M. Siegrist, C. Hartmann
Affiliations: Consumer Behavior Group, ETH Zurich

Contribution to Action Track 2: Although insects are a sustainable meat alternative, the willingness to consume (WTC) them remains generally low. Synthesizing the effect sizes of WTC correlates reported in past research could help with identifying barriers and potential avenues for entomophagy acceptance.

Abstract: Although insects are a sustainable meat alternative, the willingness to consume (WTC) them remains generally low. We synthesized WTC correlates across 37 studies and also investigated moderating effects of certain study characteristics. Affect-based factors (such as food neophobia, disgust and the expected taste of insects) were consistently strongly correlated with WTC, followed by information-based factors (such as the perceived sustainability of edible insects and the perceived nutritiousness of edible insects). Curiosity factors, specifically food sensation and innovation seeking, also positively impacted WTC. Combatting affective barriers through gradual and/or early exposure will help foster entomophagy acceptance in the long run, whereas information-based interventions may be more effective in the short term. The presentation of the edible insects (e.g. specific vs. non-specific products; pictures vs. verbal descriptions of the products) may have moderating effects in entomophagy studies. Entomophagy research has explored classical psychological factors sufficiently and should adopt a more market-oriented focus.



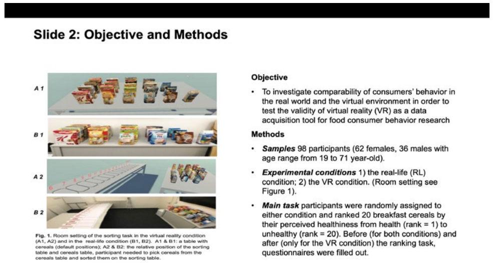


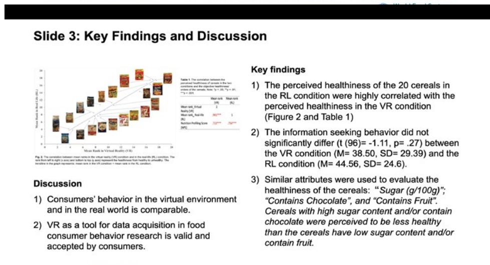
Title: The comparability of consumers' behavior in virtual reality and real life based on a cereal ranking task

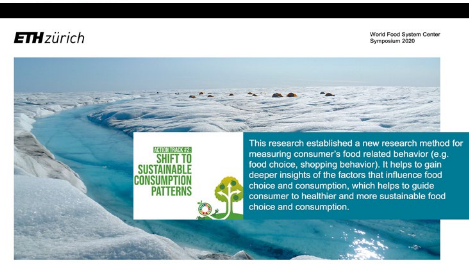
Authors: C. Xu, Y. Demir-Kaymaz, C. Hartmann, M. Menozzi, M. Siegrist
Affiliations: Consumer Behavior Group, ETH Zurich

Contribution to Action Track 2: This research established a new research method for measuring consumer's food related behavior (e.g. food choice, shopping behavior). It helps to gain deeper insights of the factors that influence food choice and consumption, which helps to guide consumer to healthier and more sustainable food choice and consumption.

Abstract: This study investigated the comparability of consumer's behavior in virtual reality (VR) and real-life (RL) to validate VR for data acquisition in consumer behavior (CB) research. Participants (N = 98) were randomly assigned to a RL or a VR condition. In both conditions, participants ranked 20 cereals by their perceived healthiness from healthy to unhealthy. We observed that the perceived healthiness of the cereals in the two conditions were highly correlated ($r_s = 0.91$, $p < .001$, $N = 20$). Furthermore, the information-seeking behavior and the attributes employed by participants to evaluate the healthiness of the cereals did not vary between the two conditions. The results illustrate that the participants' behavior in VR and in RL were comparable, which provides robust evidence for the validity of VR as a promising tool for data acquisition in CB research.





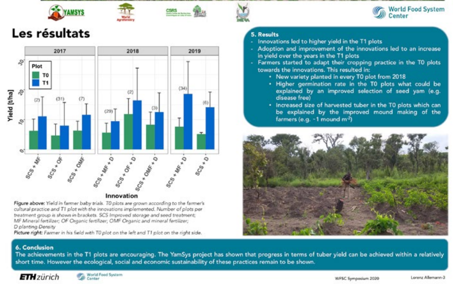


Title: Improving yam cropping systems in West Africa - YamSys

Authors: L. Allemann, L. Diby, V. Hgaza, D. Kiba, A. Kangah, E. Frossard
Affiliations: Plant Nutrition Group, ETH Zurich; World Agroforestry Centre ICRAF, Côte d'Ivoire; Centre Suisse de Recherches Scientifiques en Côte d'Ivoire CSRS, Côte d'Ivoire; Institut de l'Environnement et Recherches Agricoles INERA, Burkina Faso

Contribution to Action Track 3: The interdisciplinary approach of the YamSys project allows to take the cultural and socio-economic conditions into account. This enables a higher acceptance of the (nature-positive) developed innovations and facilitates an adaptation to food systems on a larger scale.

Abstract: Yam (*Dioscorea spp.*) is a tuber crop and the staple food of over 155 million people world- wide. In the last decades its cultivation in West Africa has increased, whilst yield per hectare has decreased. This can be attributed to the traditional cropping practice.
To address this issue, the YamSys project was launched in 2015. Its goal is the development and implementation of sustainable yam cropping practices resulting in increased crop productivity, food security, profitability and environmental sustainability in selected ecological zones in West Africa.
The approach of forming interdisciplinary innovation platforms enables co-development of innovations and increases the biophysical, institutional and economical acceptance of innovations implemented. These innovations have shown to significantly increase yield per hectare. Additionally, it was observed that farmers adapted their conventional cropping practices towards these innovations. The improvements achieved are now to be extended to a national level to further support sustainable impact on food systems.

