

ASPECTS OF THE FUTURE OF AGROTECHNOLOGIES

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ABSTRACT

The following are important factors in the future development of agrotechnologies - the development of the world population, advancements with regard to education, progress in food production systems in various regions of the world together with the critical situation of malnutrition in different countries worldwide.

It is necessary to improve the production and productivity of crops. Pre-harvest and post-harvest losses are still too high, and the use of agricultural inputs, such as fertilizers, irrigation and energy, have to be reduced as much as possible. The development and implementation of agrotechnologies has to be undertaken - especially the use of genetically modified crops – in order to feed the world in future in a more sustainable way.

Furthermore, we must substitute fossil energy in the long term. Some arable land will no doubt still be used for crops which play an important role in the bioconversion of renewable raw materials and also for new products for the market place. However, there will still be some fertile arable land suitable for food production which will be used for the production of agrofuels.

Additionally, in many countries arable land is also used for the production of pet food – something really questionable if on the other side of the world there are people starving and dying from hunger.

Finally, the developed countries have to open their markets for agricultural products from developing countries and to reduce protectionism.

The Charter for Food Security from Maxwell should be a basis for a future balanced relationship between the developed and developing countries so that hunger, migration, dictatorships, terrorism, and wars are avoided.

Keywords: world population, education, food production, malnutrition, gmo, food security charter

1. INTRODUCTION

In the past we have always been confronted with the problem of starving people as well as people dying from undernutrition, giving the impression that the food supply is insufficient and

that this problem will become worse with an increasingly faster growing world population. The fact is that the world food supply has principally been sufficient with regard to the total demand, but there has been some imbalance in food distribution and consumption [26]. But how will the food supply work in the future? By the year 2050 world food requirements will have more than doubled as a result of population growth and changes in consumption habits. We will have to produce more food during that period than mankind has produced in total since the beginning time [27, 34]. Aside of increasing population figures we will have to consider that a percentage of plants produced for the bioconversion into products, which are currently being produced from petroleum, will be needed.

2. DEVELOPMENT OF WORLD POPULATION AND POVERTY

The relative growth rate of the world population has started to decline more than 40 years ago [1]. According to the 2002 UN World Population Prospect, there has been a linear yearly growth of about 80 million people during the past 25 years. This corresponds to an annual decline from about 2 % in 1975 to 1.4 % in 1995 and 1.2 % in 2005. The maximum growth rate was reached in the 1960s with 2.1 % p. a. [15]. The prediction for 2050 varies between world populations of 10.63 billion people (high rate) and 7.41 billion people (low rate). The UN expects approximately 9.3 billion people living on our planet, about 0.3 billion more than expected a decade before [1, 27, 34]. The high and low numbers are less probable; in the case of the high number, a linear growth of 91.5 million people p.a. is predicted, which is not very realistic, as the population has grown less during the past 25 years (as mentioned above). The lower number takes a real population decrease from 2040 into account, which - at least at the moment – seems improbable. One could say that progress has been made if there were to be a growth rate reduction from 1.2 % p.a. now to less than 0.4 % p.a. in 2050 (figure 1).

DEVELOPMENT OF THE WORLD POPULATION

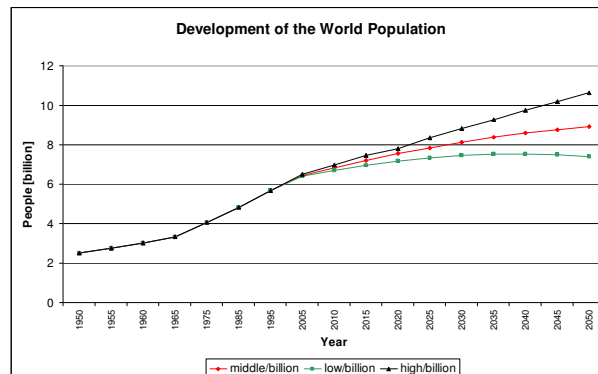


Figure 1. Development of the world population from 1950 to 2050 [1, 15, 47]

Though the situation of malnutrition in many developing countries has started to improve during the past few decades, many people worldwide lack adequate nutrition. It is calculated that at least 2700kcal/day are required as the lower limit for calorie requirements otherwise one is still talking about undernourishment. Currently nearly one billion people suffer from malnutrition, and it is difficult to foresee when the FAO goal to reduce the number of people

suffering from malnutrition (below 400 million) will be achieved (Figure 2). This will not be achieved by 2015, and even its achievement by 2050 will prove to be a difficult task [1, 14, 31, 32]. In absolute numbers of people suffering from malnutrition, there has been an increase in the Asian-Pacific as well as in the Sub-Saharan region for the last 15 years [14]. In relative numbers this oscillated between 15 and 20 % for the Asian-Pacific region (Table 1) as well as for all developing countries (Figure 3), whereas in the Sub-Saharan region it dropped from nearly 35 % at the beginning of the nineties to 27 % three years ago. Since then there has been an increase to more than 30 % again [14]. Especially those countries with protracted crises from dictatorship, terrorism, civil wars and naturally those with ecological disasters suffered more than others [14].

