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Development of Bt cotton supply

Bachelor thesis

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Declaration

I hereby declare that the thesis with title „ Development of Bt cotton supply” has been independently prepared, solely with the support of the listed literature references, and that no information has been presented that has not been officially acknowledged.

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ABSTRAKT

Tato bakalářská práce se zabývá problematikou geneticky modifikované bavlny a jejího zavedení v republice Burkina Faso. Nejprve je popsán vliv globalizace a nadnárodních společností na tzv. rozvojové země a poskytnuty informace týkající se tradiční bavlny, Bt-bavlny a jejího pěstování. Dále jsou představeny základní metody šlechtění rostlin, včetně jejich genetické transformace. Nakonec je provedena analýza dopadů, které mělo zavedení hybridní bavlny na ekonomiku republiky Burkina Faso.

Klíčová slova: globalizace, nadnárodní korporace, geneticky modifikované rostliny, bavlna, Bt-bavlna, Burkina Faso

ABSTRACT

This bachelor thesis deals with the issue of genetically modified cotton and its adoption in Burkina Faso. At first, the influence of various aspects of globalization and multinational corporations´ activities in developing countries is described. It is followed by information about both traditional cotton and Bt-cotton and its cultivation. Furthermore, the basic methods of plant hybridization, including genetic modification are introduced. Finally, the impacts of Bt cultivation in the Burkina Faso economy are analysed.

Keywords: globalization, multinational corporations, genetically modified crops, cotton, Bt-cotton, Burkina Faso

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CONTENT

INTRODUCTION

The issue of genetically modified organisms, including plants is a topic that has been discussed, analysed and argued in both popular and scientific circles in the last few decades. This revolutionary method that significantly influenced agriculture production in large parts of the world, has many advocates as well as opponents. There are indisputable advantages that adoption of genetically modified crops have brought including increased yields, resistance to insect pests and various diseases, improved quality and nutrition of food and positive influence on environment just to name the main assets quoted. However, there are numerous critics of this method who point out certain risks such as allergic reactions, antibiotic resistance or unknown effects which consumption of products with altered genes might have on animals or humans. The majority of countries involved in GM crop cultivation belong to the so called developing countries. One of the crops that are being genetically modified is cotton. This modification is called Bt cotton. As for the developed countries, the largest producer is by far the United States of America where the whole process of genetic modification including biotech cotton began. However, Bt cotton is largely produced in world regions that are considered to be developing (Pakistan, Burkina Faso) or were ranked as developing countries until recently (China, India). Cotton is one of the major commodities traded worldwide and thus its production has a great influence on countries´ economic results, especially in the developing regions.

As the world development has been strongly affected by globalization, this term will be explained and its major aspects described. The next part will deal with multinational corporations and institutions such as the World Bank, International Monetary Fund and World Trade Organization and their role in globalization. It will be followed by the information concerning the definition of developing countries and what are the major impacts of globalization on these countries. Furthermore, both cotton and Bt cotton will be presented, including their historical development and introduction to market. Another part will be dedicated to the most common traditional methods of breeding – hybridization and mutation breeding, which preceded the introduction of genetically modified organisms. The history of genetic engineering together with the characterization of genetically modified organisms, including genetically modified

crops will be given. The integral part of this chapter will include information about pesticide resistance and herbicide tolerance that represent key factors needed for improvement in plant qualities. Major positive and negative impacts of GM crop adoption will be stated.

The main objective of this bachelor thesis is to analyse adoption of Bt cotton in Burkina Faso and demonstrate its changes on agriculture, economy and other aspects of life in this West African country. This information will be presented in the final part. The author of this thesis has decided to analyse situations in Burkina Faso due to the following reasons. It is one of the poorest countries in the world and simultaneously the biggest producer of cotton in Africa. This thesis will demonstrate how the introduction of Bt cotton influenced various aspects of life in Burkina Faso.

1 GLOBALIZATION

In order to understand the complex issue of genetically modified organisms, including Bt cotton and specifically their impact on the economy and other aspects of life in the developing countries, it is necessary to briefly introduce the issues and features connected with the so called globalization as it has a significant impact on the above mentioned matter.

Globalization belongs to one of those terms which have become an integral part of the vocabulary of economists, journalists, environmentalists, and basically, the entire general public in the last few decades. This expression has been hyped and overused, but in the same way once too often misinterpreted and used inappropriately or vaguely. Nevertheless, it is essential to comprehend its consequences on the global economic system, including poverty in developing countries and particularly its effects on agricultural systems in both developing and developed countries.

There are numerous definitions of the term globalization. According to Scholte (2001), it refers to "*processes, whereby social relations acquire relatively distanceless and borderless qualities"*. Another characterization states that globalization is a process, in which people all over the world are becoming one single, global, society. (Albrow and King, 1990) According to Al-Rodhan and Stoudmann (2006, p.3), globalization *"is not a single concept that can be defined and encompassed within a set time frame, nor is it a process that can be defined clearly with a beginning and an end."* It "*involves economic integration, the transfer of policies across borders, the transmission of knowledge, cultural stability, the reproduction, relations, and discourses of power; it is a global process, a concept, a revolution, and an establishment of the global market free from socio-political control."*

1.1 History of globalization

Just as the definition, there is no common consensus among researchers concerning the beginnings of globalization. Some say it dates back to the era of first ancient civilizations in approximately 3,000 years B.C. when people started to trade commodities. (Frank, 1998) A well-known Scottish philosopher Adam Smith, who is considered to be a founder of modern economics, claimed in his work *Wealth of Nations* that globalization (though he does not use this term) started and was accelerated by Christopher Columbus´s discovery of the American continent and its subsequent overseas voyages. (The Economist, 2013)

However, many scientists and experts advocate that true globalization was launched by technological discoveries during the Industrial Revolution, which began in England in the 18th century and from there it spread to other parts of the world. Industrial Revolution is characterized as the process of change from an agrarian, handicraft economy to one dominated by industry and machine manufacture**.** (Encyclopædia Britannica, 2015) According to Scholte (2001), the initial step leading to globalization is considered to be the first permanent telegraph cable installed in the Atlantic Ocean in 1866.

From the aforementioned facts results that the beginnings of globalization depend on the researcher´s point of view and that the process called globalization can be dated in various historical periods.

The term globalization should not be confused with the term internationalization which refers to an intensifying connection between nations and their governments. There is a significant relation between globalization and state systems. An insight to the history shows that since the 17th century, the world has been based on the so-called Westphalian system of international law. This system can be characterized by the existence of sovereign nation-states with full control over their territory. Globalization has initiated changes leading towards the less sovereign states in terms of possibility of control over the globalizing processes that affects them. As for democratization, Scholte states that globalization, at first, might seem as a factor contributing to the increased democracy in the world. However, the end of bi-polar world division has not ended the

human rights violation. He also quotes that governance, in general, is being marketed and the democracy worldwide is being reduced. (Scholte, 2001)

1.2 Aspects of globalizations

There are several aspects of globalization that characterize and define its existence or emerge as its consequences in today´s world.

- *Communication* has undergone immense progress as for the distance and time. In the globalized world, communication is immediate and irrespective of location as it is realized by means of modern devices such as smart telephones, computers, satellite systems and mass media like the Internet, television, press, etc. They all enable the fast spread of information and contacts worldwide.
- *Organizations* – there is a considerable increase of various organizations that are established and carry out their activities during the ongoing globalization. On one hand, there are traditional institutions and organization like the United Nations (UN), Organization for Economic Co-operation and Development (OECD), International Monetary Fund (IMF), World Bank (WB), etc. which act globally on political and/or economic level and are run and organized by governments, politicians and economists.

  On the other hand, there exist so called non-governmental organizations (NGOs) such as Greenpeace, Amnesty International, Human Rights Watch, Third World Network to name a few important ones, which try to deal with the issues resulting from globalization in the field of environmental protection, human rights, poverty in the developing countries and many other aspects. NGOs advance their policies to strengthen their influence over the sovereign countries. (Scholte, 2001)
- *Production* has significantly changed during globalization. In the so-called global factories, the stages of production are usually separated and carried out within several countries. This system produces economic wealth, but the substantial part of those earnings is transferred to the developed countries. Their economics are nowadays based on the prevailing tertiary economic sector. For

instance, in textile industry, the majority of production is made in the developing countries (cotton production, textile manufacturing,…) due to cheap labour and poor environmental policies, but the largest share of the final profit from the goods sold, goes to the developed countries.