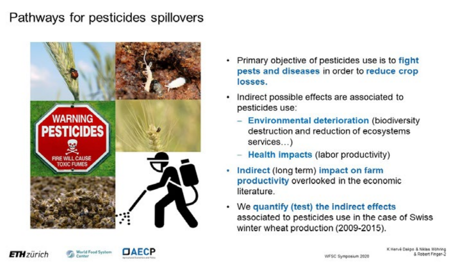


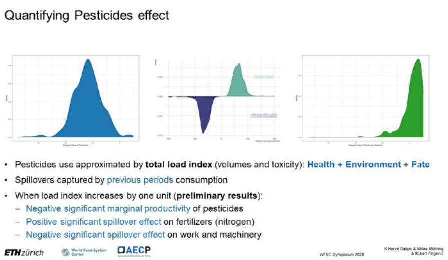
Title: Pesticide load and agricultural productivity: the case of Swiss winter wheat producers

Authors: K. H. Dakpo, N. Möhring, R. Finger
Affiliations: Agricultural Economics and Policy Group, ETH Zurich; Economie Publique, INRAE

Contribution to Action Track 3: Our research sheds light on how pesticide spillovers on health and the environment affect agricultural output. It therefore contributes to the understanding of long-term adverse effects of chemical pest control.

Abstract: Apart from their primary role of protecting crops from pests and diseases, pesticides negatively affect the environment and the human health. This directly and indirectly affects agricultural production and its ability to deliver ecosystem services. We here investigate how spillovers of pesticides on human health and the environment can adversely affect agricultural productivity, using Swiss wheat production as case study. In our analysis, we use an indicator of potential environmental and health effects of pesticides as a proxy of pesticides spillovers. We construct a production technology using an output damage specification and assess the effect of potential spillovers on productivity using farm-level data over the period 2009-2018. Accounting for all scenarios our preliminary results reveal significant and negative spillovers of pesticides on land productivity. Thus, we find a feedback loop that pesticide use reduces land productivity e.g. because of a decrease of soil fertility and the reduction of pesticides efficacy.



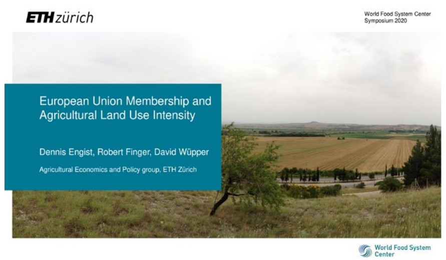


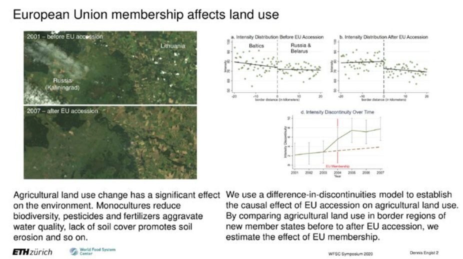
Title: European Union membership and agricultural land use intensity: Evidence from changes in border discontinuities

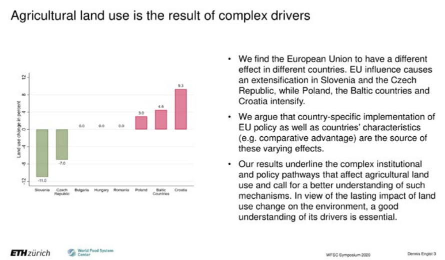
Authors: D. Engist, R. Finger, D. Wüpper
Affiliations: Agricultural Economics and Policy, ETH Zurich

Contribution to Action Track 3: We demonstrate that a far-reaching large policy change such as EU membership can have a substantial impact on agricultural production intensity and, in turn, the environment. Our results underscore the importance of holistic assessments of policy changes regarding environmental impacts.

Abstract: Agricultural land use is globally among the most important drivers of environmental change and directly affects the livelihoods of billions of people. Understanding the political and institutional drivers of agricultural land use changes is pivotal for the design of sustainable land use policies. However, establishing causality is a challenge, especially at larger scales, as confounding factors are ubiquitous. Here, we use a spatial difference-in-discontinuities design and a large panel dataset of state-of-the-art land use classifications to identify the causal effect of joining the European Union on agricultural land use intensity. We exploit changes in satellite obtained land-use intensity at borders of countries that joined the European Union since 2004. We find that entering the European Union significantly changed agricultural land use in most countries – but not uniformly. The effect of European Union accession ranges from an 11% extensification in Slovenia to a 9% intensification in Croatia.





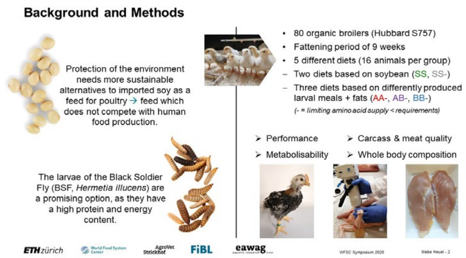


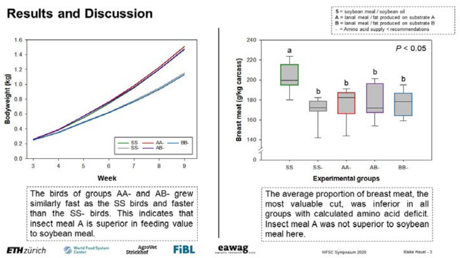
Title: Can Black Soldier Fly larvae meal replace soybean meal as a protein source in broilers?

