On Innovations in Agriculture and Aspects of Human Nutrition

Yesterday, Today and Tomorrow

by

Manfred G. Raupp

Masthead:

Author: Dr. Manfred G. Raupp

DR.RAUPP EK & Madora GmbH

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Preface

The following presentation of innovation in agriculture evolved in the frame of the EU-promoted project Biofector. Marketing aspects of bio-effectors are directly connected to this text and can be found on the internet under: http://dpg.phytomedizin.org/uploads/media/Raupp.pdf.

The project is supported in seven EU research programs under grant number 312117.

The presentation, which primarily involves the global development of agriculture, is already available in German, and an online version will be made available under www.biofector.info and www.raupp.biz as a pdf.

Manfred G. Raupp August 2016

Thoughts on innovation in agriculture in the 21st century

Historical development of food production

The first great innovation in ensuring food security took place around 12,000 years ago ni the area known as the “fertile crescent” – the broad arc of land which stretches from the Persian Gulf in Iraq through Syria and The Lebanon, Israel, Palestine and Jordan. This was the transition from a “wild collector” life style to agriculture or animal husbandry which is known as the “Neolithic Revolution”.

Crop farming, cattle breeding and food storage were the prerequisites for a settled life style. Up to this time humans were hunter-gatherers but climatic factors probably led to a limitation of year-round supplies of food, so that storage of food reserves became necessary. It is not clear whether the beginnings of agriculture came from a considered decision not to consume all food stocks but to sow some, or from the observation that food stored in the ground started to sprout. However, in either case the erection of suitable fencing to protect the crops was certainly an important step.

The latest research suggests that the first settlements were centred around existing shrines or sanctuaries. It is also presumed that this development originated in three different geographical locations and that the relevant, genetically different, ethnic groups had no communication with each other.

In Germany, the settlements of the band ceramists are linked to the beginnings of farming, and an important example is the settlement on the Michaelsberg near Bruchsal which probably existed already 3,500 years ago. The area lies at a height which was safe from the annual flooding of the Rhine plains which then occurred.

The image of agriculture is first and foremost the provision of food.

• Food production in Europe is in the middle of a conflict between food supply, food safety, economics, environmental politics and regional cultural interests. In developing countries by contrast it is a matter of simple survival of the explosive increase in population. The English pastor and economist Malthus postulated that population increases exponentially but food production only linearly – although this was disproved in Europe, perhaps he is right concerning developing countries.

Growth of the World Population

• At the present time 7.44 billion people live on the earth, and this number increases by 3 per second, i.e. 260,000 every day (as comparison Basle has 187,000 inhabitants).

• World population growth: 400 BC - 30 million; birth of Christ - 250 mio; 1650 AD 500m; 1850 - one billion; 1930 - 2bn; 1975 – 4bn; 1999 – 6bn; July 2016 – 7.44 bn.

• In 2025 it is expected that 9 bn people will be living on the planet.

• 270 mio kilojoules are required during a human life, and every day 3.4 mio tons of food, which is equivalent to 170,000 railways wagons each containing 20 tons.

• Food production needs soil, water, sun and seed; in addition fertilizer, weed control, plant disease, pests; then come harvest, storage, processing and animal husbandry for eggs, milk and meat.

Food is a fundamental need for humans:

Together with clothing and shelter food is one of the basic human needs. Foe millennia man lived in harmony with nature. Until 1840 there were fewer than 1 billion people on the earth. Nature and man himself prevented a greater expansion by means of disease and war.

Since the development of modern medicine in the 19th century Europe has seen a dramatic decrease in child mortality and increase in life expectancy, and the population doubles over ever shorter periods. A growth in birth rate has been observed for years and now three humans are born every second, meaning that every hour 10,000 more arrive in the world than die.

The problem in agriculture is that in the industrialized nations of western Europe there is a 2% advance in the technology of food production while the population stagnates. By contrast, technical progress in developing countries is less than the increase in population, exactly as Malthus predicted 100 years ago.

In the light of today's knowledge an increase in agricultural land area is not possible. Agriculture needs soil, light, warmth, and water as well as seed and nutrients. Many deserts have resulted from heat and a lack of water and it is difficult to render them suitable for agriculture. Many areas in zones of arid climate have been made useful for agriculture through artificial watering, but salinization has now rendered them difficult to use.

Thus the strategies for ensuring food supply has to be different in industrial nations to those in developing countries, above all with a view to CO_2 emission and the related problem of global warming.

Development in Global Food Demand

• the demand for carbohydrates is falling in the industrial nations – only 10-20 % of income are spent on food and less than 10% of the price of foodstuffs reach the farmer in Europe and the USA.

• the volume of luxury goods of animal origin has probably reached a maximum – because of more conscious and sensible nutrition and high production costs for animal protein.

• the demand for conventional foodstuffs is 95% of the total; for „biological products“ it is 5%, but increasing; there is little demand for genetically modified products, and EU law states that they should be clearly labelled as such.