This matter is closely connected with multinational corporations (MNCs). MNCs are big companies that have their facilities and other assets in at least one country other than its home country. Such companies have offices and/or factories in different countries and usually have a centralized head office where they co-ordinate global management, i.e., they coordinate their production among several countries and their economic transactions take place across national borders. Big multinationals have budgets that exceed those of many small countries**.** (Investopedia) As they significantly form the economic and financial flow in the globalized market and thus have an important role in setting up the rules of cotton production and trade, some of these MNCs activities will be further introduced.

- *Ecology* is another widely discussed topic that is associated with globalization. A growth of world production is often accompanied with the environmental pollution and destroying the nature. The terms like the greenhouse effect, global warming, deforestation, climate changes are often quoted when negative impacts of globalization are mentioned. There is an unquestionable fact that the developing countries are facing many ecological problems as the first stage of production is often outsourced to the regions with lower ecological standards and policies.

1.3 Multinational corporations (MNCs)

As previously mentioned, multinational corporations are the companies that act in more than one country in terms of production, trade and investments. In today´s world, they are the driving force of the global economy. The development of MNCs began after the World War II but escalated in the last thirty years owing to rapid changes in transportation (international flights, maritime cargo, road and railway network…), improvements in communication technologies (computers, mobile phones, internet…),

and last but not least by reducing trade barriers between countries. MNCs coordinate economic production among different enterprises and are led by a single parent firm with its affiliates in both developed and developing countries. Nevertheless, the majority of subsidiaries focused on production is located in the developing countries. It is interesting that such affiliates are concentrated in a relatively small number of countries, predominantly in Latin America and East Asia. MNC subsidiaries in industrialized countries are in most cases larger and more capital intensive. (Investopedia)

1.3.1 MNCs investments and its pros and cons

MNC investments may be divided into three categories. The first category is represented by cross border investment which enables to gain access to natural resources, e.g. mining of scare minerals in Africa needed for electronic production. The second category includes investment to gain access to foreign markets (building of car factories in different countries to get an easy access the car market in a specific country). In the third category, there is investment to improve the efficiency of company production (intensive labour production being outsourced to developing countries). Generally speaking, all the above mentioned investments can be summarized under the term – foreign direct investment (FDI). (Guru)

It is obvious that foreign direct investment of MNCs is made to increase the efficiency of production. FDI is a controversial topic as some experts say that it brings the needed development to the host (specifically developing) country, while others argue that this type of cross border investment has many negative impacts, particularly on the lower developed countries.

Speaking of benefits, FDI of MNCs brings both financial and physical investments into the developing countries´ economies and thus improvements in their infrastructure (transport network, telecommunication, industrial structures …), health care (healthcare facilities, staff training, vaccines …), education (school building, educational aids …) etc. Another benefit represents the technology brought to the host countries. Indigenous firms may master the technology and use it for their own production. Last but not least,

MNCs enable developing countries an access to the international market. MNCs sometimes offer managerial positions to local employees who can later use their acquired knowledge in leading and/or establishing domestic firms.

On the other hand, numerous critics claim that MNC largely siphon off the wherewithal from the host country rather than brings money in. MNCs are criticized for earning high profits, which are repatriated back to the developed world, not the host country. Other critics point out the fact that many MNCs retain their technology for themselves and that managerial positions are not occupied with people from the host country because MNCs are reluctant to do so. MNCs have been also lambasted for driving domestic firms out of business thanks to the better management, price adjustments and the situation when MNCs use inputs for their production of other resources and not from the domestic market. Such practices may have a devastating impact on the host country's economy. (Farre1 et al. 2003)

The aforementioned information shows that MNCs might have both positive and negative impacts for the host country. The truth is that multinational corporations want to enter the foreign market must make an agreement with the local government so in many cases it may not be only MNC's fault when it comes to negative impacts towards the host country. Therefore, the influence of a particular FDI in a host country always depends on the specifics of each case.

1.4 Criticisms of globalization

Together with the criticism aimed at multinational corporations, there exists a harsh criticism towards the globalization process in general. Besides the conventional reproaches concerning the negative influence on environment and ecology, high level of corruption in the developing countries because of the bribes from the MNCs, exploitation of natural resources, child labour, slavery, etc., the emphasis is put on the economic facet of globalization.

For instance, Stiglitz (2008) recognizes that globalization has brought the mankind enormous capital sources thanks to the better resource management and globalized

structures together with other benefits concerning the economy. On the other hand, these benefits are allocated unequally and are even deepening poverty in some parts of the world as globalization is not well managed. He states that the main reason for this is an absence of global economic order based on ideas of social justice and points out the fact that the United States of America has always been used to advance their interests. Their trade policies and acts that have been applying towards the developing world are unfair and to be profitable for them and the other countries from the so-called "Western World". Stiglitz gives an apt example that relates to the cotton production in USA that is subsidized, and thus African countries are not able to compete with their prices. Similar policies executed by industrial countries or multinational corporations enforce the leading position of industrialized countries and keep the developing countries underdeveloped.

1.5 WTO, IMF, World Bank and their role in globalization

World Trade Organization (WTO), International Monetary Fund (IMF) and World Bank are powerful international organizations that belong to, together with the highly developed countries, great determinants of globalization processes. They are sometimes called Bretton Woods institutions and their main role is to support international trade together with managing trade policies and agreements. They were established at Bretton Wood Conference in the United States of America in July 1944 in order to rebuild Europe, which was then destroyed by the World War II, and to stabilize exchange rates. The first task was to be solved by the International Bank for Reconstruction and Development (IBRD), which is now a part of the World Bank together with the International Development Association. The second task, stabilizing the monetary system, was reached by founding the IMF and implementation of gold standard – a monetary system in which the standard economic unit of account is based on a fixed quantity of gold. Third organization, WTO, expanded from The General Agreement on Tariffs and Trade (GATT), which was established to regulate the international trade. (Office of the Historian) Its main task was to remove tariffs and other trade barriers.

All three organizations play the key role in globalization process. Their activities overlap in many aspects, but there are some main features that characterize each institution. The World Bank provides low-interest loans, interest-free credits, and grants to developing countries. The IMF supports many developing nations by helping them overcome monetary challenges and to maintain a stable financial system. The WTO main task is the regulation of trade between participating countries by providing a framework for negotiating trade agreements and a dispute resolution process aimed at enforcing participants´ adherence to WTO agreements. Due to their global influence, they have fundamental influence on the world economy and particularly on the developing nations. They have also been subject to a range of criticism that are generally focused on the conditions of loans, lack of accountability, willingness to lend finance, reward or otherwise support inefficient and corrupt countries or countries with bad human rights records, administrative incompetence and strengthening the dominance of G7 countries. (Driscoll, 1996) Their operation is based on the neoclassical school of economics so generally speaking, their major objectives include cancelling trade barriers and other restrictions. Basically they want the individual world economies to become a single market.

2 DEVELOPING COUNTRIES

The term “developing country” is ambiguous as there is no strict definition and no set criteria for what is and what is not a developing country. However, there are generally several aspects that are used in order to determine the developing country. The developing countries are usually characterized by low revenues, less developed industry, the existence of poverty, level of infrastructure, poor education system, difficult access to water and electricity, incompetent and corrupted government, inadequate health care, high unemployment and agriculture that predominates over industry. All the above mentioned characteristics vary in every single country. (Rohland, 2015)

According to the World Bank that classifies the world’s economies on estimates of gross national income (GNI) per capita for the previous year, low income and lower middle income economies are referred to as developing economies. In July 2013, the World Bank income classifications were as follows: low income economies with GNI at $1,035 or less and lower middle income economies from $1,036 to $4,085. This means that in the poorest countries each person must manage with an average income 2.84 USD per day. (The World Bank, 2013) Nevertheless, this is an average so the majority of people in such countries must survive with two US dollars or less per day. The United Nations Conference on Trade and Development (UNTACD) characterizes these developing nations as LDCs – least developed countries. According to their statistics from 2014, there are 48 LDCs worldwide out of which 31 states are to be found in Africa. It is interesting that members of WTO classify themselves whether they are developed or developing country. (Rohland, 2015)

Geographically speaking, we may distinguish between the rich North and poor South. Most of the developing nations are situated in Africa (Ethiopia, Sudan, Burkina Faso, …), followed by Southwest Asia (Pakistan, Afghanistan, …) and Southeast Asia (Myanmar, Bangladesh, …),and several island nations in the Pacific (Vanuatu, Solomon Islands) and in the Caribbean (Haiti).