Authors: M. Heuel, C. Sandrock, F. Leiber, A. Mathys, M. Gold, C. Zurbrügg, I. D.M. Gangnat, M. Kreuzer M. Terranova
Affiliations: Animal Nutrition Group, ETH Zurich

Contribution to Action Track 3: Reducing dependence on imported soybean in poultry nutrition requires implementing resilient alternative protein sources of a similar high quality that can be produced locally in large quantities. One alternative could consist of protein from Black Soldier Fly larvae.

Abstract: The effects of Black Soldier Fly (BSF) larvae-based feeds as a potential source of both, protein and energy in different diets were investigated in a broiler experiment. Protein meal and fat was obtained from larvae raised on two regulated substrates and integrated into the broilers' diet to completely replace soybean meal and oil. Sixteen broilers (Hubbard S757) each were fattened for 9 weeks according to swiss organic guidelines on one of five diets each. In order to determine the protein value of the insect material relative to that of soybean meal, a theoretical protein deficiency was induced in four of the diets. Various parameters of growth and slaughter performance as well as meat quality were determined. The results suggest that BSF larvae as a feed can fully replace soybean components in the diet. Under supposedly limited protein supply, broilers even performed better on one larval-based feeds than soybean-fed broilers.



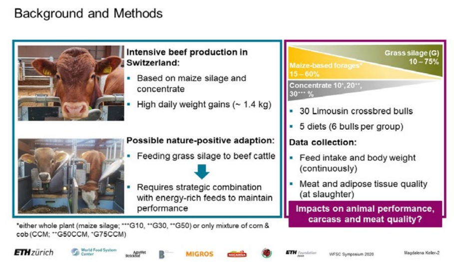


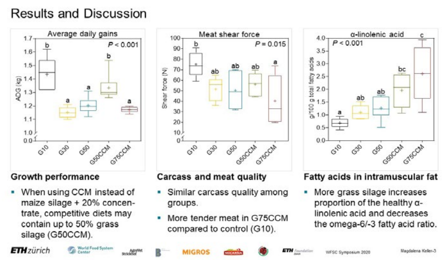
Title: Reducing feed-food competition by using elevated proportions of grass silage in intensive beef production: effects of complementation with maize silage or corn-cob mix

Authors: M. Keller, M. Kreuzer, B. Reidy, A. Scheurer, K. Giller
Affiliations: Animal Nutrition Group, ETH Zurich

Contribution to Action Track 3: The sustainability of Swiss intensive beef production systems can be improved by elevating dietary levels of grassland-derived feeds not competing with human food supply by building on the ruminant's ability to turn human-inedible biomass in valuable protein for human consumption.

Abstract: European intensive beef production systems typically rely on maize silage and concentrate feeding – feeds grown on arable land, thus competing with food production. Feeds from grasslands are used only in limited amounts as an impaired animal performance is anticipated due to lower energy contents of such feeds. In an experiment the effects of feeding 10, 30, 50 or 75% of grass silage supplemented with either maize silage or dried Corn-Cob-Mix (CCM) and limited concentrate supply to growing bulls on fattening performance, and carcass and meat quality were evaluated. A dietary proportion of 50% grass silage, supplemented with CCM, and a concomitantly limited concentrate supply, allowed to maintain a similar animal performance, carcass and meat quality when compared to a common maize-silage concentrate diet. Consequently, a strategic combination of energy-rich feeds offers alternative feeding strategies based on using grassland-derived feeds in intensive beef production.



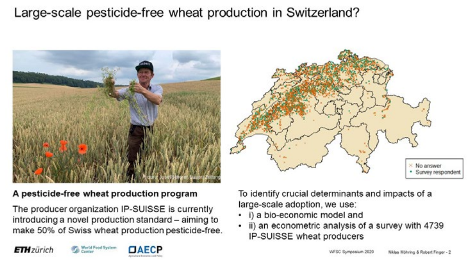


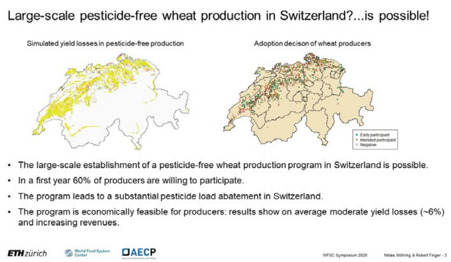
Title: PestiFreeWheat – adoption of a large-scale pesticide-free wheat production standard in Switzerland

Authors: N. Möhring, R. Finger
Affiliations: Agricultural Economics and Policy Group, ETH Zurich

Contribution to Action Track 3: The sustainable intensification of agriculture requires new, large-scale pesticide-free production systems. We analyze determinants and barriers for farmers' adoption of Swiss pesticide-free wheat production. The program has large pesticide reduction potentials and is the first of its kind worldwide.

Abstract: The sustainable intensification of agriculture requires the development of innovative, pesticide-free production systems. In Switzerland, the producer organization IP-SUISSE, representing 50% of wheat production, has recently introduced a novel, non-organic, pesticide-free wheat production standard. The program has large pesticide reduction potentials and is the first of its kind worldwide. We analyze determinants and barriers for farmers' adoption of pesticide-free wheat production. For our analysis, we combine a survey with all IP-SUISSE wheat producers (4749 farmers, 23.3 % response rate) with data on farm-level yields, soil properties, weather, climate, weed pressure and spread of herbicide resistances. Our results show that the majority of farmers are interested in adopting the program. Thus, a large-scale implementation of pesticide-free wheat production is possible in Switzerland. Farmers' expectations of positive environmental effects of the program, as well as expected yield decreases and increases of production risks are key for adoption decisions.



