XXI

Science for Life

JUNE 2012 #1

A revolution in the soil

Discover the work of the bacteria that protect the planet.

XXI
Ciência para a vida

Silvio Ávila/Mapa/Divulgation

Harvesting with precision

The next issue of *XXI – Ciência para a Vida* magazine will show how some technological breakthroughs are enhancing the precision in agriculture and in livestock, by reducing costs, rationalizing resources and increasing the output. You can contribute to the publication with your opinions, suggestions and comments to **revista@embrapa.br**.

Visit also **www.agrosustentavel.com.br** to learn about other technologies of the Brazilian farming research.

Embrapa

Ministry of
Agriculture, Livestock and Food Supply

BRAZILIAN GOVERNMENT
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THE AGRICULTURAL RESEARCH AND YOUR LIFE

Traces of the primitive agriculture in use in Pindorama–the name the Indians who lived in Brazil used to refer to part of this land–can be found in archaeological sites nationwide. Technologies such as the *Terra Preta do Índio* (Indian Black Earth), common in the Brazilian Amazon (in 3000 B.C.), and the plow–invented in very distant lands–have changed civilizations.

Throughout history, the development of nations and peoples has been associated with the evolution of farming activities, among other factors. The incorporation of technologies and new forms of organization allowed for swift, greatly impacting changes, real revolutions in some cases.

Today's changes are impressive, but what maybe has been catching everyone's eye both in cities and in the country is the speed and the (microscopic or submicroscopic) scale, because the achievements in the farming industry, based on new products, services, and technologies, affect the lives of each one of us. For such reason the dialogue between farming research and society is so important and, despite the huge amount of communication available nowadays, the need to reach several segments interested in science, technology and innovation applied to this industry is clear.

XXI - *Ciência para a Vida* magazine is a new tool created by Embrapa with the purpose of contributing for citizens to know more about farming research, so that they can build their opinions according to their convictions and with more knowledge.

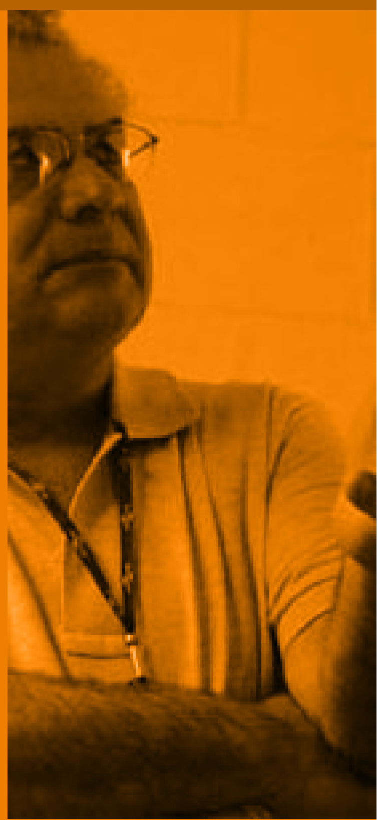
This is crucial, particularly in Brazil, where research–intensively and productively built by domestic and foreign institutions–has been decisive for the Country to reach new levels of development.

XXI - *Ciência para a Vida* has as purpose to show readers the challenges, innovations, technologies and some of the milestones of our research. In the first issue, read the story on Biological Nitrogen Fixation, a significant innovation to make Brazilian soybean competitive and that may enhance the sustainability of cultures such as maize and cowpea, among others.

The magazine also explores other topics related to the discussions at the United Nations Conference on Sustainable Development, the Rio+20, such as global warming and food production.

We hope you have a pleasant, enriching read. And we count on your opinion to improve our magazine. Have a good read!

Pedro Antonio Arraes Pereira
CEO of Embrapa
Francisco J.B. Reifschneider
Chairman of the Editorial Board



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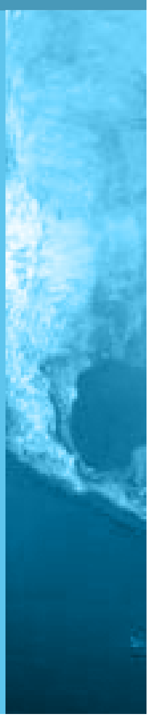

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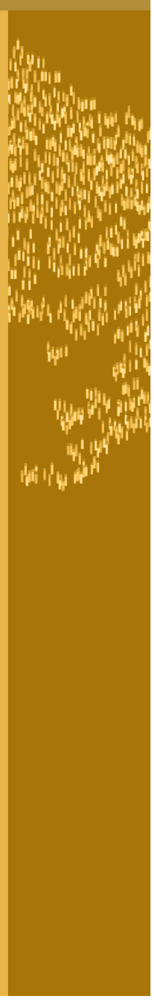

WORLD POPULATION REACHES NINE BILLION

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SUSTAINABILITY: SEARCHING FOR A CONCEPT

XXI
Ciência para a vida

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IN THE HEAT OF THE EARTH

by Marcos Esteves

The researcher Eduardo Delgado Assad is one of the greatest Brazilian authorities on climate change. This topic has been the object of his work in the last decades, and in 2011 it made him take the office of Secretary for Climate Change and Environmental Quality of the Ministry of the Environment and become a member of the Scientific Committee of the Brazilian Panel on Climate Change (pbmc). He also coordinates the sub-network Climate and Agriculture, in Rede Clima, of the Ministry of Science, Technology and Innovation (mcti), in addition to projects in the field of climate change and its impact on agriculture.

In 2008, Assad and the researcher Hilton Silveira Pinto, from the State University of Campinas (unicamp), published the study "Global Warming and the New Geography of Agricultural Production in Brazil". The research presents scenarios of how the rise in temperature may affect the cultures of cotton, rice, sugarcane, bean, sunflower, cassava, maize and soybean in Brazil.

In this interview to XXI - Ciência para a Vida magazine, Eduardo Assad talks about the current situation of the Brazilian agriculture and the main challenges of research in a scenario of alert for society.

Fábio Torresan / Embrapa

XXI | There is a group of scientists who refute the idea of global warming. Particularly, the one caused by human activities. What is your opinion about this?
Eduardo Assad – This is the great dilemma seen after 2007, when the report issued by the IPCC (Intergovernmental Panel on Climate Change) [1] concluded that anthropic activities (human actions) directly associated with the emission of greenhouse gases were interfering in the climate.

Some people disagree and say the influence of the emissions of such gases is very low, and some even exaggerate by saying the greenhouse effect does not exist. However, this concept was created by the Irish researcher John Tyndall in 1859. He discovered that gases such as carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) trap the infrared radiation, causing the warming. In 1886, the Swedish scientist Svante Arrhenius calculated the Earth temperature would increase by five degrees if the CO_2 concentration doubled. From that time to date, what we see is that those forecasts are beginning to be proven, and research now has the means to measure such variations much more efficiently.

Furthermore, surveys made in the North Pole and other parts of the world examined the quantity of CO_2 in air bubbles trapped very deep in the ice for thousands of years. The air found in the bubbles had the same composition of the atmosphere prior to the Industrial Revolution, which was 280 ppm (parts per million). The atmosphere has 400 ppm today.

Thus, there is human intervention causing the emission of several gases, not only CO_2, which make the atmosphere warm up. Evidence shows that the warming does have anthropic interference. The problem is that the models still have uncertainties which do not allow us state definitely the absolute figure in the rise of temperature.

What will be the impacts of global warming on farming?
Initially, the rise of temperature may cause water deficiencies, what can be harmful for agricultural production. Additionally, some plants abort their flowers when the temperature is too high, such as bean and coffee. Others, like cassava, undergo output losses with the increase of CO_2 in the atmosphere. We have been building a series of experiments to find out the response of such plants under the conditions foreseen by IPCC in its scenarios, in order to offer actions to mitigate this problem.