2.1 Developing world vs. globalization

There are many views on how globalization influences the development in developing countries. Despite the evidence of positive impacts of globalization on some developing nations such as the increase of growth rates, productivity, GDP and enhancement of technological capability, there are huge protests against globalization going on from people all over the world. The detractors criticize globalization mainly for the disability to redistribute the created wealth fairly in the poor economies favour. They point out that foreign companies are not interested in supporting local markets but they rather export the goods from the foreign-owned commercial farms which is very profitable. Trade liberalization allows the goods and products to be transported and distributed all over the world. Due to a large number of reasons including cheaper labour, abuse of child work, lower costs of energies etc., such goods are cheaper and thus to be successfully sold in the developed countries but on the other hand, it destroys local industries and intensifies the disproportion between the rich and the poor countries.

3 COTTON

3.1 Characterization of cotton

Cotton is *„seed-hair fibre of a variety of plants of the genus Gossypium, belonging to the hibiscus, or mallow, family (Malvaceae) and native to most subtropical parts of the world."* (Encyclopædia Britannica, 2015) Cotton requires fertile soil, high amounts of sunshine and moderate amount of water. Areas having 600 to 1200 millimetres annual rainfall are ideal for cotton production. However, in areas where the plant water needs for the rainfall are not met, irrigation is being used.

Cotton is one of the key crops produced in developing countries. About 70% of the world's cotton production comes from such territories. The leading position in cotton growing occupies Asia (approximately 90 % of the whole world cotton production) with two largest producers – China and India, then follows the American continent (approx. 5 %) and the third position is held by Africa (approx. 4 %). In 2014, the annual world production was 24.5 million tonnes. The highest share on production reached China with annual harvest 7 MT in 2013/2014, followed by India with 6.6 MT and United States of America (USA) with 2.8 MT. (FAOSTAT, 2015)

The below mentioned figure shows the individual continents share in cotton production

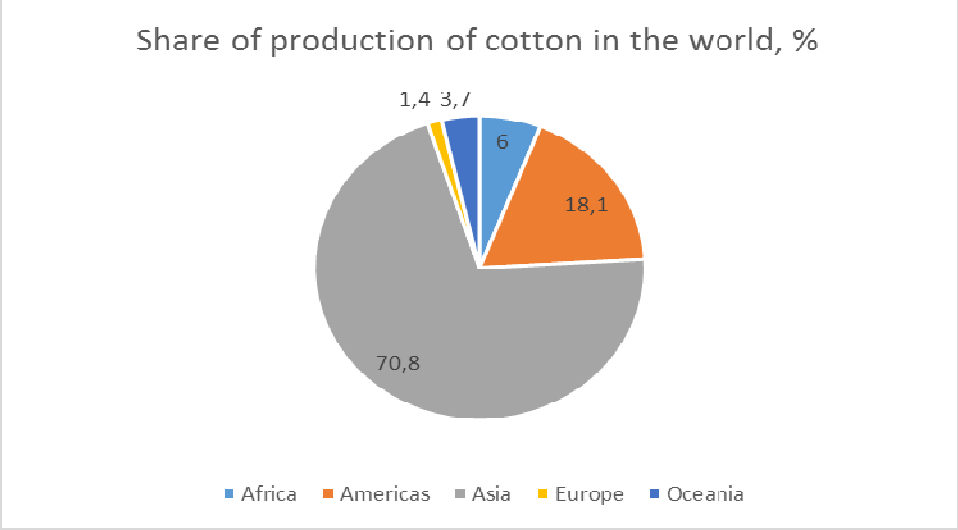

Figure 1: Share of cotton production by continents (source: Faostat.org)

3.2 Use of cotton

Cotton is one of the most planted agricultural crops. There are two main components of cotton used for industrial processing – fibre and cottonseed. The fibre is primarily utilized in textile and apparel sectors (approximately 60% of cotton fibre consumption) which is followed by home furnishing (draperies), professional garments (fire-proof apparel), other industrial products such as fishing nets, cotton paper, tents, gunpowder and last but not least its use in medical and hygiene uses e.g. cotton wool, gauze bandages, tampons, sanitary towels and swabs. Cottonseed is used as feed for livestock, soil fertilizer or for oil production. Cottonseed oil can be either used in food industry (cooking oil, salad dressings) or in cosmetics (moisturizing lotions, bath soap). (UNCTAD, 2011)

3.3 History of cotton production and its use in textile industry

There is no consensus on how exactly cotton is old. The oldest evidence of its use comes from Mexico, where bits of cotton bolls and pieces of cotton cloth proved to be at least 7,000 years old were found. In the Indus River Valley in Pakistan, cotton was being grown, spun and woven into cloth 3,000 years BC. At about the same time, natives of Egypt's Nile valley were making and wearing cotton clothing. Around 1500 BC cotton was widely used for clothing in Asia and the cotton production was expanding. At the beginning of first millennium, cotton became widely traded to Europe from the Middle East. Arab merchants brought cotton cloth to Europe about 800 A.D. When Columbus discovered America in 1492, he found cotton growing in the Bahama Islands. By 1500, cotton was known generally throughout the world. Nevertheless, the major development of cotton trade occurred in 17th century, after Great Britain's East India Company expanded in the Europe – Asia cotton trade. Great Britain thus became the major manufacturer of cotton-based products as well as the country who controlled the majority of cotton growing market. Later, in 1760s, spinning jenny and spinning frame were developed, which moved the cotton industry further. (National Cotton council of America) This was even reinforced by the invention of cotton gin in the United States of America at the end of 18th century, which made supplying large

quantities of cotton fibre to the fast-growing textile industry possible. The need for fertile land suitable for cotton cultivation led to the expansion of slavery in the United States which later represented one of the key reasons for American Civil War (1860 – 1865). Before the breakout of this military conflict, Great Britain had been the major importer of raw American cotton. The consequences of the Civil War, together with the overproduction and price inflation, resulted in the five-year period of depression in the British cotton industry known as “Lancashire Cotton Famine”. (Brady, 1963)

Therefore, the cotton growing moved to a rediscovered British colony India. By 1862, just two years after the beginning of the war, 75% of Britain’s cotton originated in India. The industry had gone global; Egypt and Brazil also provided new sources of supply. (The Economist, 2015)

The twentieth century brought significant changes to both the cotton production and textile industry. By 1912, the cotton industry in Britain as the worldwide largest manufacturer of cotton-based products was at its peak producing eight billion yards of cloth. This was reversed by World War I. The ban imposed on importing cotton to foreign markets as a result of the start of WW I, made some countries such as Japan to set up their own factories. Japan had introduced 24 hour cotton production and became the world's largest cotton manufacturer by 1933. Such circumstances, together with India´s boycott of British cotton products as a part of their fight for independence, had devastating effects on the United Kingdom textile industry. Despite the Second World War brought about a short reprieve in production, the following decades resulted in the downfall of textile manufacturing on the British Isles. By the 1980s the textile industry based mainly on cotton processing had all but vanished. Within the last few decades, textile production has been outsourced from Western Europe to lower-wage areas, mainly in Asia, Latin America and partially in Africa. Industrial production using cotton is currently located in countries like India, Bangladesh, China, Brazil or Tunisia. (BBC, 2014)

At present, the leading worldwide cotton producer is China with nearly 7 million metric tons of cotton harvested, followed by India (approx. 6.5 m), the United States of America (approx. 3 m), Pakistan (2 m) and Brazil (1.6 m).