• there has for years been a defensive attitude of consumers in Europe to genetically modified products and this remains at a high level – many European producers have gone out of business – but the EU intends to reactivate research in this area in the 7^{th} Framework Research Programme in order to prevent any future patent-dependency.

• in developing countries the main goal is maintaining the supply of plant protein and carbohydrate; salinated soil, heat and lack of water limit the area that can be cultivated and high loss on storage is the rule; water will be soon more important than oil.

The Soil is the Basis of our Nutrition.

Our planet has a surface area of 510 million square kilometers, of which one third (149 million) is dry land: one third of this fields and meadowland, one third desert, rock, infertile land, roads and housing.

The soil has its own living environment with animals, bacteria and fungi. 1.6 billion creatures can be found in one square metre of topsoil (1 metre square and 30 cm deep) – as a comparison the earth’s population is “only” 7.44 billion.

Most of these creatures are so small that they are invisible to the naked eye – it is truly amazing what lives under our very feet.

In 0.3 cubic metres of earth in the temperate climate of Europe there are to be found:

Ca. 1.6 trillion microorganisms: bacteria, fungi, algae; 1 million nematodes (threadworm); 100 thousand mites; 50 thousand sprintails; 25 thousand rotifers; 10 thousand bristle worms; 100 beetle larvae; 100 dipteran larvae; 80 earthworms; 50 snails and slugs; 50 spiders; 50 woodlice.

For less than 5% detailed information is at present known about their function in soil ecology, which particularly applies to the bacterial and fungal species which are numerically dominant. Of the other 95% we mostly know little more than their genetic fingerprint, which is one reason for the fact that bio-effectors in practice often have no or an unreliable efficacy.

Extrapolation means that a hectare of land contains around 15 tons of life in the root zone of the soil – the weight of twenty cows. There is thus more life within the soil than on it.

Soil is the basis of our food and animal feed production; for agriculture it is unavoidable and immovable; but is it also indestructible?

New Trends in Agriculture

• Technical advances have led to an annual increase in agricultural production of 2% per unit area – although farmland has decreased by 15%. Experiments to produce energy by agriculture, started in the 1970s, are now reaping rewards and are already profitable. Energy production is nowadays more profitable for farmers that food production – but this does not please the finance ministers.

• The price of energy plants is increasing, we are threatened with expensive food, but only 1 cent of the price of your breakfast roll goes to the farmer. At the same time, the search is on for new production methods such as “minimal soil cultivation” or “new crop rotation systems and concrete ways of influencing soil life.

Europe must also come to terms with an increase in temperature and unfavorable rainy periods.

• Specifically, attempts are being made, through EU-supported research, to improve the use of water and nutrients in the soil by conditioning soil-dwelling organisms and by preventing as far as possible nutrients being washed out into the ground water.

The goal ist o select plants that can cope with the expected climate change, particularly increase in temperature and decrease in available water – and in addition with less fertilizer. Experts are of the opinion that solutions are only to be found using biotechnological methods, but there are many factions which are very critical of such methods.

• The agricultural gap between industrial countries and the developing world will increase – 3% of the European population are farmers (with excess productivity), but in developing countries still 80% work on the land – as in Europe a hundred years ago. 2% technology-based progress will hardly be enough to feed the explosive increase in population.

• A goal for the third world is also to develop areas that up to now have been infertile;

to breed salt-tolerant plants and to increase the yields of species suitable for the area by gene technological methods so that there are no more famines, and that Malthus and Linnè (in particular) are proved wrong in their prediction that the human population will be afflicted by sickness and war if they spread over the earth in a way that disrupts the balance of nature.

Nowadays there are various groups which protest against the technical progress in agriculture, particularly against “green biotechnology”, among others Christian fundamentalists who argue that scientists should not mess around with the works of the Lord God – although making has been doing just that for 500 generations!

My opinion: „Without the new areas of biotechnology it will not be possible to feed the population of 9 billion people expected in the year 2025”. In this connection Einstein wrote “Knowledge without religion is lame, religion without knowledge is blind.” For him it was self-evident that belief and common sense were not in competition with one another, but that they simply cover different aspects of the same reality.

It is undisputable that research on human nutrition will remain an unending search for improvement in methods of production taking into consideration both economics and ecology.

Reflecting the work of Sigmund Freud – I believe in the power of science, reason, friendship and love to overcome the fear of new biotechnological research methods, so that the population of our earth, with all its limitations, can be replete.

The value of foodstuffs on consumer level in Germany currently stands at 300 billion € per year. This is many times the figure from 50 years ago, which is because although the nominal price for agricultural products has hardly risen, the cost of processing has substantially increased.

Nearly 40% of German households use products which have a greater processing effort. Whereas a midday meal took 2 hours to prepare 50 years ago, nowadays ready meals can reduce this to a few minutes.