The plants we have been cultivating today are not fully adapted for temperatures reaching up to 2°C. They may have problems if we do not do anything. We cannot state that global warming is already showing its effects, but we have been witnessing successive yield drops in very sensitive regions, where the temperature has risen in the last 40 years. Yes, Brazil may have agricultural problems if nothing is done about this.

The research "Global Warming and the New Geography of Agricultural Production in Brazil", published in 2008, outlined scenarios of how climate change is to affect the domestic agriculture. Nearly four years later, how do you see the Brazilian situation?
At that time, we (Embrapa and UNICAMP researchers, who organized the study) were heavily criticized when we presented the results at scientific meetings. Representatives of the coffee industry, for instance, reacted by saying we wanted to eliminate such culture. Afterwards, in 2010, I was invited to present a lecture at the world coffee congress and, the day after my speech, a CIAT (International Center for Tropical Agriculture) paper reported that culture is searching for milder temperatures on account of production. Exactly like the conclusions we reached in 2001.

We have been witnessing coffee plantation area receding a lot in São Paulo. Certainly, production costs and yield losses due to water deficiency and high temperatures transferred coffee plantations to more productive regions in the State, with milder temperatures.

Another example is soybean, which is very vulnerable too. At the research, the losses expected for grains in 2020 was R$ 7 billion in terms of output. At the end of 2009, Embrapa, IAPAR (Instituto Agronômico do Paraná [Agronomic Institute of Paraná]), EPAGRI (Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina), and FEPAGRO (Federação Estadual de Pesquisa Agropecuária do Rio Grande do Sul [State Federation for Farming Research of Rio Grande do Sul]), were commissioned by the Ministry of Agriculture to make a study on crop falls in the States of Mato Grosso, Paraná, Santa Catarina, and Rio Grande do Sul.

The data gathered at the occasion »

Andressa Teixeira

We must have research lines to quantify greenhouse gases in several production systems, in the different Brazilian biomes.

1 IPCC | The Intergovernmental Panel on Climate Change – IPCC (www.ipcc.ch) is an intergovernmental body established in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). This body aims at supplying information on climate change, its potential impacts, in addition to putting forward adaptation and mitigation strategies.

2 Plano ABC | The Low-Carbon Emission Agriculture Plan (ABC Plan www.agricultura.gov.br/abc/). Also known as Segment Plan for Mitigation and Adaptation to Climate Change to Consolidate a Low-Carbon Emission Economy in Agriculture. It was a work coordinated by the Chief of Staff of the Presidency of the Republic, the Ministry of Agriculture, Livestock and Supply (MAPA), and the Ministry of Agrarian Development (MDA). It outlines strategies involving the generation and transfer of technology and credit to allow for the reduction of emission of greenhouse gases in agricultural activities.

indicated R$ 5 billion losses for maize and soybean plantations associated with climate problems. Is this climate change? I don't know. However, water deficiencies and Indian summers are more frequent, and we faced serious problems because of this. Output losses in Rio Grande do Sul was R$ 5 billion this year due to climate problems, specifically drought.

We are anticipating R$ 7 billion for 2020, but we have R$ 5 billion in 2012. In other words, something is going on, and we have to adapt to these future situations.

The Brazilian Government expects agriculture is to spread over degraded pasturelands. To what extent can the rise of temperature in Brazil compromise this plan?
According to some studies, between 13 and 15 million hectares are in regions to be little affected, at least as for warming scenarios. This is the case of Midwestern Brazil. The proposition of the ABC Plan [2] –the integration between agriculture and livestock–aims precisely at recovering pasturelands, increasing the grain output and, if possible, planting forests. Without necessarily expanding areas and with good agricultural handling and practices, it would be then possible to increase the production and reduce the emission of greenhouse gases. As a matter of fact, the problem in Brazil is the adoption of technologies compatible with the problems we have been facing now and that are occurring in several parts of the planet.

In the past, the Brazilian farming research was successful in the adaptation of temperate climate cultures–such as soybean and wheat, among others–to warmer regions, like the Cerrado, for instance. Can this be done again if the average temperature of the regions rises?
Yes, it can be done again. The idea is that studies on the investigation of genes in the Brazilian biodiversity are carried out when researching on adaptation. The plants found today in the Cerrado, in Amazon, and in semiarid regions have already experienced much heavier warming conditions than those seen today. In terms of scientific matters, the expected is that some genes of those plants respond to environmental stresses and adapt well. We have to discover this kind of gene in such plants in order to find out how this can be introduced in commercial cultivars, enhancing thus the tolerance to the climate change witnessed nowadays.

Brazil is the only country in the world able to do it. The entire genetic potential to solve the food security issue can come from the tropical area encompassing parallels 10 to 21, where Brazil and the Brazilian biodiversity are. In addition to making research with commercial varieties, what we have to do is to look for genes also in already adapted biodiversity species, in order to do exactly what has been done with soybean, carrot and other cultures. We have the means and the technological knowledge to carry it out.

Which lines of research are priorities in this warming scenario?
We have several solutions. The first of them is not found in research, but rather, in the adoption of technologies. Good fertilization methods, and the correction of soil acidity, what allows

for roots to go deeper, already solve a lot of agricultural production problems in warming scenarios.

Fostering mitigation actions is another solution. The use of agroforestry systems, for example, with tree shadows, can alleviate the temperature issue and sequestrate more carbon. We can encourage the adoption of systems for integration between agriculture and livestock, biological nitrogen fixation, direct planting, among others. Another very important point is the search for options in our biodiversity, especially when it comes to the production of wood, fibers, and cellulose.

There are a number of other issues, such as the study of the emission of greenhouse gases by the large systems of forestry production, grain production, and pasturelands. Brazil has substantial information on those emissions, but it is necessary to systematize those pieces of information, because this is going to be part of a monitoring process to be adopted all over the world. Today, it is possible to monitor manufacturing, power industries, but not agriculture completely. We must have research lines to quantify greenhouse gases in several production systems, in the different Brazilian biomes. Many research projects comprehend such actions already.

To what extent can warming compromise the domestic supply and our exports?

Probably yes, (there will be shortage) if no action is taken. This is clear in IPCC reports. This is not a Brazilian problem, it is a world problem. France has serious problems with its wine production, especially in harvesting. The same problems also occur with orange in the United States, coffee in Central America, the production of grains in other parts of the world. One cannot state that global warming is showing its effect now in 2012, but the signs are quite clear in this sense.

It takes ten years of research to build an adapted culture, so no one is wasting time. Embrapa Soja has been working on a cultivar which is more tolerant to water deficiency, and the product is almost ready. The IAPAR was not wasting time either when it launched four bean cultivars more withstanding to drought and high temperature. Embrapa Café and the Pró-Café foundation were not wasting time either when they worked on coffee varieties more resistant to high temperatures. A great deal of time and investments have been dedicated to agriculture adaptation.

The scientific community is worried about this and looking for solutions. Can it affect (supply)? Yes, it can. Nevertheless, if we work with the prospect of adaptation and are prepared for this, we will make it. I do not envision problems if the temperature rises no more than two degrees.

What if the rise is higher?

Things get complicated then, because we don't know what is going to happen. One of the great advantages this scientific discussion brought to our community is that we began to discuss plant physiology again. We had put this topic somewhat aside. Today, there are many people researching in order to understand how plants respond to current stresses.