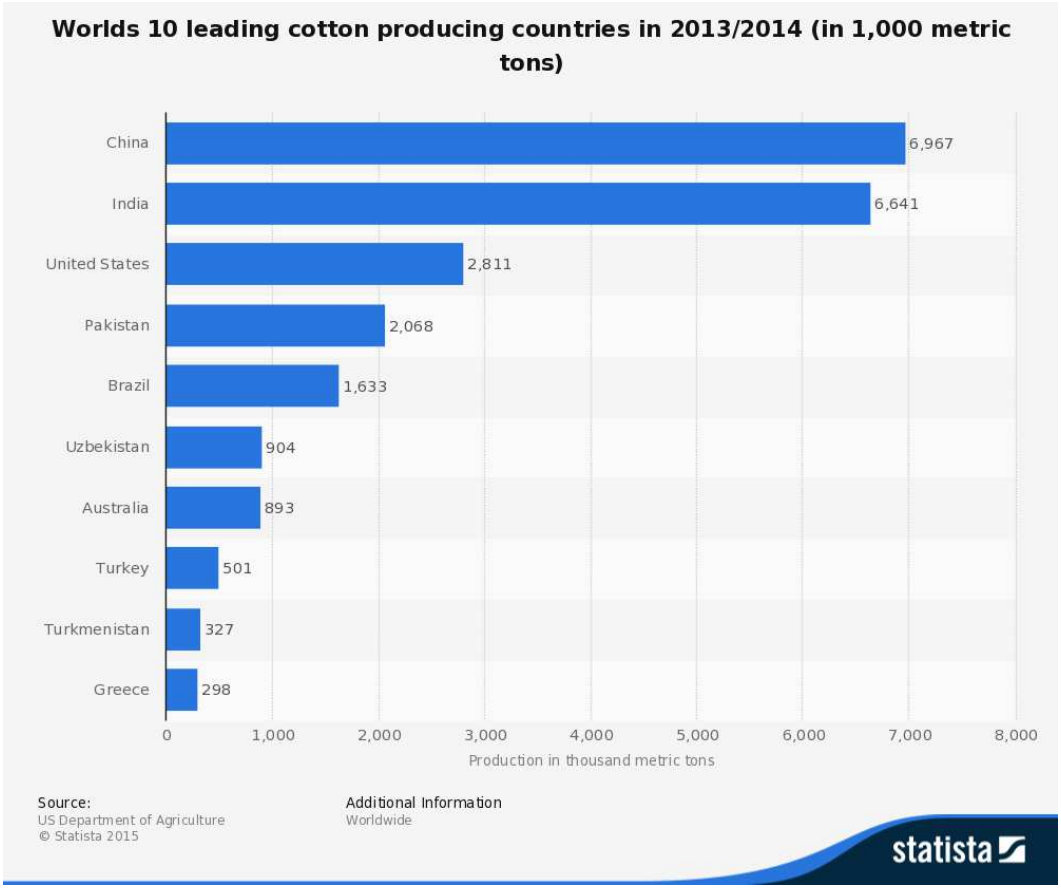

Figure 2: World 10 leading cotton producing countries in 2013/2014 (sources: Statista.com)

3.4 Bt Cotton

Among the major threats connected with cotton production belong pests and weeds. On that account, a large number of chemicals, such as herbicides, fertilizers and insecticides had to be used to eliminate the pest infestation. In order to find solution to this problem and also to reduce the negative impacts resulting from the use of chemicals, the scientists invented Bt cotton. Bt cotton is a genetically modified form of cotton due to insertion of one or more genes from a common soil bacterium, Bacillus thuringiensis (Bt). (Scott, 2007)

This bacterium was discovered by the Japanese scientist Shigetane Ishiwatain in 1901. Soon after its discovery, it was also found out, that some parts of this bacterium (Cry +)

are highly toxic for some pests. In 1938, the bacterium was used for the first time as spray against European corn borer. Further researches showed, that Bacillus thuringiensis contains protein crystals, that kill pests carrying receptors for proteins which are bound to Bt proteins. Other living creatures do not have this receptor so that they are not influenced by this substance. (Ibrahim et al. 2010)

Special formulations of microbial Bt fermentation products containing Cry proteins have been used for more than 60 years as insecticides. The reasons why the cotton producers have never applied this form of plant protection on a large scale include the low efficiency, as the sprayed formula remains on the plant only for short time, the high costs, and possible non-optional coverage of this spray. Yet this form of crop protection is nowadays widely used in organic farming. (Vitale et al. 2010)

Together with the development of genetic modification, the method how to implement Cry gene to specific plants was found. After this, plants began to create Bt protein which destroys numerous pests attacking cotton plant and thus causing high economic losses. Among the major ones belong Helicoverpa armigera aka American bollworm, Pectinophora gossypiella - pink bollworm, Earias vitella and Earias insulana known as the spotted bollworms. Cry genes are toxic for these pests. (Kranthi et al. 2012)

In 1996, Monsanto Company – a multinational agrochemical and agricultural biotechnology corporation and leading producer of genetically engineered seed worldwide, introduced Bollgard cotton (a trademark of Monsanto) that was the first Bt cotton to be marketed in the United States. The original Bollgard cotton produces a toxin called Cry 1Ac that has excellent activity on tobacco budworm and pink bollworm. These two insects are extremely important caterpillar pests of cotton, and both are difficult and expensive to control with traditional insecticides. Bollgard II was introduced in 2003, representing the next generation of Bt cottons. Bollgard II contains a second gene from the Bt bacteria, which encodes the production of Cry 2Ab. WideStrike (a trademark of Dow AgroSciences) was registered for use in the fall of 2004. Like Bollgard II, WideStrike cotton expresses two Bt toxins (Cry 1Ac and Cry 1F). Both Bollgard II and WideStrike have better activity on a wider range of caterpillar pests than the original Bollgard technology. (Scott, 2007)

Bt cotton has its advocates who point out the reduction of chemicals used in agriculture and its following positive influence on environment and ecology, increased yields and higher profits for farmers (with emphasis on those in developing regions) as well as its objectors who warn about the development of resistance genes in pest populations limiting the effect of Bt crops or the abundance of some non-target pests due to the reduction of conventional pesticides. (Tabashnik et al. 2014)

4 BREEDING

The term breeding in biology refers to application of genetic principles in animal husbandry, agriculture, and horticulture to improve desirable qualities. (Encyclopædia Britannica, 2015) Plant breeding is further specified as purposeful manipulation of plant species in order to create desired genotypes and phenotypes for specific purposes. (Science Daily) Animal breeding is defined as the application of the principles of genetics and biometry to improve the efficiency of production in farm animals. The principles of breeding were applied to change plant production or animal populations thousands of years before the sciences of genetics and biometry were formally established. (Makarechian, 2012) However, it is important to mention, that genes in crops and animals change also naturally and thus adapt new conditions. This process is called evolution and results in adaptive improvements. To give an example, we can mention wheat, which evolved around 12 000 years ago from three types of grass. (Shewry,2009)

4.1 Early beginnings of breeding

The historical period known as Neolithic revolution (around 10 000 BC – 3 000 BC) represented a fundamental shift in human civilization. Nomadic lifestyle based on instant migration, hunting and gathering was gradually replaced by the new way of living. People began to settle down and live in permanent communities. This was both caused and made possible by plant production and animal domestication. The first evidence of such communities comes from the areas where climate conditions were favourable for such lifestyle, i.e. the fertile valleys along the big rivers of the Nile, Tigris-Euphrates, Yellow River and Indus. This later resulted in the rise of the great civilizations in Egypt, Mesopotamia, China, and India. (Watkins)

4.2 Hybridization

Around 3000 years ago, people stepped further as they started to modify organisms through hybridization which became an important force of biological evolution. Hybridization is the interbreeding between animals or plants of different species which results in a novel offspring. (Russel, 2015) It arose from the experimenting when then day's farmers took two species and crossed them together. It is difficult to date those hybrids, but one of the first plant hybrids we have the evidence of was the type of rice crossbred from two different strains, Japanese rice and Indian rice. One of the first animals evolved by hybridization was a hybrid from horse and donkey. Until the 20th century, hybridization remained as the sole technique to improve quality of crops and animals. (Newton, 2014)