Agriculture in Germany has changed considerably. At the beginning of the 1950s there were 5 million farms in the country, but this number has now been reduced to under 500,000. Only 2% of the gross national revenue now comes from agriculture. At the same time, the number of people supplied by a single farmer has increased from 10 to 150.

Agriculture now faces a further enormous innovation boost. “Agriculture 4.0” will initiate further forms of production through information technology.

Innovation in der Agriculture is a Success Story

The extent to which one can be mistaken about technical developments is shown by the words of two men spoken a hundred years ago.

Wilhelm II commented on future mobility thus “I believe in the horse, motor cars are only a temporary phenomenon”.

The professor of agricultural engineering at the University of Bonn wrote in 1920 “With the invention of the sheaf-binding harvester the mechanization of agriculture has come to an end”

How wrong the two gentlemen were is shown by the present motorized mobility and the technical status of agriculture in Europe and worldwide.

Further developments in information technology will change agriculture dramatically. Key factors are mobile-big-data processing, imaging technologies and GPS control of agricultural machinery.

In the future soil maps containing information on the soil structure, nutrient content and long-term climate information will make concrete, science-based recommendations to the farmer about how he should divide up his land, which varieties, cultures and which sort of crop rotation he should use for a particular area of farmland.

Prognosis models will tell the farmer what price he can expect to obtain for which culture at which harvest time. As he produces in a polypolistic market he is basically only a quantity adjuster, and will adjust his production capacity according to the market even more than in the past.

The farmer will be able to calculate whether he should run his business on conventional lines or develop it as bio-agriculture by optimizing his use of the available subsidies. This strategic decision will decide his cropping plan and how he carries it out.

It is clear that GPS control of machines can be achieved on the large farms of north-east Germany, but it is also possible and reasonable in the south of the country, where the land is parceled in smaller lots. However, the farmer of the future will also need drones to deliver data on the state of his crops, nutrient supply, weed growth, plant disease and pests and the ripening progress in order to make detailed plans.

Precision Farming

GPS systems are now sufficiently developed that control and optimization of machinery can be performed automatically. Automatic control of combine harvesters is now a reality as much as that of the mowing robots used in gardens. The software for controlling these huge machines is already licensed as part of the production process. The state of the art is now that not only can the tracking be checked, but also monitoring of the threshing process is possible, which typically leads to a harvest wastage of under 2%.

Imaging modalities in drones will in the future have an even greater importance that satellite control. Drones with the exact coordinates of a field will, at the required intervals, will portray the type and state of development of weeds, the type and degree of nutrient shortage or disease created by this, lack of water and/or the wilting point of plants as well as attack by pests and disease. Using software on the control system of the machine the fertilizing process and application of plant protection agents will be controlled. Various agents will be applied to the soil and automatic watering system will be turned on and off.

It will also be possible in the future to apply different amounts of seed, fertilizer and protection agents to different sections of a field.

The Importance of Agriculture throughout the World

In 2008, 3% of the gross domestic product of the world came from agriculture.

In poorer countries the figure is considerably higher at an average of 26% compared to 1% in wealthy countries. Within the context of long-term economic development there will be a structural transformation whereby the relative importance of agriculture will decrease, as will the number of people employed in agriculture. For example, in 2008 this was 75% of the population of Tanzania, in the Netherlands 1%.

Around 1900 a farmer in the German Empire produced food for four other people; in Federal Germany in 1950 it was 10 people. At the beginning of the 21^{st} century (2004) it was already 143. Despite this increase in productivity Germany remained a net importer of agricultural goods and foodstuffs. In 2008 the agricultural imports were 9 billion Euro more than the exports.

In the year 2007 there were 374,500 agricultural business employing 1.25 million people, either full or part-time (equivalent to 530,000 full-time jobs). A total of 0f 16.9 million hectares (ha) of land were used for agriculture, 47.4% of Germany's total land area. Around 11.8 million ha were used for crops and 5 million ha were permanent pasture. In 2009 the main crops were cereals (6.5 million ha), maize (2.1 million), rape (1.5 million) and sugar beet (0.4 million). In comparison orchards, tree nurseries and Christmas tree plantations play a minor role.

Agriculture is increasingly playing a role in energy production, particularly through crops of "energy plants" and the use of biogas and photovoltaics and by renting land for wind energy plants. German farms invested 18.2 billion euro in renewable energy facilities between 2009 and 2012 according to data from the German Farmers' Association. Nowadays farmers count as "essential drivers of the energy revolution".

Agriculture, forestry and fishing earned 45 billion euro, which can be expressed as 1% of the gross value added from 2.2% of the labor force. The basis of this calculation is the production costs which are, however, often substantially lower than the price paid by the consumer. Through progress in production, increasing industrialization and development in the service sector employment in agriculture has sunk from 38% to a little over 2% of the population in the last 100 years.

Farmers from a Sociological Point of View

Farmers are sociologically of interest because they are often seen as examples of resilience and adaptability. Although they often live in poverty if one takes a global view, the typical effects of poverty are seldom observed in their children.

