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Research strategy of the German Agricultural Research Alliance (DAFA) for the development of the organic farming and food sector in Germany

Ulrich Hamm · Anna Maria Häring · Kurt-Jürgen Hülsbergen · Folkhard Isermeyer · Stefan Lange · Urs Niggli · Gerold Rahmann · Susanne Horn

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Abstract The Federal Government of Germany regards organic farming as particularly resource-efficient and environmentally sustainable economic activity. It therefore supports the expansion of organic farming up to 20% of the agricultural area. Against this background, the German Agricultural Research Alliance (DAFA) together with a broad alliance of representatives from business, science, and public policy developed this research strategy in a theme-finding and prioritization process that ran over more than 2 years. It sets out how German agricultural research can make a substantial contribution to noticeably improving the performance and competitiveness of organic food and farming while at the same time helping the sector meet its own goals and be an example as an especially sustainable type of economic activity in terms of the four international umbrella organization of the organic world (IFOAM) principles of organic farming (health, environment, fairness, and care).

The DAFA recommends that three approaches be pursued in parallel: (1) focusing of research on the most important themes, (2) the establishment of efficient structures for research and funding, and (3) more funding for research on organic farming. The following most important research topics in crops were identified: plant breeding tailored to the need of organic agriculture, plant–microbe and plant–plant interactions, autonomous field micro-robots, alternative control of fungal diseases and management of nutrients, and soil fertility. In organic livestock production, the most important topics are to meet competing goals in production systems, to ensure optimum supply of essential amino acids in poultry, and to foster successful animal production by implementing research-practice networks. In addition, progress in the processing of organic foods and the transfer of trustworthiness features as well as reinforcing organic principles in the food chain are needed. It is called for new research

U. Hamm
Department of Agricultural and Food Marketing, University of Kassel Witzenhausen, Steinstraße 19, 37213 Witzenhausen, Germany

A. M. Häring
Faculty of Landscape Management and Nature Conservation, Applied University for Sustainable Development, Schicklerstraße 5, 16225 Eberswalde, Germany

K.-J. Hülsbergen
Department for Plant Science, Technical University Munich, Liesel Beckmann Straße 2, 85354 Freising, Germany

F. Isermeyer · S. Lange (✉)
Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Bundesallee 50, 38116 Braunschweig, Germany
e-mail: stefan.lange@thuenen.de

U. Niggli
FiBL—Research Institute for Organic Agriculture, Ackerstraße 113, 5070 Frick, Switzerland

G. Rahmann
Institute of Organic Farming, Johann Heinrich von Thünen Institute, Federal Research Institute for Rural Areas, Forestry and Fisheries, Trenthorst 32, 23847 Westerau, Germany

S. Horn
Neumarkter Lammsbräu Gebr. Ehrnsperger KG, Amberger Straße 1, 92318 Neumarkt, Germany

and funding structures which are no longer strictly time limited; for research-practice network offering "co-learning" between farmers, advisors, and researchers; for real transdisciplinary funding instruments; for model regions to facilitate transfer of advancement of research and knowledge as well as for federal and state co-funded university chairs. However, these prerequisites for 20% organic agriculture can only be achieved by a parallel increased funding by the governmental authorities.

Keywords Agricultural politics · Consumer behavior · IFOAM principles · Organic agriculture · Strategic development

Introduction

Organic farming in Germany

At the end of 2015, there were 24,736 organic-production holdings in Germany farming 1,088,838 ha of land organically in accordance with the EU legislation governing organic farming. They account for 8.7% of all holdings, farming around 6.5% of the total utilized agricultural area (Table 1). Most organic farms in Germany have joined associations. In addition to the Bioland and Demeter associations (the largest and oldest organic associations), there are also other associations such as Naturland, Biokreis, Bundesverband Ökologischer Weinbau (Federation for Organic Viticulture, ECOVIN), Gäa, Ecoland, Biopark, and the Verbund Ökohöfe. Representatives from organic farming associations, organic food processors, and organic trade founded the "Bund Ökologischer Lebensmittelwirtschaft" (BÖLW, Organic Food Industry Federation) in 2002 as the umbrella organization of the entire organic sector.

Some of the guidelines of German organic farming associations are stricter than those laid down in the EU legislation governing organic farming. For example, pursuant to the EU legislation governing organic farming, a holding may under certain circumstances only

Table 1 Developments in organically farmed land, its percentage of total agricultural land, and developments in the number of organic farms and their percentage of the total number of farms since 1996

Year	Area (ha)	Percentage of total agricultural land	Number of farms	Percentage of total number of farms
1996	354.171	2.1	7353	1.3
1997	389.693	2.3	8184	1.5
1998	416.518	2.4	9213	1.7
1999	452.327	2.6	10,425	2.2
2000	546.023	3.2	12,740	2.8
2001	634.998	3.7	14,702	3.3
2002	696.978	4.1	15,626	3.6
2003[a]	734.027	4.3	16,476	3.9
2004	767.891	4.5	16,603	4.1
2005	807.406	4.7	17,020	4.2
2006	825.538	4.9	17,557	4.6
2007	865.336	5.1	18,703	5.0
2008	907.786	5.4	19,813	5.3
2009	947.115	5.6	21,047	5.7
2010	990.702	5.9	21,942	7.3
2011	1015.626	6.1	22,506	7.5
2012	1034.355	6.2	23,032	7.7
2013	1044.955	6.3	23,271	8.2
2014	1047.633	6.3	23,398	8.2
2015	1088.838	6.5	24,736	8.7

[a] Due to a change in coverage in Thuringia not fully comparable with previous years

partially convert to organic farming, whereas the organic farming associations always prescribe the total conversion of a holding. In Germany, the conversion of the entire holding is a prerequisite for support with public funds.

Income situation

According to calculations by the Thünen Institute, organic test farms earned, on average, profits plus labor costs per man-work unit (MWU) in the 2014/2015 marketing year of €33,222. As compared to the previous year, this corresponds to a rise of 2%. Comparable conventional farms earned, on average, in the 2014/2015 marketing year profits plus labor costs per MWU of €31,533. Thus, the average income of the organic test farms exceeded the income of the conventional reference farms by around €1700 or 5%.

The accounting results of 425 organic farms and of 2106 conventional reference farms were used for the 2014/2015 marketing year (http://www.thuenen.de).

Cited from Organic Farming in Germany, as of: January 2017 Federal Ministry of Food and Agriculture (BMEL) of Germany, Division 516—Organic Farming, Rochusstraße 1, D-53123 Bonn URL: http://www.bmel.de/DE/Landwirtschaft/Nachhaltige-Landnutzung/Oekolandbau/_Texte/OekologischerLandbauDeutschland.html?nn=309814

History and development

In the draft German Sustainability Strategy (May 2016), the Federal Government of Germany emphasized the role of organic farming. Specifically, it states: "*Organic farming is a particularly resource-friendly and environmentally sound type of economic activity […]. The declared goal of the Federal Government is therefore that 20 per cent of the total agricultural area be farmed organically.*"

At present, the proportion of agricultural land farmed organically is still below 7%. It has approximately doubled over the past 15 years (Table 1). This doubling is a considerable success but also shows that the Federal Government's target would take decades to reach with the current rate of growth.

