GIUNTI EDITORE

Planting the Future: biodiversity benfits us all

by

Salvatore Ceccarelli
And
Stefania Grando

Pages: 224
Size: 14 x 21.5 cm
Binding: softcover with flaps
Price: Euro 18,00
Illustrations: none
Publication date: September 17, 2019
First print run: 4,500 copies
Imprint: Giunti / Slow Food Editore

- *All food comes from seeds, so it is there that we must begin if we wish to change the way in which food is produced, as well as reduce the negative effects that it may have on our health and on the environment.*

1

The seed at the center of everything

Some of the most frequently debated global problems today are poverty, malnutrition (which includes both malnutrition and obesity), lack of water, the reduction of biodiversity in general, of agricultural (or agro-biodiversity) in particular, and climate change. These topics are often discussed separately, although they are interdependent and their solution is part of the set of sustainable development goals identified in September 2015 by more than one hundred and fifty leaders of the United Nations.

Connected to all of these topics, and at the center of the entire discourse, are seeds.

The seed is a fascinating vegetal organ because, to put it in the words of the American researcher Jack Kloppenburg, in the process of agricultural production it is at two opposite extremes, being both the starting point and the ending point of the complete process. It is a grain that we eat, we grind, we transform into plants, and we sell.

Seeds are connected to climate change because there will be an ever greater need of plants capable of withstanding gradually increasing temperatures and reduced rainfall. The problem is further complicated in this case by a whole series of questions that do not receive nearly enough attention. One of these regards climate prediction models: despite their increasing accuracy, they are still very imprecise and in the best-case scenarios they can predict - and even here not all models agree - climate change for large geographical areas, and thus will likely be unable to predict the increase in temperature and reduction in precipitation for any specific place on the planet with an acceptable degree of precision. Consequently, the programs for the genetic improvement of plants which aim to augment crop adaptation have a mobile objective, which changes with the improvement of prediction models and on the basis of different geographical areas. Consider, for example, the important role played by altitude, latitude, exposition (in the case of hill and mountain agriculture), and type of terrain.

Another aspect of the problem, which is obvious to everyone but seems to be neglected at a scientific level, are the variations not only in temperature and precipitation, but in the intensity and period of the year in which they occur; in other words, short and very short-term climactic variability, even from one year to the next.

The increased concentration of carbon dioxide (CO_2), another factor dependent on climate change, provokes the reduction, in Mediterranean grain harvests, of iron and zinc content, whose deficiency is already causing the loss of 63 million life-years annually. There are research programs whose purpose is to "biofortify" the most important crops from a

nutritional standpoint with micro-elements - those nutrients necessary in small quantities - and vitamins.

The term "biofortification" defines the process of genetic improvement that increases the concentration and bio-availability of micronutrients and vitamins in food crops. One of the best-known programs of this sort is HarvestPlus, a part of the research program of CGIAR – a global partnership for a safe food future – that looks at agriculture for nutrition and health. Between 2003 and 2016 HarvestPlus invested 300 million dollars to develop and spread iron, zinc and vitamin-A-rich crops for the benefit of roughly 20 million people in developing countries. The program's results were summarized and published in 2017.

One of HarvestPlus's most important goals is to develop and make more available crops that are rich in iron, given that it is one of the micronutrients in which foods are most often lacking: roughly one-third of the world's population is affected by anemia, and half of these cases are due to Iron deficiencies. Diets poor in or devoid of iron limit the development of the brain and learning capacity, and consequently the potential of individuals and society, generation after generation. This deficit thus has serious consequences, which include, in addition to delayed mental development, an increase in weakness, fatigue, and, when it leads to anemia, at-risk pregnancies. In low and middle-income countries, roughly one out of every four women of child-bearing age and two out of every five children are anemic due to iron deficiencies.

A recent overview of studies conducted on the effectiveness of bio-fortified rice, pearl millet and beans in the Philippines, India and Rwanda suggests that making available iron-rich foods significantly increases concentrations of iron in the body, and that the effects of bio-fortified crops are greater in people with iron deficiencies at the beginning of treatment.