When I hear researchers saying there is too little CO_2 in the atmosphere, they are right. It is too little, but it suffices to change plant photosynthesis. As for cotton, there is a point at which breathing becomes equal to photosynthesis, and the plant stops producing. It is a phenomenon called thermal compensation. Maize requires a temperature gradient between day temperature and night temperature. We notice this temperature gradient is decreasing. This can affect maize production. If production is affected, the possibility of affecting food availability exists. However, I think Brazil can become the main world player concerning the supply of food, in view of its land availability and the possibility to recover degraded pasturelands. There will be a 600 billion-ton demand for food in the world in the years to come, and Brazil is one of the few countries able to reach such level of output.•

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THE BRAZILIAN COMMITMENT TO THE LIFE OF SOILS

Five seconds. This is the time required for Brazil to save about USD 1 thousand with the use of the Biological Nitrogen Fixation (BNF) in soybean plantations, the main Brazilian agriculture commodity.

Fábio Colombini

BIOLOGICAL NITROGEN FIXATION

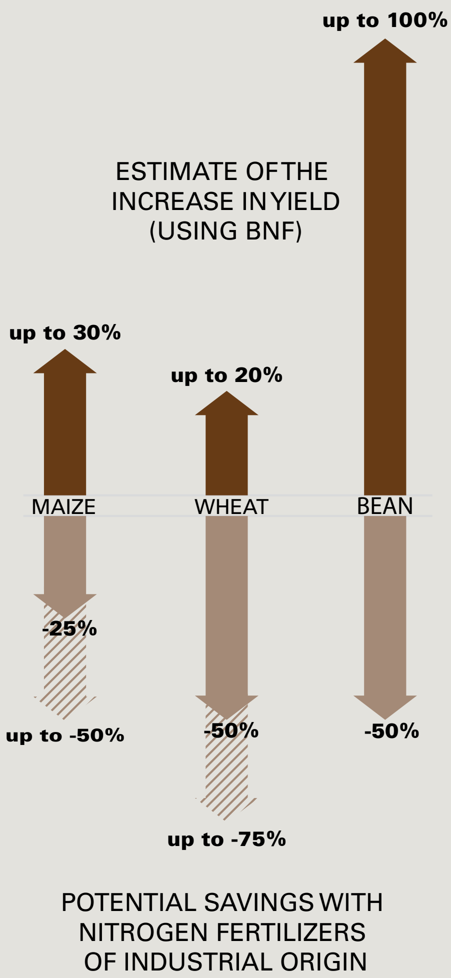
by Sandra Zambudio | collaboration Ana Lúcia Ferreira

After photosynthesis–the process performed by plants to produce the energy necessary for their survival, the biological nitrogen fixation (BNF) is regarded as the planet's most important biological process. The reason is that some bacterium genera can capture the nitrogen (N2) present in the air (78% of the atmosphere gases) and turn it into N which can be assimilated by plants.

It is a real "biologic factory" able to meet the needs of plants, by averting nitrogen chemical fertilization. Undoubtedly, this is a process which makes the production of soybean in tropical regions feasible today, and it is also considered as the most successful as for low-carbon emission agriculture, says Mariangela Hungria [1], one of the most distinguished Brazilian BNF researchers.

This researcher is known worldwide due the outcomes she has been reaching at Embrapa Soja (Londrina, PR) laboratories, among them the selection of *Azospirillum* stocks for maize and wheat cultures. Under family agriculture conditions and with low use of inputs, the inoculation with those stocks enhances maize output by 30% on average and, in case inputs are used, high yields can be obtained by reducing nitrogen fertilizer doses by 25 to 50%. Concerning wheat, 20% increases on average can be attained by reducing nitrogen fertilizers by 50 to 75%.

The BNF made with bacteria of the *Bradyrhizobium* genus is currently adopted on all the areas with cultivation of soybean in Brazil–approximately 24 million hectares – and makes Brazil save about USD 7 billion a year by not resorting to nitrogen fertilizers in plantations. »



COMMITMENTS

The BNF is one of the agricultural technologies which are part of the commitments taken by Brazil at the COP-15, held in Copenhagen in 2010, and which establish the reduction of emissions of greenhouse gases between 36.1% and 38.9%, what means a reduction around 1 billion tons of carbon dioxide – the main greenhouse gas in the atmosphere. Thus, it became one of the points included in the Low Carbon Agriculture (ABC) program of the Brazilian Government.

Soybean is the case with the highest economic impact resulting from the use of the BNF in Brazil. We can say without a shadow of a doubt the success of such culture in the Country is directly related to the BNF process, able to supply the entire N required, even in the case of high-yield cultivars. Another significant example of the use of the BNF is seen in bean plantations. The inoculation with rhizobia stocks selected by the research has been resulting in outputs over 2000 kg/ha with such technology alone. This means more than the double of the domestic yield achieved in plantations today, what can lead to savings of USD 500 million a year. In the case of higher outputs, the BNF helps bean plants to reduce by more than 50% the nitrogen fertilizer dose to be applied.

The Brazilian research has already identified dozens of such bacteria, able to supply N to leguminous grains (e.g., soybean, bean plant, and cowpea), temperate forage (e.g., alfalfa), tropical forage (e.g., forage peanut), green manure (e.g., crotalaria), and arboreal species (e.g., mesquite).

No wonder the BNF is the object of work for over 50 Embrapa researchers, who are in charge of research projects with this topic. This technology also makes carbon sequestration easier, i.e., where the N balance is positive, the formation and maintenance of organic matter is stimulated, causing carbon to be incorporated to the soil and diminishing its return to the atmosphere.

Studies show the biologic fixation of 90 million tons of nitrogen is equal to the sequestration of 770 to 990 million tons of carbon a year, as pointed out by the researchers Fábio Bueno dos Reis Junior and Iêda de Carvalho Mendes, who are experts in this subject, working for Embrapa Cerrados (Brasilia, DF).

The use of this technology on the soils may also contribute to minimize other serious problems associated with nitrogen fertilizers. According to Fábio and Iêda, the absorption of these products by the plants is low, rarely in excess of 50%. This means that when you apply 100 kg of N, at least 50 kg are lost by means of different processes occurring in the soil. When it comes to the BNF, the addition of N is expected not to exceed agroecosystem needs. In addition to economic implications, fertilizers lost account for a serious source of environmental pollution, entailing the contamination of rivers, lakes, groundwater, as well as the introduction of greenhouse gases, including nitrogen oxides, which the most impacting ones on the ozone layer.

1 Mariangela Hungria has always been dedicated to the BNF research, and the main difference in its work is in associating basic (genomic, proteomic, taxonomy and phylogeny) research with applied research, especially to develop microbial inoculants and select rhizobium and *Azospirillum* stocks. Such dedication made her win the Frederico de Menezes Veiga Award 2012, created by Embrapa to reward every year researchers who have made relevant contributions to the Brazilian farming industry

Sandra Zambudio / Embrapa

HOW EVERYTHING STARTED

Everything started with two great researchers in the late 1950s, when few scientists believed the Biological Nitrogen Fixation could compete against mineral fertilizers. The researcher Johanna Döbereiner began a research program on the limiting aspects of the BNF in tropical leguminous plants at Embrapa Agrobiologia (Seropédica, RJ). In Rio Grande do Sul, Professor João Ruy Jardim Freire concentrated his research on the soybean culture, and assisted the implementation of the first inoculant factory in Brazil. Both of them worked together at pivotal moments for the Country, such as the Brazilian soybean enhancement program, initiated in 1964.

In the 1970s, the energy crisis renewed the interest in the research on the BNF, and accordingly, the connections between gramineous plants and diazotrophic microorganisms. Johanna Döbereiner was involved in these studies, which began in 1966 with the discovery of the occurrence of the nitrogen fixation bacterium *Azotobacter paspali* in association with roots of *Paspalum notatum* (Bahia Grass). Such discovery eventually led recently to the development of the very first experimental inoculant for sugarcane, currently under validation of the agronomic efficiency.