The demand for organic food has grown more strongly than supply from German domestic production. Germany now imports a considerable proportion of the organic products sold. Consumer demand in Germany therefore already offers opportunities to reach the Federal Government's growth target more quickly. However, this will only be possible if organic farming in Germany significantly improves its competitive position.

However, the targeted increase in organic farming (the 20% target) is not an end in itself. It is important to maintain the four international umbrella organization of the organic world (IFOAM) basic principles which underpin the high standards of organic food in terms of environmental and social sustainability: health, ecology, fairness, and care. It is also important to address remaining weaknesses in organic production and thus build the most convincing production, processing, and trading systems that impact on all areas of agriculture.

In order to achieve both the competitiveness and the sustainability objectives, research efforts for organic farming have to be considerably strengthened. This is also but not just a matter of money. Three different approaches have to be developed in parallel:

– *Content*: The Sections 'Extent and characteristics of farming systems—organic crop production' to 'Consumer demand and markets—societal expectations and consumer behavior' outline research themes that should receive priority support in order to achieve the dual objective of this strategy: (a) high performance, competitiveness, the 20% objective, and (b) exemplary sustainability as defined by the IFOAM principles.
– *Structures*: The research infrastructure and research funding mechanisms supporting the organic sector only partly meet the requirements of the sector. Simply providing more funding is not sufficient. Structural deficits also need to be addressed. The proposals for this are summarized in the Section 'Policy and governance—establishing high-performance structured (research and research funding)'.
– *Financing*: If the organic food industry is to have a market or area share of 20%, then policy must ensure that the share of this sector in the agricultural research budget must increase accordingly.

The idea behind the current research strategy was to illustrate the reasonable and necessary steps to reach the self-declared 20% goal of the Federal Government of Germany for the area with organic agricultural in Germany.

Extent and characteristics of farming systems—organic crop production

Organic crop production has a broader range of objectives compared with conventional crop production because in addition to economic output (yield and quality), it addresses environmental aims such as biodiversity. In addition, most external inputs are excluded. Under these conditions, producing a sufficient amount of high-quality harvested produce is a major challenge. The following sections address five areas which are particularly important for the improvement of the performance of organic crop cultivation and should therefore be given priority in research funding.

New structures for plant breeding

Since organic farming uses neither synthetic chemical plant protection products nor readily soluble nitrogen fertilizers, it is dependent on robust plant species and cultivars that capture and use nutrients effectively. Breeders considering the needs of this market are faced with the problem of low sale volumes. As long as organic farming has a relatively low market share and a relatively broad spectrum of crop types, the incentives for independent breeders are low.

There is a risk that the yield difference between conventional and organic farming will increase over time. The private plant breeding sector is holding back on investing in the breeding of (a) special cultivars for organic farming and/or (b) economically less important crops (for example, cultivars for intercropping and legumes for nitrogen fixation). Furthermore, multinational breeding companies invest billions to improve the genetic potential of the world's leading crop types. This development not only reduces the competitiveness of organic farming but also affects crop diversity in conventional farming.

The challenge will not be solved by public investments of a few million euros in a program to support alternative breeding programs for individual crop species. The problems outlined have a system character and the economic levers in a globalized agricultural are very strong. Therefore, the focus of research policy should first be on establishing one or two well-resourced, interdisciplinary consortia at the interface between plant breeding, economics, and legal sciences working with a longer-term perspective and developing knowledge-based organizational solutions.

Improved crop performance in complex systems

The breeding programs for different leading organic crops that are currently funded to a large extent by private foundations are very important. The improvement of the legal, structural, and financial framework of this breeding work is therefore of great importance (see Section 'New structures for plant breeding'). This breeding work will in the long term increase the competitiveness of organic farming.

One of the great innovative aspects of plant breeding for organic farming lies in the holistic approach to the crop in and with its environment. New findings from epigenetics and rhizosphere research suggest that plants can interact with the environment to a much greater extent than previously understood. Thus, the plant can alter its gene expression in response to stress and pass this information on over several generations. With root exudates, the plant can attract microorganisms and enter into a symbiotic relationship with them.

Microorganisms are therefore of great importance for the nutrition and resistance of the plants. In order to make use of these findings in organic farming, a better understanding and exploitation is required of the contribution that plant breeding can make to improved plant–microbe and plant–plant interactions. More attention to plant–plant interactions would lead to the selection of varieties which improve the performance of inter- or mixed-cropping systems and which better support symbiosis. This can improve the resilience of organic systems.

It is proposed that consortia consisting of basic research, applied research, and organic breeders be developed using idea contests (see Section 'Changes to research funding mechanisms') in order to develop solutions for plant breeding under low-input conditions and for resiliency and complex systems.

Technical innovation for organic farming

Organic farming is based on the core idea of the targeted support and use of ecological regulation mechanisms. The use of agricultural technology should serve this purpose. The latest advances in digitalization and the prospects for autonomous vehicles open up new potential.

Computer-controlled small self-propelled robots open up the possibility of providing an improved starting environment for individual plants even as early as at sowing and planting. As the crop develops, undesired plants can then be automatically detected and mechanically removed or suppressed using heat. In the case of insect or fungal attack, the location of outbreaks sites can be recognized at an early stage, which increases the chance of appropriate treatment. Drones equipped with tanks enable rapid and cost-effective application of plant protection agents. The feasibility has already been demonstrated in the use of hatching *Trichogramma* wasps against corn borer.

Biodiversity in the field can be increased by growing different crop species closely together. Diverse cropping is an alternative to successive monocultures. The harvesting of the different crops at different times could be made possible by appropriately designed robots. In addition, this approach shows a way to break the trend to bigger machines on larger farming units, which causes problems to soil structure. This development opens up new options for crop cultivation in the medium and long term without the use of fossil fuels.

It is not yet possible to reliably assess whether the widespread use of small robots is technically and economically feasible. If the relevant research work, which has already started, leads to a positive assessment, it is recommended that German agricultural and mechanical engineering researchers work with the private sector to establish a powerful research and development focus together. This would also provide an important basis for well-funded research.

This research would benefit organic farming and the wider agricultural sector. Positive environmental effects would arise and the research has the potential to impact worldwide. It would place the German agricultural machinery industry in a good position to play the role of an international technology leader in this transformation of crop production systems.

Alternative control of fungal diseases

The extensive literature review conducted by the OKnetArable EU Thematic Network showed that plant diseases are an important cause of yield reduction in organic farming. Various European and German research projects have already devoted themselves to the improvement of crop health. In particular, direct and indirect alternatives to the use of copper-containing fungicides have been sought. Despite great progress, the goal of securing healthy crops has not been achieved. Crop losses not only reduce the competitiveness of organic farming but they also compromise the environmental excellence of organic farming. Unresolved disease problems affect many crop species, but the most important affect potato, grape, and other fruit crops.

To improve the resilience and health of organic crops, previous research has made progress in five areas: (a) epidemiological modeling and prognosis of different pathogens in different crops, (b) development of diagnostic kits that detect early infection, (c) the breeding and testing of cultivars that are resistant or tolerant, (d) optimizing the use of existing plant protection agents and the development of new active substances for the future direct regulation of plant diseases, and (e) better coordination of crop management measures.