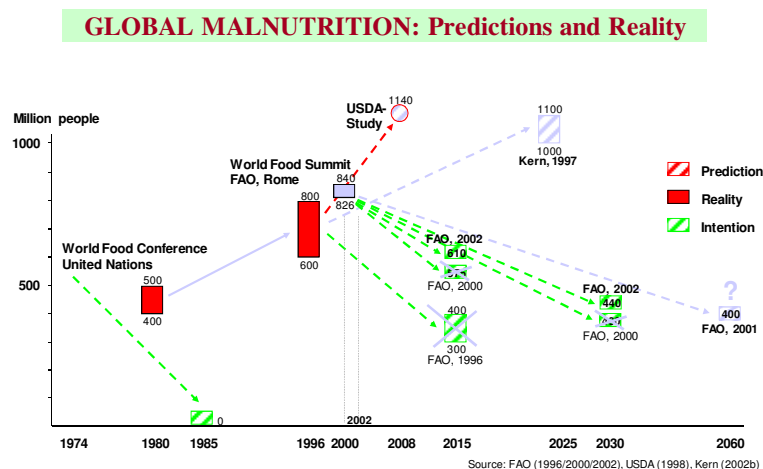


Figure 2. Global malnutrition: Predictions and reality, 1974 to 2060 [11 - 14, 32, 48].

Table 1. Number of undernourished people in Asia [14]

NUMBER OF UNDERNOURISHED PEOPLE IN ASIA										
PREVALENCE OF UNDERNOURISHMENT in developing countries and countries in transition										
WORLD: Region / subregion / country	Total population 2005-07 (millions)	Number of people undernourished (millions)				Proportion of undernourished in total population (%)				MDG* trend 1990-92 to 2005-07
		1979-81	1990-92	2000-02	2005-07	1979-81	1990-92	2000-02	2005-07	
WORLD	6 559.3	920.0	843.4	833.0	847.5	28	16	14	13	↓
Developing countries	5 283.7	na	826.6	816	835.2	na	20	17	16	↓
ASIA AND THE PACIFIC	3 558.7	727.3	587.9	531.8	554.5	32	20	16	16	↓
East Asia	1 402.1	307.7	210.1	133.1	130.4	29	18	10	10	↓
China	1 328.1	303.8	210.1	133.1	130.4	30	18	10	10	↓
DPR Korea	23.6	na	4.2	7.8	7.8	na	21	34	33	↑
Southeast Asia	555.5	na	105.4	88.9	76.1	na	24	17	14	↓
Cambodia	14.1	4.0	3.8	3.7	3.0	60	38	29	22	↓
Indonesia	221.9	36.6	28.9	30.4	29.9	24	16	15	13	↓
Philippines	87.1	12.8	15.2	14.5	13.2	27	24	18	15	↓
Thailand	66.5	10.4	15.0	11.5	10.8	23	26	18	16	↓
Viet Nam	85.1	16.8	21.0	13.3	9.6	32	31	17	11	↓
South Asia	1 520.1	255.4	287.5	331.1		22	21	21	22	↔
Bangladesh	155.4	33.8	44.4	42.3	41.7	40	38	29	27	↓
India	1 147.7	261.5	172.4	200.6	237.7	38	20	19	21	↑
Central Asia	58.7	na	4.2	10.1	6.0	na	8	18	10	↑
Tajikistan	6.6	na	1.8	2.9	2.0	na	34	46	30	↓
Uzbekistan	26.6	na	1.1	4.7	3.0	na	5	19	11	↑

* Millennium Developmental Goals

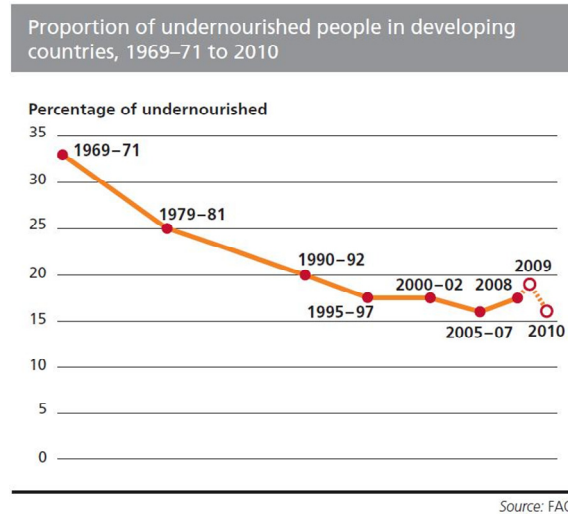


Figure 3. Proportion of undernourished people in developing countries [14]

3. EDUCATION, FOOD, AGRICULTURE AND TECHNOLOGY

Demographic and economic prospects have to be taken into account when considering the future development of progress in food production, agriculture and technology. The current situation in food supply, especially in developing countries, will only make small gains if the situation continues as it is, although mankind has been able to improve agriculture and technology to currently feed 6 billion people. Therefore, further technological development can change the situation positively, if some conditions change (Figure 4).

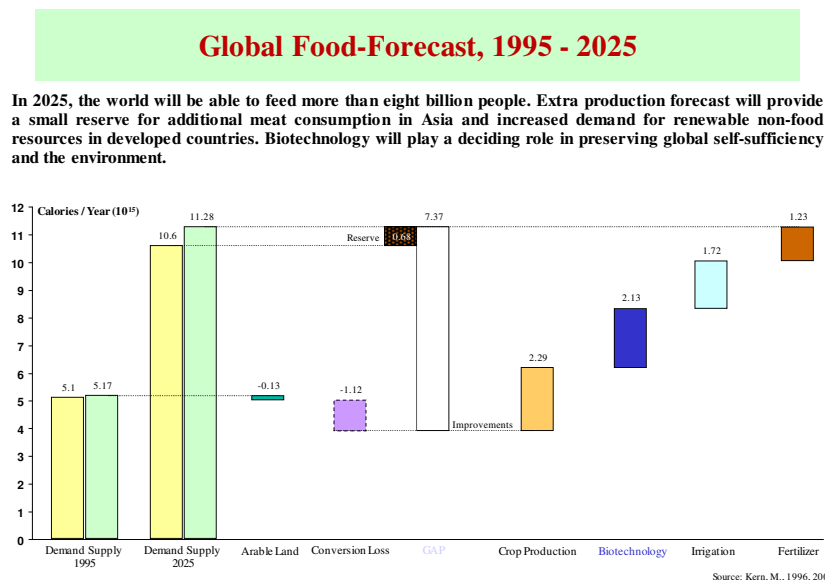


Figure 4. Innovations in agro-technologies are key-factors to satisfy future food demand