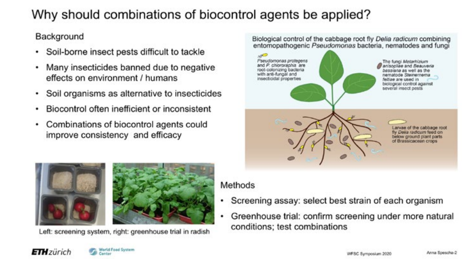


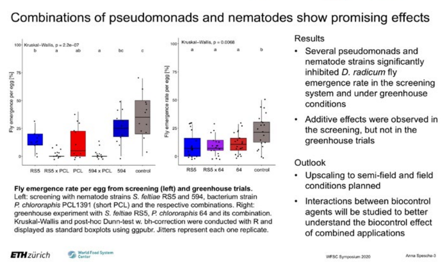
Title: Biological Control: Fighting below ground insect pests with entomopathogenic *Pseudomonas* bacteria, nematodes and fungi

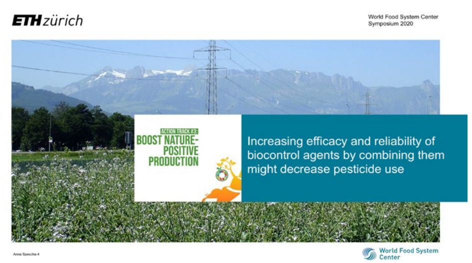
Authors: A. Spescha, M. Brunner, J. Weibel, F. Scheibler, F. Gillieron, S. Müller, A. Guyer, R. Campos-Herrera, G. Grabenweger, M. Maurhofer
Affiliations: Institute of Integrative Biology, ETH Zurich; Plant Protection Unit, Agroscope, Zurich; Institute of Grapevine and Wine Sciences, Spain

Contribution to Action Track 3: Increasing efficacy and reliability of biocontrol agents by combining them might decrease pesticide use

Abstract: Below ground pests are difficult to control because either no effective control methods exist or suitable insecticides are or will be banned due to their negative effects on the soil and non-target organisms. We evaluate the potential of a specific group of plant-beneficial fluorescent *Pseudomonas* bacteria with entomopathogenic activity for insect control. In a first screening, Pseudomonas strains were successfully tested against the cabbage root fly Delia radicum, an important pest in vegetable production. These promising *Pseudomonas chlororaphis* strains were further evaluated and combined with entomopathogenic fungi (EPF) and entomopathogenic nematodes (EPN), which are already well-established biocontrol agents used in organic production. First results suggest that these biocontrol agents can be used in combination as the different organisms did not inhibit each other's infectiousness. We will further evaluate the efficacy of selected combinations under field conditions and hopefully provide a new approach for the biological control of soil-dwelling pest insects.



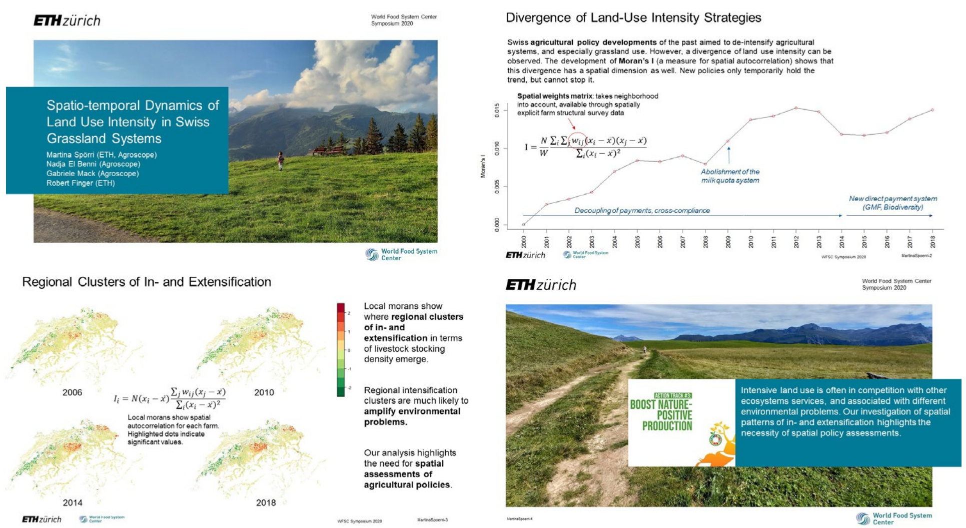




Title: Spatio-temporal dynamics of land use intensity in Swiss grassland systems
Authors: M. Spörri, N. El Benni, G. Mack, R. Finger
Affiliations: Agricultural Economics and Policy Group, ETH Zurich

Contribution to Action Track 3: Intensive land use is often in competition with other ecosystems services, and associated with different environmental problems. Our investigation of spatial patterns of in- and extensification highlights the necessity of spatial policy assessments.

