The pioneers of the green revolution as forerunners of today's ecological and biotechnological revolutions

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THE PIONEERS OF THE GREEN REVOLUTION AS FORERUNNERS OF TODAY'S ECOLOGICAL AND BIOTECHNOLOGICAL REVOLUTIONS

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Abstract: *This paper presents the milestones of the Green Revolution, outlining its role in the development of today's sustainable and biotechnological agriculture, as well as Romanian contribution. In order to do this we used the material found in papers and books on the research in agriculture from the 1940s to the late 1980s. Current sustainable agriculture and biotechnological advancement, incuding the creation of genetically modified organisms could never have been possible without the Green Revolution. Reducing the height of the stalk allowed the production of high-yielding cultivars that now are and will be used and modified with genetic engeneering methods in the context of a sustainable agriculture. We conclude the paper with proposing a model for the New "Really Green" Revolution.*

Key words : green revolution, ecology, biotechnology, plant breeding

INTRODUCTION

The Green Revolution refers to a series of research, development, and technology transfer initiatives, occurring between the 1940s and the late 1970s, that increased agriculture production around the world, beginning most markedly in the late 1960s. It forms a part of the 'neo-colonial' system of agriculture wherein agriculture was viewed as more of a commercial sector than a subsistence one [1].

The initiatives, led by the American agronomist **Norman Borlaug** (1914–2009) – *fig. 1*, the "Father of the Green Revolution" credited with saving over a billion people from starvation, involved the development of high-yielding varieties of cereal grains, expansion of irrigation infrastructure, modernization of management techniques, distribution of hybridized seeds, synthetic fertilizers, and pesticides to farmers.

Apparently, there is a contradiction between an intensive agriculture intendwed to feed millions of people, like the one proposed by the Green Revolution, and an extensive agriculture imposed by the principle of sustainable development. But there is not.

Paradoxically, genetic engineering provides the means to increase production without spoiling soil or polluting it with chemicals.

That is why we think that now is the time for a Second Green revolution, a "Really Green" Revolution, which needs to be both quantitative and qualitative, providing plenty of healthy food for the world's increasing population, while preserving their environment. As Borlaug put it, you can't build a peaceful world on empty stomachs.

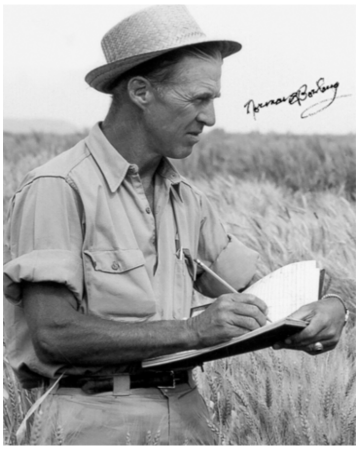

Fig. 1. **Norman Borlaug** (picture in the public domain)

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MATERIALS AND METHODS

This paper present the milestones of the Green Revolution, outlining its role in the development of today's sustainable and biotechnological agriculture. In order to do this we used the material found in papers and books on the research in agriculture from the 1940s to the late 1980s.

RESULTS AND DISCUSSIONS

The Green Revolution in common wheat

Cecil Salmon (1885–1975), an American biologist working in post-World War II Japan, collected 16 varieties of wheat, including one called “Norin 10”, which was very short, thus less likely to suffer wind damage. Salmon sent it to the American agronomist **Orville Vogel** (1907–1991) – *fig. 2* in Washington in 1949. Vogel began crossing Norin 10 with other wheats to make new short-strawed varieties. Vogel led the team that developed Gaines, the first of several new varieties that produced 25 percent higher yields than the varieties they replaced. Vogel shared his germplasm with Norman Borlaug, who later received the 1970 Nobel Peace Prize for his role in the “green revolution.” Borlaug publicly acknowledged Vogel’s contributions to his research [2].

