Status Seminar PLANT 2030
Speakers Corner Report – A Market of Ideas

Energy and Raw Material Efficiency

Sustainability and Yield

Food and Lifestyle

Environment and Biodiversity

Content

Preamble – The great challenges in future plant research

Growing demand

The demand for food and renewable raw materials will rapidly increase in the coming decades. The United Nations Organization (UNO) estimates that by the year 2050 more than 9 billion people will populate the world. Today we already count 7 billion. With growing prosperity the demand for meat will increase by 75% to nearly 470 million tons until 2050. To produce one kilogram of meat, depending on the animal, one and a half to three kilograms of feed is needed. Also, the energy and resource consumption is increasingly growing and competing with food production. Biogenic resources step by step should replace the scarce fossil raw materials. This change also has to be brought forward with regards to climate and environmental protection.

Limiting factors

According to estimates, the agricultural production must more than double by 2050 in order to meet the increasing demand. The usable agricultural production areas - currently about 760 million hectares – can hardly be expanded any further. According to the Food and Agriculture Organization of the United Nations (FAO) a maximum of 90 million hectares of land could be additionally utilized. Therefore the required yield increase must be covered by higher and increasing productivity. But, climate change will reduce yield stability worldwide, we will face marginalization of formerly fertile soils (e.g. drought, salinization and overfertilization) water and nutrient resources will become scarce and expensive. Agriculture also contributes significantly to climate change and environmental degradation: 70% of the global water use and 30% of greenhouse gas emissions account to agriculture.

Urbanization and food distribution

Food distribution is a key factor. Nearly every seventh person suffers from hunger and half of them are farmers. Social unrest is one consequence of unfair food distribution. This hunger is not only caused by unproductive farming techniques, drought or high food prices but also by high post-harvest losses, lack of transport and storage infrastructure and food waste. Especially the poor people in developing countries are threatened by malnutrition and its consequences: physical and cognitive damage, an increased vulnerability, declining productivity. Hunger is one of the reasons for the migration of the rural population to urban areas. It is estimated that in 2050 approximately 70% of the world's population will live in cities. Therefore an effective food distribution is becoming more important. Additionally the importance of processed food, packaging and logistics across the supply chain increases in cities.

Concept

Speakers Corner – A Market of Ideas During the Plant 2030 Status Seminar 2012

Goal

The goal is to develop long-term threads from the plant research point of view for innovative and interdisciplinary R&D projects within the framework of the national research strategy "BioEconomy 2030". The voices of those junior scientists who contribute their visions/ideas should find particular consideration here. Strategic lines for a continued discussion, i.e. as World Cafés during the Status Seminar 2013, are to be developed and condensed.

Tool / Method

The "Speakers Corner – A Market of Ideas" is to be a tool with which to set impulses and to catch as well as condense a broad spectrum of ideas. The "Speakers Corner" is a meeting place during the Status Seminar 2012 in Potsdam. For 2.5 hours the speakers corners are stages on which ideas, concepts and comprehensive approaches will be shaped. Focus subjects and instigators (subject promoters) will be defined for the four dedicated "Speakers Corners". The subject promoter will hold a 15 minute lightning round and – next to the impulse with regards to the content – will also set a second focus on career opportunities within the subject complex for junior scientists. The underlying reason is that veritable future-oriented subjects offer career opportunities but also require excellent young scientists (note: brightest minds) with a high professional and social competence.

The participants choose one "Speakers Corner" to sketch out their own ideas. These will be introduced to the listeners in spontaneous abstracts and recorded respectively. In parallel, ideas can be worked-out/placed on wall newspapers (meta-planers at each speakers corner) to allow all proposals to be documented independent of speaking time and one's own stage presence. To heat-up an animated discussion from the impulse given by the "Speakers Corner's" subject promoter, "discussion supporters" will be strategically placed. With the exception of the instigator (subject promoter) all talks are entirely improvised. They should not be restricted in terms of content or method, merely **limited in time to a maximum of 3 minutes**. Speakers will register with a corner assistant who will ask them to the podium. The requested brainstorming character promotes a free and entirely open as well as creative discussion.

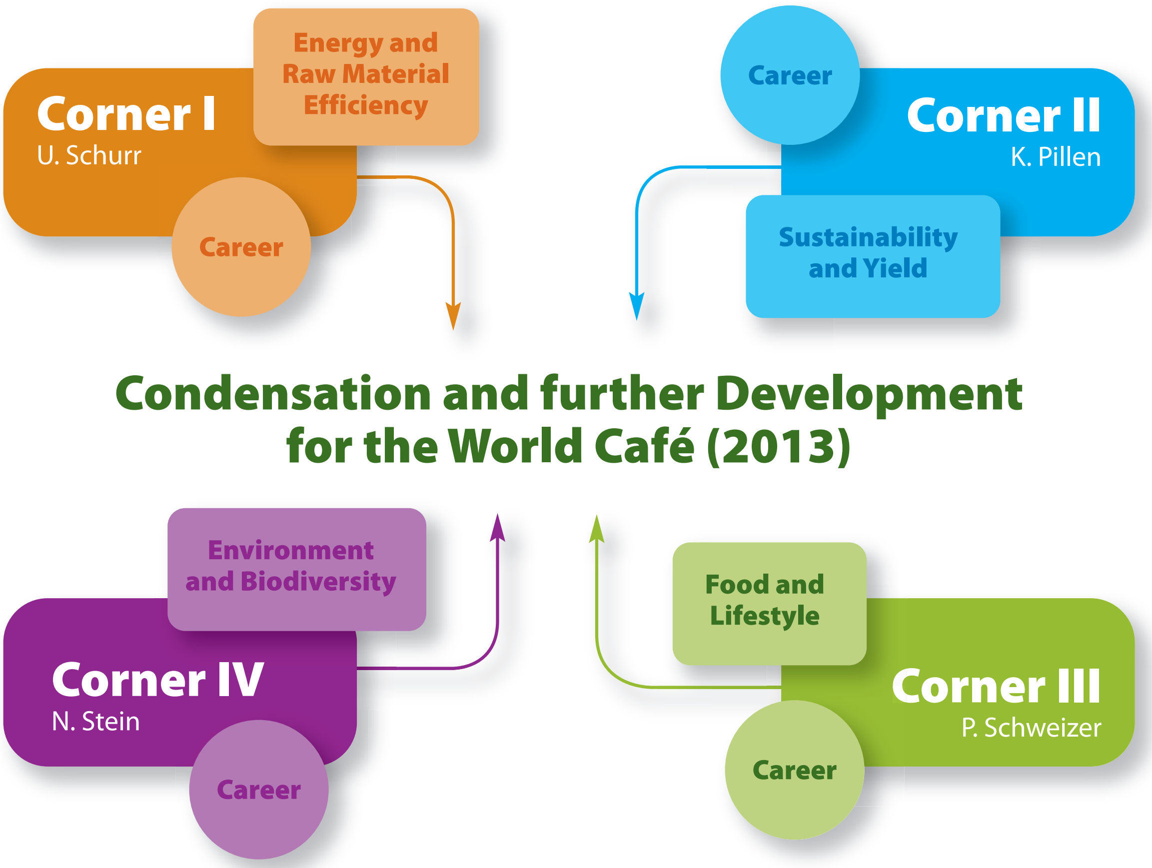
Structure

After a brief introduction on the significance and role of plant research as part of the national research strategy "BioEconomy 2030", the goals including a short outlook and line of action will be outlined. Once the instigators (subject promoters), their subjects as well as their location in the four "Speakers Corners" have been introduced, the participants select their "Speakers Corner".