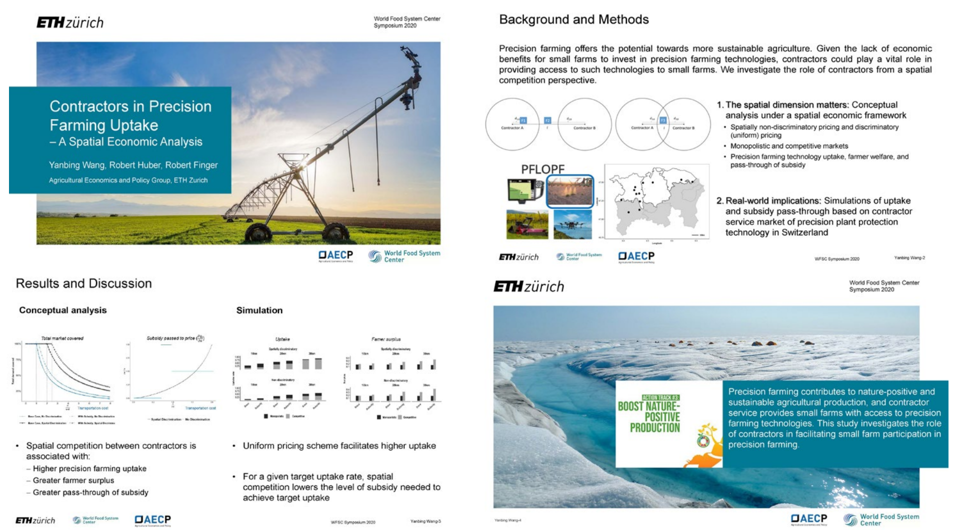
Abstract: Land use intensity determines the provision of multiple important ecosystems services and disservices of agriculture. Swiss agricultural policy developments of the past aimed to de-intensify agricultural systems, and especially grassland use. We provide a spatial and temporal assessment of grassland use intensity changes to assess policy impacts. We use spatially explicit farm-level census data over the 2000-2018 period to investigate patterns of in- and extensification over time and space. We find that while average changes over time in grassland use intensity are small, there is a substantial increase in heterogeneity in grassland use intensity strategies over time. Our analysis shows the emergence of regional clusters of ex- and intensification. The emergence of the latter amplifies environmental problems. Thus, our analysis highlights the need for spatial assessments of agricultural policies.



Title: Contractors in precision farming uptake – A spatial economic analysis
Authors: Y. Wang, R. Huber, R. Finger
Affiliations: Agricultural Economics and Policy Group, ETH Zurich

Contribution to Action Track 3: Precision farming offers the potential towards more sustainable agricultural production, and contractor service provides access to precision farming technologies to small farms. This study investigates the role of contractors in expanding the scale of small farm adoption in precision farming.

Abstract: Contractors will play a vital role in providing farms access to new precision farming technologies, especially in small scale farming systems. We investigate the role of spatial competition among contractors in the uptake of precision farming, the distribution of farmer surplus, and the realization of policy interventions, accounting for alternative spatial pricing schedules. Conceptual and simulation analyses show that a lack of spatial competition among contractors hinders uptake of precision farming technology and farmer surplus. The effectiveness of policy interventions to support precision farming among small farms is also contingent on the market structure and pricing schedules of contractors.

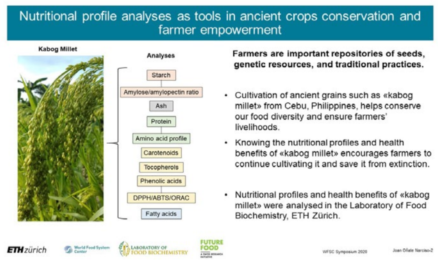


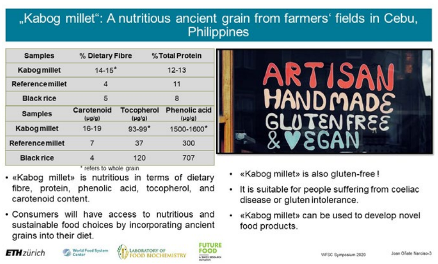
Title: Ancient grain Kabog millet: Empowering farmers through food science research

Authors: J. O. Narciso, L. Nystrom
Affiliations: Laboratory of Food Biochemistry, ETH Zurich

Contribution to Action Track 4: Ancient grains are good sources of nutrients. In economics, they are not dependent on the global market, unlike the major crops (e.g., rice, wheat); hence, they provide farmers a sustainable livelihood and contribute to resilience to vulnerabilities in food systems.

Abstract: Consumption of underutilised ancient grains has huge benefits for our society. It improves food security by diversifying our staple foods and makes our agriculture more adaptable to climate change. Ancient grains possess good nutritional profiles and resilience towards extreme climate conditions. They are cultivated globally, but mostly concentrated in specific regions, and many of them have sustained indigenous cultures for millenia. However, these ancient grains have been pushed towards oblivion by the introduction of high-yielding rice and wheat varieties. Putting them back on our plate will help small-scale farmers and their families preserve their livelihoods. In addition, consumers will have access to safe and nutritious food. Promoting the consumption of ancient grains, alongside the world's major crops, will also help our complex food systems become resilient in the face of a global catastrophe, such as the current pandemic.



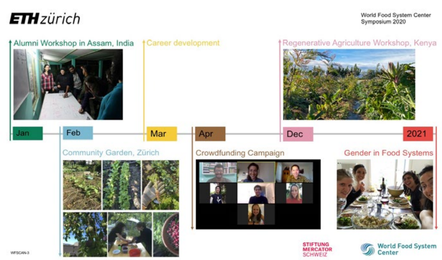


Title: The World Food System Center Alumni Network (WFSCAN)

Authors: M. Wiget, V. Loaiza, N. Bartolome
Affiliations: World Food System Center, ETH Zurich

Contribution to Action Track 4: The WFSCAN supports equitable livelihoods by contributing to collaborative projects on equity and equality issues within sustainable food systems. Further, the WFSCAN helps alumni as community setting up projects and in their career paths to promote equal opportunities.