Solutions that have not been implemented due to their complexity and labor costs can become economically interesting with advances in agricultural technology. Further direct regulation methods must be developed and combined with preventive measures. There are good prospects that more progress can be made in the near future. Therefore, it is proposed that a contest for the best possible solutions be organized (see Section 'Changes to research funding mechanisms') with the intention of putting the best proposals into practice. In this ideas contest, the integration of different methods and measures should be a priority.

Nutrient management and soil fertility

A central aim of the organic sector is the closure of the nutrient cycles within farms, between farms, and along the food chain. However, the full implementation of the "cradle-to-cradle" principle (i.e., the efficient use of waste and the avoidance of undesirable substances in organic material) raises questions that go beyond the organic sector. These cannot be fully addressed by the organic sector alone. The DAFA sees a need for a comprehensive nutrient strategy that includes the food sector, accounts for urban development, and that considers waste recycling structures.

Closely related to the nutrient issue are the questions of organic matter accumulation and carbon storage in agricultural soils. Organic farming has particular potential for carbon storage. The question of the role of organic farming in global climate protection requires a comparison with the potential and costs of other important climate protection options. The DAFA encourages the commissioning of an independent, cross-sectoral investigation.

Against this backdrop, the strategy presented here can only be a partial solution. It is, however, an important contribution to the future success of organic farming. The foundation of the nutrient supply from agricultural soils and the control of nutrient mobilization differ considerably between different crops and sites. Both the natural circumstances (soil type, precipitation) as well as the agricultural and economic conditions (livestock farming, marketing possibilities) play a decisive role.

From this starting position, it is essential to integrate agricultural practice considerations very closely into the research design. A research concept should be developed which consists of four inter-connected components:

- Jointly conducted, structured problem analysis through practice and research. In long-term cooperating alliances (see Section 'Research-practice networks'), practical experience, current scientific knowledge, and possible solutions should be explored.
- Evaluation of data (field maps etc.) from farm and other businesses. The aim is to find a sufficient number of farm businesses that wish to cooperate in the long term, harmonize their data, provide the data for scientific research, and to discuss the results in meaningfully composed working groups.
- On-farm research. For selected farms, targeted changes to the production systems and the incorporation of results into cross-farm comparison can be conducted. In this way, certain hypotheses can be tested under practical conditions in a relatively large number of farms.
- Networks of experimental stations. For more complex experiments, which are less suitable to on-farm research, experiments on experimental stations are to be expected. In order to take into account of the natural diversity, it is important to include test stations and existing long-term experiments from different parts of Germany in the overall network.

A long-term practice-research network, which consists of these four components, could organize co-learning over time and in part organize coordinated experimentation. The research questions so identified would then be assigned to the most appropriate level to be worked on. This presupposes that the four components are also closely linked to each other, and that both research funders and those involved in science and practice make longer-term commitments (see Section 'Policy and governance—establishing high-performance structures (research and research funding)').

The building of soil fertility is a basic objective of organic farming and essential to sustainable economic farm practice. However, it is difficult for farmers and advisors to assess the soil fertility status of farmland, monitor changes in soil properties, and the effect of farm practice on soil properties. New scientific methods offer great potential for a more precise analysis of soil fertility, but have so far not been widely used in farm practice (too expensive, not available, no experience, lack of guideline values…).

In close collaboration with science, advisors, and farmers, a "soil fertility methodological toolbox" which contains practical tools for the assessment of soil fertility as well as rules, guide values, and decision aids for increasing soil fertility should be developed on the basis of the latest scientific knowledge. This methods toolbox should then also be made available in the form of apps for farmers and their advisors. Such apps can combine laboratory data from the cloud, results from field-based rapid methods, or sensory assessment of practitioners, and can be used to accurately assess the short-, medium-, and long-term yield levels of soils, depending on the management measures. Competitive consortia should be sought for such developments.

Extent and characteristics of farming systems—organic livestock production

The organic sector aims to keep livestock in a way that allows the animals express their natural behaviors as fully as possible and ensures they are content in their environment and are healthy.

The development of conventional livestock farming has become more and more subject to societal scrutiny. From this, one might expect that organic livestock production would enjoy increased support. This is valid to a point. The debate about how we use and keep livestock has led to increased questioning of animal husbandry in general, including that on organic farms. Vegetarianism or veganism is becoming more common. This presents a challenge for the organic sector because animals play an important role in the nutrient cycle of most organic farms.

The lively societal debate about the future of livestock farming also means that some emerging segments of the conventional market fulfill the same standards as organic farming in terms of animal welfare. Because these do not need to use expensive organic feed, they offer a lower-cost high-welfare option to consumers. The future economic significance of these emerging market segments cannot yet be assessed.

Overall, there is uncertainty about the future conditions in which the organic livestock will develop, and it is not easy to derive undisputed recommendations to support development. This is because different goals in society for the livestock sector are not easily reconciled (animal health, freedom of movement, access to a variety of housing conditions, emissions, grassland use, food prices, food safety, etc.). This requires weighing up options considering more than individual scientific and technical aspects separately. It is necessary to analyze (a) how the production systems are perceived in society and (b) the willingness of consumers to support certain social goals through their own consumption decisions (e.g., purchasing higher-priced products, reducing the consumption of livestock produce). The consumer-related research approaches are presented in the Section 'Consumer demand and markets—societal expectations and consumer behavior'.

Ruminant husbandry and the associated use of grassland are particularly important in organic food production. However, the focus of the present strategy is on pigs and poultry production for three reasons. Firstly, it is to be expected that the societal scrutiny of intensive production systems for monogastrics will sooner or later extend to organic pig and poultry production systems. Secondly, research on organic farming has hitherto been primarily concerned with ruminants while the research structures for the organic farming of pigs and poultry are underdeveloped. Thirdly, DAFA has already identified the need for research into grassland in its own strategy which addresses the further development of grassland-based organic farming.

Future production systems—a focus on pigs

There are many different ways to keep livestock in controlled environments and protect them from the weather, predation, etc. Some practices still found in organic farming today (e.g., the tethering of cows) developed under the economic conditions and technical possibilities of the last century. These are criticized with respect to animal welfare. However, the same is true for some of the forms which have become widespread due to structural changes in conventional livestock farming over the past three decades (e.g., fully slatted floors in pig housing).

In addition to animal welfare considerations, the question of emissions to the environment (e.g., emissions of ammonia, methane, bio-aerosols) has also increased in importance. Legislators have focused on the use of air filtering technology for pigs and poultry houses in particular. However, this encourages forms of livestock production which are out of sight of most people and which are intuitively judged negatively by many critics. Especially in organic farming, systems which fit harmoniously into an intact cultural landscape and do not look like a closed industrial facility are expected by many.

Animal welfare, emissions, landscape—just the very brief discussion of these three criteria shows that difficult trade-offs need to be addressed in the further development of management systems. Research organizations, providers of livestock housing, advisors, veterinarians, and farmers face the challenge of developing livestock farming systems that:

(a) meet all animal health and animal welfare requirements in all seasons;
(b) enable the most efficient and environmentally friendly use of the nutrients;
(c) can be supported from a commercial and an employee's perspective; and
(d) are accepted by society.