Plant breeding has also improved foodstuff safety. Unlike fruits, plants do not have their own immune system and so they have evolved various forms of chemicals to protect themselves. Most of such chemicals may be dangerous or allergenic to humans. By means of plant breeding, breeders have lowered the volume of these chemicals and thus make plants suitable for human consumption. (Halford, 2003)

4.3 Mutation breeding

The further step in plant cultivation after hybridization represents mutation. Mutation is a sudden heritable change in the DNA in a living cell, not caused by genetic segregation or genetic recombination but via exposure of seeds to chemicals or radiation in order to generate mutants with desirable traits to be bred with other cultivars. Mutation breeding is the purposeful application of mutations in plant breeding and unlike hybridization and selection mutation breeding has the advantage of improving a defect in an otherwise elite cultivar, without losing its agronomic and quality characteristics. (Pathirana, 2011) This fairly new scientific form of plant modification was discovered at the beginning of 20th century when American scientist Lewis Stadler of the University of Missouri used X-rays on maize and barley and discovered the impact of ionizing radiation on plant mutation. The radiation then began to be used in mutation research but the high rates of

chromosome aberrations caused by the application of this method along with the accompanied detrimental effects made researchers look for alternate sources for inducing mutations. As a result an array of chemical mutagens has been discovered in 1940s. Among the most widely used and popular chemical mutagens belongs ethyl methanesulfonate (EMS). Other methods in plant mutation breeding include the use transposons, high-energy (220MeV) or low-energy (30keV) ion beam implantations, insertional mutation and zinc finger DNA-binding proteins. However, it was not until the establishment of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture in 1964, with its global coordinating and synergistic roles when plant mutation breeding became a common tool available to plant breeders worldwide, enabling them to form new mutations and thus improve and increase their crops. (Pathirana, 2011) Regardless the popularity of mutation breeding methods, most of the scientists talk against them due to its unpredictable impact on environment. (Stratilová, 2012)

5 GENETICALLY MODIFIED ORGANISM

The term genetically modified organism (GMO) means an *"organism, i.e. plant, animal or microorganisms that has been genetically modified through the addition of a small amount of genetic material from other organisms through molecular techniques." (*Bessin, 1999)

Such modification is carried out in laboratories through genetic engineering. This relatively new science creates unstable combinations of plant, animal, bacterium and viral genes that do not occur in nature or through traditional crossbreeding methods. (Non GMO Project, 2015) This thesis will further deal only with the issues of genetically modified plants.

5.1. History of genetic engineering

Beginnings of crop genetics may by dated back in 1859, in Charles Darwin's book „On the Origin of Species by Means of Natural Selection" where Darwin describes how species compete each other and how populations evolve through natural selection. (Halford, 2003) Nevertheless, the founder of genetics is considered scientist and an Augustinian monk Gregor J. Mendel who discovered the basic principles of heredity through experiments with pea traits his monastery's garden. In 1865, he described the transfer of determinants in pea plants to the Brno Natural Science Society but his revolutionary discoveries were then not understood. Next year, his short monograph, Experiments with Plant Hybrids, was published and later was acknowledged as one of the most enduring and influential publications in the history of science. Until 1900, no one recognized that Gregor J. Mendel had discovered the Law of Heredity. (Biography, 2015) Therefore, the first experiments with crop hybrids go back at the beginning of 20th century, after the Mendel's work was rediscovered and provided scientists with theoretical basis. (Halford, 2003)

In 1953, the geneticists James Watson and Francis Crick described the structure of deoxyribonucleic acid (DNA) and thus made a huge step in its study. Later, in 1950s and 1960s, the fast progress was made in the field of DNA structure and finally, in

1973, Stanley Cohen and Annie Chang, together with Herbert Boyer and Robert Helling, cut DNA with a specific enzyme and combine it with DNA molecules from plasmids bacteria. (Halford, 2003**)**

In 1978, a private research institution Genentech, Inc. and City of Hope National Medical Center in California first used genetic engineering in practice and produced human insulin using E.coli bacteria. During 1980s, the popularity of genetic engineering kept rising and this new scientific method found its use largely in pharmacology. In 1983, the first transgenic plant was tobacco with resistance to antibiotics was cultivated and in 1991, scientists began with experiments for the purpose of changing genetic code in agricultural crops. In 1994, FlavrSavr' fresh tomatoes from Calgene (now Monsanto) resistant to Tobacco mosaic virus were developed and commercialized in the United States together with processing tomatoes developed in the United Kingdom. (Stratilová, 2012) The main introduction of GM crops took place in 1996, when biotechnology-derived herbicide-tolerant (HT) and insect-resistant traits were launched into the market in soybean, cotton, corn, and canola**.** (Schwember, 2008)

A great advantage of mutation breeding in comparison with previous methods resides in the fact that the process of modification is controlled and the final product has desired properties. The scientists are able to isolate gene with a specific feature and implant it inside another living organism.

5.1.1 Green Revolution

In the middle of 20th century, with the world population growing exponentially, it became obvious that soon, the crop yield would not be satisfactory in order to provide sufficient food supplies for the mankind especially in the so called developing countries. Such state of affairs was further strengthened by growing demands for meet and thus increased needs for crops in order to feed livestock. Therefore vast sums of money and great scientific efforts were put into the activities that would improve plant breeding, agronomy, and also invent and develop inorganic fertilizers and modern pesticides. This effort led to quick yield improvements and sufficient food security achievement in over whelming majority of developed countries.

In the late 1960s, some developing countries, mostly in Asia and Latin America, also faced positives impacts on yield improvement and costs of production. An impact of Green Revolution on development in African continent was lower, especially due to lack of infrastructure, high transport costs and limited investment in irrigation and agronomic policies. (IFPRI, 2002)

5.2 Genetically modified crops

Genetically modified crops (GM crops) or transgenic crop plants are plants used in agriculture that have been genetically modified using recombinant DNA technology. This may be to express a gene that is not native to the plant or to modify endogenous genes. The protein encoded by the gene will confer a particular trait or characteristic to that plant. (Key et al. 2008) Plant breeder supresses the characteristics, that make the plant susceptible to certain diseases or he/she enhances the desired plant qualities. (Stratilová, 2012) The technology can be utilized in these ways:

- to engineer resistance to abiotic stresses, such as drought, extreme temperature or salinity,
- to create resistance to biotic stresses, such as insects and pathogens, that would normally prove detrimental to plant growth or survival,
- to improve the nutritional content of the plant, which might be of particular use in the developing world,
- to produce recombinant medicines and industrial products, such as monoclonal antibodies, vaccines, plastics and bio fuels especially with a new-generation of GM crops. (Key et al. 2008)

5.2.1 Pesticide protection

Within last few decades, crops have been usually treated with pesticides in conventional agriculture. A pesticide is any substance used to kill, repel, or control certain forms of plant or animal life that are considered to be pests. Pesticides include:

- ✓ herbicides for destroying weeds and other unwanted vegetation,
- ✓ insecticides for controlling a wide variety of insects,
- ✓ fungicides used to prevent the growth of molds and mildew,
- ✓ disinfectants for preventing the spread of bacteria,
- ✓ compounds used to control mice and rats. (National Institute of Environmental Health Sciences, 2015)

At present, two forms of genetic modification are being used in practice the most. The first is carried out in order to provide tolerance against herbicides such as glyphosate, known as Roundup, atrazine and chlorpyrifos. The second form is due to building resistance against insects – it is so called Bt modification. (Kažmierski, 2008)

5.2.2 Herbicide tolerance

Pesticides which are used for destroying weeds and other harmful vegetation that take away the necessary nutrition are called herbicides. There are various types of herbicides for different types of weeds. It means that it is inevitable to apply several herbicides in one farming area. It is not only expensive but also requires repeating the herbicide application several times which makes the plant growing more difficult. There exist so called “total herbicides” but their use is counter-productive as they destroy everything including the plant´s essential enzyme and thus the whole plant itself. Therefore scientists invented the method of genetic modification in which the same enzyme from soil bacteria (but resistant to the herbicide) is inserted in the plant gene. Such enzyme might be used by the plant in case when the original essential enzyme is destroyed. This herbicide tolerance is widely used in soya, corn, rape (colza), cotton and beet. (Stratilová, 2012) In, 2010 there were around 62% of all single-gene and 21% of all multi-gene GMO´s herbicide resistant.