Conventional Farming

This is the customary way of farming which has developed from traditional methods. With regional variation, the role of farming can be seen as producing food and feedstuffs, and caring for the cultivated landscape, using techniques recommended by agricultural science and simultaneously complying with agricultural laws and EU regulations.

In industrial and emerging nations this is by far the most common form of farming, and thus the largest element of the primary economic sector. It is embedded in a complex system of supplier-customer relations within the “agro-business”. As the term “conventional farming” has emerged since the arrival of “alternative” farming, and since it is primarily used by champions of the latter, it has to some extent negative connotations.

Conventional agriculture uses the customary crop rotation and seed types, fertilizer and protection agents approved by the competent authorities. The highest possible yields are reached by use of a combination of crop rotation systems and plant protection regimes. Integrated crop cultivation, taking into consideration damage thresholds to minimize use of resources is nowadays standard in conventional farming.

A growing trend towards specialization and increase in herd size can be observed in livestock farming, particularly in dairy farming. This trend is more pronounced in conventional than in alternative farming. It is also obligatory on ecological farms for the livestock to be allowed more room, more movement and the possibility to graze on open land.

Sowohl in der konventionellen als auch in der ökologischen Tierhaltung dürfen keine vorbeugenden Antibiotika verabreicht werden. Mischbetriebe, die sowohl Ackerbau als auch Viehzucht betreiben, kaufen meist einen Teil des Kraftfutters (z. B. Sojaschrot, Getreide) zu.

In einigen auf die Massentierhaltung spezialisierten Betrieben werden hingegen ausschließlich zugekaufte Futtermittel verfüttert. Eine solche Industrielle Landwirtschaft wird oft der Konventionellen Landwirtschaft zugerechnet, sie ist aber nicht typisch für die Mehrzahl der Betriebe in Europa.

Organic Farming

Organic farming is an alternative agricultural system which originated early in the 20th century in reaction to rapidly changing farming practices. Organic agriculture continues to be developed by various organic agriculture organizations today. It relies on fertilizers of organic origin such as compost, manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Biological pest control, mixed cropping and the fostering of insect predators are encouraged. In general, organic standards are designed to allow the use of naturally occurring substances while prohibiting or strictly limiting synthetic substances. For instance, naturally occurring pesticides such as pyrethrin and rotenone are permitted, while synthetic fertilizers and pesticides are generally prohibited. Synthetic substances that are allowed include, for example, copper sulfate, elemental sulfur and Ivermectin. Genetically modified organisms, nanomaterials, human sewage sludge, plant growth regulators, hormones, and antibiotic use in livestock husbandry are prohibited. Reasons for advocation of organic farming include real or perceived advantages in sustainability, openness, self-sufficiency, autonomy/independence, health, food security, and food safety, although the match between perception and reality is continually challenged.

Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM), an international umbrella organization for organic farming organizations established in 1972. Organic agriculture can be defined as:

An integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity whilst, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones.

Since 1990 the market for organic food and other products has grown rapidly, reaching $63 billion worldwide in 2012. :25 This demand has driven a similar increase in organically managed farmland that grew from 2001 to 2011 at a compounding rate of 8.9% per annum. As of 2011, approximately 37,000,000 hectares (91,000,000 acres) worldwide were farmed organically, representing approximately 0.9 percent of total world farmland.

Agricultural Science

Sometimes called Agronomy, this deals with everything involved with the primary production of food for humans and animals, as well as with renewable resources. One of its founders was Albrecht Thaer. As well as including parts of other scientific disciplines it has its own specialist areas of crop science, animal science and agricultural economics.

Possession of a higher education degree is usually denoted by the addition of FH to the name. In the course of the Bologna Process most colleges in Germany nowadays offer a tiered study system with bachelor’s and master’s degrees, although some of them offer double degrees, for instance the master’s degree “Organic Agriculture and Food Systems” (EUR-Organic) at Hohenheim University.

Important Institutions Relevant to Agricultural
(a selection, in alphabetical order)

ABISTA

The „Association for Biostimulants in Agriculture“ was recently founded in Braunschweig in the framework of the 6th symposium of 2014, as participant and latterly as a member of the Symposium Committee. The seat of the association has been established in the co-ordinating institute of the Biofector project in Hohenheim.

The structure of the database and the questionnaire about Bio-Effectors have been developed and pilot operation started. At the moment the link to the literature database of the Julius Kuehn Institute is being set up

The project leadership will once again contact vendors for the acquisition of data about all products available on the market. For data expansion in the practical phase of the project, participants will be involved in translation of the input form into relevant languages for practitioners.

Evaluation of the Bio-Effector market continues. More than 100 firms with Bio-Effector products have now been contacted.

Demonstration fields were set up for 2014 together with participants of WP9, and the scientific and practical aspects demonstrated to the DLG Field-Day in Bernburg. Further such presentations are in preparation.