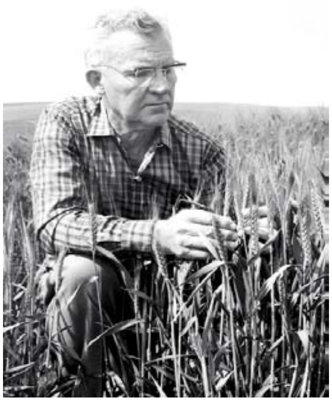

Fig. 2. **Orville Vogel** (picture in the public domain)

Dwarfing is an important agronomic quality for wheat; dwarf plants produce thick stems. The cultivars Borlaug worked with had tall, thin stalks. Taller wheat grasses better compete for sunlight, but tend to collapse under the weight of the extra grain—a trait called lodging— from the rapid growth spurts induced by nitrogen fertilizer Borlaug used in the poor soil. To prevent this, he bred wheat to favor shorter, stronger stalks that could better support larger seed heads. In 1953, he acquired a Japanese dwarf variety of wheat called Norin 10 developed by Orville Vogel, that had been crossed with a high-yielding American cultivar called Brevor 14 [20]. Norin 10/Brevor is semi-dwarf (one-half to two-thirds the height of standard varieties) and produces more stalks and thus more heads of grain per plant. Also, larger amounts of assimilate were partitioned into the actual grains, further increasing the yield. Borlaug crossbred the semi-dwarf Norin 10/Brevor cultivar with his disease-resistant cultivars to produce wheat varieties that were adapted to tropical and sub-tropical climates [2].

Borlaug's new semi-dwarf, disease-resistant varieties, called Pitic 62 and Penjamo 62, changed the potential yield of spring wheat dramatically. By 1963, 95% of Mexico's wheat crops used the semi-dwarf varieties developed by Borlaug. That year, the harvest was six times larger than in 1944, the year Borlaug arrived in Mexico. Mexico had become fully self-sufficient in wheat production, and a net exporter of wheat [2]. Four other high yield varieties were also released, in 1964: Lerma Rojo 64, Siete Cerros, Sonora 64, and Super X.

The Green Revolution in durum wheat

Proving the possibility of obtaining high yield cultivars from parents with low productivity (through heterosis), [3] between 1967 and 1989, the Romanian agronomist **Zoe Țapu** (1934–2013) – *fig. 3*, working at the National Agricultural Research and Development Institute in Fundulea, developed a research program for improving winter durum wheat, in order to obtain cultivars with fall resistance and high yield, using height-reduction genes from summer durum developed at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico [4][5][6].

Fig. 3. **Zoe Tapu** (picture in the public domain)

In order to achieve that, she used dwarf plants from CIMMYT, which survived to a mild winter, back-crossing them with Romanian durum wheat varieties. Repeated selection for cold resistance of semi-dwarf variants led to the creation of the first semi-dwarf winter durum wheat varieties, Topaz (1977) and Rodur (1984) [7]. This original type of wheat set the ground for further progress in durum wheat breeding in many countries.

Directions of the New Green Revolution

Based on the experience of the past reen Revolution, and taking into account the advances in Biotechnology and ecology, we think that the New Green Revolution should include the following areas:

* **Transgenic crops** is an emerging topic that has escaped science to be now a major social, economical and political issue. As a consequence, transgenic crops is a well-suited research topic for agronomists that use sociology and economics. like all major scientific breaktroughs, there are many arguments in favor of genetically modified organisms and many arguments against their use.

*__Adapting crops to climate change__. Developing later-maturing cultivars could greatly increase yelds of maize and sorghum, because of the major effects of climate change on agriculture, that have lead to shortening of the growing season in the south with higher risk of frost damage, a higher yeld variability due to extreme climate events, and an increase of 50-70% of water demand in Mediteraneean areas.

Polyculture, though it often requires more labor, has several advantages over monoculture:

- The diversity of crops avoids the susceptibility of monocultures to disease. For example, a study in China reported in Nature showed that planting several varieties of rice in the same field increased yields by 89%, largely because of a dramatic (94%) decrease in the incidence of disease, which made pesticides redundant.
- The greater variety of crops provides habitat for more species, increasing local biodiversity. This is one example of reconciliation ecology, or accommodating biodiversity within human

landscapes. It is also a function of a biological pest control program.