Just as the research landscape in the agricultural sector has developed over the past decades, it is not to be expected that an interdisciplinary consortium will be formed by itself at any research facility that carries out this development and evaluation work. It is therefore recommended that research funding be used to support a contest for ideas, as outlined in the Section 'Changes to research funding mechanisms', which if successful would also lead to follow-up implementation phase activities.

It is proposed to develop the idea contest approach for better systems for organic pig production. This sector could provide a particularly important model for the whole of agriculture because the challenge of reconciling animal and environmental aspects with new animal husbandry and meeting social expectations is particularly acute in pig farming. On the basis of the experience gained with the proposed idea contest for organic pig farming, the adoption of this concept for other livestock systems should be explored.

Feeding and genetics of the future—a focus on poultry

Feeding approaches in organic livestock farming are still based mostly on conventional system concepts. For example, the feeding of dairy cows and fattening cattle still depends on large amounts of concentrate feed, and various conventional feed components are often used in poultry and pig production. This means that organic feeding systems comply only partly with expectations such as of 100% organic feed coming from the region and that priority be given to forage.

In the case of ruminants, organic production can rely completely on forage provided that the legal and economic framework conditions are supportive and that the agricultural structural circumstances are correspondingly adapted. There is an extensive knowledge base in farm practice and there is also sufficient bovine genetic diversity. The extent to which these potentials are used is thus essentially a question of incentives (e.g., adaptation of guidelines, pricing under labeling programs) and the exchange of experience and information between farm businesses (see Section 'Successful organic livestock husbandry in practice').

There are major challenges in the production of pigs and poultry because it is difficult to achieve a sufficient and balanced supply of essential amino acids while relying completely on regional organic feed production. If this is not achieved, the efficiency of the use of protein drops and nitrogen emissions increase. The search for solutions is complicated because feeding and animal breeds are closely matched in modern farming. It is therefore proposed to tackle the problem through inter- and transdisciplinary cooperation, including animal nutrition, animal breeding, and management. The aim of the research work should be to optimize livestock farming on the basis of locally available feedstuffs so that the animals are healthy, maximize nitrogen and phosphorus utilization, and minimize emissions. For this purpose, coordinated livestock breeding and feed formulations are required. New feed components (for example amino acids from fermentative processes) should also be included in the considerations.

Particularly in poultry, it is difficult to reconcile available breeds, husbandry systems, and protein supply. At the same time, however, there are opportunities for real progress which is economically relevant in view of the high turnover in this sector. Therefore, it is proposed to first promote interdisciplinary work on chicken production. Farm businesses and the poultry breeding industry as well as feed mills should be involved from the outset.

Successful organic livestock husbandry in practice

Fundamentally improved husbandry systems, which are to emerge in particular from the research projects initiated in the Section 'Future production systems—a focus on pigs', will impact on practice after years and decades, especially if larger housing investments are required. Therefore, it is important to establish additional research concepts to support innovation in livestock husbandry on a wide range of farms in the short and medium term.

This is difficult because of the variation is site conditions. Farmers have to consider different factors simultaneously in the development of their livestock farming: animal welfare, livestock health, labor costs, production costs, environmental impacts, local acceptance, consumer expectations, etc. However, in order to optimize operations, aspects such as changes in housing and equipment, design of the feeding, cleaning out, ventilation, water supply, animal health management, grassland management, the labor inputs, etc. need to be considered. There are often interactions between these different management factors. Furthermore, these interactions can be affected by site conditions, season, or weather.

Thus, each individual farm is faced with a complex, multi-criteria optimization task for which there is usually no standard prescription (e.g., from using a particular computer program). Farmers are therefore very much dependent on education and training, experience, intuition, and competent advisors.

Supporting innovation in organic livestock farming therefore cannot be based on simply setting up one or two experiments in which innovations can be developed and tested. The findings so gained are often not easily transferred to other farms because other local conditions prevail there (housing, transport circumstances, feed sourcing, etc.). Each experimental station can adjust only a few variables in its experiments, while farmers have to consider a much larger range of variables in designing their systems.

It is therefore proposed to establish a staged practice-research infrastructure for the most important livestock production systems (dairy cows, pigs, chicken) as outlined in the Section 'Nutrient management and soil fertility' for this theme. It comprises four components: (a) joint identification of problems, (b) evaluation of detailed and differentiated operating data, (c) implementation and evaluation of experiments conducted on farms, and (d) coordinated experiments in a network of testing stations. These four components are then interlinked in such a way that the organic livestock production is provided with an optimal basis for "co-learning" and also can partly use "coordinated experimentation."

However, in organic livestock farming, the impact of insufficient research capacity is more evident than for organic crops because of the small number of experimental stations equipped to conduct this type of research. This is where policy is called for since such experimental facilities are an indispensable part of the research and practice infrastructure outlined above.

Managing young animals whose rearing seems unprofitable is one aspect of organic livestock farming which deserves special attention in the research-practice networks. Examples are the rearing of male chicks produced in the breeding of laying hens and using low-priced male calves from specialized dairy cows. The killing of these animals raises legal and ethical questions. Especially for organic farming with its high ethical standards, it is therefore particularly important to develop alternative concepts. In the production of eggs, alternatives to the killing of the male chicks are already being worked on (dual-purpose chicken, Bruderhahn initiatives, in ovo selection), and analogous approaches are also available for dairy farming. However, considerable research is still required in supporting breeding, rearing, and marketing. With the help of the networks, different concepts should be developed, investigated, and compared. The aim is that exemplary concepts are implemented across the whole organic sector.

Extent and characteristics of food systems—processing, retailing, and certification

The process quality of organic farming that is appreciated by consumers (with respect to environmental performance, nature protection, animal welfare, working conditions, or trading practices) is an important basis for the higher product prices compared to conventional products. However, since consumers are usually not able to see the quality of the production process while looking at the final product, the purchase of organic products is also a question of trust: consumers want to be able to trust that the principles of organic food production (see Introduction) apply at all parts of the value chain (from the farm to the retailer's shelf).

In the past, the organic sector has generally succeeded in establishing itself in public perception as a particularly trustworthy segment of the food industry. This prominent positive image is not secure for all time and cannot be taken for granted. It must be reinforced—especially since other parts of the food system are also offering consumers high process-quality options. For example, markets now address free-range, vegan, "free-of," or regional trends.

There are three challenges for the organic sector. First, it must ensure that the demanding principles are applied in processing as well as in farming. Second, it must be demonstrated to the customer as much as is practically possible where and how the food was produced and how the different wishes of the organic consumers are met (transfer of trustworthiness features along the food chain). And third, the control structures must be constantly optimized so that the high-price organic sector is protected from fraud and it can be demonstrated credibly that all appropriate preventive measures have been taken.

Processing of organic food

Processing has a great influence on the quality and the market position of organic products. The processing companies aim to produce particularly high-quality food products from organic produce, meeting the four IFOAM principles (health, ecology, fairness, care) at the procurement, processing, and retailing stages, too.