5.2.3 Insect resistance

Another major issue concerning the plant production represents the harmful effects caused by insects. In order to minimize the devastating impact of various kinds of insects on crop yield, the farmers use pesticides called insecticides. Insecticides are agents of chemical or biological origin that control insects. Control may result from killing the insect or otherwise preventing it from engaging in behaviours deemed destructive. Insecticides may be natural or man-made and are applied to target pests in a myriad of formulations and delivery systems (sprays, baits, slow-release diffusion, etc.). (Ware and Whitacre, 2004) One of the most popular natural insecticides used for a last few decades was a soil bacterium Bacillus truringiensis (Bt). This bacterium produces so called Bt toxin which damages digestive tract of several abundant insects yet remains harmless for useful insect (bees), livestock and humans. Unfortunately this type of protection is rather costly and its effects are significantly reduced by rain and sunlight. (Stratilová, 2012) The science of biotechnology has, in recent years, enabled to incorporate bacterial genes responsible for a production of Bt toxin into various crop plants that deal death to unsuspecting pests that feed on them. As for the insecticides, in 2010, 16% of all single-gene and 25% multi-gene GMO's contained Bt gene. (Ware and Whitacre, 2004)

5.3 Impacts of growing GM crops

Since the commercial launch of GM crops in the market in 1994, their sale has spread all over the world and is growing. Unfortunately, there is still no consensus concerning the safety hazards and risks that cultivation of such products might bring. This topic has been widely discussed among scientists and many researches have been made in order to confirm or disprove the negative impacts of GMOs cultivation and consumption.

5.3.1 Positive impacts

GM crops are widely grown all over the world due to their economic advantages. Christou and Cappel (2009, p. 4) summarizes the main benefits as: "*resistance to insect*

pests and tolerance to weeds; resistance to fungal, bacterial and viral diseases; tolerance to a range of abiotic stresses including drought, salinity, cold, hypoxia; improvement in yield and nutritional content; utilizing the plant cell's machinery as a factory to produce valuable recombinant proteins and metabolites". As a result, farmers usually reach higher yields and their production is less susceptible to damages.

GM crops also have some positive impacts on environment. As some crops are resistant to different kinds of insect, smaller amount of pesticides is needed. Likewise, when drought tolerant crop in areas with water scarcity is grown, the higher protection of water resources is achieved. Other positive environmental aspects include reduction of fossil fuels needed for the cultivation and its subsequent processing and thus help to reduce the CO_2 emissions. The GM growing also provides higher security for farmers as those who cultivate GM crops do not need to use herbicides and pesticides, so the health risks resulting from exposure to harmful substances are lower. There are also specific modifications providing higher nutrition to the plant and though preventing society from various diseases. (Stratilová, 2012)

5.3.2 Negative impacts

Notwithstanding those benefits, large number of scientists talks against GMO and its use in food industry. Among the main arguments against the GMO belong their potential health risks, including allergies, antibiotic resistance, and unknown effects. To genetically modify a food, scientists take genes from one food to put into another food. This can cause allergic reactions and other side effects when people consume the modified foods. Until now, the worst case happened in the USA in 1989, when a genetically modified dietary supplement of tryptophan allegedly killed 37 people, permanently disabled 1,500 people, and caused 5,000 people to develop a blood disorder before the product was recalled. Another serious concern is that GM foods contain antibiotic markers, which is thought to be one of the reasons that the effectiveness of treatments are decreasing. This means that more powerful drugs are going to be needed to treat infections and diseases in the future. Other negatives that stem from GMOs are that scientists are tampering with nature by mixing genes and no

one knows what this is doing to the animals or the environment. There is a criticism towards cultivation of GMOs as it may be dangerous for biodiversity. GM plants allow farmers to increase the amount of pesticides and herbicides used on their land, which will increase the amount of chemicals finding their way into the water system, damaging the soil and negatively affect both flora and fauna. (Vaesa, 2013) Another problem also represents the fact that the seeds of genetically modified crops are considered to be a form of intellectual property so the farmers have to buy new seeds as the plants are modified in the way which disables their reproduction. (Stratilová, 2012)

5.4 GMO in the world

The most spread GM crop worldwide is soybean. Three largest producing countries of this plant are the USA, Brazil and Argentina. In these countries, about 70 – 90 % out of the entire production is genetically modified. There has also been a rapid increase in share of GM maize varieties being produced. (Kažimierski, 2008)

In terms of world production of GM crops, 181.5 million hectares were cultivated in 2014, in 28 countries in the world. The world top producers are United States, Brazil, Argentina, India, Canada and China.

6 Bt COTTON PRODUCTION ANALYSIS IN BURKINA FASO

6.1 Burkina Faso geography and climate

Burkina Faso is a landlocked, Sub-Saharan, country in West Africa inhabited by 17.8 million of people and covering 274,220 km^2 of land area, of which 120,700 km^2 is an agricultural land. Capital city is Ouagadougou, national language is French. When independence on France was proclaimed in August 1960, country was named Upper Volta. This name remained until 1984, when it got the name Burkina Faso. (Encyclopædia Britannica, 2015)

Burkina is one of the poorest countries in the world, with annual (2013) GDP of $12.88 million, GDP (2013) per capita $760.9, and annual growth of 6% in the same year. Burkina Faso is listed by UNTACD as one of the LDCs. (The World Bank, 2013)

Around 90% of inhabitants work in agriculture, covering 33% of GDP while cotton is the main cash crop. (The World Bank, 2013) Together with gold, cotton represents the key export article and therefore Burkina's economy relies on global prices of those two commodities. Other economy revenues come from livestock, sugar and fruit, which is being exported to other African countries. (Encyclopædia Britannica, 2015)

Burkina Faso has a primarily tropical climate with two very distinct seasons, rainy season and dry season. During the rainy season the country receives between 600 and 900 millimetres of rainfall; in the dry season, the harmattan, a hot dry wind from the Sahara, blows. The rainy season lasts approximately four months, from May / June to September, and is shorter in the north of the country. Three climatic zones can be defined: the Sahel, the Sudan-Sahel, and the Sudan-Guinea. The Sahel in the north typically receives less than 600 mm of rainfall per year and has high temperatures, 5–47 °C. A relatively dry tropical savanna, the Sahel extends beyond the borders of Burkina Faso, and borders the Sahara to its north and the fertile region of the Sudan to the South. The Sudan-Sahel region is a transitional zone with regards to rainfall and temperature. Further to the south, the Sudan-Guinea zone receives more than 900 mm of rain each year and has cooler average temperatures. (World Weather and Climate Information)

Burkina Faso is a member of ECOWAS, which associates almost all the states in western Africa, and its main aim is to coordinate economic activity through the region. (Encyclopædia Britannica, 2015)

6.2 Agriculture in Burkina Faso

Around 90% of economically active population work in agriculture that covers 33% of the country´s GDP and cotton is the main cash crop when 99% production is being exported. (The World Bank, 2014) Together with gold, cotton represents the key export commodity and therefore Burkina Faso economy relies on global prices of these two commodities. Other share of economy comes from livestock, sugar and fruit, which is being exported to other African countries. Among other crops grown belong sorghum, millet, corn, rice and she a nuts – they predominantly serve for local consumption. 90% of country's export comes from agricultural sector. (Encyclopædia Britannica, 2015)

6.3 Cotton production in Burkina Faso

As mentioned above, cotton is the key cash crop for Burkina Faso. Although it accounts for a small share of GDP, it is a key source of livelihood for rural population and a catalyst for economic development. Cotton production is therefore strongly interconnected with the needful improvements in infrastructure such as construction of schools, roads and hospitals. However, this economic sector deals with numerous problems. Farmers have to cope with weather changes, fluctuation in international purchase prices and exchange rates and last, but not least threats resulting from pests, use of pesticides and either water shortage or excess.