AN INTERNATIONAL BENCHMARK

It is not a surprise that Embrapa Agrobiologia is regarded as an international benchmark in studies in this field, according to Sacramento Urquiaga Caballero, who works at that Unit, and who has today one of the largest Collections of Diazotrophic Bacterium and Multifunctional Microorganism Cultures in Brazil. This is the outcome of research dedicated to the investigation and identification of microorganisms with potential to either enhance or benefit the BNF in different cultures.

As result of this work, researchers also developed inoculants for cowpea (black-eyed pea) culture, which have been used in Northern and Northeastern Brazil by small family farmers, and more recently by major producers in the Midwest, where this culture is expanding freely. The product is being tested in Ghana, Africa too, and it has satisfactory outcomes already.

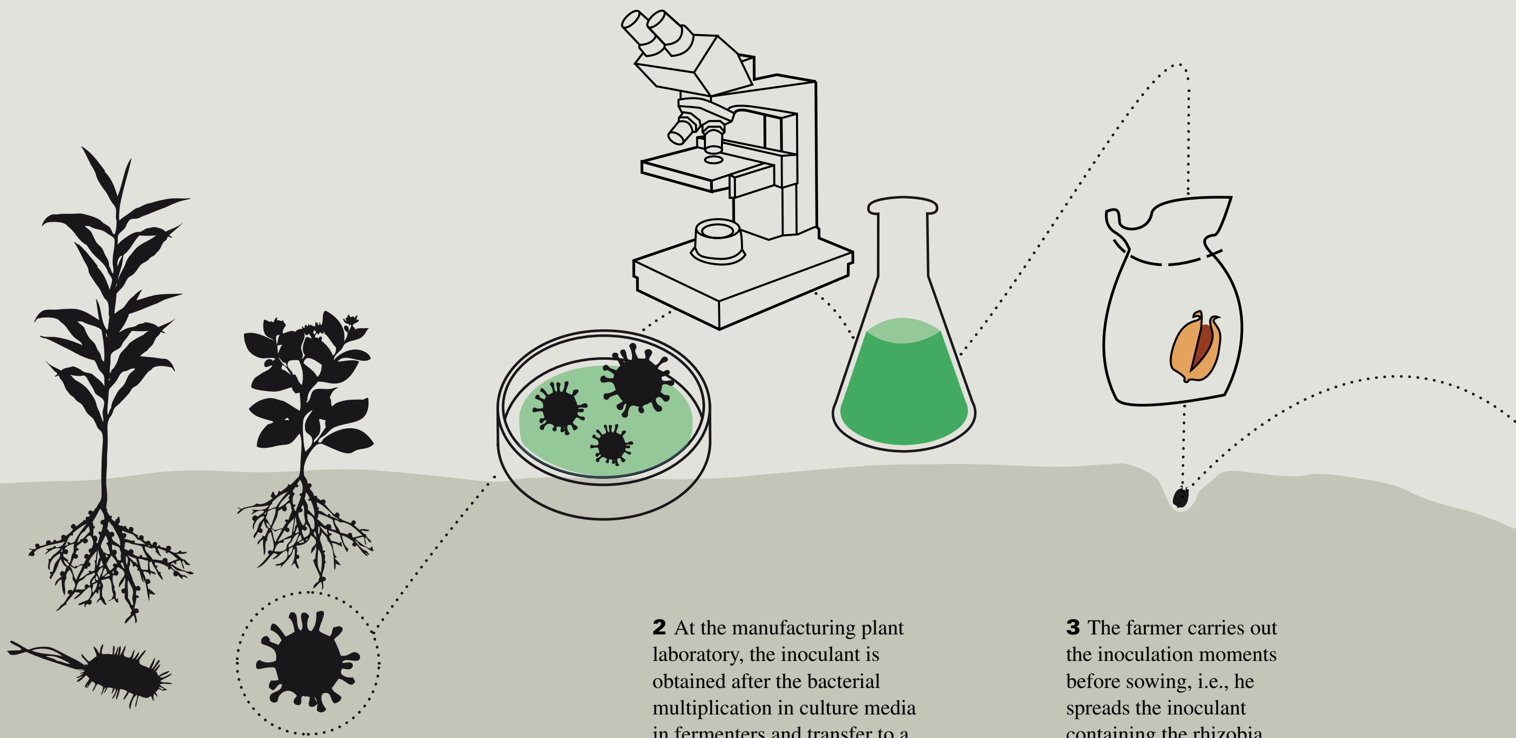
Embrapa Agrobiologia researchers also work toward the efficient use of inoculated leguminous plants as green manure, which is one of the alternatives for the supply of N in agriculture, especially organic production, where the use of synthetic fertilizers is not allowed, what also contributed to increase the amount of organic matter in the soil. Likewise, the use of leguminous arboreal species to recover degraded areas is a powerful strategy to improve the environment, allowing the growth of plants which did not manage to survive before due to the advanced state of soil degradation. »

UNDERSTAND THE BNF

The Biological Nitrogen Fixation (BNF) is a very complex biologic process resulting from an evolution occurred throughout millions of years. Although gaseous nitrogen (N_2) accounts for 78% of atmospheric gases, no animal or plant can use it as nutrient because of the triple bond existing between the two N_2 atoms, which is one of the strongest in nature we know of.

The outcome of the BNF research is the use of such biological process in agricultural systems, by means of inoculation with research-selected bacteria. When the seeds inoculated by the bacteria (inoculants) begin to sprout in the soil, over 200 genes of the plants and of the bacteria are activated, emphasizes Mariangela.

Some of these microorganisms, known as diazotrophs [2], can break the bond joining the two atmospheric nitrogen atoms (N_2), by transforming them into ammonia (NH_3), which can be assimilated by plants, as explained by the researchers. If the association among these microorganisms and the plants is efficient, the fixed N is able to supply the needs of the vegetal, dispensing with the use of nitrogen fertilizers and offering thus economic and ecologic advantages. The most popular example consists in the symbiosis of bacteria of the Rhizobiales order, called rhizobia, with plants of the Leguminosae family, of which soybean and bean are part. •