Current results were presented as posters at the BIOFECTOR meeting in Naples. A number of practical experiments have been planned for 2015 in such a way that the use of Bio-Effectors can be demonstrated at the field days of those running the experiments.

The significance of the current approval and distribution channels for Bio-Effectors is currently the subject of political discussion. In particular, a harmonization of approval regulations and processes is being addressed. Through the formation of the Association of Bio-Stimulants in Agriculture (ABISTA), and its acceptance as a forum for experts in Bio-Stimulants / Bio-Effectors, the insights of the projects can provide direct inputs into this working group. These differ according to the use of the various plant protection agents, fertilizers and strengtheners. A further detailed acquisition process of the market situation by means of a survey of market experts will follow during the next reporting period.

Development of further possible distribution channels will start as soon as the relevant product information is available and future Europe-wide approval regulations are decided.

http://www.abista.eu/

ABIM

The Annual Biocontrol Industry Meeting (ABIM) in Basel is an annual conference of manufacturers of biological plant protection products worldwide. Every year since 2005, 700 – 800 delegates from 300 – 400 firms take part in this English-speaking meeting.

The goal of the conference is the exchange of business and scientific experience and presentation of commercial and scientific advances on the subject of the protection of plants and pest control in plant crops by natural (biological) methods, with particular reference to Bioeffectors.

The meeting takes place every autumn in Basel, and is organized by the Swiss Research Institute for Biological Agriculture (FiBL). In parallel is the annual meeting of the International Biocontrol Manufacturers' Association (IBMA), the association representing the biological plant protection industry, is held.

http://www.abim.ch/home.html

BIOLAND

Bioland is the largest organic food association in Germany. Its organic certification standards exceed EU minimum requirements.

During the 1920s, a number of agricultural movements began with the goal of countering the effect of industrialization and globalization on food production. One of these was the Jungbauernbewegung ("Young farmer homeland movement"), which influenced Bioland.

The original 12 founders developed formal guidelines for organic vegetable production, which were published in 1972. In 1974, the association was renamed Fördergemeinschaft organisch-biologischer Landbau e.V. At first, it used the brand name Dr. Müller Bio Gemüse for products sold in health food stores. In 1978, the certification trademark Bioland was registered. A number of other Bioland associations were founded throughout Germany. In 1987, the original association changed its name to Bioland Verband für organisch-biologischen Landbau e.V.("Bioland association of organic-biological agriculture").

When the EU harmonized standards for organic food production, the older organic food associations criticized the new standards as weaker than existing guidelines.[citation needed] After the resolution of the EU organic-food recommendation, the associations brought their standards in line with those of the EU so that any Bioland-certified organic food would meet the requirements for EU organic food (although Bioland's requirements exceed those of the EU).

EU Eco-regulation

Farmland use: 100% of the farm must be devoted to organic food production. Allows not organic and traditional food production on the same farm.

Maximum number of animals per ha: the permissible number of animals is lower for poultry and pigs: 140 laying hens, 280 chicken or 10 fattening pigs per ha

Nitrogen fertilizer: amount limited by livestock numbers (lower than the legal maximum) Amount limited by national laws setting a legal maximum by farmland area

Organic waste fertilizer: blood, meat, bone, manure and guano prohibited. Dried blood, guano, meat and bone meal are allowed.

Copper pesticides: only for perennial vegetables (3 kg/ha/year) Up to 6 kg/ha/year

Additional purchased fodder: no more than 50%; majority of pasture must be grown on the farm any amount allowed

Genetically modified seed: no genetically modified seeds allowed (includes a ban on fodder purchased from genetically modified plants)

Additional ingredients: certified product must contain 100% organic ingredients. Certified product must contain at least 95% organic ingredients.

The Bioland association and subsidiaries, like the Bioland market, are members of the “Bio mit Gesicht” (“Giving Organic a Face”) initiative which aims to increase transparency in organic food production.[citation needed]. Organic products may have a "BMG" number, which can be entered on a website showing the farm and farmer. This idea parallels an EU initiative by which all eggs must bear a number which can be entered on a website for details of their origin. Only the address of the farm was initially shown, but the website has been updated to include photos as well. While the egg number is regulated by European law, the BMG number is voluntary.[citation needed]. Notable organic-food associations include Bioland, Naturland and Demeter International (Demeter). The “Bio mit Gesicht” association shares an address with the German branch of the FIBL (Research Institute of Organic Agriculture), which is based on a Swiss initiative (Bio Suisse organic certification).

Bio-effector / BIOFECTOR

A bio-effector is a viable microorganism or active natural compound which directly or indirectly affects plant performance (bio-fertilizer), and thus has the potential to reduce fertilizer and pesticide use in crop production.

Bio-effectors have this direct or indirect effect on plant performance by influencing the functional implementation or activation of biological mechanisms, particularly those mediating soil-plant-microbe interactions.. In contrast to conventional fertilizers and pesticides, the effectiveness of bio-effectors is not based on a substantial direct input of mineral plant nutrients, either in inorganic or organic form.