A critical point with regard to progresses in agrotechnologies is the situation of education, especially in emerging and developing countries [4]. In many of these countries, there are children who do not receive any basic education, and, additionally, qualified teachers are lacking. The total number of such children is estimated to be at least 75 million (Table 2). It is quite clear that only a good basic education system with further possibilities for higher education will permit escape from poverty and intolerable human suffering. For this purpose the World Bank, together with the UN/UNESCO, established the system “Education for all – a fast track initiative” (EFA-FTI) at the beginning of this century. However, the monitoring of the education situation in many countries shows that improvement is slower than expected and hoped [45,46]. It is important to see that in the case of undernourished women malnutrition for their kids will start in the womb. The consequence is that those children will not have a good cognitive development, because hunger impairs an adequate cognitive development.

Table 2. Out-of-School children in the world [45, 46]

Out-of-School-children in the World

Table 1.4: Key indicators for goal 3

	Out of school adolescents of lower secondary school age (000)		Total secondary enrolment (000)		Total secondary gross enrolment ratio (%)		Technical and vocational education as a share of secondary enrolment (%)	
	2008	Change since 1999 (%)	2008	Change since 1999 (%)	2008	Change since 1999 (%)	2008	Change since 1999 (%)
World	73 604	-19	525 146	21	67	14	11	-2
Low income countries	24 466	-1	59 771	51	43	29	6	47
Lower middle income countries	45 741	-74	288 564	31	63	22	10	7
Upper middle income countries	3 002	-50	92 856	0.2	90	7	13	-2
High income countries	922	-20	84 463	1	100	1	14	-11
Sub-Saharan Africa	19 875	1	36 349	75	34	40	7	-6
Arab States	4 571	-16	29 050	35	68	20	13	-7
Central Asia	325	-50	10 913	16	97	13	15	123
East Asia and the Pacific	13 277	-41	164 021	25	77	22	18	9
South and West Asia	31 486	-12	130 312	33	54	21	1	-5
Latin America and the Caribbean	2 100	-45	59 101	13	89	11	11	3
North America and Western Europe	471	-74	62 333	3	100	0.3	13	-10
Central and Eastern Europe	1 699	-46	32 258	-21	88	1	19	5

Sources: Annex, Statistical Tables 4 and 7 (print), 8 (website); UIS database.

Fertilizer use will play an important role in the future as could be observed by the development of fertilizer applications during the past 40 years (Figure 5). On the other hand it has been observed in Germany that phosphate fertilizers contain metals like uranium, cadmium and others which are often companions in phosphate mining. The content varies and it should be observed whether those uranium containing fertilizers will accumulate this substance in plants or animals being fed by such plants or if there exist some risk of getting contaminations into the water systems [2, 20].

A further important point that influences food production is soil degradation. There are four items that have especially to be taken into account: Sloping land, desertification, salinization and nutrient mining. About 45 % of the world's agricultural lands have slopes of more than 8 %, and out of this 9 % has slopes of more than 30 %. Therefore, due to water erosion in wet areas where slopes exceed 10 – 30 % and any conversion measures are lacking, crops yields may fell by 8 – 21 % within the next 25 years. Desertification in arid and semi-arid regions seems to come and go with natural climate changes and, probably, is not a spreading irreversible process. On the other hand, the destruction of large forest areas in the tropics can cause irreversible growth

of deserted areas. Salinization occurs in irrigated areas, usually when inadequate drainage causes salts to concentrate in the upper soil layers. This may cause yield decreases up to 25 % for many crops. It is estimated that about 3 % of the world's agricultural land is affected. Nutrient mining results in the insufficient use of fertilizers to replace nitrogen, phosphorus and potassium (NPK), which has been lost with crop harvest and through leaching. Studies in Latinamerica found nutrient depletion in nearly all areas and for many crops. The NPK losses amounted to 54 kg/ha/year during 1993-95. On the other hand you have to be aware of heavy metal contamination by phosphate fertilizers (see above).

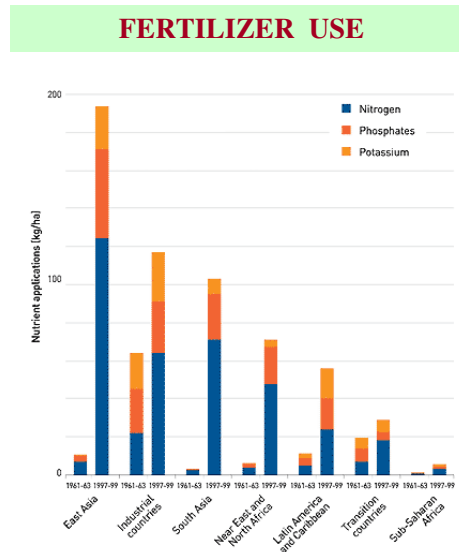


Figure 5. Changes in fertilizer use [13]

The production of cereals is a key component in the worldwide food supply, as stated by Deng Xiaoping: “There is no stability without agriculture, and there is chaos without cereals.”