Schedule Speakers Corner Session

Time	Acitivity	Location	Responsibility
16:00	Speakers Corner – A short introduction	Lecture Hall	N. Stein
16:05	Role, importance and emphasis of plants and plant research within the national research strategy „BioEconomy 2030" under the umbrella of the German high-tech Strategy (*working title*)	Lecture Hall	C. Herok
16:20	*Participants split into corner discussions on their own thematic choice (ca. 5')*		
16:25	Speakers Corner impulse talks	(in the four corners/rooms)	
	Corner I Energy & Raw Material Efficiency Corner II Sustainability & Yield Corner III Food & Lifestyle Corner IV Environment & Biodiversity	Instigators (subject promoters)	U. Schurr (FZJ) K. Pillen (MLU) P. Schweizer (IPK) N. Stein (IPK)
16:40 – 18:00	Parallel sketch out of own ideas (spontaneous abstracts) (3'short presentations or notes on wall papers)	Foyer (Corner I-IV)	all
18:05	Summary (5' each)	Lecture Hall	Instigators (Sp. Corner I-IV)
18:25	Outlook	Lecture Hall	N. Stein
18:30	End of the session		

Speakers Corner – A Market of Ideas
During the Plant 2030 Status Seminar 2012



Speakers Corner I	Speakers Corner II	Speakers Corner III	Speakers Corner IV
BioEconomy topics			
Energy and Raw Material Efficiency	**Sustainability and Yield**	**Food and Lifestyle**	**Environment andBiodiversity**
Theses for future approaches			
artificial photosynthesis, new materials and ingre-dients, nutrient efficiency, low-input/high-output agriculture	greenhouse gases, nitrogen emissions, availability of phos-phorus, vertical farming	eating habits, healthy food, protein plants and meat consumption, emerging countries, low-input/high-output agriculture	modulation approaches, novel crops, development of presently under-utilised crops
Promoter/Instigator			
U. Schurr	**K. Pillen**	**P. Schweizer**	**N. Stein**

Corner I

Summary – Corner I
Energy and Raw Material Efficiency

Preconditions

Artificial photosynthesis, new materials and ingredients, nutrient efficiency, low-input/ high-output agriculture

Impulse

Instigator: Ulrich Schurr , Research Center Jülich – FZJ

Are we doing the right things?

The significant increase of yield in agriculture during the last century was always linked to increased input of energy or resources. On a global scale nitrous oxide is one of the most significant drivers of global warming.

Given the challenges ahead and the footprint of agriculture a central question is: if we work on the most pressing topics as a science community, which wants and needs should be delivered? A short analysis of the PLANT 2030 status seminar indicates that vaguely three of about 100 abstracts presented as posters or speeches deal with aspects of increased resource efficiency. Three abstracts describe ongoing research activities in one of the most important plant organs for resource use efficiency, the plant root. None of the submitted abstracts addressed the stand level, which is the real world of plant production. While there may be good reasons for this and as there are more indirect links in the posters and presentations, we as a plant science community need to perform an efficiency check, if we could not do better.

Today, agricultural production already consumes almost 75% of fresh water used by mankind. If we continue to grow plant production without major changes we will be using 95% of the fresh water consumption in 2050 for agriculture alone. Climate change will eventually make water an even more limiting resource for plant production. The nutrient resources available for crop production will be equally deficient. Especially phosphorous is a mineral nutrient which we will be running out of soon from concentrated resources for mining. Global research activities on phosphorous efficiency are still in the early stages.

Ways out!

A second Green Revolution is required aiming to produce more from less. A revolution based on (a) optimized plants as well as (b) on a balanced interplay of crops and plant production as well as processing technologies for most efficient use of resources and (c) on evaluation of novel biomass production systems (like algae, etc.). This revolution must be driven by comprehensive knowledge of the plant resources and the plant interactions in their environments. Efficient and real interdisciplinary science approaches based on sound disciplinary bases needs to be implemented. Plant breeding and plant production must be integrated even more than today: e.g. precision agriculture combined with optimized genotype adjusted to a specific environment, can lead towards concepts of crops matching a specific management ("personalized crops").

Quantitative knowledge of genotype plasticity and their interactions in the field (environment) become prerequisites for such an innovative approach. So far plant research ignores major influences. For example, plant research concentrates on individual plants but ignores the stand level.

However, plants are not cultivated as individuals but in stands of monocultures or mixtures. Therefore a much better understanding of interactions in stands as well as environment interactions is needed. Horticulture should gain more awareness as well, as it today always offers a high degree of integration of plant production with plant management. Fitting to the relevant management scheme genotypes with either the ability to respond or to ignore changing conditions in the field will be needed. Based on the comprehensive knowledge of plants and technologies, a so-called agriculture and horticulture 2.0 with an efficient use of resources may be developed for emerging countries as well as for a more resource intensive agriculture.

Novel production systems e.g. algae farms or systems such as vertical (sky) farming integrate plants and technology even to a much higher extent and provide yet more options for scientists to link with practical plant production and learn about the biology of plants themselves at the same time. New varieties with modifications in their shoot and root architecture as well as their physiology are necessary. In the extreme, plant processes may also be simulated, e.g. in artificial photosynthesis, in bionic approaches. However, such systems always have to undergo significant Life Cycle Analysis and System Analysis to check for real advantages in sustainability. It is of paramount importance for such LCA to compare entire systems and not only parts of them.

All these production systems (fields, greenhouses or algae) equally need improvements to optimize their production potential and to reduce input costs at the same time (low-input and high-output production).