Products in use are: Microbial residues

Composting and fermentation products

Plant and algae extracts

Bio-effector-preparations (bio-agents) as ready-formulated products are applied: with the purpose of stimulating plant growth (bio-stimulants),

to improve plant nutrient acquisition (bio-fertilizers),

to protect plants from pathogens and pests (bio-control agents)

or to generally advance cropping efficiency; they can contain one or more bio-effectors along with other substances

Well established bio-effectors with documented positive results in the field level are: Rhizobia strains for soil or seed inoculation as a prerequisite for symbiotic N_2-fixation when establishing new legume species or varieties.

positive effects of mycorrhiza inoculation for soils with a (temporarily) low potential for natural root mycorrhization.

sufficient mycorrhization enhances nutrient (P) and water uptake and increases resistance to pathogenic fungi.

Further mechanisms for the positive impact of bio-effectors on plant growth have been postulated, promising a high potential for resource preservation due to reduction of fertilizer and pesticide use:

active nutrient mobilization by exudation of acids and carboxylates (e.g. P-mobilization),

exudation of micro-nutrient mobilizing siderophores/chelates (e.g. Fe^{3+}),

reduction of trace elements from less soluble oxidized to highly soluble reduced forms (e.g. Fe^{3+} to Fe^{2+}, Mn^{4+} to Mn^{2+}),

associative/non-symbiotic N_2-fixation, protective antagonism to plant pathogens,

enhancement of mycorrhizal infection and growth, and stimulating hormonal effects.

Research and Public Dissemination

Under the term Biofector the European Union supports the Research of Bio-Effectors under the leadership of the University of Hohenheim (Coordinator Guenter Neumann). The results of the project will be evaluated by the members of the Association Bio-stimulants in Agriculture (ABISTA) and provided to agriculture for use and EU institutions for the legislative and registration procedures.

Other Bio-stimulant Organizations are the European Bio-Stimulant Industry Council, the International Biocontrol Manufacturers' Association and the Annual Biocontrol Industry Meeting.

EBIC

Das European Biostimulant Industry Council (EBIC) sees itself as an association of producers of bio-stimulants for agriculture. It was founded in 2011 as the Bio-Stimulant Industry Consortium (name changed in 2013) with head office in Antwerp.

There is a great variation in registration criteria for the use of bio-stimulants and bio-effectors in agriculture across the countries of the European Union (EU).

The EBIC represents an association of agricultural experts with a special knowledge of soil organisms and plant extracts. Bio-stimulants act on nutrient uptake, nutrient effectiveness, tolerance against abiotic stress and plant quality although they are not nutrients themselves. They act as plant strengtheners in agriculture without any direct effect on disease or pests and are thus not subject to plant protection legislation.

The criteria for registration of such plant strengtheners varies greatly between countries of the EU. A harmonization should be introduced by 2017 and the EBIC wishes to make the necessary expertise available and bring together scientists, administrators, industry representatives and legal experts in workshops.

http://www.biostimulants.eu/

FIBL

The Research Institute of Organic Agriculture (German: Forschungsinstitut für biologischen Landbau, in short: FiBL), is one of the world's leading organic farming information and research centers. As an independent, non-profit organization, FiBL promotes research and projects that help farmers improve their productivity with consideration of environmental and health impacts. FiBL is located in Frick, Switzerland with branches in Germany and Austria.

FiBL was founded in Switzerland in 1973 by a group of organic farmers and scientists who wanted to promote the growth of the organic farming industry. FiBL is a member of the International Federation of Organic Agriculture Movements, IFOAM, and helped in establishing the International Society of Organic Agriculture Research ISOFAR. FIBL has also worked with IFOAM to develop international organic standards.

FiBL Germany, with a staff of 30, and FiBL Austria, with a staff of 18, were established in 2000 and 2004, respectively. FiBL maintains a vast European network of researchers and takes part in various EU projects. FiBL also supports research projects and advisory services in Eastern Europe, Asia, Latin America and Africa. FiGL's goals are to promote best farming practice training materials that will help smallholder farmers transition to a more long-term and economically viable agriculture

http://www.fibl.org/en/homepage.html

IBMA

The International Biocontrol Manufacturers' Association (IBMA) is the worldwide association of the Biocontrol industry with its head office in Brussels.

The IBMA was founded in Brighton (England) in 1995. Founding president was Bernard Blum, in whose honour the Bernard Blum Award was launched, first awarded in 2015.

Later presidents were Michel Guillon, Denise Munday, Owen Jones and Willem Ravensberg. The association sees itself as representing the manufacturers of Biocontrol products mainly within the European Union, the OECD and FAO. Workshops are held for members to exchange experience, in particular at the annual ABIM Congress in Basel.