*Water management

* Internal renewable water resources. This is the average annual flow of rivers and groundwater generated from endogenous precipitation, after ensuring that there is no double counting. It represents the maximum amount of water resource produced within the boundaries of a country. This value, which is expressed as an average on a yearly basis, is invariant in time (except in the case of proved climate change). The indicator can be expressed in three different units: in absolute terms (km3/yr), in mm/yr (it is a measure of the humidity of the country), and as a function of population (m3/person per yr).

* Global renewable water resources. This is the sum of internal renewable water resources and incoming flow originating outside the country. Unlike internal resources, this value can vary with time if upstream development reduces water availability at the border. Treaties ensuring a specific flow to be reserved from upstream to downstream countries may be taken into account in the computation of global water resources in both countries.

* Dependency ratio. This is the proportion of the global renewable water resources originating outside the country, expressed in percentage. It is an expression of the level to which the water resources of a country depend on neighbouring countries.

* Water withdrawal. In view of the limitations described above, only gross water withdrawal can be computed systematically on a country basis as a measure of water use. Absolute or per-person value of yearly water withdrawal gives a measure of the importance of water in the country's economy. When expressed in percentage of water resources, it shows the degree of pressure on water resources. A rough estimate shows that if water withdrawal exceeds a quarter of global renewable water resources of a country, water can be considered a limiting factor to development and, reciprocally, the pressure on water resources can have a direct impact on all sectors, from agriculture to environment and fisheries.

*The new soil management

Some Soil Management techniques

1.No-till farming: a way of growing crops from year to year without disturbing the soil through tillage.

2.Keyline design: a system of amplified contour ripping to control rainfall run off and enable fast flood irrigation of undulating land without the need for terracing

3.Growing wind breaks to hold the soil

4.Incorporating organic matter back into fields

5.Stop using chemical fertilizers (which contain salt)

6.Protecting soil from water runoff

Possible alternative sources of nitrogen that would, in principle, be available indefinitely, include:

1.recycling crop waste and livestock or treated human manure

2.growing legume crops and forages such as peanuts or alfalfa that form symbioses with nitrogen-fixing bacteria called rhizobia

3.industrial production of nitrogen by the Haber Process uses hydrogen, which is currently derived from natural gas, (but this hydrogen could instead be made by electrolysis of water using electricity (perhaps from solar cells or windmills)) or

4.genetically engineering (non-legume) crops to form nitrogen-fixing symbioses or fix nitrogen without microbial symbionts.

***Protecting** biodiversity.** Biodiversity loss due to industrial agriculture is a major threat to sustainable agriculture. For example, the number of bees has decreased, as they are essential to the reproduction of some crops such as blueberries. Higher biodiversity also means to control crop disease because pathogens and natural antagonists are better balanced.

*__Alternative farming systems__ involve mixing plants, as in intercropping and agroforestry. The benefits ar higher overall productivity, better pest control and better ecological services. To reduce the weed seed bank rotations that include crops with different life cycles such as wheat-maize and winter wheat-sugar beet are necessary. To design and evaluate innovative cropping systems on a medium and long term basis, new methods are requiredcombining simulation and field experimentation.