With regard to this point we have to observe some important facts. The world market prices for food generally dropped from 1960 to 2000, but started to oscillate during the past 2 decades (Figure 6). On the other hand, the demand for cereals has grown (Figure 7).

In the past average cereal production per capita has generally risen until the mid-1980s up to 371 kg and then to fall off to around 350 kg in the mid-1990s and to about 320kg in 2012. [10]. The worldwide relative slower growth of cereal production per capita can mostly be attributed to agricultural policies in Europe and North America. Nevertheless, there are actually stocks of grains, though those of wheat and coarse grains (maize, barley, sorghum, millet, oats, rye and others) have become smaller during the past years, whereas that of rice has grown [14].

In 2001 during the opening of the International Food Policy Research Institute held an International Conference about *Sustainable Food Security for All by 2020* in Bonn the German Minister for Economic Cooperation and Development, Ms. Heidemarie Wieczorek-Zeul, stressed:

At the 1996 World Food Summit, the international community set itself the target of halving the number of undernourished people by no later than 2015. To meet that goal, all players need

to shoulder their share of the responsibility: The industrialized nations need to reduce their agricultural protectionism and open their market. The EU has taken steps toward allowing the least-developed countries tariff-free access to EU markets.... the initiative needs to be expanded. After all, the developing countries lose out on income of around \$40 million each year because of the protectionism of the rich countries. The governments of the developing countries, in turn, need to launch the required agrarian and land reforms and invest in rural institutions and in education and health. The donor community needs to support them in that effort.... The United Nations recent Human Development Report accords a positive role to biotechnology and genetic engineering in solving the problem of hunger.... Genetic engineering cannot completely eradicate hunger in developing countries, but the technology does offer opportunities that we should use together with the developing countries... If crises result in hunger and a decline in agricultural production, the reverse is also true: hunger and unsatisfied basic needs are often at the root of conflicts. Once politically dominant groups take possession of land and food supplies and bar minorities access to these resources, violence becomes virtually inevitable. ... We need to break the vicious cycle of hunger and war and focus on prevention. This is where the government of the developing countries have a special duty to act...[49].

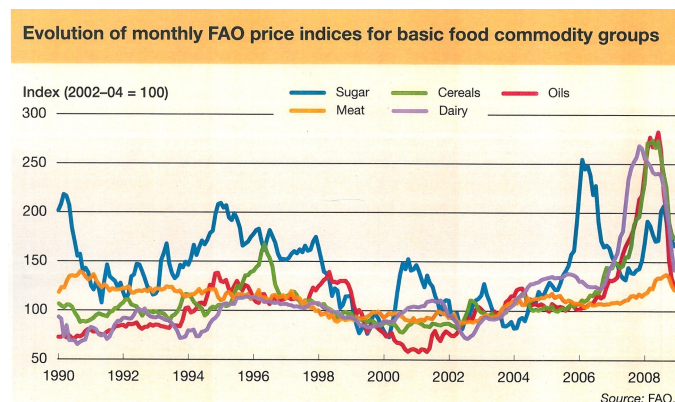


Figure 6. Evolution of FAO prices indices for basic foods [14]

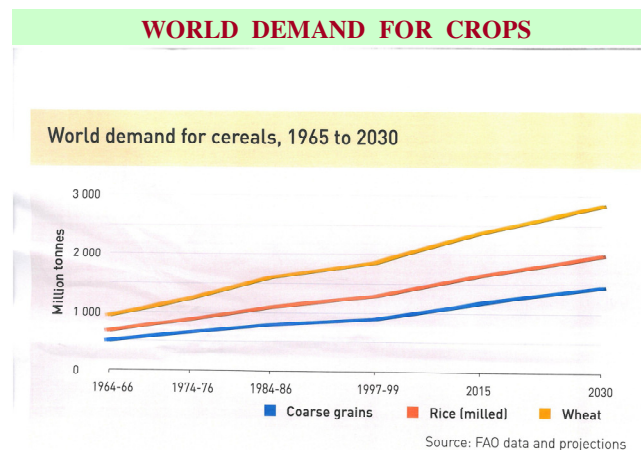


Figure 7. World demand for crops [13]

Therefore, besides democratic structures and sufficient sustainable agriculture both regional and global, the above mentioned problems must be overcome. Unfortunately, during the past decade not many things happened to overcome the problems, especially due to terrorism and regional wars, and in 2002 and 2008 due to economic crises caused to a great extent by uncontrolled actions of many banks looking only for big gains on short terms. Such things cause *e.g.* migration, *i.e.* rural exodus or fugitives and refugees as a consequence of increasing poverty and/or war. Migration is caused by among other things inadequate agriculture, undernourishment, health problems and bad education. Additionally, religious, political and military factors are also contributory influences. On the other hand, migration into the cities does not actually reflect better living conditions for the population involved – in fact, it seems to provide less favourable conditions. As cities explode they become ungovernable and the slums become those parts of such mega-cities in developing countries [33], where drinkable water and simple toilets are seldom available. However, mega-cities as a consequence of migration influence the eating habits of the inhabitants, as traditional food is no longer required as it was previously. The “new” food is more expensive since it is not available to the same extent and in the same quantities as traditional food; it is not produced in sufficient quantities in the country and, therefore, has to be imported.