A further complication of climate change is its influence not only on men and plants, but on the microscopic fungi that cause plant diseases, on insects - both harmful ones and those that are beneficial, such as pollinators - and on pest plants, which are living organisms in their own right. This further supports the idea that, for those working on genetic improvement, climate change represents not simply a mobile goal, but multiple goals that need to be achieved contemporaneously if we want the varieties cultivated in the future to adapt to all these changes.

Another question that mustn't be neglected is water use, because agriculture accounts for 70% of fresh water consumption, so crop varieties that are capable of producing just as well

with a more rational use of irrigation would leave more water available for human use. Here it is useful to remember that three of the crops that we will frequently discuss - grain, corn and rice - take up the lion's share, accounting for roughly 70% of that 70%, or more or less half of all fresh water use.

"Irrigated wheat?" some readers might be asking themselves. Well, yes: all Indian wheat, a large part of Middle Eastern and North African wheat, and that in Mexico and some parts of the United States is entirely irrigated – with up to seven watering cycles from planting to harvest – or receives abundant backup irrigation, without which it couldn't produce.

In many countries, but especially in Africa and Asia, women and children are forced to walk an average of 6 kilometers per day to find water due to a lack of adequate plumbing and water retrieval systems. And, as difficult as it is to believe, in sub-Saharan Africa, which includes the forty countries with roughly one billion inhabitants south of Mauritania, Algeria, Tunisia, Libya and Egypt, people with cellphones outnumber those with access to water.

Another interesting aspect of the relationship between seeds and water is the "water we eat," though this expression may sound strange. This refers to the water necessary to produce a certain amount of food or drink. The differences are striking, as shown in the following table.

Seeds are also related to malnutrition and poverty: childhood malnutrition, particularly in the first thousand days of life, can have a profoundly negative impact on growth and learning capacity, and thus on the possibilities of accessing decently-paying jobs and earning enough to make a living. Children in these conditions, once they become adults, will be unable to nourish their own children in a healthy manner, thus perpetuating the vicious cycle of malnutrition, mental handicap, and poverty. This process is also known as the "poverty trap."

We must also mention the connection between seeds and biodiversity, and particularly between seeds and agrobiodiversity, because in the case of biodiversity in general and agrobiodiversity in particular there is a great contradiction in the scientific world: while the scientific literature periodically underlines in its publications the importance of agrobiodiversity for food safety, the genetic improvement of the last sixty or seventy years, as we shall see later on, has pursued uniformity almost exclusively.

Otto Frankel was a renowned scientist who dedicated significant effort to the study of biodiversity. Born in Austria, he considered himself a geneticist, but also took an interest in genetic improvement and cytology, the science of cells and their components. He was a personal friend of Nikolai Vavilov, the famous Russian scientist known for his extraordinary

contribution to the study of the origin of cultivated plants. Along with Erna Bennett, an Irish research who worked for years at FAO, Frankel also coined terms such as "genetic resources" and "genetic erosion." The two scientists wrote a book about the importance of biodiversity in the plant world. Frankel's words in 1950 are pertinent here, particularly with respect to the abovementioned contradiction: "Ever since its beginnings, genetic improvement has pursued uniformity with great determination and there are many reasons for this: technical, commercial, historical, psychological, and aesthetic. The concept of purity [genetic or varietal] has been pushed to such a limit that it has become an enemy to the achievement of maximum production." It should be noted that, among the reasons Frankel ascribes to this drive toward uniformity, the terms "scientific" and "biological" are conspicuously absent.

The fact that today there is still so much talk about biodiversity, a term, furthermore, which began to be used after Frankel's death (he spoke of "genetic resources," and a resource it truly is), is itself an indication that little attention was paid to his arguments. What's more, this is clear for all to see, given that the agricultural landscape is dominated, in most of the industrial world and to some extent in developing countries, by vast cultivations of an ever-decreasing number of crops and varieties.