Urban farming is the process of growing and distributing food, as well as raising animals, in and around a city or in urban area. According to the RUAF Foundation, urban farming is different from rural agriculture because "it is integrated into the urban economic and ecological system: urban agriculture is embedded in -and interacting with- the urban ecosystem. Such linkages include the use of urban residents as labourers, use of typical urban resources (like organic waste as compost and urban wastewater for irrigation), direct links with urban consumers, direct impacts on urban ecology (positive and negative), being part of the urban food system, competing for land with other urban functions, being influenced by urban policies and plans, etc". There are many motivations behind urban agriculture, but in the context of creating a sustainable city, this method of food cultivation saves energy in food transportation and saves costs. In order for urban farming to be a successful method of sustainable food growth, cities must allot a common area for community gardens or farms, as well as a common area for a farmers market in which the foodstuffs grown within the city can be sold to the residents of the urban system

Vertical farming is cultivating plant or animal life within a skyscraper greenhouse or on vertically inclined surfaces. The idea of a vertical farm has existed at least since the hanging Gardens of Babylon. The modern idea of vertical farming uses techniques similar to glass houses, where natural sunlight can be augmented with artificial lighting.

Ecovillages are communities whose goal is to become more socially, economically and ecologically sustainable. Ecovillagers are united by shared ecological, social-economical and cultural-spiritual values. They seek alternatives to ecologically destructive electrical, water, transportation, and waste-treatment systems, as well as the larger social systems that mirror and support them

1. They are not government-sponsored projects, but grassroots initiatives.
2. Their residents value and practice community living.
3. Their residents are not overly dependent on government, corporate or other centralized sources for water, food, shelter, power and other basic necessities. Rather, they attempt to provide these resources themselves.
4. Their residents have a strong sense of shared values, often characterized in spiritual terms.
5. They often serve as research and demonstration sites, offering educational experiences for others.

Eco-cities are cities designed with consideration of environmental inhabited by people dedicated to minimization of required inputs of energy, water and food, and waste output of heat, air pollution – CO2, methane, and water pollution. They are cities with no cars, with many parks, and large pedestrian areas.

CONCLUSIONS

Current sustainable agriculture and biotechnological advancements, incuding the creation of genetically modified organisms could never have been possible without the Green Revolution. Reducing the height of the stalk and increasing pest resistance allowed the production of high-yielding cultivars that now are used and modified with genetic engineering methods in the context of a sustainable agriculture.

Along with United States agricultural scientists as Borlaug, Vogel, and Salmon, Romania had an important contribution to the Green Revolution through Zoe Tapu, who extended it to durum wheat, with its high nutritive value in the form of pasta and good quality bread.

High-yielding varieties of durum wheat developed also using genetic modification technologies can thus be a solution of feeding millions, in the context of a sustainable agriculture.

We think that now is the time for a Second Green revolution, a “Really Green” Revolution, which needs to be both quantitative and qualitative, providing plenty of healty food for the world's increasing population, while preserving their environment, and, in this paper, we proposed a model to this effect.

Studying the methods and work of the personalities of the past can only be to the benefit of a new agriculture designed for future generations.

BIBLIOGRAPHY

[1] ****"In Memoriam"*. Ferma 3, 2013, (118): 78. March 2013.

[2] INCDA Fundulea - *Câteva din rezultate: ameliorare și genetică* Retrieved 12-11-2013 from http://www.incda-fundulea.ro/50ani/rezgen.html

Ceapoiu, N. (red.) (1984) *Grâul*, Ed. Academiei, p. 241

[3] Săulescu N.N. (2003). *The Romanian durum breeding program*. In Conxita Royo and Natale Di Fonzo (Eds.) *Durum Wheat Breeding: Current Approaches and Future Strategies* , The Haworth Press, Inc., New York: 907-920.

[4] Săulescu N. N., Ittu G., Ittu Mariana, Mustăţea P. (2007) *Cinci decenii de ameliorare a grâului la Fundulea,* Romanian Agricultural Research 24:22

[5] Voolston J. E. *Wheat, barley, and triticale cultivars: A list of publications in which national scientists have noted the cooperation or germplasm they received from CIMMYT*, CIMMYT, 1997, p. 78

[6] V. IONESCU-SISEȘTI. "*Performance of some new winter wheat lines in comparative irrigated and non-irrigated trials*." Lucrări științifice: Agronomie 17 (1977): 14.

[7] Verzea M. (2007) *Fifty years of breeding in field crops at NARDI Fundulea, Romania*, Romanian Agricultural Research 24 :22