There is an additional need for innovation because the use of additives and processing aids is strictly limited and therefore some "simple solutions" from conventional food processing are not available. There is a need for public research investment because most of the farms in this sector cannot afford their own research department due to their small scale. The more successful this approach to research and development is, the greater is the chance that these innovations will impact on the whole food industry.

A comprehensive analysis of the knowledge and the research needs in this sector was carried out on behalf of BMEL in 2012 by a consortium coordinated by FiBL Germany. The numerous research and transfer themes which were identified in the study are still relevant. With respect to the core objective of the DAFA strategy presented here, three complex issues appear to be of paramount importance.

First, it is necessary to examine how the production of bakery products can be further developed. Research should include the whole value chain, in particular (a) plant breeding for certain ingredients (including low asparagine content), (b) the outcome-oriented assessment of the baking quality of the grain, and (c) the optimization of dough management and baking process. The end result should consist of consistently high-quality baked goods, which are of high quality with regard to the desired constituents (nutrients) and the unwanted substances (acrylamide) as well as excellent sensory properties.

The second question relates to the slaughter of animals and the production of processed meat products. As explained in the Section 'Organic livestock production', livestock farming is subject to particularly critical public scrutiny. Many critical citizens call for a paradigm shift here, both with regard to the treatment of farm animals and with regard to the role that livestock farming should play in agriculture and in our diets. If the organic food industry is to play a pioneering role in this important transition, the focus must not be restricted to animal husbandry. It must also take into account the slaughter and processing of the farm animals. The research questions to be addressed here relate to (a) the spatial distribution and size of the slaughterhouses, (b) the slaughter process, and (c) the product quality. Product quality relates mainly to developing meat processing without the addition of nitrite while meeting consumer demands regarding aroma, color, and shelf-life. It is recommended that, in view of the reasons set out in the Section 'Future production systems—a focus on pigs', the research work should initially concentrate on pig production and the resulting food products.

The third area of research is the perishability of organic food. On this point, consumers can directly experience eventual drawbacks in organic products. It is to be expected that in the future, the conventional food sector, with which consumers compare organic producers, will further optimize its processes and products by using a wide range of preservation methods and additives. It is therefore important to achieve comparable performance in terms of shelf-life for the expansion of the organic market share by developing and applying innovative processing technologies and by using alternative but equally effective additives for their products. In addition to the already mentioned nitrite theme relevant to sausage-type products, the other focus areas are vegetables (for example, carrots, edible pumpkins) and fruit (especially apples), but also certain dairy products and fruit juices.

Packaging also presents central challenges for the future. This concerns the development of packaging alternatives from non-petroleum-based organic materials. It also relates to the avoidance of the transfer of undesirable substances or of nanoparticles from the packaging material into the food. The food industry as a whole, not just the organic sector, benefits from improvements in these areas. They should therefore be supported by policy and research funding to support innovation in both the conventional and the organic sectors.

Transfer of trustworthiness features

Particularly in long value chains (many processing steps, long distances) or value chains characterized by bottle necks, it is difficult for processors and retailers of organic food to get a picture of the process quality at all upstream stages. Accordingly, it is also difficult to transmit the quality accumulated in the chain from the farm to the point of sale and to convincingly communicate this to the final consumer.

In principle, there are two ways to address this:

- Indicator-based certification systems: Here, the characteristics of the respective production stages are documented using indicators (if necessary, checked by independent certification bodies) and the resulting certificate is allocated to the products as a package note as they pass through the food chain.
- The "face behind the production": Here, for each production stage, it is clearly known who is responsible for each processing step. The companies can also describe those value-adding aspects, which cannot be adequately covered by the usual standardized indicators.

Theoretically, maximum confidence in the market can be achieved by combining both concepts (certification and personalized declarations). In practice, however, there are obstacles to this ideal situation. For example, it is not always in the commercial interest of processing companies to have information about their suppliers publicly disclosed because such trading information can give market actors competitive advantage. Moreover, it is questionable whether such individualized supply relationships can be made sufficiently flexible if, for example, in case of a short-term supply shortage companies have to source upstream products from another supplier.

Against this background, process design and combination possibilities should be scientifically analyzed. In this context, the consumer viewpoint (which concepts or indicators are particularly important for the development of trust?) should be included as well as the business viewpoint (which concepts or indicators can be used by the companies with a reasonable cost?) along with legal aspects (data ownership, data protection). These investigations should also be used to evaluate experiences from other economic sectors (e.g., experiences from the certification of sustainability in other sectors). Furthermore, it should be analyzed how rapid advances in information technology can be used to achieve the best possible transmission of the trustworthiness to the final consumer.

Ensuring the organic principles along the food chain

The demands that society places on the agricultural and food sector regarding a responsible and ethically acceptable approach to natural resources, livestock, and fairness between value chain actors are likely to increase in the future. With the IFOAM principles (health, ecology, fairness, and care) mentioned at the outset, the organic sector itself has established a corresponding value-base and benefits from an advanced position.

Developing these corporate principles under the conditions of intense competition and increasingly interconnected markets is a major challenge. As a research approach, it is therefore proposed that the development of corporate ethics in organic businesses should be studied. The gap between theoretical considerations and practical action must be bridged: What concepts are used in different companies along the value chain to put concrete emphasis on corporate ethics in practice? What successes or failures are there and what conclusions can be drawn from them for economic and policy decision makers?

The organic sector has long been using independent control systems to effectively fight against fraud attempts as a responsible business community. In a growing and globally interconnected industry, it can never be completely ruled out that individual entrepreneurs try to gain an economic advantage through fraud. With the development of complex, international economic structures, the challenges of controlling organic food have become even greater than in the past.

For the credibility of the sector, it is important that it does not act only in the event of a crisis, but proactively deals with the possible weaknesses in its control systems, analyzing alternative concepts and evaluating them comparatively. Here, independent science can make a contribution.

The focus of the analyses should be on how a control system for organic foodstuffs can be designed as effectively and efficiently as possible. For this purpose, various possibilities for (a) the design of process declaration and control, and (b) the analysis of the food should be investigated. Particular attention should be paid to the question of how the individual measures can be designed as risk-oriented as possible and how they can be linked sensibly to a system as effective as possible that operates under the legal and economic conditions of a globally interconnected economy. Another important aspect is the optimal design of sanctions measures to be taken in the event of the detection of misconduct.

Consumer demand and markets—societal expectations and consumer behavior

A special feature of the organic food sector is that it has very high standards regarding the sustainability of the production system. To ensure sustainability, specific technologies are excluded (for example, the use of mineral nitrogen) while at the same time specific solutions (for example, more freedom of movement for farm animals) are promoted.

In the further development of these regulations, assessments play an important role: How can complex ecological systems be managed sustainably? How are the societal values changing? The challenge is to strike the right balance between maintaining valued traditions and adapting to new technological developments and changing societal expectations. Only if this is successful will the organic sector continue to mobilize sufficient political support and sufficient purchasing power for organic food products.

Science can make an important contribution to the development of the profile of the organic sector through the development of socially desirable innovations (see Sections 'Extent and characteristics of farming systems—organic crop production' and 'Extent and characteristics of farming systems—organic livestock production') and by scientifically analyzing social expectations and through target-oriented communication on organic food production.