Abstract: The WFSCAN consists currently of 118 alumni from 54 countries. We all have different backgrounds but are passionate fascinated about the food system. The network's vision is to support alumni-driven initiatives that foster connecting, learning and contributing towards sustainable food systems.
Some examples of 2020 initiatives are: (1) a workshop in India where an alumni group supported another alumnus to find potential solutions to some challenges he faces on his organic farm, (2) a project about the impact of COVID-19 in food systems initiated by an international group of alumni, and (3) more local, in Zürich, an alumni group cultivated together in a community garden where not only delicious food is harvested but also interesting activities take place, such as an open-air movie night. The network also shares ideas, job opportunities, and reading material on an online platform. In 2021, the WFSCAN aims to develop into a self-sustained association.

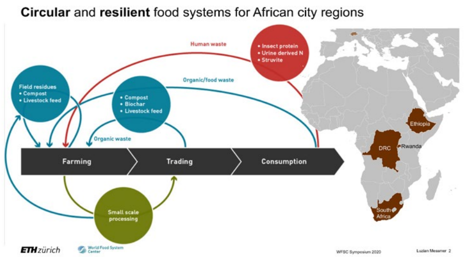


Title: RUNRES: Establishing a circular economy for resilient city region food systems

Authors: B. Wilde, L. Späth, M. Surchat, L. Messmer
Affiliations: Sustainable Agroecosystems Group, ETH Zurich; TdLab, ETH Zurich

Contribution to Action Track 4: Circular economy involves a re-configuration of production and consumption systems and reshaping our relationship to natural resources and their value. It is a systemic approach which results in a combination of actions and a research for synergies on different scales.

Abstract: City regions worldwide have growing quantities of nutrient-rich waste accumulating in urban cores. Meanwhile, the rural periphery suffers soil depletion and a lack of farming inputs to amend soils and achieve sustainable intensification. The high urbanization rate and the intensification of production systems in sub-Saharan Africa, aggravate the resource paradox rapidly. To address this issue, we propose to install nutrient-based circular economies linking the rural periphery with the urban core. However, for a functioning circular economy, we need to understand (1) viable products, (2) their markets, and (3) the motivation of stakeholders to take action. Case studies in Kigali, Bukavu, Arba Minch and Msunduzi will build knowledge on circular economies and on how to research complex dynamic systems. It will also reinforce a view going beyond linear, monodisciplinary development problems towards a transdisciplinary understanding. This view is urgently needed for a system transformation from which the most underprivileged will benefit.

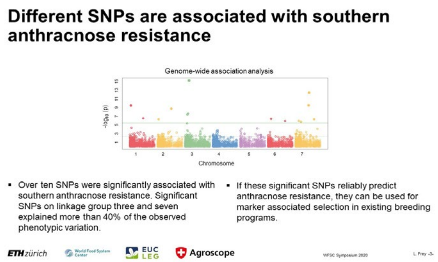


Title: Elucidating the genetic control of southern anthracnose resistance in a diverse set of red clover accessions

Authors: L. Frey, F. X. Schubiger, B. Studer, R. Kölliker
Affiliations: Molecular Plant Breeding, ETH Zurich

Contribution to Action Track 5: Grassland-based ruminant livestock production allows to sustainably produce high quality protein for the human diet. Supplying conventional and organic farming systems with adapted forage crop cultivars resistant to prevalent pathogens is crucial to ensure stability and productivity of such production systems.

Abstract: Red clover (*Trifolium pratense L.*) is an important forage legume of temperate regions, particularly valued for its high yield potential and its high forage quality. A world-wide collection of 395 red clover accessions was genotyped using a pooled genotyping by sequencing approach. Resistance to southern anthracnose, caused by *Colletotrichum trifolii*, was assessed in the greenhouse using spray inoculation. Mean survival rate for single and mixed isolate inoculation was 23% and 15%, respectively. Genome-wide association analysis revealed few loci, which were significantly associated with the trait and may represent promising candidate genes for anthracnose resistance. If these associated regions reliably predict the phenotypic trait they can be used for markers associated selection. Although we detected a few accessions with considerable resistance (survival rates > 50%) in the entire collection, the majority of the accessions were highly susceptible. This highlights the urgent need to improve resistance to southern anthracnose in red clover.

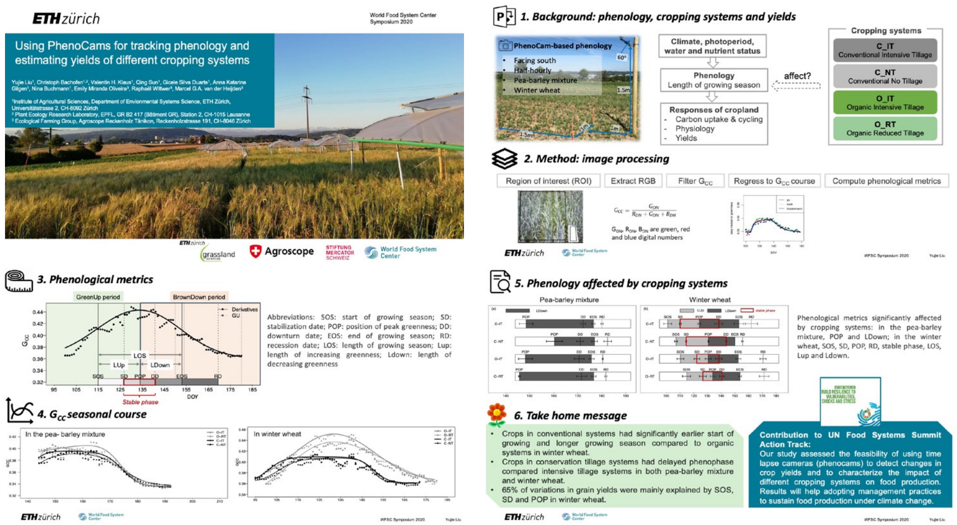


Title: Using PhenoCams for tracking phenology and estimating yields of different cropping systems

Authors: Y. Liu, C. Bachofen, V. Klaus, G. S. Duarte, Q. Sun, A. K. Gilgen, E. Oliveira Hagen, R. Wittwer, M: G.A. van der Heijden, N. Buchmann
Affiliations: Grassland Sciences group, ETH Zurich; Plant-Soil-Interactions group, Agroscope Zurich

Contribution to Action Track 5: Our study assessed the feasibility of using time lapse cameras (phenocams) to detect changes in crop yields and to characterize the impact of different cropping systems on food production. Results will help adopting management practices to sustain food production under climate change.