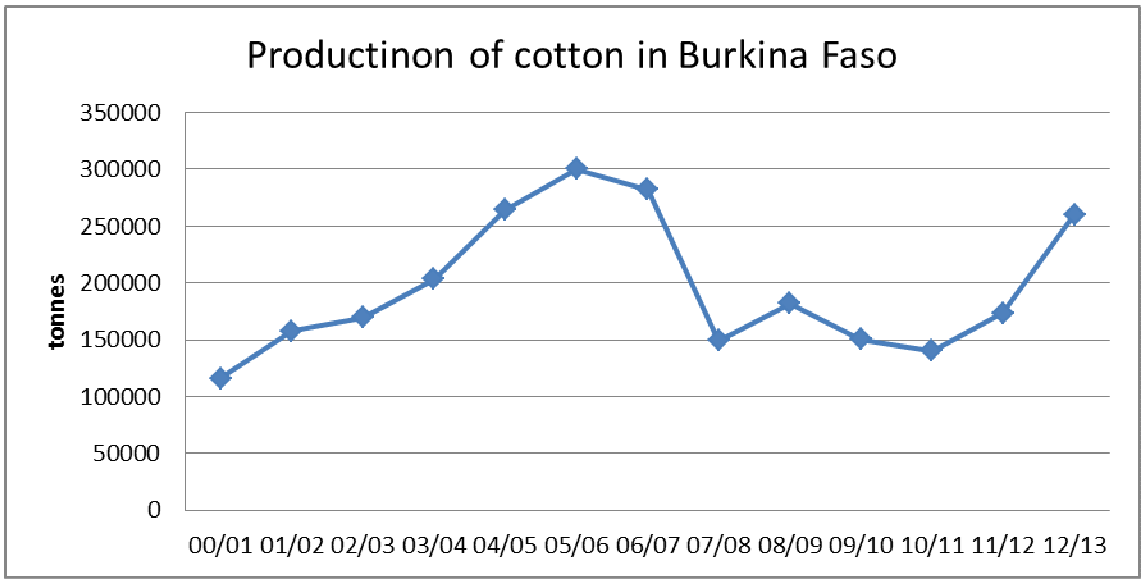

Figure 3: Production of cotton in Burkina Faso (source: own elaboration according to ICAC.com)

Cotton growing began during the French colonization in the first half of the 19th century. The large-scale production was launched during the Green Revolution when the improvements in technologies enabled the crop production intensification. It included, for instance, the development of new conventional cotton strains and the implementation of modern fertilizers, pesticides and insecticides. Yields increased from approximately 200 kg per hectare in 1963 to 1400 kg per hectare in the middle of the 1980s. (Vitale, 2011)

Cotton growing was initially concentrated in drier, semi-arid areas. Although more humid localities provided higher yields, cotton grown in such areas was by far exposed to risks of insects and diseases. (Traore et al. 2008) In 1990s, cotton production started to expand to the wet areas and therefore the total area of land cultivated with cotton increased significantly. Due to the abovementioned risks and hazards resulting from the climate, the application of new methods and agents to secure the crop protection was inevitable.

A remarkable growth of production, an increase of nearly three-fold, was achieved between the second half of the 1990s and mid-2000s. This was due to several factors.

Firstly, it was owing to the expansion of cultivated land, especially in the earlier years. The cultivated land expanded from 74,000 hectares in 1981 to 406,000 hectares in 2003, bringing to relief the issue of long-term land sustainability. Secondly, there was a fundamental influence of structural reforms carried out by the government. The important change resulted from the implementation of the principle of "free-adhesion." It allowed farmers to join production groups individually instead of being tied to a village allegiance. This fact helped to increase incentive and self-initiative. Another change resided in passing responsibility for coordination of the sector to an inter-professional association comprised of the national farmers' and ginners' associations. These reforms encouraged better market coordination and more self-enforcement of contracts. Thirdly, the better efficiency and bigger volume of production were also achieved due to the facilitation of access to finance and inputs for small farmers, the change in transportation services from public to private sector, better training in irrigation and crop rotation, supply of higher quality seeds to farmers and last but not least, more efficient application of GMO technology.

Nowadays, the cotton sector stands for around 4% of Burkina Faso GDP, 18% of all export and employs about 15 – 20 % of all Burkinabe citizens.

Cotton is produced in Burkina Faso generally by smallholder farmers using mainly household labour. Its production is divided among three main companies. SOFITEX that is the state-owned ginning company, and SOCOMA and Faso Cotton which are owned by a mix of private investors, both foreign and domestic, as well as quasi-state actors such as the Burkinabé transportation company (SOBA). These two companies currently control roughly 20 percent of production. (Redifer et al. 2014)

6.4 Bt cotton in Burkina Faso

At the beginning of new millennium, Burkina Faso was facing significant problems with cotton production. The main issue were pest damages caused by main cotton pest Helicoverpa armigera. On that account, in 2003, they began tests with Monsanto's GM version of cotton – Bollgard II Conventional cotton and GM cotton were compared in test centre in order to assess efficiency of the new GM cotton. The final results were

positive, Bollgard II had a 38% increase in yields comparing to conventional cotton. (Traore et. al. 2008)

Burkina Faso approved Bt cotton for commercial cultivation in 2006, but the first genuine experience with Bt cotton was realized in 2008, when approximately 8,500 ha of Bt cotton was planted. At that time, Burkina was already behind with Bt cotton growing as nine other countries had already been cultivating it. An adoption of Bt cotton in Burkina Faso is being considered a "test" of biotechnology in the region and it is highly likely that if positive impacts prevail, other three remaining countries out of C4 (cotton four) countries from the West African region – Mali, Chad, and Benin, will follow Burkina Faso and also adopt biotechnology.

At present, Burkina Faso is one of the three countries in African continent, together with South African Republic and Sudan that commercially grow GM crops. Although the majority of the "black continent" remains sceptic to biotechnology, other seven countries (Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria, and Uganda) have already been performing field tests with genetically modified crops, namely maize, rice, sorghum, wheat, bananas, sweet potato and cassava. (Clive, 2014)

Total cotton planted in Burkina Faso in 2013 was 690,971 hectares compared with 615,796 hectares in 2012, equivalent to a 12% increase over 2012, despite the fact that global hectares of cotton was down significantly by 10 to 15%. Out of 690,971 total cotton hectares, 474,229 hectares or 69% were planted to Bt cotton (BGII), an increase of 51% in 2013 from 313,781 hectares in 2012. Based on average cotton holding of 3.16 hectares the number of farmers growing Bt cotton in 2013 was approximately 150,072. The increase in total cotton area was principally due to the fact that success with Bt cotton and the benefits that it offers has provided the incentive for Burkina Faso farmers to increase planting of Bt Cotton. (ISAAA, 2014)

7 ANALYSIS OF Bt COTTON ADOPTION IN BURKINA FASO

Adoption of GM plants always brings changes into the country´s economy and has influence on various socioeconomic aspects. The same applies to Burkina Faso. There are several indicators which demonstrate these impacts. The defining year is 2008 because it is a year when Bt cotton was adopted and its production began.