Societal expectations

In the development of technologies, production systems, and regulations, there is rarely one option that is superior for all societal objectives. More often, trade-offs need to be considered where one development objective is favored (e.g., animal welfare) at the expense of another (e.g., climate protection). A tendency to favor one over the other depends on priorities.

Every citizen and, of course, every scientist has his/her individual opinion about which social objectives are more or less important. However, if policy guidelines are to be laid down for technology development, only the majority position established through democratic processes rather than the views of scientists and technologists matters. It is, however, practically impossible to have the many small decisions which are to be taken in the course of the development of a technology made democratically in society at an early stage. Scientists and companies therefore make their decisions mostly without feedback from society, running the risk of pushing technology development in a direction which is not accepted by the majority of society in the longer term.

Against this background, it is useful for science to develop a sounding board for early evaluation of how the different development options are viewed by different societal groups. The importance of such a soundboard for various questions relevant to organic farming has been shown in the previous sections. For example, a farming system which uses micro-robots (see Section 'Organic crop production') can be evaluated positively (e.g., mechanical weed control) as well as negatively (reduced employment). With regard to the social acceptance of the development, two questions are always of interest: (1) In which direction should innovation be steered to further develop the ecosystem service provision by the organic sector and to find the greatest possible societal acceptance? (2) What communication strategies are appropriate to enable a reasonable exchange of ideas with the different groups in society?

However, creating the right format and the appropriate organizational structure for the analyses required is a challenge. It would certainly not be cost-effective to establish a dedicated research infrastructure for every question to be investigated (micro-robots, animal housing, etc.). Using opinion polls conducted by establishing polling organizations also does not appear to be promising since the questions to be examined are often complex. They must be explained step by step to the interviewees. For this purpose, smaller survey formats, e.g., using focus group discussions, are more suitable.

Against this background, it is recommended to gradually work on an effective research infrastructure used in the long term, preferably as a network of relevant institutions. The first step would be a contest to generate ideas for promising methods and organizational forms. In the second step, the particularly promising proposals would have to be described in more detail and tested on individual questions. On the basis of the experience gained, the third step is to establish a long-term research infrastructure.

Organic consumption behavior

Many stakeholders along the value chains from producers to consumers do not associate organic farming only with an alternative production process; they also consider ethical values implemented for all actors in the value chain, including their own approach to diet and nutrition. However, actors' decisions in the market often deviate from the expectations that many actors place on themselves and on others. Therefore, priority should be given to (a) how consumers can best meet their expectations with respect to sustainability and (b) how the consumption of organic products can be positively influenced. A good image for the organic food industry in society does not automatically lead to a strong demand for organic products.

In the scientific analysis of the consumption of organic products, the expectations and behaviors of different groups of consumers need to be considered with respect to the products themselves and to the different purchasing options and locations. In particular, the expectations and the purchasing behavior of the younger generation are of interest. Recognizing the key trends at an early stage to optimally position production, processing, and marketing in the future is of great importance for the long-term success of the organic sector.

Modern information technology opens up the possibility of entering into dialog instead of the one-sided corporate-based communication through advertising and public relations measures. The organic sector can build partnerships with consumers and support their efforts to consume sustainably. In this context, there are three important research questions:

– Firstly, it is necessary to examine the possibilities offered by new information technologies used by consumers. What is particularly interesting is how the sustainable consumption topic can be placed in an attractive way in everyday life and how interested people are in interactive communication about their buying and eating habits.

– Based on this, it is necessary to clarify what the organic sector has to offer in terms of consumption patterns and sustainability. This involves examining how food is consumed (shopping routes, packaging, food preparation, food waste, etc.) and what is consumed (dietary choices that affect the sustainability of the food system).
– Thirdly, examine how different groups respond to such offers and actually change their purchasing and consumption behavior. This also raises the question of how stable such changes are in the course of time, how they impact on the self-esteem of the actors, and how they impact on other people through providing example.

Policy and governance—establishing high-performance structures (research and research funding)

Additional research funding is necessary, but this alone is not sufficient, to enable the desired developmental steps that the organic sector needs to take. Appropriate research and research funding structures are also needed.

Here, four proposals for more efficient research and research funding structures are presented. These proposed measures are inter-connected and therefore all should be implemented.

Changes to research funding mechanisms

A part of the additional research funding needed should be used to establish the infrastructure outlined in the Sections 'New structures for plant breeding' to 'Technical innovation for organic farming' and to systematically work on improving the organic sector within these infrastructures. The new collaborations that are to be established here as well as the already existing inclusive alliances need a longer-term financial perspective.

The usual, usually 3-year project funding is not suitable for this. In particular, transdisciplinary research approaches (see Section 'Nutrient management and soil fertility') often require much more time for research and business to successfully implement their project from problem analysis to implementation.

The Federal Government should therefore engage with those federal states which are interested in co-operation to develop longer-term cooperation agreements in which the tasks of the participating institutions as well as their financing are reliably set. With the established infrastructures, some of the research questions outlined in the Sections 'Organic livestock production' to 'Consumer demand and markets—societal expectations and consumer behavior' can be dealt with. In addition to this, however, sections of this report include research questions that are not answered iteratively in systematic network collaboration. These research questions require groundbreaking ideas. In these cases, research funding needs to support a wide ranging competition for ideas.

The discussions in the Expert Forum showed that the current project-based research grant system is also not suitable for supporting research to explore new ideas. The project proposals and grants are usually aligned with the 3-year funding of early-stage researchers who are required to address a particular problem during this time based on outlined work plans.

An ideas contest needs to be organized more like an architectural competition: in the first step, the funder describes the problem to be solved and calls for suggestions for solutions; in the second step, researchers contribute their designs for addressing the problem as plausibly as possible (i.e., proposals for solutions, supplemented by an initial rough impact assessments). In the third step, the best possible solutions are selected for further consideration. Whether and how the first-placed proposal (or perhaps also the second or third placed) is then implemented remains open initially. The funder first assesses the selected proposals and then decides separately whether the implementation seems to be meaningful in terms of cost and benefit or whether a completely different approach to the problem should be considered.

It is recommended that a research funding organization tests this form of competition in the framework of a pilot project. On the basis of the experience gained, the process should be developed iteratively with the aim of providing as much incentives as possible for the development of ideas which (a) are innovative and (b) have a particularly great potential for the achievement of the objectives of this strategy.

Research-practice networks

Organic farming aims to minimize the use of external inputs. Therefore, increased performance depends to a great extent on whether farmers are better able to use the natural resources they have using know-how to sustainably increase yield and improve ecosystem service provision.

The innovations required are generally not one-dimensional cause-and-effect events in which specific measures or specific remedies can be applied to deliver clear operational improvements. The connections and interactions in organic farming systems are complex. Consequently, the classical linear approach to research-supported innovation, in which a technology is first developed in a private or public research facility and then implemented in broad practice by means of technology or knowledge transfer, quickly reaches its limits—especially if very few research institutes work in the area.

In this situation, it is necessary to implement and strengthen more effective forms of cooperation between research and practice. Practice should no longer be seen as implementer of knowledge that has been generated and tested elsewhere. Instead, it must be involved as a source of ideas, co-experimenter, data provider, and evaluator in the research and development process.