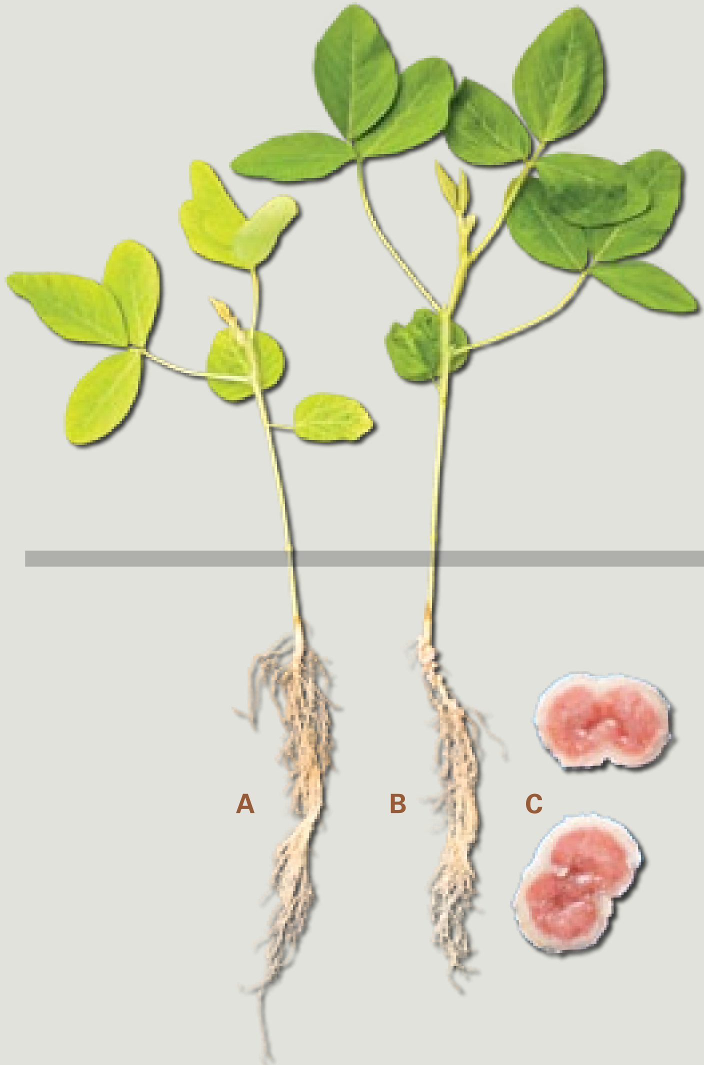
Lygia Akemi Kanegusuku

1 Among hundreds or even thousands of isolates (types of bacteria), the researchers selected the most promising rhizobia to perform the BNF. Initially, the stages are carried out in the laboratory, in the vegetation house, and finally the field experiments. After their efficiency is proven, they are enrolled with the Ministry of Agriculture, Livestock and Supply (MAPA) and made available to the industry.

2 At the manufacturing plant laboratory, the inoculant is obtained after the bacterial multiplication in culture media in fermenters and transfer to a solid (sterilized peat) or liquid (combinations of sources of carbon, salts, buffers, etc.) matrix, so that they remain viable until the moment of their use by the farmer.

3 The farmer carries out the inoculation moments before sowing, i.e., he spreads the inoculant containing the rhizobia uniformly over the seed surface, and then, the sowing is performed.

RR Rufino / Embrapa



2 Bacteria Among the diazotrophic bacteria, as those which fix the air nitrogen are known, the group of bacteria which form nodules on plant roots (collectively known as rhizobia) consists of several species associated with plants of the *Leguminosae* family, such as soybean, bean and cowpea, among others. The nodules are on the roots in most leguminous plants. However, some leguminous species have nodules on the stalk, for instance, the *Aeschynomene* species, what enables the plants to perform the BNF in the flood season in Pantanal, when the roots are submersed.

A Development of a plant without the BNF
B Development of a plant with the BNF
C Cross section of a radicular nodule, red inside because of the leghemoglobin, indicating the nodule is active

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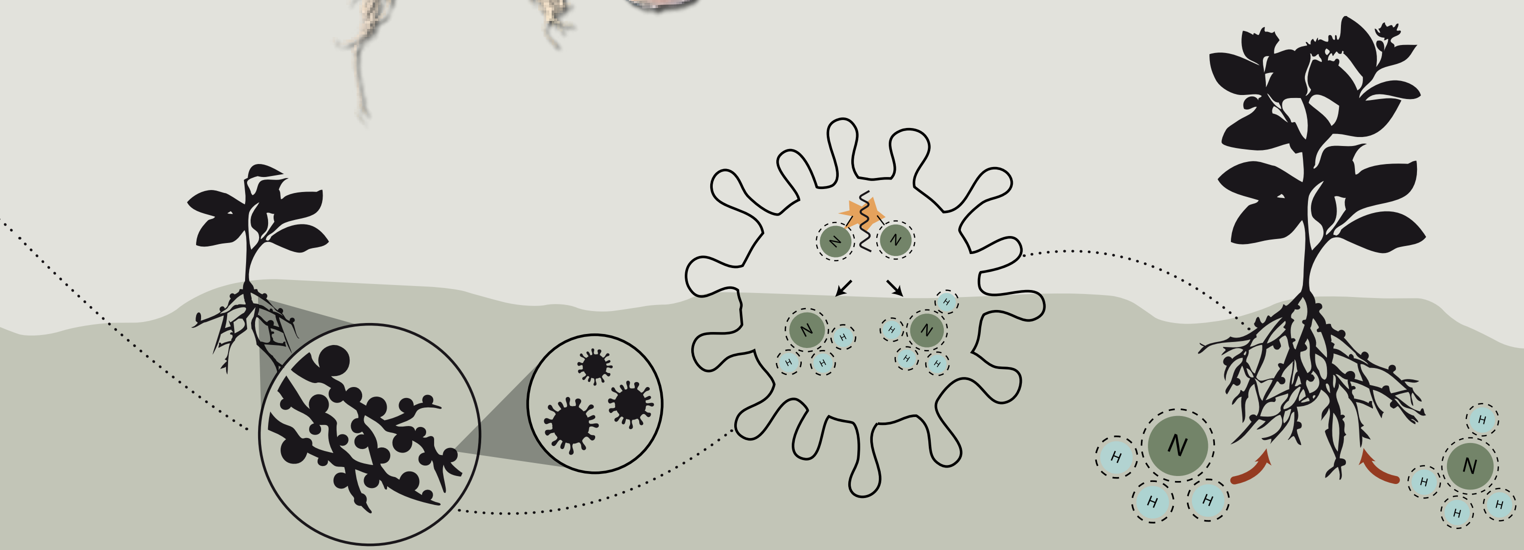


4 At this stage, a chemical relationship between the plants and the bacterium begins. The plants emit chemical signs through their roots in order to attract the rhizobia nearby. The latter also respond chemically they are arriving. With such communication, the cells of the radicular cortex start dividing themselves in order to build a structure which is to shelter the guests: the nodule.

5 Once they are protected in the nodule, the bacteria turn into bacteroids (they lose their original shape), leghemoglobin is formed, nitrogenase, and the BNF process commences. Due its high catalytic capacity, nitrogenase converts the N_2 into NH_3 and then into NH_4^+.

6 The plant has now at its disposal the N in a form it can assimilate, to be used to synthesize proteins and other macromolecules, at a low financial, environmental cost.

PURER AIR FOR THE PLANET

by Sandra Zambudio

The world is worried about climate change on the planet, arising especially from the emission of carbon dioxide (CO_2) and other greenhouse gases (GHG), such as methane (CH_4) and nitrous oxide (N_2O), which are found in agricultural soils. Aware of such fact, Brazilian researchers have been working to help the world discover actions to minimize global warming effects.

Quantifying the greenhouse gases emitted by agricultural, livestock and reforestation activities in Brazil and understanding the mechanisms to sequestrate soil carbon [1] is the core of the work developed by the researcher Carlos Clemente Cerri, one of the winners of the Frederico de Menezes Veiga Award 2012. This award is given by Embrapa, and is one of the most important awards in Brazilian farming industry.

Cerri, who is also a professor at the Center for Nuclear Power in Agriculture, University of São Paulo (CENA/USP), has a goal to reach: discover methods able to reduce the carbon footprint [2] of agribusiness bioproducts.

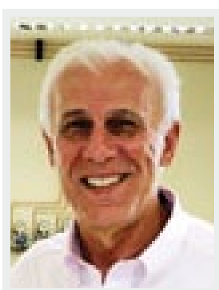
His research in based on the emission of greenhouse gases discharged into the atmosphere in all the stages of the farming production. This begins when preparing the soil and includes the N_2O emitted through the application of fertilizers. Other gases are also emitted due to plantation methods, harvest, in industry (improvement and processing), and transportation of agribusiness commodities in Brazil.

Cerri explains: "The works attempt to calculate the gains the agricultural activity can produce for the environment too. We cannot forget that any piece of soil properly treated can receive carbon from the atmosphere. It is what we know as carbon sequestration by the soil".