These modified and continuously changing circumstances imply alterations for the food production in developing as well as in developed countries. In order to achieve higher production rates of the necessary food, it is important that several technologies are used: these are newly developed chemical as well as biological fertilizers, biotechnology and genetic engineering, better irrigation technologies, and a well reflected reuse of traditional methods where this will be possible. A good example is the Milpa traditional agricultural production of maize together with other plants (normally beans and pumpkins) in Mexico [18], but also in other countries as Germany, France, Ghana, Senegal, traditional agricultural production systems has shown good results, competitive with biotech agriculture [18]. New types of crops, which can be used for safer crop production, have already been developed by several industries. Adequate use should be implemented in collaborative projects between developed and developing countries to ensure higher crop production.

Let us have a look at some things that will be of importance for actual and future production systems.

Pet Food

Food production involves not only food production for humans but also for pets, especially cats and dogs. Euromonitor Petfood Industry, London, calculates that there are currently about 500 million household pets (cats and dogs), at the beginning of the 3rd Millennium. This means that in Germany with nearly 7 million cats and more than 5 million dogs about 8 – 9 % of arable land is used for pet food production [32]. This is not only true for industrialised countries, but also a trend for emerging countries such as Brazil, China, Thailand and South Africa among others.

Harvest Losses

For eight important crops the estimated harvest losses as results of pests come close to 50 % (Figure 8).

Arable Land

In many countries the arable land will be reduced drastically during the next decades, which needs special technological inputs to obtain even better quantitative results to feed the world population.

4. FOSSIL ENERGIES, TECHNOLOGICAL INNOVATIONS IN AGROTECHNOLOGIES

One of the most important energy sources, oil (and gas), will become scarce within the next 50-80 years. The actual demand for oil is increasing, especially when one considers countries as China and India. New reserves are not being discovered which would match the demand for them worldwide (Figure 9) and this means that the price for oil (and gas) will increase. This means the oil prices will not drop anymore below 50 US\$/barrel, it more likely to establish above 100US\$/barrel [5]. Therefore, new energy sources, as well as new products, which will be produced from renewable raw materials to substitute products coming from oil, will become important and this will directly influence the agro-technological development [17].

It is important to know what effects biotechnology and genetic engineering have for crop production systems. We know that there are currently around 75,000 edible plant species, of which only about 7,000 are used for nutritional purposes. Only a few dozens of these play a significant role in food

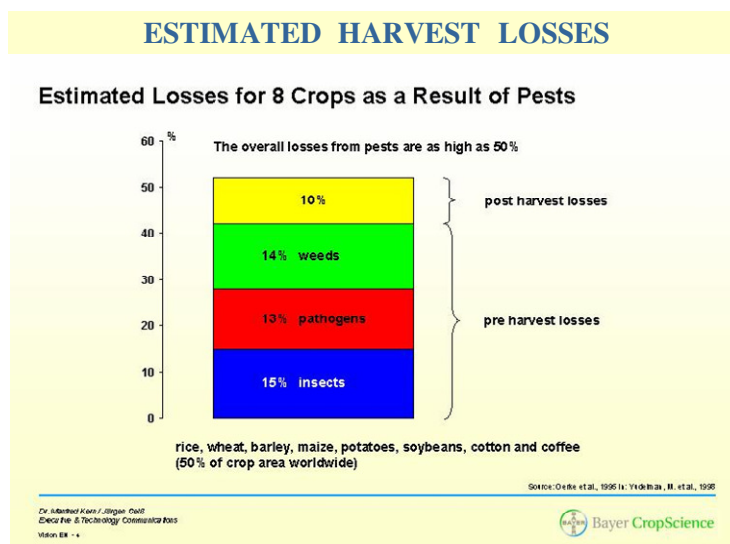


Figure 8. Estimated losses for eight important crops as a result of pests [24]

OIL: Reserves-to-Production-Ratio

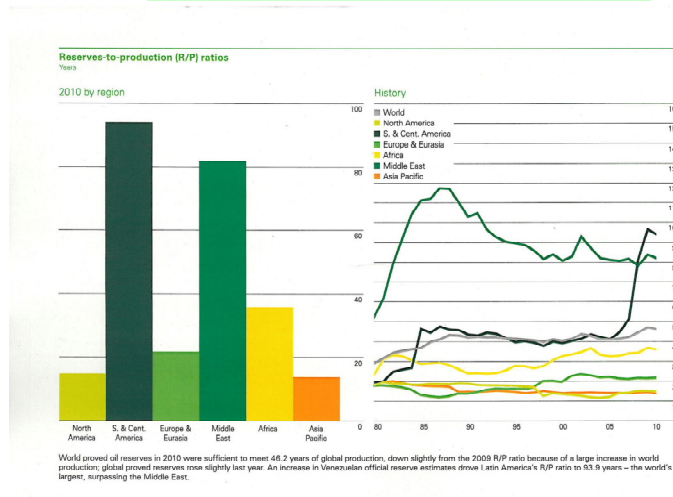


Figure 9. Future of oil: reserves-to-production-ratio [5]

production (Figure 10). If rice is taken as an example, there are about 30,000 edible varieties, of which 50 are currently being used (Figure 11).