In contrast to the chemical crop protection industry (Agricultural Industry Association) the IBMA members produce Bioeffectors, i.e. botanicals, pheromones, invertebrate biocontrol agents and micro-organisms as a basis for plant protection products.[4] These biocontrol products against plant disease and pests are such that they can be used in the organic production of food as well as in IPM production systems.

Although the products sold generally result in plant vitalization, the further aim of the group is to fight specific diseases and pests in plants and food production with biological systems. In European politics promotion of organic vegetable production is increasing greatly. The organization makes a significant contribution with their members' products.

http://www.ibma-global.org/en

IAPPS

The International Association for Plant Protection Sciences (IAPPS) has the goal of gathering results from plant protection research worldwide and making them globally available to science and practice. To this end the organization periodically publishes the Plant Protection Magazine and every four years organizes an international congress, the latest of which took place in Berlin (IPPC 2015)

The IAPPS was founded in 1946 during the first International Plant Congress in Louvain, Belgium. The first president of the organization was Olaf Freyberg of Malmö, Sweden, who made the following comment: “The world needs a plant protection organization, not only to plan future congresses, but much more to provide a platform for the discussion amongst scientists of current research results”.

A newsletter has been periodically published over the years, a yearbook has appeared, and congresses have been held. Every four years international congresses have been held in various parts of the globe. Plant protection scientists and agricultural research societies from all over the world are represented in the governing body. The IAPPS organization now has 15 regional offices.

At the International Plant Protection Congress in Berlin in 2015 meetings were organized by the German Phytomedical Society (Deutsche Phytomedizinische Gesellschaft), the Julius Kuehn Institute and the German Association of Industrial Partners for Agriculture.

https://www.plantprotection.org/PlantProtection/Introduction.aspx

ISTA

The International Seed Testing Association (ISTA) was founded in 1924[1] and has more than 100 members worldwide. It is an association of laboratories which are authorized to check on the marketability of seed as defined by law in various countries. Part of its duties is the definition of methods to determine the ability to germinate, the vigour of seed, and the content of genetically modified organisms (GMOs) in the seed. The test results, as certified by ISTA member laboratories, are accepted by the trading partners of the World Trade Organization (WTO) in international seed traffic.

The North American equivalent of the ISTA is the Association of Official Seed Analysts (AOSA).

http://www.seedtest.org/en/home.html

UPOV

The International Union for the Protection of New Varieties of Plants or UPOV (French: Union Internationale pour la Protection des Obtentions Végétales) is an intergovernmental organization with headquarters in Geneva, Switzerland.

UPOV was established by the International Convention for the Protection of New Varieties of Plants. The Convention was adopted in Paris in 1961 and revised in 1972, 1978 and 1991. The objective of the Convention is the protection of new varieties of plants by intellectual property rights. By codifying intellectual property for plant breeders, UPOV aims to encourage the development of new varieties of plants for the benefit of society.

For plant breeders' rights to be granted, the new variety must meet four criteria under the rules established by UPOV:

1. The new plant must be novel, which means that it must not have been previously marketed in the country where rights are applied for.

2. The new plant must be distinct from other available varieties.

3. The plants must display homogeneity.

4. The trait or traits unique to the new variety must be stable so that the plant remains true to type after repeated cycles of propagation.

Protection can be obtained for a new plant variety (legally defined) providing it has been obtained, e.g. through conventional breeding techniques or genetic engineering.

http://www.upov.int/portal/index.html.en

University of Hohenheim

The University of Hohenheim (German: Universität Hohenheim) is a campus university located to the south of Stuttgart, Germany. Founded in 1818 it is Stuttgart's oldest university. Its primary areas of specialization had traditionally been agricultural and natural sciences, but today the majority of its students are enrolled in one of the many study programs offered by the faculty of business, economics and social sciences. The faculty has regularly been ranked among the best in the country, making the University of Hohenheim one of Germany's top-tier universities in these fields.[1] The university maintains academic alliances with a number of partner universities and is involved in numerous joint research projects.

From 1770 to 1794, the Karlsschule was the only university in Stuttgart. Since its founding in 1818, Stuttgart's oldest university has been the University of Hohenheim. The eruption of the Indonesian volcano Mount Tambora in 1815 triggered a global climate change and was one of the causes of the massive famine suffered in the Kingdom of Württemberg at the beginning of the 19th century. King William I of Württemberg set up an Agricultural Academy in Hohenheim in 1818 to radically improve general nutrition in the kingdom through teaching, experimentation and demonstration and, in so doing, laid the foundation for the University of Hohenheim. At that time there were 18 students enrolled and a staff of three professors. It is not connected to or affiliated with the University of Stuttgart (founded in 1829), although there is collaboration between the two.

Architecturally, the university re-opened its doors in 1946 and had survived World War II relatively undamaged. In 1964 the faculties of Agricultural Sciences and Natural Sciences were created, followed in 1968 by the Faculty of Business, Economics and Social Sciences. Hohenheim has enjoyed university status since 1967 when it became known as Universität Hohenheim.