Speakers corner input and ideas

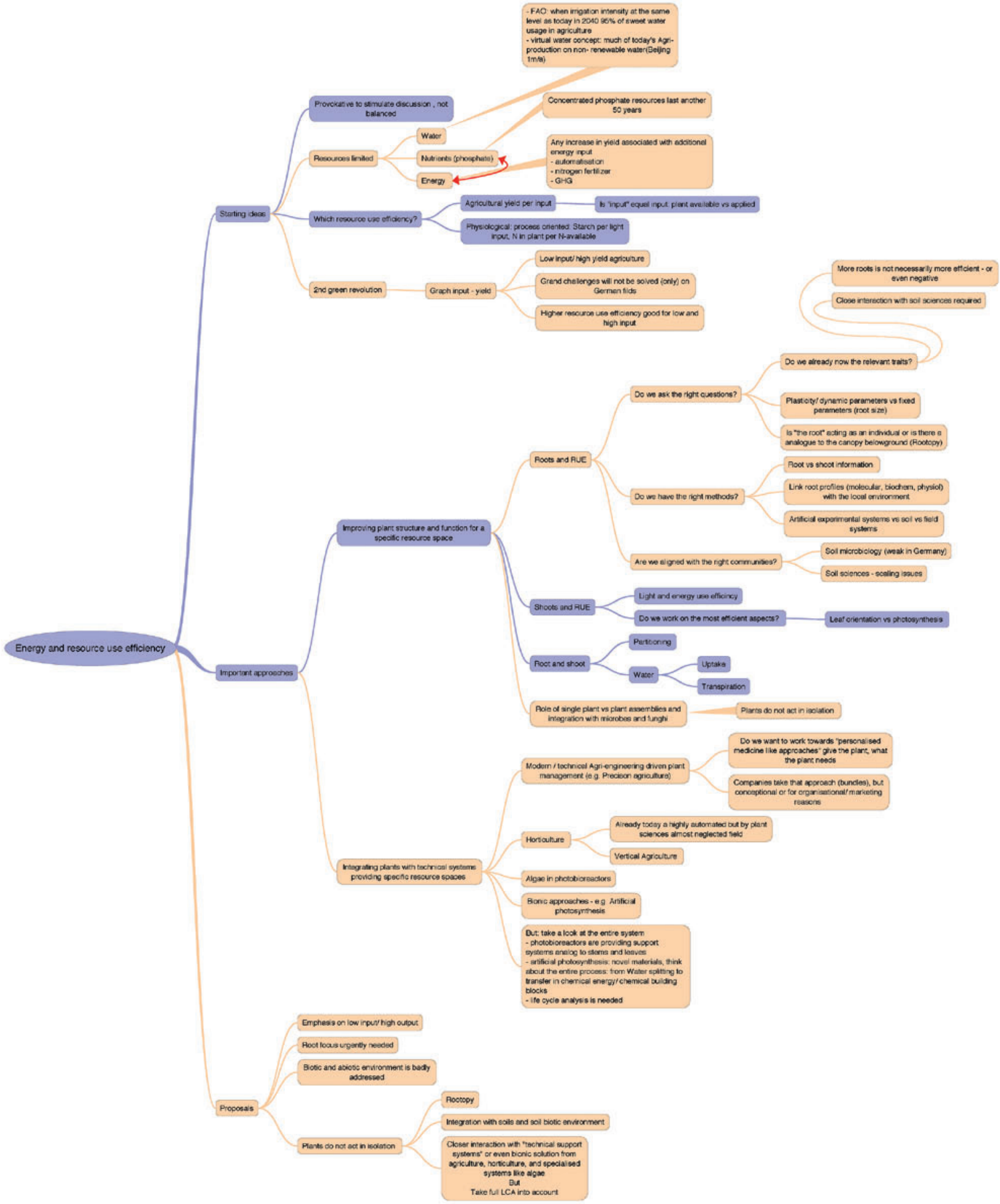
Several major needs for action where identified and supported by concrete ideas. Contributions were clustered in major topics:

- Technological developments and knowledge transfer
- Environment and complex interaction
- Interdisciplinary approach to bioeconomy
- International cooperation
- Efficiency in the (science) system
  - data-use efficiency as well as
  - human capacity building and human resource efficiency

Environment

Agriculture is an important activity for human beings. Plants are in intimate interaction with their above and below ground environment, to gain all resources from soil and air, by being exposed to numerous abiotic and biotic stresses and by significantly altering their environment in the short and long-term. Agriculture will thus be strongly affected by climate change and extreme events such as drought, heavy rainfall, heat as well as pathogens etc. On the other hand, agriculture is a major factor of man-made GHG emissions. Agriculture is the most significant geo-engineering activity ever. Thus it is essential to integrate environmental aspects in holistic plant and agricultural research activities. Currently the multifactorial character of plant research becomes more visible than ever. A better understanding of plants will improve resource and energy efficiency. To establish research that is able to develop fertilizer and pesticide free/reduced high yielding production systems was one of the visions mentioned here (low input – high yield). Integral systems instead of only yield-maximizing approaches have to be developed and implemented in order to optimize global production systems sustainably.

Energy and resource use efficiency mind map



Soil research and particularly the capability of soil to store carbon for longer time periods as well as the improvement of soil fertility under climate change conditions will lead to a closer cooperation between agriculture and environmental management. Similar to plant research, soils science is multifactorial and interdisciplinary. Soils provide nutrients, water and anchor plants. They represent a complex, heterogeneous and dynamic environment including organisms that are synergistic as well as antagonistic to plant production.

Roots provide the interfaces by which plants interact biologically, chemically and physically/mechanical with their soil environment. Therefore root research will be one of the most important issues of future plant research. Root research can be seen as the sleeping giant in plant science.

Technology

Technological approaches to improve and/or to make best use of the multi-functionality of plants have to be developed. Technologies allow us to use the full potential provided by crops as well as algae or organic residues. A major principle of resource and energy efficiency is the principle of cascade utilization of biomass by coupling cyclic matter fluxes optimizing material and energy efficiency. Technologies improving cascade utilization are urgently needed developments. Besides molecular biology and biotech process development, engineering approaches need to be coupled and integrated. Improving plants for optimal usage, not only for biomass but also e.g. as raw material for chemicals or as the basis for lightweight construction materials (biomass based composites, glass fiber etc.), promises significant progress through technology improvements. The role of plant sciences is to increase the quality and quantity of biomass in close interaction with engineering sciences and practical engineers.

More than one hundred years after the beginning of rational plant breeding by Gregor Mendel many phenomena are still unknown or poorly understood. For the optimum use of plants the existing diversity and the genetic potential of plants need to be understood much better. Especially concerning their interactions with the complex environment novel approaches as well as technologies are needed. Furthermore basics of plant breeding such as hybrid developments or prediction of heterosis need to be understood even better to develop concepts of rational plant breeding (plant improvement). Key words are breeding by design or smart breeding approaches.
Science and research have to provide alternatives. Therefore no limitations in the usage of technologies should be given. Synthetic biological approaches, cell free systems as well as genetic engineering (cis- or transgenic approaches) or novel technologies such as RNA-based technologies or zinc-finger-nucleases should be included. The freedom of research needs to be guaranteed to develop and to prove novel approaches. Low-input high-yield agriculture is a vision and a requirement of a bio-based economy.

Additional emphasis was given to the transfer of research results from lab and green houses to the field (translational research activities). Models, lab and greenhouse experiments are a necessity to prove concepts. In the end, novel

strategies for recourse efficiency have to be implemented in the field. Openness for all available technologies as well as new technological developments plus a new quality of interdisciplinary work are the main requirements to optimize resource efficiency.

Interdisciplinary Approaches

The role of plant scientists within the bioeconomy framework has to be defined more clearly. Disciplines such as process development or material science have to become integrated in "real" projects to push communication as well as synergy developments. Translational competences, communication tools and skills have to be trained, integrated and practiced in new projects. It is inevitable that such projects require long-term approaches whilst trust and common understanding as well as new forms of cooperation have to be built. Different research disciplines use specific ontologies and scientific languages.

Cooperation

International cooperation is immanent to progress in science and research and is key for addressing some of the challenges (e.g. food security) that can only be solved, when significant interaction and finally implementation takes place in emerging and developing countries. Technology and knowledge transfer as well as training in tropical and subtropical agriculture linked with modern approaches were identified as future tasks; as was the need to make this a global responsibility. Further, a request for a closer link to international research organizations from the CGIAR like CYMIT, IRI, CIAT or ICRISAT were mentioned and should be reflected in future research programs. It is necessary to define our role in a more international context.