Concerns regarding the decline in biodiversity vary in nature. This reduction has increased crop vulnerability: genetic uniformity makes them incapable of responding to significant climate changes such as sudden variations in temperature and precipitation (which now occur regularly each year), in addition to the changes caused by diseases, insects and plant pests that climate change itself causes.

Before proceeding, it would behoove us to clarify that when we speak of biodiversity (and its reduction), and particularly of agrobiodiversity, we are referring to three distinct levels: diversity between species (for example, wheat, corn, rice, barley, etc.), between varieties within a species, and between plants within a variety. In traditional agriculture the three levels often coexist, because farmers grow different species contemporaneously, some in more than one variety, and which are quite often the result of a long tradition and not uniform from a genetic standpoint. The reduction of agrobiodiversity concerns all three of these levels.

Consider that we calculate a total of roughly 250,000-300,000 described plant species in the world, of which man in the course of his history has employed approximately 7,000 for various uses (food, medicine, fabrics, construction, manufacturing, etc.), while at present just 30 crops meet 95% of global food demand, 4 of which (wheat, rice, corn and potato) take up the lion's share. Moreover, the number of varieties of species that supplies us with most of our

calories is far lower than in the past. Finally, as far as the plants of modern varieties are concerned, they are all nearly identical genetically.

There are numerous examples in history of how all this augments crop vulnerability. One of the most recent regards wheat: the study in question shows that the production of wheat, of which uniform varieties are cultivated, oscillates between 31-51% in western Europe, 15-45% in Italy and Greece, and over 75% in southern Spain. This suggests that current genetic improvement programs and selection techniques do not produce varieties suitable to climactic variability and uncertainty.

Climate change and agrobiodiversity are thus intimately linked, inasmuch as diversity is the necessary condition for the adaptation of crops to climate change, and both are therefore associated with seeds.

Finally, seeds are linked to health: the crops that provide 60% of our calories - wheat, rice and corn - are less nourishing than others, such as barley, millet and sorghum, which also happen to require less water. Since becoming familiar with their characteristics, which we shall discuss in detail in the chapter dedicated to intelligent foods, we like to think of millet and sorghum as the "plants of the future."

If we broaden our perspective, it is not only plant biodiversity that has been drastically reduced: animal biodiversity is not faring much better, with chickens raised in battery farms representing 70% of all birds and intensively-raised cattle accounting for 60% of all mammals. And if things don't change, in 2050 the oceans will contain, by weight, more plastic than fish. There is also another form of biodiversity to which we must pay attention, this, too, connected to seeds and health. It is inside of us and, to be more precise, inside of our intestine.

2

Biodiversity and Health

Recently the scientific world, and medicine in particular, has associated the decline in biodiversity with the increase in inflammatory disorders, which represent a vast range of illnesses, from an irritable colon to ulcerative colitis, cardiovascular problems to various liver disturbances, and even many types of tumors. This increase seems to have been caused by the weakening of our immune system, itself probably dependent on reduced vegetal biodiversity.

Even more recently, the association between gut microbiota - the term for the collection of bacteria, viruses, fungi, yeasts and protozoans located in our intestine, and which is sometimes also referred to as the microbiome, despite the fact that this refers to the microbiota's genetic material - and our immune system, and thus the possibility of contracting inflammatory diseases, has been further confirmed.

The microbiota weigh an average of 2 kilograms - keep in mind that the human brain weighs up to a kilogram and a half - and contain billions of microorganisms that perform a whole series of important tasks, from the synthesis of vitamins and essential amino acids to completing the digestion of foods that have yet to be completely broken down. Some of the products of these activities represent an important source of energy for the cells of the intestinal wall, and contribute to intestinal immunity.

The microbiota are strongly influenced by diet, which can modify their composition in just twenty-four hours, while forty-eight hours are necessary, upon resuming one's previous diet, before they return to their initial conditions.