Abstract: Variations in timing of plant development affect many ecosystem functions such as productivity. Organic farming and conservation tillage provide many ecological benefits, but may also impact crop phenology. Our study aims at understanding how different cropping systems affect crop phenology and yields as a consequence.
We extracted the daily relative greenness index of an unfertilized pea-barley mixture (PB) and fertilized winter wheat (WW) from time-lapse camera images. Early stage phenological phases were strongly affected by cropping systems, with a later start of crop growth and later occurrence of peak greenness in organic compared to conventional systems. Grain yields were significantly lower in organic systems than conventional systems in WW but not in PB. We were able to explain up to 65% of the variance in WW yields with three phenological metrics. Thus, it is possible to follow crop phenology and predict yields with camera-based metrics in fertilized croplands.



Title: Exploring funding options to forest landscape restoration in the global tropics

Authors: S. Löfqvist, R. Garrett, J. Ghazoul
Affiliations: Environmental Policy Lab, ETH Zurich; Ecosystem Management Lab, ETH Zurich

Contribution to Action Track 5: Restoring forests and landscapes across the global tropics is crucial to build resilience in ecosystems and to promote agroforestry. Lack of funding is a core issue in upscaling restoration. This project explores how finance for restoration can be unlocked.

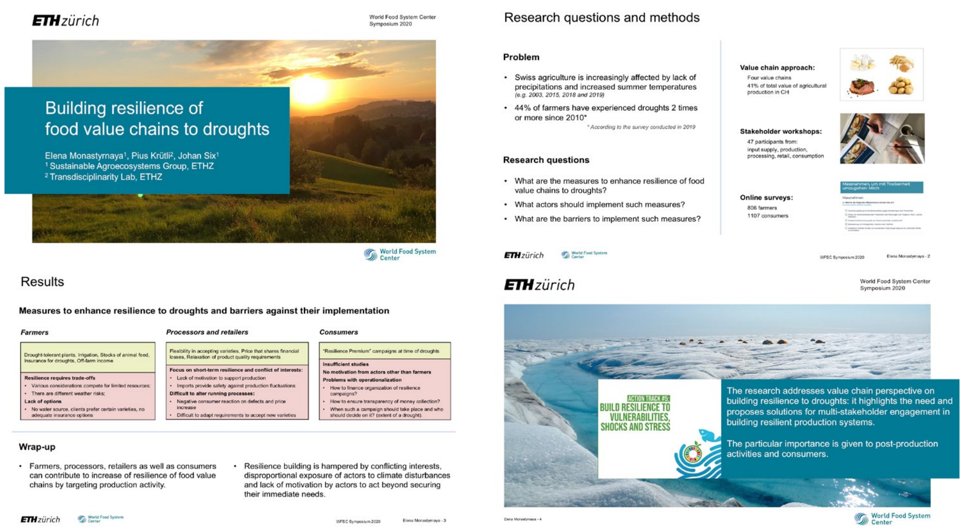
Abstract: Forest landscape restoration across the global tropics is of crucial importance to reverse biodiversity loss, mitigate climate change, and support global food security. A core barrier for reaching global restoration goals is lack of funding, and though restoration is believed to have a strong economic incentive, funding remains well below needs. In this research we use semi-structured interviews with investors, corporations, restoration funding brokers, and public funding actors, to assess what motivates and hinders these actors to fund restoration. The aim of the study is to assess under what circumstances different actors are likely to fund different types of restoration interventions, and how current barriers can be alleviated.

Title: Building resilience of food value chain to droughts

Authors: E. Monastyrnaya, P. Krütli, J. Six
Affiliations: Sustainable Agroecosystems Group, ETH Zurich

Contribution to Action Track 5: The research addresses value chain perspective on building resilience to droughts: highlights the need and proposes solutions for multi-stakeholder engagement in building resilient production systems. The particular importance is given to post-production activities and consumers.

Abstract: The research presents measures to increase resilience of the value chains to drought identified by stakeholders at the workshops. While the measures target to increase resilience of value chains, they are mostly focused on the production activity and are aimed to avoid production disruptions and mitigate economic losses among farmers. While some of these measures (e.g. irrigation, drought-resistance varieties, off-farm income) can be implemented by farmers themselves, other measures (e.g. compensating prices, adjustment of quality requirements) require interventions from stakeholders including post-production actors (processors, retailers) as well as consumers. However, our results indicate that such implementation is hampered by conflicting interests, disproportional exposure of actors to climate disturbances and the lack of motivation by the actors to act beyond securing their own operational needs.