Efficiency in the science system

Data-use efficiency is a major field of action. The availability of old, new and so-called "unsuccessful" experiment data has to be optimized. Therefore new approaches to make data accessible across scales and topics are required. Availability and access require persistent infrastructure funding and both are inevitable in post-genomic times to deal with huge amounts of data of highly diverse classes. Better-trained systems able to interact with other databases have to be developed. BioMoby is an example for how database interaction can be realized even if data is stored in different places. The experiences with BioMoby are useful to structure and design even more holistic databases in the future including e.g. phenotypic data.

Furthermore, there is a need for standards to guarantee data quality and cross-compliance of experiments. Defined ontologies and controlled vocabularies are the "door-opener" for effective interaction and a prerequisite for a synergistic data management. New and old data need a new quality of support and interpretation infrastructure. Avoiding fruitless duplication will be a major aspect in the efficiency of funding for data-use. The comparability of data is a big topic in (bio-) informatics. While it is very hard to guarantee comparability of experiments performed in different labs, standard operating procedures at various levels may help, but need to be continuously revisited to allow further use of data without hindering advancement in scientific concepts. Balanced approaches in themselves will promote better understanding of similarities and differences between different organisms e.g. monocots and dicots or algae and higher plants etc. Data integration becomes the major bottleneck for efficient data use. New cooperation approaches between research institutions are strongly needed for progress; not only for research but also for funding and interaction with industrial partners (users' rights, owners' rights etc.).

One huge task will be to accumulate all available phenotypic data to combine it with molecular and environmental data. The underlying vision is that of a virtual plant where researchers are able to model and prove best genotypes in a certain environment. A new quality of data handling and data analysis will be developed in the post-genomic area. Former more linear approaches in the analysis of genomic, proteomic, metabolomic and phenotypic data will be developed into real cross-talk analysis. Semantic and new algorithms for pattern recognition and pattern interpretation will lead to real analysis of cross talks. Pattern recognition will be a key development in modern biology. First approaches in the field of medical research using such Google-like analysis tools already exist.

Do science and research make the best and most efficient use of the available talent? Science and research addressing questions to answer the global challenges are built on the commitment of motivated and excellent individuals. A high diversity in concepts, in technologies applied and a high diversity in disciplines combined requires additional capabilities and expertise. Balanced approaches of project-based activities, as well as longer lasting and institutional funding are needed. Basic research is the precondition to get a comprehensive knowledge basis. Application-oriented research is needed to find solutions to practical questions. Successful R&D programs combine these aspects and support the transfer of knowledge.

To attract the best talents innovative and solid career options have to be developed and should become visible and tangible for the young generation. New approaches of dual as well as interdisciplinary education/ studies have to be built up on the basis of a strong cooperation between universities, research institutes and companies. The idea of cooperation and team performance has to become an integrative part in future R&D programs. These kinds of programs should also provide high flexibility. Besides theoretical and practical skills, social and communication competences need to be conveyed.

So far, there is not a single department/faculty dedicated to bioeconomy at a German university. Establishing a bioeconomy research

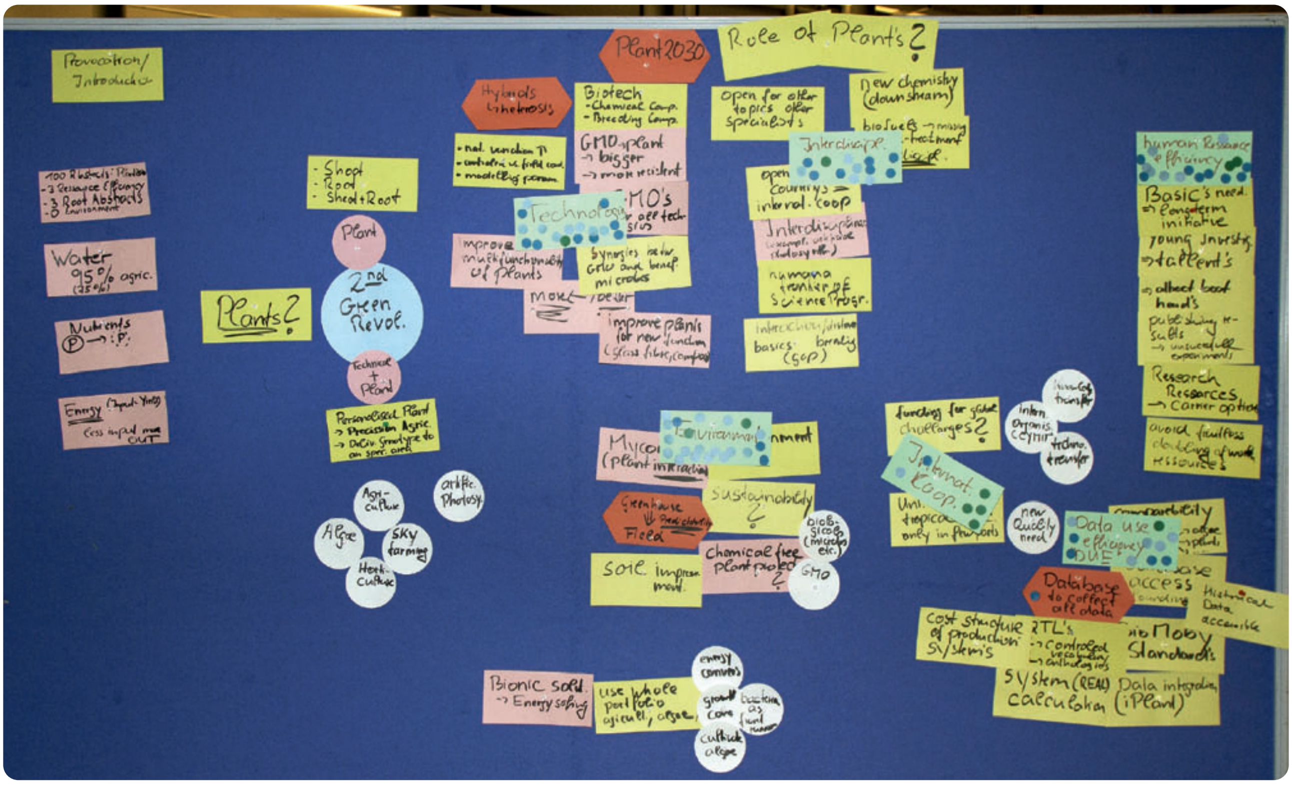
school could be the starting point for an integration of bioeconomic concepts at universities. Such a graduate or postgraduate research school could become a crystallization point for the development of a bioeconomy faculty. The bioeconomy research schools integrate bioeconomy concepts and will improve interdisciplinary approaches.