DAFA therefore recommends establishing long-term research and practice networks for organic food production. They should be linked to existing network structures to enable collaboration across Germany and be attractive to interested entrepreneurs (farmers, small and medium-sized food processing companies), advisors, and scientists. In particular, when joint experimentation is attempted in these networks, the private sector businesses involved must be eligible for funding.

In principle, the European Innovation Partnerships (EIP) offers opportunities to anchor and finance such practice research networks within the framework of EU Common Agricultural Policy. However, the use of these possibilities for organic farming has remained unsatisfactory. Firstly, there were too few networks. Secondly, the networks were established with too short or uncertain time perspectives. Third, the EIP-supported projects are supported separately at the federal state level. It is difficult to use the EIP in Germany to establish a nationwide co-learning and, if necessary, co-experimentation network for organic farming. Fourthly, the experience so far shows that the bureaucratic effort to apply for and implement EIP projects is perceived by the stakeholders involved as being too great so that the current form of the instrument does not match the desired outcomes.

This finding leads to the recommendation that the EIP concept in Germany should be fundamentally revised and, if necessary, changes to the EU rules should be made. The aim should be to tap into the existing potential of this instrument for the organic food industry as well as for the entire agricultural and food industry.

Designing funding instruments to support transdisciplinarity

The organic farming sector practitioners act in a complex environment characterized by economic goals and constraints, their own ideals and experiences, sociocultural ties, etc. Their decisions and priorities are derived from balancing these diverse influences. Scientists, on the other hand, usually deal with subsystems, for example components of a farm or business system, even where an interdisciplinary approach is taken. This often results in a difference in perception of priorities and deficits, which leads to the perception by researchers that their findings are not used in practice. Actors from practice complain that much research is not relevant to practice.

This discrepancy can be overcome if science, business, advisory agents, and possibly other social actors cooperate across disciplines to jointly develop solutions and examine their practical application. However, the current framework conditions for research funding do not yet support such transdisciplinary approaches. These should be developed with a view to the following core points:

– *Better participation opportunities for economic operators*: The experience of actors in primary production, processing, and trade is an important source of innovation. Economic operators must be able to participate more intensively in research agenda setting, in the identification of urgent innovation needs, and in research projects. Particularly from the point of view of small and medium-sized enterprises (SMEs), it is important that the time taken to make project-related decisions with economic participation is significantly reduced. In addition, the resource contribution that SMEs are required to make hinders participation for many SMEs and thus the desired transdisciplinarity.
– *Better participation for civil society actors*: A large number of actors now in the traditional political, economic, and administrative institutions (networks, independent institutes, consumer initiatives, NGOs, etc.) are available to develop ideas and make

important contributions to the social evaluation of future innovations. Many of these stakeholders share goals with the organic sector and are thus partners for organic food production. However, they often cannot participate in projects or networks because they do not have sufficient resources. Where appropriate, the involvement of these actors should be facilitated to better tap their potential for supporting innovation.

– *Financing of project start-ups*: Transdisciplinary projects should be given the opportunity to consider different options to achieve the desired goals more carefully in a promoted preliminary phase and to offer opportunities for "crazy ideas" wherever they emerge. In this preliminary phase, rough impact assessments should also be made to assess the extent to which progress can be expected in the event of a project being successful. The largest possible freedom is required to finance this phase. If the core objective is to carry out creative research, it is not useful to request applicants to provide detailed information on research tasks, travel etc.
– *Process monitoring of complex projects*: Researchers and practitioners often speak a different language. An external facilitation of transdisciplinary projects can facilitate the constructive exchange between all project participants and exploit the maximum potential for innovation. To this end, research sponsors should encourage the involvement of professional moderators in project consortia and, in the case of an authorization, also finance them.
– *Enhanced assessment criteria*: The engagement of researchers in practical, transdisciplinary work must be assessed more strongly in evaluating their performance. To this end, the criterion of the scientific impact, which is dominant today, must be supplemented by criteria or procedures that cover the contribution made to the solution of practical questions. This also includes transfer activities, e.g., the transfer of research results into target-oriented practice recommendations (together with supporting advice). The consideration of the practice relevance is necessary for the evaluation of the performance of applied research; research funders can develop and operate decisive levers if they consider the expected impact on practice in addition to scientific criteria. This would help applied researchers to improve the perception and recognition of their work within their research organizations.

Model regions

While the actors in the research and practice networks are grouped according to sector characteristics (e.g., horticulture, poultry farming, artisan food processing, general food retailing, and gastronomy), model regions offer the opportunity to bundle economic and scientific activities on a regional basis.

This regional bundling offers a number of advantages: infrastructures that are important for several projects can be used at low cost, the relevant actors are more frequently in contact with one another promoting constructive-critical exchange of ideas, and regional concentration creates better conditions for the efficient marketing of organic products. In the course of time, the effects of the regionally bundled activities on the regional economy, society, and the ecosystem can be seen, and these effects can then be analyzed in regional comparative studies.

Against the background of these considerations and the positive experiences which have already been made with model regions in other research fields, the suitability of the approach for research on organic food processing was discussed. Two different concepts emerged, namely:

(a) an effort to bring about an extensive conversion of agriculture into organic farming in a region and to monitor and assess this conversion scientifically; and
(b) an effort to focus the consumption structures in a region as much as possible on the organic food sector (with a focus on organic food from the region) and to monitor and assess this development scientifically.

The discussion of the feasibility and the expected gain in knowledge led to the estimation that the consumption-oriented option is likely to be more cost effective. This is particularly the case when it is integrated into a federal competition, in which municipalities are asked to create innovative concepts. Candidates must demonstrate (a) how they want to increase the consumption of organic food in their region (e.g., focus on local restaurants and/or canteens), (b) how to relate to organic production in the region, and (c) how they wish to integrate their application into other sustainability strategies of their region (e.g., based on the "Copenhagen model"). Such a competition would also have a positive impact on the development of organic foodstuffs in regions that are not part of the selected and supported model regions.

Federal and state financed professorships

In order to achieve the planned expansion of the organic food sector to achieve a market share of 20%, a large number of highly qualified young people are needed in all areas of the organic sector and in science. The present university landscape is not adequately equipped for this purpose. Of the ten agricultural faculties in German universities, only one faculty is particularly relevant to the organic sector. In the other nine faculties, the organic production form plays only relatively a minor role. The situation at the applied universities is similar. This means that only a small proportion of students of agricultural and food sciences are able to study the organic sector comprehensively and deeply.

Under current circumstances, it is not expected that universities and colleges will set up new professorships for organic food production on their own initiative. Given this situation, the Federal Government could consider establishing a competition by using the new Article 91b of the German Constitution to part-finance additional professorships in organic farming in agricultural faculties if these professorships are part of an overall and meaningful national concept.

The professorships need to be set up in such a way that they network in two directions:

- link to the other faculty professorships to better position the organic sector in teaching and to initiate joint research activities with other chairs; and
- through an interdisciplinary research and teaching, network between the organic farming specialists. The easier it is to establish a range of differently profiled organic professorships at different locations, the more favorable are the prospects for the development of an efficient overall structure in the cross-site network.