When you talk to this researcher, you realize his work is not easy. Besides, he is very meticulous, since each culture or agricultural product has different requirements. It is necessary to examine each product individually. Cerri and his team have been working on this since 1992, when the Project "Soil carbon sequestration, emissions of greenhouse gases by agriculture, livestock, and reforestation activities: bases for mitigation actions" was initiated.

"We have been working on this calculation", he points out. It is a tough job because it changes in accordance with each production system and from region to region", he says. The first step is to assess the amount of gases being emitted, and then find out the carbon sequestration indexes. With these figures in hands, we can come up with technologies able to reduce the emissions of greenhouse gases.

Cerri believes Brazil needs more researchers working on mitigation, i.e., techniques which help diminish global warming. As for technologies, the researcher considers Brazil already has techniques to reduce the greenhouse effect. Direct Planting [3] and Agriculture-Livestock-Forest Integration [4] are examples of technologies available to producers already.

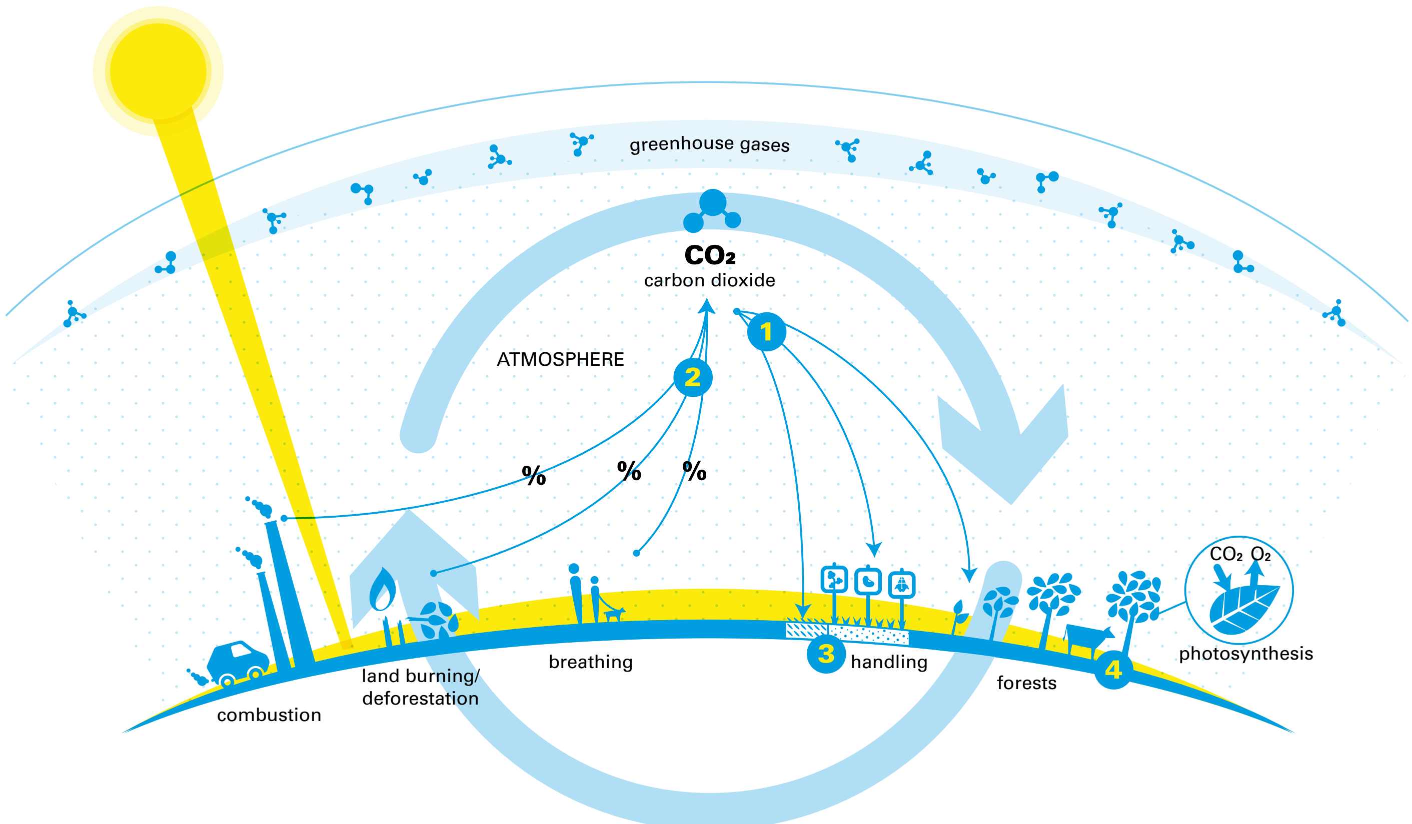


Marcelo Basso

Carlos Cerri

Professor of the Center for Nuclear Power in Agriculture, University of São Paulo

Project:
Soil carbon sequestration, greenhouse effect gases emitted by agriculture, livestock and reforestation activities – bases for mitigation actions



André Scofano

1 Carbon sequestration | Absorption of large amounts of carbon dioxide (CO_2) existing in the atmosphere. The most usual form of sequestration is the one performed by forests naturally, when they absorb large amounts of such element for their development.

2 Carbon footprint | This is a form of determining the amount of carbon dioxide (CO_2) emitted either directly or indirectly by any activity performed on our planet.

3 Direct Planting | | It is one of the most efficient and sustainable farming production systems adopted today. It is implemented based on three principles: do not plow or fence in the soil before the planting, keep it covered with vegetal remains or living plants during the year, and rotate the cultures.

4 Agriculture-Livestock-Forest Integration | Technology which allows for the production of grains, beef, milk, fibers and wood in the same area.

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GREENHOUSE EFFECT

There are two kinds of greenhouse effect: the natural and the anthropic. The natural occurs due to the concentrations of greenhouse gases in the atmosphere prior to the appearance of man. Solar energy with very short wavelength crosses the Earth atmosphere without interacting with the gases present in this layer. When it reaches the Earth surface, the energy is reflected back to the atmosphere with a longer wavelength (infrared radiation), which interacts partially with the greenhouse effect gases present in this layer. Part of such irradiation is absorbed into the atmosphere and, consequently, increases the air temperature. Such interaction allows for the average temperature of the Earth atmosphere to be 15ºC. If such gases did not exist in the atmosphere, the average temperature on Earth would be 33ºC lower, i.e., -18ºC, what would make life existing currently unfeasible. The use of natural resources such as coal, oil and forest areas made the amount of gases–especially CO_2 – increase in the atmosphere substantially. The outcome was more interaction with the infrared radiation emitted by Earth, and accordingly, rise of the atmospheric air temperature. This process is called global warming, and has consequences on climate change.

André Scofano

WORLD POPULATION REACHES NINE BILLION

by Marcos Esteves

This headline above is evidently fictional, but it might certainly be on the screens or other means of communication in 2050. Obviously, such news would have the same repercussion as the announcement of when the number of seven billion inhabitants on the planet was reached, at the end of October 2011. This figure is expressive, and reflects the achievements of modern society, among them advancements in the fields of health and nutrition.

The fact is that the growth of the world population presents substantial challenges for mankind. In the case of the farming industry, the main one was made explicit by the Secretary-General of the United Nations Organization (UNO), Ban Ki-moon: "seven billion people need food". With this statement, he showed a new paradigm the agriculture industry will have to incorporate.

Notwithstanding, although it is not possible to know how the news on the nine billion inhabitants will be broken in 2050 yet, farming research has been trying to anticipate scenarios for the future. The researcher Elísio Contini, Joint Head of the Center for Strategic Studies of Embrapa Estudos e Capacitação (Brasilia-DF) says: "research institutions and agribusiness companies cannot work stuck to the past. The Brazilian agriculture industry must be built on the anticipation of risks and take advantage of opportunities, by taking the responsibility of increasing the food production, both for the domestic market and for exports."