Future approaches (focal points)

- Balanced approaches including basic, strategic and application-oriented research activities

- Combination of project-oriented as well as the long term and institutional funding of research infrastructure (to develop and maintain resources), preferentially as public-private concepts or concepts with high potential for entrepreneurs (start-up companies)
- Creative concepts to win (and keep) the best talents globally, implementation of joint career support programs in research projects to link universities, research institutions and enterprises
- Technology centers for breakthrough technologies to provide services and to build up training and teaching platforms (but not duplicating already (commercially) available services e.g. by private companies)
- Emphasis on root research and links to environmental and soil sciences to develop strong integrated approaches for the efficient use of resources and ecosystem services
- Holistic approaches, combining technology developments and unresolved biological questions and concepts such as the virtual plant or visionary ideas on low input, low footprint but high yield production systems
- Openness and equal opportunity for all available technologies to provide applicable solutions
- Concentrating on truly interdisciplinary approaches combining natural, engineering and social sciences in a balanced manner
- Efficiency of data acquisition and use: comparability of data, optimized database access, optimized database design, definition of global standards and ontologies and structure-function models for interpretation
- Integrating aspects of sustainability in all R&D funding schemes/projects as well as educational efforts to fully embed sustainability concepts on all levels

Meta-Planer Speakers Corner I



Summary – Corner II
Sustainability and Yield

Corner II

Preconditions
Greenhouse gases, nitrogen emissions, availability of phosphorus, vertical farming

Impulse
Instigator: Klaus Pillen, Martin-Luther-University of Halle-Wittenberg

K. Pillen: To meet the growing demand for food, feed, fiber and fuel, agricultural production has to double by 2050. Because arable land and other resources such as water and phosphorus are limited, great efforts are needed to increase the *agricultural productivity*. Besides the necessary increase in yield, agriculture has to become more sustainable. Modern agriculture is one of the major consumers of water, has strong impacts on the environment and produces great amounts of greenhouse gases. On the other hand, climate change strongly affects agricultural outcomes. **How can we make agriculture both more productive and more sustainable? What strategies are to follow?**

Modern plant breeding has to achieve three goals: **to ensure and to increase yield and to improve product quality**. Depending on the plant species and the product of interest, there are different strategies to increase **yield**. Concerning *vegetative crops*, e.g. sugar beets, the breeding is focused on vegetative growth to maximize the biomass output. One strategy is to *delay the formation of flowers*. Regarding *generative crops*, e.g. wheat, the goal is to maximize seed production. This can be achieved, for instance, by *shortening the life cycle of a plant*. Varieties with shorter life cycles may be harvested twice a year. In both cases research may be focused on particular flowering genes which assist in controlling flowering time. Besides manipulating life cycles there are other strategies available to increase yield potential. These include *hybrids, winter crops, double utilization of plants, for instance, flax for food and fibre production, and application of genomic selection to speed up the selection gain per year in a breeding program.*

To increase *yield per hectare* it is not sufficient to select for single plant yield potential. One has to genetically elaborate on the optimal plant density per area and to overcome **environmental factors** which may cause biotic or abiotic stresses. *Biotic stress is caused by* pathogens and pests. *Abiotic stresses* include *light and soil conditions* in the field, and the effects of *climate change, for instance*, drought, heat, flooding and cold; but also the exposure to *toxic compounds*, for example, heavy metals.

Strategies to promote **sustainability** focus on the optimization of water, nutrient and pesticide efficiency, the minimization of greenhouse gas emissions as well as energy use and on multiple utilization approaches. **Socio-economic factors** have to be taken into consideration as well, for instance, restrictions on plant or technology utilization and market demands. Furthermore, farmers must be able to generate their income through farming – this **economic sustainability** is influenced by the prices for seeds, nutrients, pesticides, energy and the market price of food.

Speakers corner input and ideas

On the basis of these introductive preliminary considerations the participants discussed their ideas on the topic "Sustainability and Yield":

Crops: The best studied crops are wheat, rice and maize. The rising demand of meat and protein rich crops requires further research on profitable varieties of *legumes* for feed and food. Further research has to focus on rather holistic farming strategies that include *crop rotations* and cultivation in *mixed cultures*.

Stress factors: Future research has to adapt crops to different *biotic* and *abiotic stress* factors to secure yields in times of *climate change*, changing pest pressure and deficient *soil conditions*. Breeding goals are drought, heat and frost resistance, salt resistance and pathogen resistance.

Basic Research: Research on *plant architecture* and *photosynthesis* should be extended. It helps to adapt plants to different light conditions and to optimize them for new production systems, e.g. vertical farming. Further research is needed to understand *ecosystem relations*. This understanding is essential to protect *biodiversity* and to utilize genetic diversity better.

Low-input agriculture: The goal of low-input agriculture is to find the optimum balance between input and output. Agriculture needs to secure and increase yields (= output 1) while reducing inputs (land, water, nutrients, pesticides, energy) and negative effects for the environment (emissions, pollution) and for society (aspects affecting food security, food safety, health, prices) (output 2). To sum up the costs of production all effects on environment and society have to be taken into consideration.

Losses: Post-harvesting losses resulting from transport or spoilage represent a major problem for food security. Plant research, material sciences, logistics, sociology and nutrition sciences as well as the industry and society have to work together on strategies to reduce losses.

Trend of urbanization: Today every second inhabitant of the Earth lives in a city. To flee from hunger especially poor people from rural areas migrate to the cities. This creates great challenges for food production, distribution and storage. Research collaborations can help transfer knowledge and create adapted and efficient strategies. Investments in local infrastructure and efficient food production techniques are essential.

Second green revolution: New sequencing and phenotyping technologies accelerate scientific progress and open new possibilities for research, breeding and husbandry. They are the door-opener for a second "green revolution" and for the development of *sustainable production systems* "eco 2.0".

Genomic selection speeds up breeding success per growing cycle. The knowledge of the genome and the functions of genes make breeding faster, more precise and even cheaper. The entire genetic diversity can be used as a resource for breeding.

Precision farming facilitates the appropriate husbandry for particular environments combining environmental and genetic information. Vertical farming brings food production closer to the consumer. In this vision agricultural products grow in vertical greenhouses high as sky scrapers. So far high costs for construction and operation (e.g. energy) prevent vertical farms from becoming reality. The production system may be interesting for breeding, for the small scale production of pharmaceuticals or high value products. It seems less beneficial for food production. Today there are hardly any suitable varieties of cereal crops adapted to the particular light conditions in greenhouses (in contrast to typical greenhouse vegetables such as tomatoes). In vertical farms the height of plants is another key feature for breeding – to maximize the total yield, single plants have to be low growing.

Urban farming uses uncultivated land in or around a city, like roofs and fallow grounds for small scale food production, e.g. for income-earning or relaxation.

Multiple biomass use: The complete plant can be used as a resource for food, feed, fibre and fuel in a multiple or cascade utilization approach. Until now plants are mostly optimized for one particular product (e.g. in biorefinery). An approach for multiple usages promoting the idea of bioeconomy has to focus on different needs and therefore requires a complex breeding strategy.

Holistic approach: Research projects should focus on the whole value chain to optimize sustainability, to face the complex needs of bioeconomy and to consider the demands of society. Funding programs should promote holistic approaches by involving farmers and other partners of the value chain.

Interdisciplinary cooperation: Combining plant architecture and genomics is expected to push forward modelling approaches. For research on topics such as frost or heat resistance it could be interesting to collaborate with local experts from regions with these particular environments.

Funding structure: A "sustainable" *long term funding* framework should be established to facilitate projects with complex research questions.

Knowledge transfer: Research groups working on different crops or on different aspects of plants should work together more intensively. Plant scientists and animal scientists partly use the same technologies and therefore can profit from sharing knowledge. Funding structures should promote transfer between disciplines and support transfer from research into practice. Technology transfer in Germany should be centralized. Presently every university and region has their own technology transfer agencies and procedures. In contrast France has a national transfer organization (INRA) with effective centralized procedures.

Invest in human capital: The education of excellent PhD researchers in the fields of plant sciences was one major output of the previous GABI calls. These researchers are now pushing forward the research frontiers in our bioeconomy companies. To keep up with research in other countries Germany has to increase its investment in human capital and better working conditions. Scientific jobs have to become more attractive for young qualified scientists. Especially young researchers should be supported.