Technological innovations in agrotechnologies will be key factors to satisfy future food demand [13, 24, 31, 32]: these include improvements in crop production, the application of biotechnology, the use of irrigation systems and fertilizers. Modern plant breeding is also a necessity, including genetic engineering, in order to achieve essential productivity gains. The following is also important for the

EATABLE PLANTS

Eatable Plants

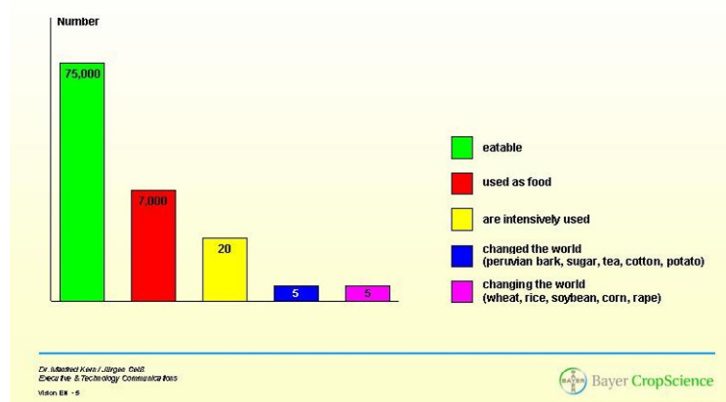


Figure 10. Eatable plants and those of economic importance [24]

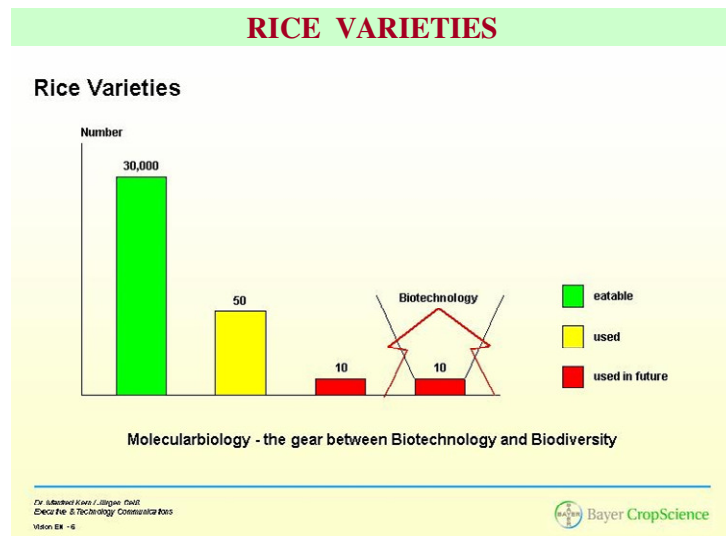


Figure 11. Rice varieties and their use in agriculture [24]

development of sustainable progress in food production in order to feed the world's population: resistance to diseases and pests; improved tolerance of crops with regard to abiotic stresses such as salinity and acid soils, ozone, drought, frost, and high variations in temperature; higher nutritional value of various foods; improved durability of foods during storage and transport. Nevertheless, modern genetic modification in plants (Figure 12) needs to be submitted to a realistic kind of biosafety assessment [8, 9]. Nevertheless, many factors will still continue to take their toll and contribute to losses in the yields of harvest such as various contaminations found in soils, solar radiation, extreme weather conditions and natural catastrophes. There are some interesting examples of genetically modified crops:

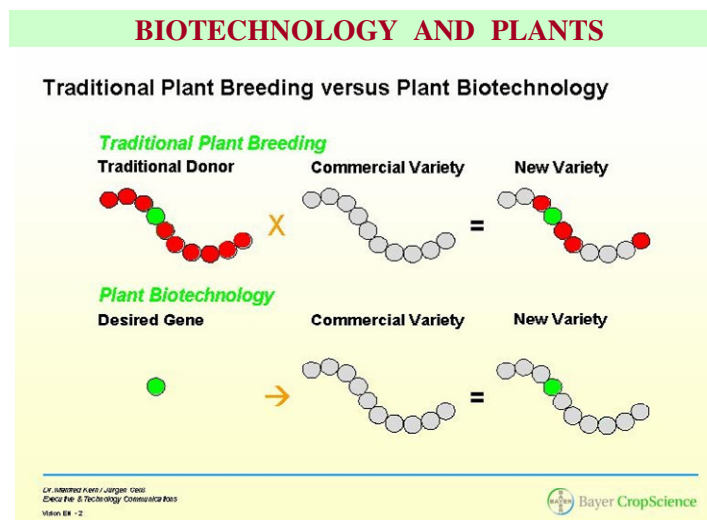


Figure 12. Traditional plant breeding versus plant biotechnology

Golden Rice

A good example of a genetically modified crop with an important function is the so-called “golden rice”. Vitamin A has been added to this variety, in order to counteract such a deficiency in some million children worldwide, causing blindness. This “golden rice” was developed by the Swiss Federal Institute of Technology by inserting three genes into the rice, so that it is now able to produce provitamin A. This rice will be freely available for farmers in developing countries in the very near future.

Transgenic (Bt)Cotton in China

Another example is transgenic (Bt)cotton which is produced in China mainly by small and medium-sized farmers with very good results (Figure 13) [21].

Prediction of genetically modified organisms

There are further examples of newly developed genetically modified crops, which are going to help the developing world with regard to both humans and animals [29, 30]. Efforts must be made to ensure that the future development of genetically modified organisms (GMO) does not come about as currently predicted for 2025. Here about 28 % of production in developed countries (USA, Canada, Europe, Australia) will be from GMOs, in Asia about 20 % of its food production is GMO related, in Latin America 17 % whilst in Africa only 6 % will be GMO related.