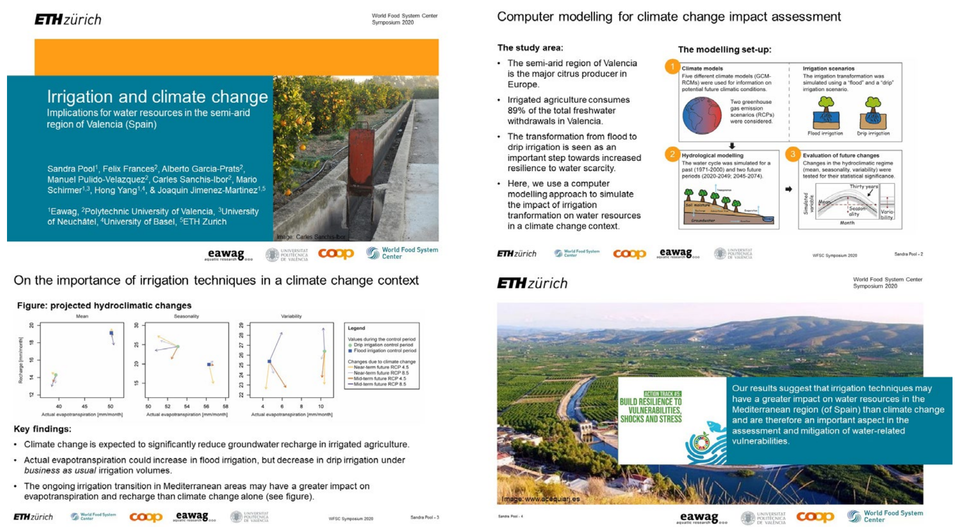


Title: Irrigation and climate change: implications for water resources in the semi-arid region of Valencia, Spain

Authors: S. Pool, F. Frances, A.Garcia-Prats, M. Pulido-Velazquez, C. Sanchis-Ibor, M. Schirmer, H. Yang, J. Jimenez-Martinez
Affiliations: Water Resources and Drinking Water, Eawag; Systems Analysis, Integrated Assessment and Modelling, Eawag; Research Institute of Water and Environmental Engineering (IIAMA); Valencian Center for Irrigation Studies, Polytechnic University of Valencia; Centre of Hydrogeology and Geothermics (CHYN), University of Neuchâtel; Environmental Science, University of Basel; Civil, Environmental and Geomatic Engineering, ETH Zurich

Contribution to Action Track 5: Our results suggest that irrigation techniques may have a greater impact on water resources than climate change and are therefore an important aspect in the assessment and mitigation of water-related vulnerabilities.

Abstract: The region of Valencia is one of the major citrus producers in Europe. Valencian agriculture heavily relies on irrigation and consumes 89% of the total regional freshwater withdrawals. Climate change is expected to add additional pressure on water resources as precipitation might decrease and the occurrence of droughts might increase. To improve the resilience to water scarcity, the Spanish and Valencian governments have been promoting the transformation from flood to drip irrigation. In this study, we assess the relative role of irrigation techniques and climate change for the availability of future water resources. Our findings suggest that climate change could lead to significant changes in actual evapotranspiration and groundwater recharge. However, the choice of an irrigation technique may have a greater impact than climate change itself. We therefore highly recommend to consider both climate change and irrigation technique when assessing future water resources in irrigated Mediterranean agriculture.

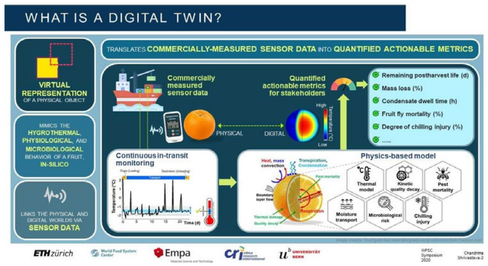


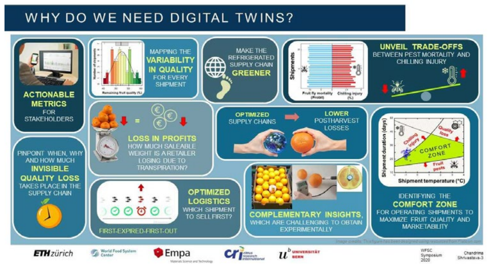
Title: How can digital twins reduce food loss in postharvest supply chains?

Authors: C. Shrivastava, T. Berry, P. Cronje, T. Defraeye
Affiliations: Laboratory for Biomimetic Membranes and Textiles, Empa St. Gallen; ARTORG Center for Biomedical Engineering Research, University of Bern; Citrus Research International, University of Stellenbosch (South Africa)

Contribution to Action Track 5: A substantial amount of fresh produce is lost due to unpredictable boundary conditions in supply chains, such as cooling interruptions or logistical mismanagement. Our research pinpoints where and why these vulnerabilities lower product quality, and how these critical loss points can be mitigated to reduce postharvest losses.

Abstract: Postharvest supply chains must continuously maintain a narrow hygrothermal window around fresh produce, to preserve its quality and consumer acceptability. However, every shipment has a unique hygrothermal history, including possible cooling interruptions, routing delays, and handling by multiple stakeholders. To identify when, why, and how much quality and marketability is lowered for every shipment, we developed a physics-based digital twin for a fruit. This digital twin employs mechanistic simulations to mimic the fruit's physical, physiological, and microbiological behavior in-silico. It is linked with commercially-measured real-world data of the environmental conditions in shipments. We demonstrated this for the trans-continental citrus export supply chain. Here, we characterized the ideal tradeoff window for maintaining fruit quality, while also killing fruit fly pests based on international protocols, and avoiding chilling injury. Our findings can help maximize fruit shelf life at the retailer's store and reduce postharvest losses, so that maximum fresh produce can reach consumers.





ETH Zürich
World Food System Center
Stampfenbachstrasse 52
STE K15
8092 Zurich

www.worldfoodsystem.ethz.ch

Layout & Content: Nathalie Manetti and Jeanne Tomaszewski