Openness to new technologies: Being open to new technologies is the key to success in maximizing both yield and sustainability in agriculture. A diversity of research, breeding and cultivation techniques is crucial in order to select the best technologies for every single plant and product.

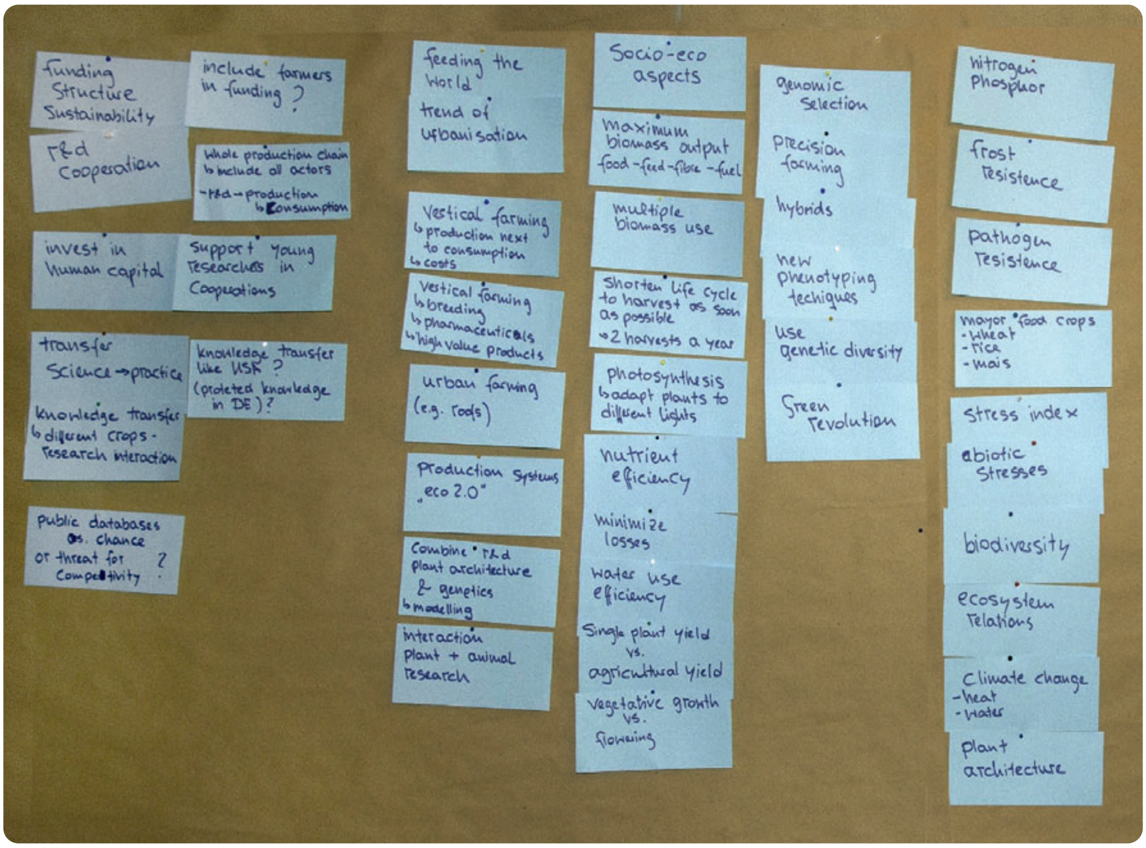
Public database: The knowledge created in public-private partnerships is protected in Germany; in the USA it is available to every research group. While genome data is often published in public databases, phenotyping data is mostly kept secret and is only available for the scientists working on the particular project. The scientific community could profit from open databases making genome and phenotyping data available for research. On the other hand, freely available data can be a threat to the competitiveness of research-driven companies.

The discussion showed that the challenge to make agriculture both more productive and sustainable is recognized by all but that strategies were only covered superficially. Efficient strategies have to integrate knowledge and key technologies throughout the disciplines and the whole supply chain from plant breeding and production up to distribution and consumption. Visionary thinking beyond the edge of the own working field is the key to success. It seemed as if the participating scientists found it hard to create new visions for research in the future and to link them to the broader context.

Future approaches (focal points)

- Stronger focus on: interdisciplinary research, knowledge and technology transfer
- Approaches to realize a low-input agriculture
- Research to adapt crops to stress factors: increase yield and stress resistance
- Breeding to adapt plants to new production systems and needs
- Evaluation and integration of genetic diversity as a resource for breeding
- Modeling for visual breeding: linkage of genetics with plant architecture
- Optimize plants for multiple biomass use (cascade utilization of biomass)
- Funding should focus on: long-time projects, whole value chain projects, promoting young scientists

Meta-Planer Speakers Corner II



Summary – Corner III
Food and Lifestyle

Corner III

Preconditions

Eating habits, healthy food, protein plants and meat consumption, emerging countries, low-input/high-output agriculture

Impulse

Instigator: Patrick Schweizer, IPK Gatersleben

The consumers' attitude towards food and nutrition changed heavily in Europe and North America during the last century. Only some decades ago a majority of the population still remembered personally experienced times of war or crop failure where food was not always readily available. Therefore, a sufficient supply of food was not taken for granted and it was appreciated as a precious and important aspect of daily life. Also people had closer contact with a more transparent value chain. The fact that societies tended to be more rural lead to a more localized food supply, which automatically limited the extent to which food production was uncoupled from the consumers as is seen today. Lastly, food preparation needed time and attention because it usually was cooked "from scratch" by using unprocessed raw materials. All in all, people did care more about their "daily bread" prepared from a seasonal supply of largely unprocessed ingredients that, on the other hand, consumed a higher percentage of their monthly budget. The rapid spread of civilization diseases such as diabetes or obesity during the last few decades strongly suggests that traditional eating habits - prevalent in our countries until the late seventies of the last century - were healthier.

At present, a huge amount and highly diversified range of food is available in supermarkets. This mainly leads to two kinds of attitudes towards the consumption of aliments: the **unconscious consumers**´ buying decision is primarily based on the (cheap) price. This group forms the majority of the population. On the other hand there is the **conscious consumer**, whose buying decisions are based on aspects of quality or sustainability. They tend to buy organically grown food, a decision mainly based on good trust rather than knowledge (LOHAS – lifestyle of health and sustainability). Although organic food potentially contains hazards and risks (mycotoxins, copper residues, bacterial contamination e.g. EHEC), it is believed to be generally safe and healthy in contrast to conventional food. The current situation poses the following important questions to plant and environmental scientists, breeders, farmers and the food industry:

- How to deal with health risks in both groups?
- How to minimize ecological risks and sustainability problems derived from large-scale organic farming?
- How to strengthen a more rational consumer behavior driven by knowledge and cautiousness?

To face the future challenges of feeding a world population of approximately nine billion people, a high yield is important to guarantee availability and affordable prices of aliments. Yield safety as well as quality is threatened by pathogens and abiotic stress factors such as drought. A **higher yield** of resistant cultivars will thus result in less land needed for the production of food. To meet the challenge of the ongoing or already happened transition in eating habits in developing, newly industrialized and fully industrialized, western countries towards more fat, meat, starch with a high glycaemic index and sugar, **increased quality** in terms of health benefits will be important and can be reached by developing plants for functional food.