In addition to the great challenges to be faced by a farming industry producing food, fibers and energy, this segment is to become increasingly multifunctional, as explained by Embrapa's Research & Development Director, the researcher Maurício Lopes. According to him, it is not exaggerated to say that agriculture will play a significant role in the decades to come, not only in Brazil, but all over the planet. "The agriculture of the future will produce also bioenergy, environmental services, and products with a higher nutritional density, and use biomass to develop a new green chemistry, for instance."

Farming innovation is a crucial component for such new reality to be reached. The recent history of the Brazilian agriculture is abundant with examples of how the work carried out by universities, state research institutes and Embrapa can transform scenarios. Such changes increased the average output of grains in Brazil from 783 kilos per hectare in the early 1960s to 3,173 t/ha in 2010. A growth of 774%, what made the Country leave the role of importer and become one of the major world producers and the third largest exporter of agricultural products in the world.

According to Maurício Lopes, farming is to be more and more benefitted by the technological breakthroughs occurred in several fields of knowledge. He mentions Biology, with research in genomics, and Physics and Chemistry, with studies on nanotechnology as examples, besides new information and communication technologies, robotics, remote sensing, automation and advanced tools, which must contribute to enhance efficiency, productivity and sustainability in the agriculture industry. "The study of genomes is enabling us to widen the knowledge on the biological mechanisms of plants, animals and microorganisms. Thus, it makes possible for agriculture to increase the productivity and improve the quality, in addition to making more specific products. Likewise, nanotechnology innovations can revolutionize the development of tools, processes and products, increasing the efficiency in the farming industry", he says.

According to the researchers, the Brazilian farming research continues to evolve in order to create technologies able to allow for agriculture to meet the increasing domestic demand, and the need to produce surpluses which can be exported to the world. However, the increase in the production and productivity gains must necessarily be together with practices to preserve natural resources such as the soil, water, forests, and the biodiversity.

This challenge becomes even more complex due to the scenario of climate change, which is to cause impacts on agriculture, especially in tropical countries. Thus, according to them, researchers have already elected their priorities. Maurício Lopes e Elísio Contini list innovation aspects that must be focused by Brazilian research institutions in the years ahead.

For Elísio Contini, the challenges of the Brazilian agriculture are big, but so are the opportunities. "It's up to us to transform them into concrete products. The farming research will play his role, by generating knowledge and technologies to enhance the production efficiency and the rational use of natural resources", he says. •

‹ link ›

www.cecat.embrapa.br Embrapa Estudos e Capacitação

INNOVATION ASPECTS

Genetic Enhancement the development of more efficient, adapted animal production systems and better seeds is to keep being one of the main forms of operation of both state- and privately-owned R&D companies;

Handling and tropicalization of inputs replace chemical fertilizers and pesticides made based on oil with efficient alternatives and with lower environmental impacts will be a demand made by society toward the agriculture industry;

Water agriculture is currently the industry which uses water the most. The use of irrigation tends to grow on account of global warming. Improving the use of this technique in order to lessen the pressure of this industry on water resources is one of the main challenges for the future;

Monitoring there will be more demand for research which lead to innovations in zoning, satellite monitoring, modeling and remote sensing. These tools are crucial to organize the Brazilian territory and plan the sustainable use of natural resources;

Integrated systems and reduction of gases the Brazilian agriculture will expand over currently degraded pasturelands formed in the 1970s and in the 1980s. Innovations such as systems for integration of agriculture, livestock and forests (iLPF) and others will enable the intensification of the use of natural resources on a sustainable manner;

Precision mechanization, automation and agriculture automation and precision technologies will help agriculture to overcome problems, as alternatives to the shortage of workers in the countryside and the increase in the cost of inputs such as water, seeds, fertilizers and power, for instance;

Functional food a new paradigm in health, focusing on the prevention of diseases, has turned the development of food with higher nutritional and functional density into a priority for farming research;

Biological security and protection of agriculture the advancements in transportation, trade and tourism made the circulation of goods and people around the world easier. Similarly, they increased the inflow of foreign invading organisms or species into the countries, what results in a higher number of barriers against the entry of agricultural products. Technological innovations are pivotal in this context, in order to block the dissemination of harmful organisms, develop monitoring, traceability and certification practices which meet the demands of food importing countries.

BIOLOGICAL LONG-LIFE PRODUCTS

The use of fungus-based biological insecticides and fungicides (biological substances to kill pest insects and fungi which cause diseases in plants) to control agricultural pests has been increasing significantly in Brazil. However, most products available in the domestic market have their stability reduced during storage under high temperatures, what diminishes its marketing potential and can lead to unsatisfactory control levels.

Embrapa Recursos Genéticos e Biotecnologia (Brasilia, DF) developed an industrial process able to solve this problem. It is the TEV - Tecnologia de Vida de Prateleira (Shelf Life Technology), created in partnership with the Agricultural Research Service (ARS), of the U.S. Department of Agriculture (USDA), and Cornell University, in the USA.

According to the researcher Marcos Faria, one of the persons in charge of the project, while the shelf life of chemicals is measured in years, the biological ones is counted in months, even in weeks. The TEV is based on the reduction of water activity to extremely low levels and on the reduction of oxygen levels inside the packages.

Tests have been carried out with products based on several fungi utilized in Brazil for the biological control of agricultural pests. The following is highlighted among them: *Metarhizium anisopliae*, to control the little cicada of sugarcane, and that is applied today in nearly one million hectares all over the Country; *Beauveria bassiana*, to control the silverleaf whitefly and the coffee berry borer; and those of the *Trichoderma* genus, applied in more than one million hectares on cultures such as bean and soybean. The experiments evaluated the products at temperatures higher than 30 degree during the storage period of time. — by Fernanda Diniz

‹ **links** ›

www.cenargen.embrapa.br Embrapa Recursos Genéticos e Biotecnologia
www.ars.usda.gov Agricultural Research Service
www.usda.gov Departamento de Agricultura dos Estados Unidos
www.cornell.edu Universidade de Cornell

GENOME CRACKED

Brazilian researchers have sequenced the genome of Zebu race animals for dairy purposes (Dairy Gyr and Guzerat). The announcement was made in Uberaba at the Expozebu –one of the world's largest livestock exhibits. This is the very first sequencing project of a major genome entirely made in Brazil.

The study was conducted by researchers of Embrapa Gado de Leite (Juiz de Fora, MG), Federal University of Minas Gerais (UFMG), René Rachou Research Center - Fiocruz, Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG), as well as the participation of the State Department for Science, Technology and Higher Education of Minas Gerais (SECTES), Excellence Centers for Milk and Bovine Genetic, and breeder associations.

The announcement was made three years after the disclosure of the bovine genome in April 2009, a task which involved about 300 scientists from all over the world, including Brazilian researchers.

The animal object of that study was a cow of the European-origin Bos taurus taurus subspecies, as well as Holstein, Jersey, and Brown Swiss races. The animals of the Gyr and Guzerat races are of the *Bos taurus indicus subspecies*, which account for most of the Brazilian herds.

The Brazilian scientific community believes the sequencing of the Zebu cattle can back the studies for genetic enhancement of those herds, allowing for the development of specific tools to select Zebu race animals.

Afterwards, the studies are to focus on the mapping of Sindhi races and the Girolando synthetic race.