Today there are approximately 9,000 students and a teaching staff of around 900, of which slightly more than 100 are professors. Over 2,000 people now work at the university. The current rector of the university is the agricultural economist Prof. Dr. Stephan Dabbert (*June 23, 1958), who took office on April 1, 2012.

The University of Hohenheim is located in southwest Germany, in the district of Plieningen on the southern rim of Baden- Württemberg’s capital Stuttgart. It was named the most beautiful campus university in Baden-Württemberg in 2009 and is generally acknowledged as having one of the most picturesque campuses in the country. The baroque palace, the University's emblem and its main building, is surrounded by historic parklands and botanical gardens, including the historic Landesarboretum Baden-Württemberg.

https://www.uni-hohenheim.de/en/english

Latest Publications from the Biofector:

Bioeffectors for a Sustainable Intensification of Agriculture

This article collection was initiated as an outcome of a satellite session at the "Rhizosphere 4“ conference, held in Maastricht, the Netherlands from 21-25 June 2015. The majority of the manuscripts originate from contributions presented at the conference, and promote research activities of the integrated EC Project BIOFECTOR, which is located within the European Union’s 7th Framework Programme (Grant Agreement n°312117) with the aim of investigating perspectives for the use of bioeffectors of microbial and non-microbial origin to optimise the efficiency of fertilisation systems as more sustainable alternatives to conventional mineral fertilisation. The presentations address not only promising approaches, but also limitations and future research needs of the strategies investigated.

Edited by: Prof. Dr. Günter Neumann

The effect of Penicillium bilaii on wheat growth and phosphorus uptake as affected by soil pH, soil P and application of sewage sludge

Penicillium bilaii may enhance P availability to plants, since it has been shown to increase plant growth and P uptake. There is currently increasing interest in using microorganisms t...

S. Sánchez-Esteva, B. Gómez-Muñoz, L. S. Jensen, A. de Neergaard and J. Magid
Chemical and Biological Technologies in Agriculture 2016 3:21
Published on: 20 July 2016
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Carbon nanomaterials: production, impact on plant development, agricultural and environmental applications

During the relatively short time since the discovery of fullerenes in 1985, carbon nanotubes in 1991, and graphene in 2004, the unique properties of carbon-based nanomaterials have attracted great interest, wh...

Olga Zaytseva and Günter Neumann
Chemical and Biological Technologies in Agriculture 2016 3:17
*
Micronutrients (Zn/Mn), seaweed extracts, and plant growth-promoting bacteria as cold-stress protectants in maize. Low soil temperature in spring is a major constraint

for cultivation of tropical crops in temperate climates, associated with impaired seedling development, inhibition of root growth and root activity. In this...

Klara Bradáčová, Nino F. Weber, Narges Moradtalab, Mahmood Asim, Muhammad Imran, Markus Weinmann and Guenter Neumann
Chemical and Biological Technologies in Agriculture 2016 3:19
Published on: 4 June 2016

Improving fertilizer-depot exploitation and maize growth by inoculation with plant growth-promoting bacteria: from lab to field

Among other responses, plants tend to increase root growth to scavenge nutrients from more soil when soil nutrient concentrations are low. Placement of fertilizers near seeds or roots facilitates nutrient acqu...

Peteh M. Nkebiwe, Markus Weinmann and Torsten Müller
Chemical and Biological Technologies in Agriculture 2016 3:15
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Physicochemical analyses of plant biostimulant formulations and characterisation of commercial products by instrumental techniques

The objective of this study was to develop instrumental protocols for evaluating physicochemical characteristics of plant biostimulant/biofertiliser formulations. Six formulations (Rygex, Algavyt, Ryzoset, Man...

H. S. S. Sharma, C. Selby, E. Carmichael, C. McRoberts, J. R. Rao, P. Ambrosino, M. Chiurazzi, M. Pucci and T. Martin
Chemical and Biological Technologies in Agriculture 2016 3:13
Published on: 28 April 2016
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Phytochemical profiling of tomato roots following treatments with different microbial inoculants as revealed by IT-TOF mass spectrometry

In light of the growing interest for eco-compatible fertilization, tomato plant roots were treated with four different strains of microorganisms (B1–B4) capable of positively affecting plant growth. The methan...

A. Nebbioso, A. De Martino, N. Eltlbany, K. Smalla and A. Piccolo
Chemical and Biological Technologies in Agriculture 2016 3:12
*
Bio-refining of perennial ryegrass (Lolium perenne): evaluation of aqueous extracts for plant defence elicitor activity using French bean cell suspension cultures

There is growing interest in the bio-refining of foliage grasses to yield a range of industrial raw products. The aim of this research was to evaluate if aqueous extracts from grasses have the potential to act...

Christopher Selby, Eugene Carmichael and H. S. Shekhar Sharma

Chemical and Biological Technologies in Agriculture 2016 3:11

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Bio-Effectors Quo vadis - http://dpg.phytomedizin.org/uploads/media/Raupp.pdf