Speakers corner input and ideas

Land use: The availability of food is not guaranteed everywhere. This has to be taken into account when dealing with issues of extensive (organic) farming and the resulting increase in land use, especially for the production of nitrogen fertilizer (manure from cattle). An increased consumption of meat will raise the required primary calorie production. This also leads to an extended land use. Generally organic farming needs more land due to yield losses (pests, extensive farming, etc.). Therefore the production efficiency in this area has to be improved significantly by emphasizing on **pathogen and pest resistance** as well as on **nutrient use efficiency**.

Organic farming: Organic food is believed to be healthier, tastier and produced in a more sustainable way than conventional food. The market share increased within the last years, although this is mainly based on high subsidies for farmers. Its positioning on the market as "the best food you can get" leads to higher prices which consumers are willing to pay. On the other hand, there is no scientific evidence that this claim is true. At the level of plant cultivars there is no clear difference between organic and conventional breeding (except GMOs) because a cultivar with high yield potential will most likely still produce more under limiting conditions of e.g. nitrogen supply than a generally lower yielding one. A known risk of organic farming is the increased contamination and disease pressure arising from plots of infested crop plants. An example in this respect is contamination of conventional wheat fields with spores of common bunt (Tilletia caries) from organic fields. A liability regulation as has been put into law for GMOs by many countries might therefore become necessary in the future. In general, disease-related problems will become more dramatic with ever increasing areas used for organic farming.

Food price: In Germany food prices in relation to income are as low as never before. On the other hand, organic food is not affordable for all people, as the price is generally much higher than for conventional food. A general strategy should combine moderate prices with high quality at the plant level also considering aspects of real sustainability. This can be achieved by combining biological, chemical and physical forms of plant nutrition and protection (integrated production type). What is more, a concentration on more local and basic food should be achieved.

GMOs: GMOs can easily be identified as a negative quality label similar to the "Bio" label which enjoys an overwhelmingly positive public perception. Knowledge-based education and communication on this topic was unsuccessful in the last decades and led to today's negative atmosphere. GM plants are a non-issue in Germany; and especially organic farming stakeholders fight GM plants intensely. Additionally, the consumer does not have the choice to buy GMOs. There are hardly no GM products (which can be easily identified as such) available in Germany. It is expected that GMOs are no real option in Europe within the next ten to twenty years. However, with regards to increasing future challenges we cannot afford not to develop and use GMO techniques.

Modern lifestyle: The modern lifestyle is highly affected by our work and mobility. Also changes in modern family life lead to different types of eating habits; especially in the Western world and growing economies. These, often based on convenience food or fast food, are in conflict with a healthy diet. There are, for example, more people globally who become overweight than those who starve.
Another problem is the long, consumer-uncoupled and thus obscure value chain in modern food production. The path from farm to fork is long and has many knowledge gaps. This leads to missing transparency and limited comprehension of the consumers towards production techniques and challenges. Bridging these gaps is a future challenge for all stakeholders in this area (science, industry, consumers).

Health aspects: It cannot be unequivocally defined what a healthy diet is. Many ideas of a healthy lifestyle are based on dietary myths. Beliefs and habits highly influence our daily diets. Also industrial interests and the marketing of health promoting formulas play a role. To solve this problem, education on food topics is needed, and this should basically happen at primary school or even before. The aim is to re-establish a knowledge-based common sense of a healthy diet independent of industrial interests. Generally a sound mixture of local and seasonal food is the key to a healthy and balanced diet.

Quality: Quality aspects could play a big role in obtaining a better diet and healthier food. Improved texture, color and taste of plant products have to be prioritized because they will facilitate the re-establishment of a general interest in "good food". It is important to train people´s and especially children's senses concerning aspects of taste etc.

Functional food: To gain additional health benefits from the diet, additional quality traits such as "stealth" (neither visible nor able to taste) higher dietary fiber content can be di-

rectly introduced in plants. As long as consumer education remains inefficient there is an increasing need for food additives also in Germany, in order to reduce enormous economic burdens for society arising from food and life style-related diseases. In addition to plant improvement many ingredients (vitamins, minerals, etc.) can also be included within the industrial production process although this option always is more costly.

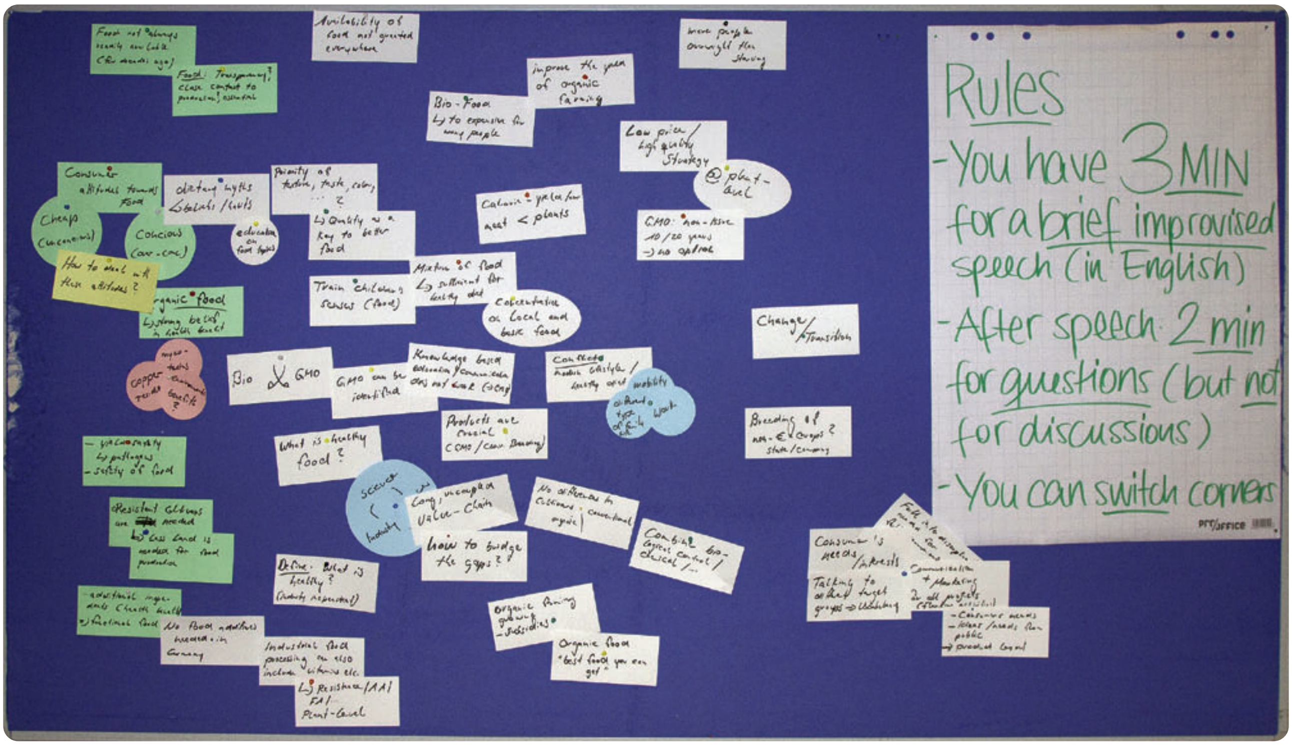
Communication skills: Successful communication is crucial for the acceptance of modern (conventional) innovations in the area of food-related bioeconomy. It is essential to use the appropriate vocabulary when talking to different target groups. Also interdisciplinary communication approaches should be considered to mediate between stakeholder interests.