With this basic institutional framework in place, a structure can emerge in which additional contract research has a greater levering effect.

Conclusion

Content focus

Most of this strategy outlines research themes regarded as priority for the overall strategic goal of the Federal Government of Germany (20% of the agricultural area for organic farming) and the IFOAM principles. Themes that are not included in this list might also be worthy of funding and be innovative.

For clarity, the priority research themes are set out in different report sections. In the implementation of the strategy, it is important to keep in mind the systems approach to the improvement of the organic farming and food sector. For many themes, it is therefore necessary to use interdisciplinary approaches to link natural sciences, engineering, and social sciences.

Organic crop production

- *New structures for plant breeding*. For economic reasons, the plant breeding sector concentrates on a few leading crop species. This means that the difference in performance between these leading species and other crop species is widening, crop diversity is reduced, and organic farming is disadvantaged. Consortia at the interface between plant breeding, economics, and legal science are needed to develop concepts for solving this systemic problem.
- *High-performance crops for complex systems*. A major requirement for innovation in breeding in organic farming is the holistic view of the crop in and with its environment. Improved plant–microbe and plant–plant interactions will lead to improved nutrition and resistance of plants for use in low-input systems. A close cooperation between research and breeders will realize this potential.
- *Technical innovations for organic crop production*. Great potential can be opened up for new plant cultivation systems if autonomous micro-robots can be developed, for example for mechanical weed to manage floral diversity in the field. Public research and the German agricultural machinery industry could lead in opening a promising area of research.
- *Alternative control of fungal diseases*. Direct and indirect regulation of diseases prevents crop failure. Potato, fruit, and grape crops present the greatest

challenges. New developments in agricultural technology, models of risks to crop health, biological plant protection, diagnostics, new cultivars, and stock control can be combined into successful, practical concepts.

– *Nutrient management and soil fertility*. Since farm practice requires site-specific solutions, a long-term research-practice alliance with four components is proposed: shared identification of problems, analysis of data from practice, on-farm research, and networking of experimental stations. In addition, new methods for the analysis of nutrient cycles and soil fertility should be developed.

Organic livestock production

– *Livestock systems of the future—pigs*. The organic sector is also looking for livestock production systems that meet competing goals (animal welfare, climate protection, economic competitiveness, etc.) and acceptance in an increasingly critical society. An ideas contest can lead to interdisciplinary consortia that develop new livestock farming and animal husbandry systems.
– *Future feeding and genetics—poultry*. The optimum supply of essential amino acids is difficult to guarantee with 100% organic feed from regional sources. It is recommended that consortia comprising animal nutrition, animal breeding, and business management actors that effectively combine investigations into organic poultry meat production systems, poultry breeds, and feed formulas be supported.
– *Successful organic animal production in practice*. It is recommended to support research-practice networks to create an exemplary framework for "co-learning" and if necessary, "co-designed experimentation," research-practice networks are recommended. The aim is to optimize animal husbandry within the existing livestock production facilities and to create new solutions for ethically exemplary farm animal husbandry.

Processing, marketing, and certification

– *Processing of organic foods*. The sector's processing companies, mostly small and medium-sized enterprises, rely on publicly funded innovations. This is particularly relevant for the value chains for bakery products, abattoirs and meat processing, and innovations for increasing the shelf-life of food products.
– *Transfer of trustworthiness features*. The high-quality production and manufacturing processes are sometimes not evident in the finished product. Therefore, the quality must be made evident in some other way. Different concepts (for example, labeling, control procedures, proof of origin, and combinations of these) and their efficient communication shall be analyzed and further developed.
– *Ensuring organic principles along the food chain*. Maintaining the principles of organic food production under the conditions of intense competition and globally linked markets is a challenge. Scientific analyses of corporate ethics and control systems should provide insights for optimizing existing concepts or, if necessary, implementing new concepts.

Societal expectations and consumer behavior

– *Societal expectations*. For the future of the organic sector, it is important that decisions that shape the future of the sector are perceived positively in wider society. For this reason, the scientific community should develop concepts for the early evaluation in society of different development options and innovations.
– *Organic food consumption styles*. Consumer behavior is important for achieving sustainable development objectives. It shall be analyzed how consumers can be engaged in dialog about purchasing and nutrition should be investigated, what the industry can do to foster improved dietary habits, and how consumption changes affect self-esteem and whether they can serve as a role model.

Establishing better performing structures

The objectives of this strategy will not be achieved if policy focuses its research funding merely on the abovementioned priorities using conventional time-limited research grants. The DAFA therefore makes five proposals about more efficient research and research funding structures:

– *New research funding mechanisms*. The typical 3-year project funding is not suitable for addressing many research questions that require longer-term networking of research and innovation partners. It is recommended that the Federal Government together with federal states develop and implement a more suitable research investment concept. For research which searches for breakthrough ideas, a change of the research funding structures is recommended (idea contests).
– *Research-practice network*. "Co-learning" between farm businesses, advisors, and researcher offers great potential for the development of organic farming. For this reason, DAFA recommends the establishment and expansion of long-term research-practice networks. Their integration into the European Innovation Partnership (EIP) "Agricultural Productivity and Sustainability" is desirable, but requires a fundamental modification of this instrument so that long-term cooperation between partners in different federal states is made possible and attractive.
– *Structuring funding instruments to support transdisciplinarity*. Many applied questions can be answered with greater relevance to practice when research, business, advisory, and civil society groups can work together to develop solutions. Since the framework conditions for the promotion of transdisciplinary cooperation and recognition of research focused on development and innovation are inadequate, a systematic orientation of funding instruments to support transdisciplinary solution concepts is recommended.
– *Model regions*. The bundling of economic and scientific activities in model regions offers opportunities for more efficient advancement of research and knowledge. For this reason, the DAFA recommends the establishment of a federal competition aimed at factors influencing consumer demand with respect to the organic food sector (with a focus on organic food from the region) combined with the scientific observation and assessment of this development.
– *Federal and state funded university chairs*. It is questionable whether the current university landscape is capable of generating a sufficient number of highly qualified graduates to achieve the 20% target. Therefore, the feasibility of using the new Article 91b of the Constitution to increase the number of professorships in organic farming in higher education should be investigated. Such an initiative must be coherent across Germany.

Increased financial resources

– The increase in funding is an important prerequisite for achieving the 20% target for Germany. However, since this is essentially a political decision, it is only mentioned in this research strategy to remind the reader of its importance, but it is not addressed deeper here.

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• Initiation event at BioFach 2014 in Nuremberg (February 2014)
• Written survey of organic food sector stakeholders (May 2014)
• First workshop "Finding a way together" in Berlin (June 2014)
• Publication of the first draft strategy for consultation (February 2015)
• Second workshop on topic-finding and prioritization in Berlin (May 2015)
• Publication of the second strategy draft for consultation (November 2015)
• Discussion of the third draft strategy at the BMEL Forum for the Future Strategy of Organic Farming in Plankstetten (June 2016)
• Production of the final research strategy for final agreement (October 2016)
• Approval of the strategy by the DAFA Annual General Meeting (end of 2016)