Actual situation of GM Crops

In the Americas, Australia, India, and China, commercial utilization of biotechnological crops is under way. Starting in 1996 with a global area of 1.7 million hectares used for genetically optimised crops it achieved 160 million hectares in 2011[23]. The number of participating countries jumped to 29 with 17 of them, Argentina, Australia, Bolivia, Brazil, Burkina Faso, Canada, China, India, Mexico, Myanmar, Pakistan, Paraguay, Philippines, South Africa, Spain, Uruguay, and the USA, are counting for more than 99 % of the used area and the global market in GM crops [23]. The global area will double within the next decade. The most important biotech crops are soybean, maize (corn), cotton and canola (rape) (Figure 14) [23]. It is estimated that nowadays more than 50 % of the total crop area in North America is used by genetically optimised crops, amongst which corn, soybean, cotton, potato, tomato, sugar beet, and oilseed rape are the principle ones. China especially has started to make efforts to use GM plants by investing more than 100 million US\$ in plant biotechnology [31]. Genomic research will help us to develop safer substances for pest control necessary to maintain or to elevate production levels as well as the security of food supply [6, 28, 50].

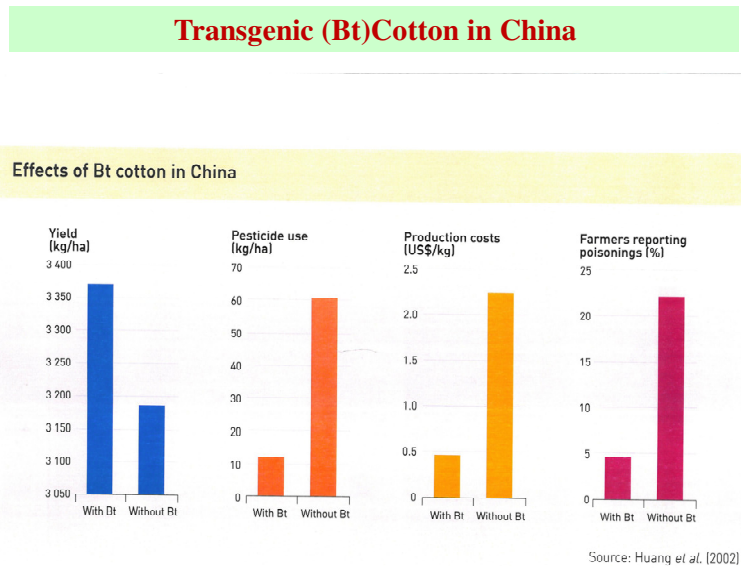


Figure 13. The success of planting transgenic (Bt)cotton in China [21]

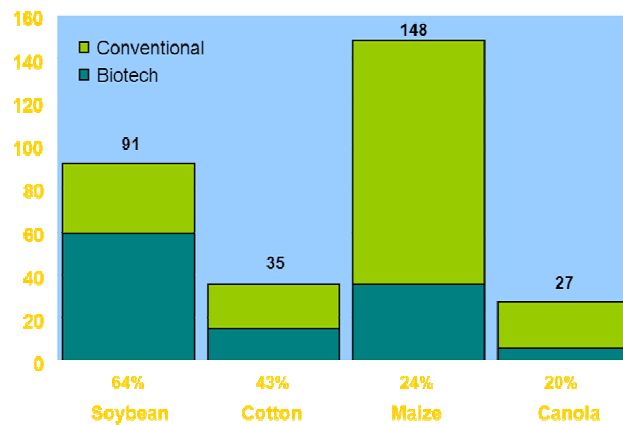


Figure 14. Global adoption rates (%) for principal biotech crops (million hectares) in 2007 [23]

Efficient crop production, modified seed and good infrastructure for genetic engineering are of strategic importance for nations, regions, and the world. Governments should be encouraged to actively support specific programmes [38]:

- ° to establish a coherent national (or regional) biotechnology policy
- ° to provide incentives for R&D
- ° to establish effective bio-safety and food safety regulations
- ° to ensure effective public awareness
- ° to enact IP legislation to establish a regime consistent with legal obligations under the World Trade Organisation

As mention above, intensive implementation of biotechnology in developing countries will make an important contribution to safeguarding world food security and to help feed mankind. Poverty is mainly found in arid or semi-arid zones, because agriculture there suffers from little rainfall and from limited irrigation potential. Most of the people are engaged in agriculture and they spend more than 90 % of their income on food. For the short- and mid-term, effective technologies must involve a combination of locally available inputs with selectively applied external help. Therefore, also traditional methods should be considered.

5. FUTURE TECHNOLOGIES IN FEEDING CONCEPTS AND FURTHER PRODUCTS

Precision farming will be one of the elements in the near future which will help to achieve increases in productivity by using fewer inputs, i.e. a more sustainable agriculture. This includes the exact application of fertilizers, pesticides, herbicides, and fungicides as well as seed material. This can be managed by the Global Positioning System (GPS) – a system that uses satellites to give support to elaborate soil maps and consequently plans for irrigation, fertilizer adjustment, etc. GPS needs to be supported by the Near Infrared Vegetation Index (NVI) System. The NVI Spectrum allows weed-infested areas to be distinguished from stubble and subsequently mapped.

Functional Food

Biotechnology specifically will play an important role in what is now called *Functional Food*. This means “foods that provide health benefits beyond those of basic nutrition and have measurable clinical effect” [40]. Actually, functional food is already produced in industrialized countries, but it will be an important factor also in developing countries. Reasons for these changes are better living conditions, an increase in life expectancy, rising costs of health care systems, and an increasing demand for healthier food and biopharmaca [17, 34, 35].