Scientific news marketing: Communication as well as marketing aspects should be integrated in future calls for tender. It is important to include the consumers' needs and ideas in the layout of a plant-based product. Possible issues e.g. experienced by potato cultivar "Linda" or tomato brand "Toscanella" should be included in marketing considerations. Research on non-cash-crops should be financed publicly as they are important for the consumer but may not be on the companies' research agendas. The availability of products together with attractive scientific news marketing will be crucial for the consumers' appreciation of modern plant innovations (GMOs as well as conventional, integrated approaches).

Future approaches (focal points)

- **Yield** potential and stability are the keys to food security. Land use should be minimized as much as possible.
- **Integrated production methods** are necessary to obtain high quality food at affordable prices.
- **GMOs** have no chance on the market at the moment but will most likely be of great importance in addressing future challenges.
- **Quality aspects** in terms of more enjoyable food could be a key to a healthier diet. They should play a role in research and communication/education.
- **Functional food** will become an important option for specific problems of industrialized countries such as diabetes or obesity.
- **Professional communication** training and education is needed to foster transparency in the value chain resulting in acceptance of integrated and mission-oriented approaches as well as a knowledge-based discussion on food-related risk-issues.
- **Scientific news marketing** should be an integral part of future research projects. They could be included as a co-funded flanking activity.

Meta-Planer Speakers Corner III



Summary – Corner IV
Environment and Biodiversity

Corner IV

Preconditions

Modulation approaches, novel crops, development of presently underutilized crops.

Impulse

Instigator: N. Stein, IPK Gatersleben

N. Stein: The world is facing many serious problems such as *climate change* or *population growth*. These problems trigger the discussion about our environment and biodiversity but also limit the possibilities, e.g. some plants will not be able to survive the higher temperatures in the future. Everybody would agree that preserving the natural biodiversity is a necessary and useful task. But **how can we preserve it usefully and what is the benefit?** Concerning agriculture: **how can we utilize agrobiodiversity?** Do we have to consider economic issues? And what exactly do we mean by the term "**environment**"? Is it the *industrialized nature* with its agricultural usage?

Further we have to think in a *bioeconomy* context. Building an economy based on biological resources is not only a national, but also an international aim. **Can bioeconomy increase the diversity?**

Different approaches have been developed and have led to different methods of farming. On the other hand we also have to consider the size of the agricultural production areas available. This comes along with deliberations regarding the need to *import* goods. Maybe we have to change our way of thinking and start reducing the imports?

Speakers corner input and ideas

On the basis of these introductive preliminary considerations the participants presented and discussed their ideas on the topic "environment and biodiversity":

Change in communication: Participants agreed that many aspects of the *public discussion* are based on emotionalized arguments and prejudices rather than facts. To solve this informational gap, practical proposals were submitted: provide a *web platform* with information for breeders, scientists and the interested public and we have to inform and convince the general public by showing them *examples*. Breeders and researchers have good examples but maybe we have to work on advertising them better. Dooming scientific programs from the beginning is not the right way.

Interdisciplinary training: The necessity of *interdisciplinary training* of scientists was brought up in this context. We cannot afford to have scientists only knowledgeable in their discipline and unwilling to look beyond. Study paths such as *Bioinformatics* have a bright future. Not only do we need the linkage between disciplines to achieve greater knowledge of our environment, we can also gain new perspectives. Globalization and the common fight against global problems have to be condensed in new forms of cooperation.

Funding structure: Funding structures need to be adapted to the new requirements: a *long-term funding framework* should be established. Further the benefits of *dual funding* from industrial partners and governmental funds should be considered closely. The *economic interest* of companies can create a pulling force to public/private R&D.

Novel crops: Another rather social problem seems to be, that we have the same amount of harvesting area but increasingly need more and more (e.g. for *energy crops* or organic farming). Therefore we have to invest in research which helps *increase the yield* and makes our crops more resistant to diseases and pests. And we have to make an effort to *fully* understand the genome of the crops in order to improve

Meta-Planer Speakers Corner IV

them. The main question is: *how can we get high yield with low input?*

Environmental sustainability: The topic *environmental sustainability* has to be considered: what effects arise from human impact? Are we aware of our role in the environment?

New types of use: We also have to think about new usages of species. How are they used currently and what potential do they have? Do we use them efficiently or would they be more effective if applied differently? Modern research, for example, made it possible to use plants as production areas e.g. for latex or pharmaceuticals.

Market: But neither farmers nor companies will provide products that are not wanted by the consumers. But is it the best way to only produce what the customer buys, or should we start producing those goods, that they should rather buy and influence their buying behavior? Plant breeding and genetic engineering have made an effort to improve crops. But these techniques have triggered open discussions; farmers for example are not willing to buy plants that include genes of *wild types*. But on the other hand the market can also create a *pull effect*. Demand determines supply and this can push scientific research.

Genetic recombination: In order to utilize natural diversity the potential of *genetic recombination* has to be improved since recombination is limited in large parts of the crop genomes.

Pre-breeding: Another important topic was *pre-breeding*. Desired traits have to be identified and undesired traits have to be sorted out in order to improve the crops. Therefore the potential of the primary, secondary and tertiary gene pool has to be analyzed. This is a very time-consuming and expensive technique. The existing research infrastructure used to be better – JKI cannot provide as extensive pre-breeding activities as the former BAZ. For most crops the pre-breeding activities are too costly for breeders alone. Find ways to improve pre-breeding infrastructure and networks.

Orphan crops: But not only do the rich countries have to face all of these challenges, poor countries have to be included too. *Orphan crops* for example should be put into focus by scientists who have the tools and the knowledge that is needed. Yet neglected crops - that are usually important for the world´s poorest regions but receive no attention whatsoever - could bear unknown potentials.

Genebanks: We need new and efficient ways to access comprehensively the hidden power of natural (domesticated) diversity collections.

To sum up, we have seen that the necessity of establishing new ideas to utilize biodiversity is recognized. The precise approach of unlocking the broadly accepted potential yet needs to be developed. New strategies have to be worked out and discussions have to be initiated among all the important stakeholders. Efficient ways have to be found to integrate knowledge and key technologies throughout the disciplines and the supply chain. Creativity and visionary thinking is the key to success.

In general it was mentioned that the science system has to work together with the industry and has to provide information for the general public, so that scientific research can be used efficiently to solve the problems of mankind. Threads can be seen in missing financing and a lack of acceptance in parts of the society. In the past, funding focuses have changed and complicated scientific work e.g. the discontinuation of pre-breeding funding. Furthermore better access to *gene banks* with their genetic material has to be ensured.

Future approaches (focal points)

- Stronger focus on: interdisciplinary research and training, improved basic research for unlocking the potential of natural genetic resources
- Research to adapt crops: increase the yield, resistance
- Genetic recombination
- Phenotyping + linkage of phenotyping with molecular methods
- Pre-breeding (new approaches needed, public-private cooperation)
- Technology transfer for optimization of under-utilized or under-improved crops in developing countries
- Emotionalize plant research activities by linking it with society requests /needs

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