A study published in January 2018 demonstrated that the microbiota of patients who suffer from melanoma and are capable of responding to immunotherapy are different and more varied than those of patients who don't respond to the therapy. The research concludes that the composition and diversity of the microbiota are important in determining immunity levels to tumors. This result has since been corroborated by the reaction of laboratory mice to fecal transplants from patients who had responded to the therapy. The transplant consists in transferring the microbiota from a healthy patient to one affected by a disease, and is

becoming a common practice in the treatment of pathologies that don't respond to antibiotics, such as the colitis caused by *Clostridium difficile*, a very resistant bacterium.

The microbiota also seem to be involved in various neuro-psychiatric disturbances, such as depression, schizophrenia, autism and anxiety, as well as in the response to stress and in one's overall quality of life. This is partly due to the damage that inflammatory processes cause to myelin, the sheath that surrounds the neurons, altering the normal transmission of nervous impulses and, to some extent, the ability of the microbiota to produce or distinguish molecules that interfere with the nervous system.

It comes as no surprise, therefore, that, since the microbiota are so important to our physical and mental health on the one hand, and so heavily influenced by nutrition on the other, there are many studies that investigate the effects of various diets (Western, omnivore, Mediterranean, vegetarian, pescatarian, vegan, etc.) on the their composition and diversity.

Among the most-studied dietary components are proteins and fats. An excessively protein-rich diet seems to be associated with the illness known as "Irritable Bowel Syndrome." Many studies have focused particularly on the effect of animal proteins, compared to their vegetable counterparts, and it appears that a diet rich in animal proteins increases the frequency of cancer and diabetes, while a higher amount of vegetable proteins increases the number of beneficial bacteria, such as lactobacilli. In the case of fats, on the other hand, it is now clear that saturated fats - those found in animal-based foods such as beef, lamb and pork, cream, milk and butter - increase the risk of cardiovascular diseases caused by cholesterol, while the unsaturated fats found particularly in small fish and in plant-based foods such as dried fruit (pistachios, peanuts, walnuts and almonds), olives and olive oil are beneficial. The former, of course, abound in the so-called "Western Diet," which from a health standpoint is probably the worst.

Nevertheless, the conclusions of studies on the effects of the various diets do not always concur; but what nutritionists do seem to agree on is that dietary variety is crucial for healthy microbiota.

And this is where the problems begin. How can we have a diversified diet if, as mentioned above, 60% of our calories derive from only three plant species, wheat, rice and corn? And how can we vary our diet if almost all the food we eat is produced by varieties which, in order for the seed to be legally sold - and thus its products be legally sold in supermarkets - must be registered in a catalogue called a variety registry, in which the only varieties of plants accepted are distinct, uniform and stable?

As far as the European Union is concerned, the law clarifies that a variety is distinct if it is differentiated by one or more important characteristics from any other one known at the moment the application is presented. It is sufficiently uniform if the plants that compose it, rare aberrations aside, are genetically similar or identical with reference to a group of characteristics, such as, in the case of wheat, plant height, ear form and length, grain color, and many others. Finally, it is stable if it conforms to the definition of its essential characteristics at the end of subsequent reproductions and multiplications; if a variety is uniform, we take for granted that it is also stable. The law adds that a new variety must also have characteristics desirable for cultivation, but the requirements of uniformity and stability are those which raise the most concern as to their effects on health and their consequences on adaptation to climate change.

It's clear that there is a strong contradiction between the need for a diversified diet, mentioned above and advised by doctors, and the uniformity imposed on crops by law. Just as there is an obvious contradiction between uniformity and stability on the one hand and the need to adapt crops to climate change on the other.

Seed laws have only appeared recently. Until the 19th century, farmers conserved their seeds and exchanged them freely with their neighbors. During the first years of the 20th century, certification programs promising higher-quality, more uniform seeds began to spread in the United States. Then farmers began to buy their seeds from small family-run companies specialized in the multiplication of varieties that were of public domain, produced for the most part by genetic improvement programs conducted by universities and public research institutes. This tendency changed again with the introduction of corn hybrids around 1930, which led to a progressive concentration of the seed market.

As we shall see, however, regulations regarding seeds, at least in Europe, no longer seem as immutable as did only a few years ago. Nevertheless, a great amount of damage has already been done.