Old substances from new sources

Table 3. Industrial products from renewable natural resources [3,7,25,37,41,42,43,51]

EXAMPLES OF INDUSTRIAL PRODUCTS FROM RENEWABLE NATURAL RESOURCES			
Source	Product	Application	Reference
Glycerol from natural oil	1,3-propanediol	Plastic material	Steinbüchel(2001), Biebl et al (1999)
Oil from rape seed	Lubricating oil Hydraulic oil	Machines, Motor engines	BVEL(2002)
Sugar cane	Ethanol	Car fuel	
Sugar, bacteria	Polyhydroxyalcanoates	Health care industry: stents, orthopedic material, heart valves	Steinbüchel (2001) Sabirova et al (2006)
Sugar, bacteria	Xanthan	Food industries: thickener / binding agent for various industries / stabilizer in sprays and cleaning agents	Sutherland(1996)
Sugar, bacteria	Polyester amines	Package industry	Steinbüchel(2001)
Sugar, lactic acid, bacteria	Polylactic acid	Cosmetics, textiles, packing material	Steinbüchel(2001), Kascak et al(1996)
Sugar, bacteria	Succinic acid	Nylon and other industrial polymers	Steinbüchel(2001), Zeikus et al (1999),Kohan(2003)

As far as the total demand of planted crops is concerned, a further point has to be considered. This will be the use of plants for producing substances, which are currently being produced until now from resources such as petroleum. But oil will become scarcer within the next 50 years and obviously more expensive. This will provide the impetus for the development of new products, which at the moment are still too expensive (Table 3). But the development of those products has to start now to avoid a gap between reduced availability of oil-based products and newly developed substitutes.

The future of food and farming

A very relevant report from The Government Office for Science, London, UK (2011) titled: “*Forsight. The Future of Food and Farming 2010, Challenges and Choices for Global Sustainability*” promotes sustainable intensification and the use of a broad spectrum of technologies [44]. This report should find use in many countries as a basis for strategic action with a view to achieving improvements with a view to global security, the fight against poverty and hunger, conservation of resources, and sustainable social development. The report should be a compulsory reading for all decision makers, scientists, for schools, and ultimately for every one of us.

6. CONCLUSIONS

Agrotechnologies have developed very rapidly during the last decade and, therefore, provide hope for an increasing growth rate of food in the world, satisfying future demands and correspondingly safeguarding the world food supply. But these technological advances can only be effective when ecological, economic, political, social, ethical and demographic factors are taken into account. In other words, there must be a constant and constructive dialogue as well as cooperation between farmers, scientists, economists, politicians, and NGOs, and all will have to make concessions in order to achieve progress.

Furthermore, it is necessary that developed countries help to support adequate scientific and technical infrastructure growth in developing countries in order to enable them to overcome their food and health problems by means of an integrated networking of developed and developing countries [22].

Finally, for its part the developed world has to open its markets for agricultural products from developing countries and has to help to implement suitable new technologies, whereas the developing countries have to invest in innovations in agriculture, education, health care systems and land reforms. We should remember the Charter for Food Security published by Maxwell [39], and finally we should go for: “*Let us do more with less, better and in time!*” [36].

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TÓM TẮT

CÁC KHÍA CẠNH CÔNG NGHỆ NÔNG NGHIỆP TƯƠNG LAI

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Bài báo trình bày một số yếu tố quan trọng trong việc phát triển công nghệ nông nghiệp (CNNN) tương lai: gia tăng dân số thế giới, tăng tiến về giáo dục, tiến bộ về các hệ thống sản xuất thực phẩm, suy dinh dưỡng tại nhiều quốc gia trên thế giới.

Cần cải thiện việc sản xuất và năng suất lương thực. Sự thất thoát trước và sau thu hoạch hãy còn quá cao, và việc sử dụng các nguyên liệu nông nghiệp đầu vào như phân bón, thủy lợi và năng lượng phải giảm thiểu nhiều nhất có thể. Việc phát triển và thực thi các CNNN phải được tiến hành, nhất là sử dụng các giống lương thực biến đổi gen, để có thể nuôi sống thế giới trong tương lai một cách bền vững. Ngoài ra, về dài hạn chúng ta phải thay thế năng lượng hóa thạch. Một số đất canh tác chắc chắn vẫn sẽ được dùng cho những loại cây lương thực đóng một vai trò quan trọng trong sinh chuyển (bioconversion) các nguyên liệu thô tái sinh, và cả các chế phẩm mới cho thị trường. Tuy nhiên, một số đất màu thích hợp cho sản xuất thực phẩm sẽ được dùng cho sản xuất nhiên liệu sinh học. Hơn nữa, tại nhiều quốc gia đất màu cũng được dùng để sản xuất thức ăn gia súc – một câu chuyện đáng đặt vấn đề khi mà bên kia thế giới, bao nhiêu người đang thiếu ăn và chết đói. Cuối cùng, các nước phát triển phải mở cửa thị trường nông sản của họ cho các nước đang phát triển và để giảm thiểu bảo hộ mậu dịch.

Hiến chương Maxwell về An ninh Lương thực cần phải là cơ sở cho quan hệ cân bằng giữa các khối nước phát triển và đang phát triển trong tương lai, sao cho tránh được các nạn đói, di dân, độc tài, khủng bố, và chiến tranh.

Từ khóa: dân số TG, giáo dục, sản xuất thực phẩm, suy dinh dưỡng, gmo, HC an ninh lương thực.