— by Rubens Neiva

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www.cnpgl.embrapa.br Embrapa Gado de Leite
www.ufmg.br Universidade Federal de Minas Gerais
www.cpqrr.fiocruz.br Centro de Pesquisas René Rachou / Fiocruz
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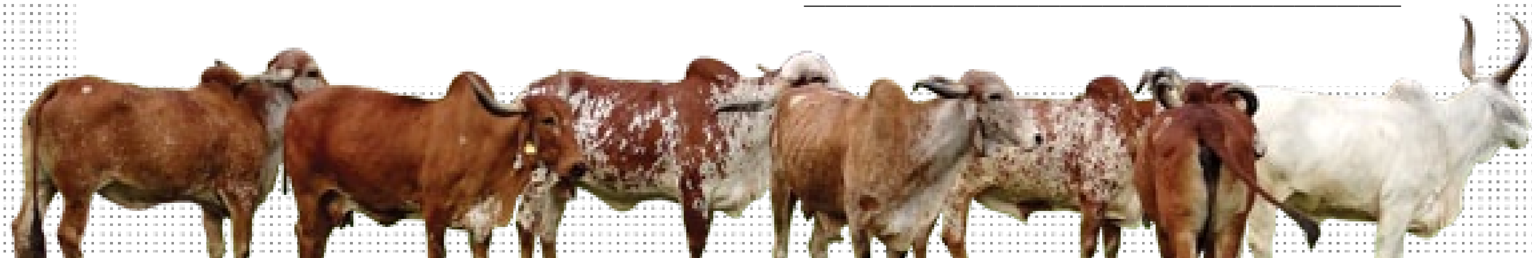
www.tecnologia.mg.gov.br SECTES



Rubens Neiva / Embrapa

SWEET SORGHUM

The first step toward dual-fuel plants

Embrapa has been researching on the production of first- and second-generation ethanol from sweet sorghum. The works aim at finding alternatives to reduce the idleness of sugar/alcohol plants during the sugarcane off-season, which lasts even five months in Mid-Southern Brazil.

Some plants have already tested the production of ethanol from this species at the beginning of this year. The concept of "Dual-Fuel Plants"– which will use different raw materials to produce ethanol, has been included in the series of discussions in search of solutions to solve the current ethanol supply crisis in Brazil.

The researcher Cristina Machado, from Embrapa Agroenergia (Brasilia, DF), explains that sorghum has characteristics similar to sugarcane. Juice is extracted from its stems, which can be fermented to make ethanol. "The industrial processing of sweet sorghum would be the same already in use by Brazilian plants, possibly with minor adjustments", she says.

However, the sugar composition of the sweet sorghum juice is different, and it may affect its industrial yield. Studies made at Embrapa Milho e Sorgo (Sete Lagoas, MG) indicate the content of sugar in this species is similar to the one found in sugarcane, between 15% and 21%. Notwithstanding, sucrose predominates in sugarcane, whereas glucose and fructose prevail in sorghum. "So, this raw material ought to be used more to produce ethanol than sugar", points out Cristina. On the other hand, the content of lignin in the bagasse is lower, what can be favorable for the production of second-generation ethanol.

Embrapa has been also commissioned to assess the technical and financial feasibility of other vegetal species which might complement sugarcane in the ethanol producing chain. It is important to highlight the interest in the use of sugar beet in Southern Brazil, of blue agave in the Northeastern Brazil, and of cassava in several regions. — by Daniela Garcia Collares e Vivian Chies

‹ links ›

www.cnpae.embrapa.br Embrapa Agroenergia
www.cnpms.embrapa.br Embrapa Milho e Sorgo

BIOFORTIFICATION

Reduce hidden hunger and provide micronutrients to billions of people through the supply of biofortified food. This is the main purpose of the HarvestPlus program, an initiative coordinated by the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI).

The scarcity of micronutrients like iron, zinc and vitamin A in diets accounts for serious public health problems, particularly in underdeveloped countries. Increasing the content of such nutrients in staple food by means of genetic enhancement is the biofortification strategy.

The program, already in progress in Sub-Saharan Africa and in Southern Asia, will have now operations in Latin American & Caribbean (LAC) countries. HarvestPlus will be part of the AgroSalud program, a continental initiative that was developing more nutritious staple food for LAC.

Saulo Coelho / Embrapa

The researcher Marília Nutti, of Embrapa Agroindústria de Alimentos (Garatiba, RJ), is coordinating LAC activities. She has been coordinating Embrapa-led BioFORT biofortification program since 2000. The project focuses on the development of staple food such as rice, bean, cowpea, cassava, sweet potato, maize, pumpkin, and wheat. BioFORT has a network of 150 Brazilian partners, including eleven Embrapa units, universities, state and local institutions, NGOs, farmer associations and researchers. — by Soraya Pereira

‹ links ›

www.harvestplus.org HarvestPlus
www.ciat.cgiar.org Centro Internacional de Agricultura Tropical
www.ifpri.org Instituto Internacional de Pesquisa de Políticas de Alimentação
www.agrosalud.org AgroSalud
www.ctaa.embrapa.br Embrapa Agroindústria de Alimentos
www.biofort.com.br BioFORT

SUSTAINABILITY: SEARCHING FOR A CONCEPT

by Zander Navarro

Marcos Esteves / Embrapa

Zander Navarro

Embrapa Estudos e Capacitação researcher

Fields of activities: Sociology of rural social processes; Studies on (agrarian and rural) development; Social movements and rural organizations; Democratization processes in rural regions; Sociological theory; Agrarian history of Brazil; Democratic theories; Social participation; Democratization processes.

It has been suggested that Rio+20 should establish "sustainable development goals", corresponding to the still in force "millennium development goals". The latter–initially seen with huge skepticism– eventually proved to feasible, and most countries managed to meet a substantial part of the goals established. Why not doing the same as for "sustainable development", by agreeing on a set of goals to be reached within a reasonable deadline?

Even if the conference approves the recommendation and establishes new "global objectives", it is unlikely the countries will make efforts to carry them out. This happens because the word "sustainable", which was disseminated by the "Brundtland Report" (1987), was born already with an ambiguous, relatively obscure meaning. As years went by, "sustainability" became an even more confusing and vague word, and began to encompass almost everything and almost every situation. The opportunity to determine more accurately actions of citizens and governments to reorganize the civilization standards, under which we live, by adjusting it to the economic, social and environmental demands of our age, was thus missed.

Two aspects are considered for illustration purposes. In its origin, the widespread definition for sustainability suggested that a sustainable standard ought to ensure "the needs of the present without compromising the needs of future generations". This concept was broadly disseminated because it was too simple, but it was not duly examined. What are "needs"? Any study on consumer practices and standards will show that needs vary among different cultures and societies. Particularly, they change with time, in view of social and economic transformations. Therefore, it is certain that the needs of future generations will be radically different from those of the present-day generation. However, how can we preserve them if we do not know what they will be? To say the least, the initial formula is therefore contradictory.

Another aspect refers to the so-called sustainability "pillars". While the understanding on the economic and environmental pillars grew more in this period of time concerning their procedures, especially because they are more and more quantifiable, the "social" sustainability pillar remains at an exclusively rhetoric level. Probably, it will remain at such level. The reason is simple: the goals usually referred to in order to describe "social sustainability" require fundamental changes, virtually the principles of the economic system we live in. Nevertheless, in order to change it, a comprehensive political agreement is required and, particularly, the existence of another system to replace capitalism. Do such models exist? Is there a general political resolve demanding another social and economic order able to govern our society in special? It is unrealistic to assume that such transition is feasible within a noticeable period of time in history.

These are only two illustrations of the profound inconsistencies of the sustainability notion, which is still far from being a concept properly. For this reason, this guideline for society transformation is much more a general value under construction, a future goal, nearly a utopia. Nevertheless, the efforts made in every field, including agricultural research, are extremely relevant to build gradual advancements toward a renewed, different civilization standard, even if this is a goal to be reached in a very distant future. •

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