7.1 Share of agricultural and arable land in Burkina Faso

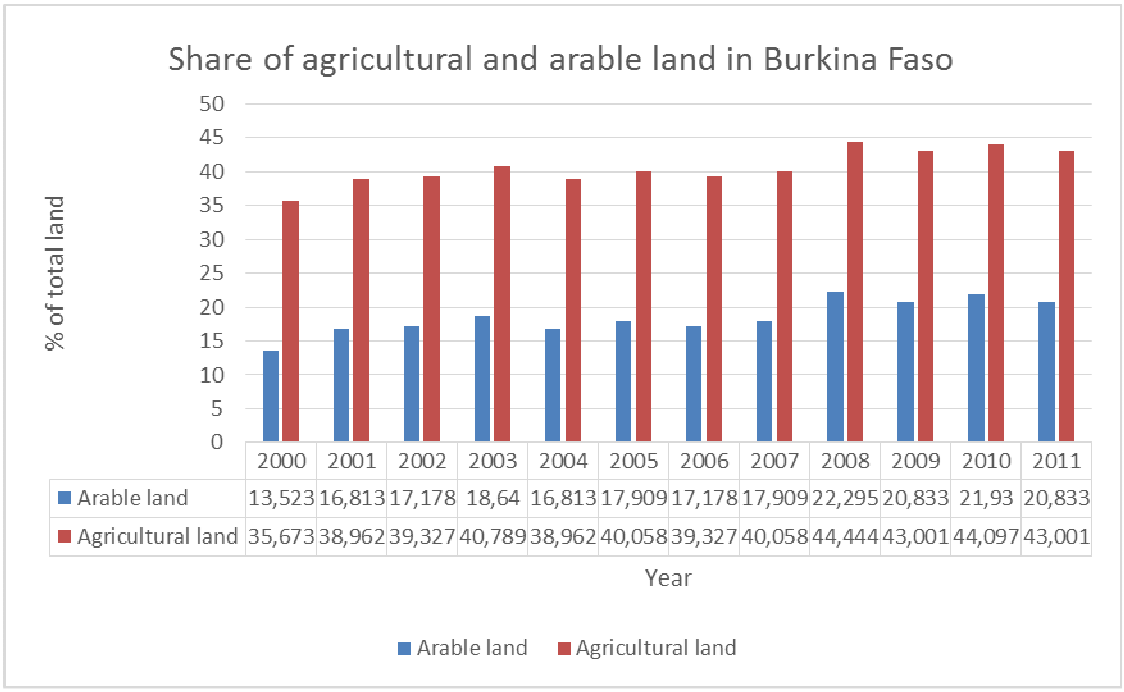

Figure 4: Share of agricultural and arable land in Burkina Faso (source: own elaboration according to Worldbank.org)

In the selected period, there is a gradual increase in both agricultural and arable land with occasional drops in both cases. Between 2000 and 2007, the total area of arable land expanded from 13,523 ha to 17,909 ha which is an increase of 4,386 ha (approx. 32 %). At 2008, the arable area reached 22,295 ha, which represents a 12 % increase against the previous year. In 2011, the total area of arable land was 20,833 ha which represents a 7 % decrease against 2008.

A similar situation is as for the agricultural land. The data between 2000 and 2007 show that agricultural land area expanded about 12 % (4,325 ha). In 2008, there was an increase up to 44,444 which is a growth of 11%. In 2011, total area of agricultural land slightly decreased to 43,000 ha (approx. 3%).

There was an increase in both arable and agricultural lands after implementation of Bt cotton in 2008, however the total area of arable land in 2011 was only 7% larger than before Bt cotton and agricultural land expanded about 8 % in comparison with the era before Bt cotton. It can be said the Bt cultivation enlarged the land used for agricultural purposes between 7 and 8 %. In my opinion, the main reason for gradual expansion of land used for agricultural purposes in Burkina Faso is the annual increase in population which is approx. 3% (Worldbank.org). In a long run it causes that the number of people converting land for farming rises which is indicated by the fact that an average arable land per person has been 0,36 Ha for the last few years (Worldbank.org.) If this trend continues, the Burkinabé people will face serious problems with agricultural land.

7.2 Share of agricultural land of total land in C4 countries

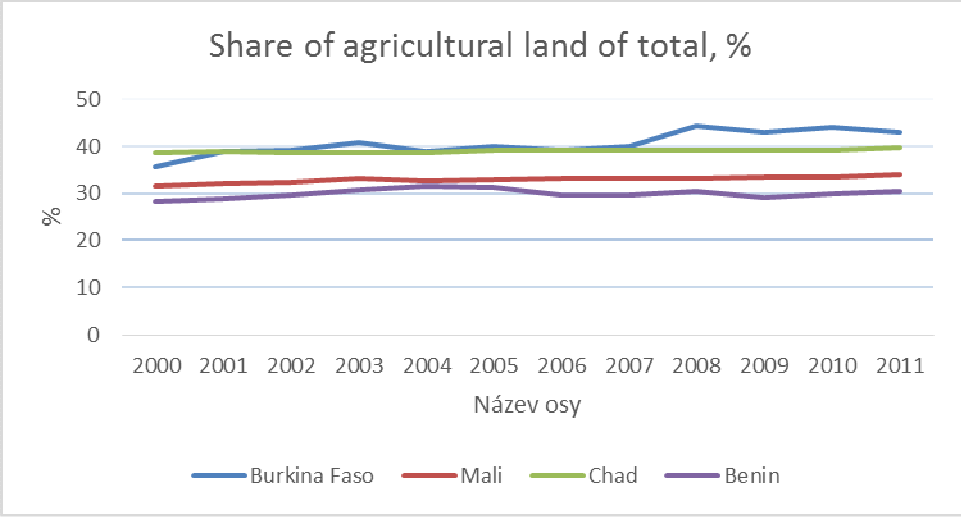

Figure 5: Share of agricultural land of total land in C4 countries (source: own elaboration based on data from Worldbank.org)

C4 countries include four West African countries – Burkina Faso, Mali, Chad and Benin. The dominant economic sector and thus a major source of income in all countries is agriculture and they all cultivate cotton. From the graph in figure 5 results that Burkina Faso is the only country whose share of agricultural land increased between 2008 and 2009, approximately by 10% (from 40% to 44%). In case of remaining C4 countries, no changes can be observed. It proves that such increase was due to implementation of Bt cotton in Burkina Faso which also led to an overall increase of cotton planted.

7.3 Total cereal production including maize, sorghum, millet and rice

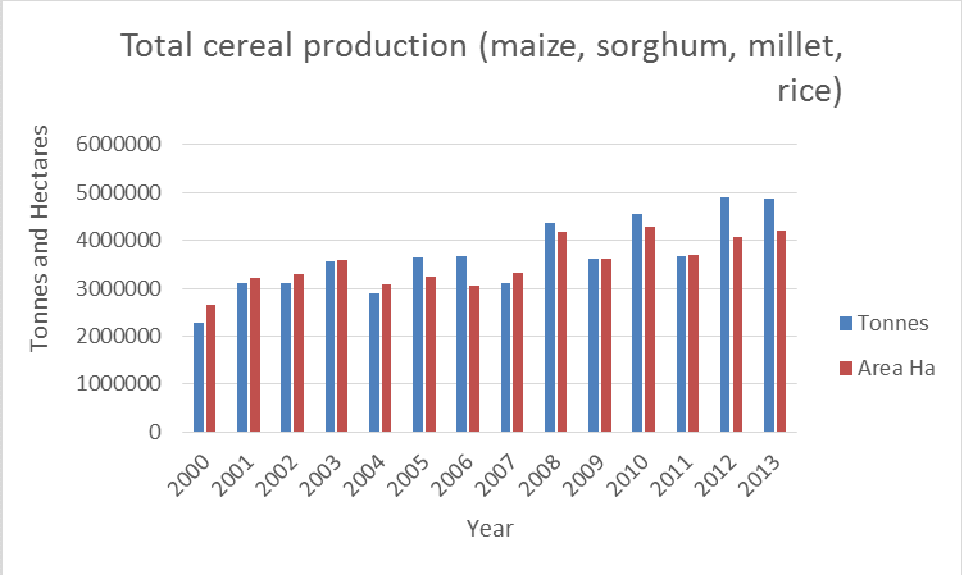

Figure 6: Total output and area of major crops produced in Burkina Faso - maize, sorghum, millet, rice (excluding cotton) (source: own elaboration according to data from Worldbank.org)

Among other major agricultural products cultivated in Burkina Faso belong maize, sorghum, millet and rice. The table shows that total amount and area of these crops produced in Burkina Faso between 2000 and 2013. Between 2008 and 2009, when Bt

cotton became to be largely planted, no significant change in other crop production occurred. In some cases, conventional crops are being forced out of production in favour of genetically modified crops due to their economic benefits. However, according to my estimate, this is not a case in Burkina Faso.

7.4 Value of agricultural production

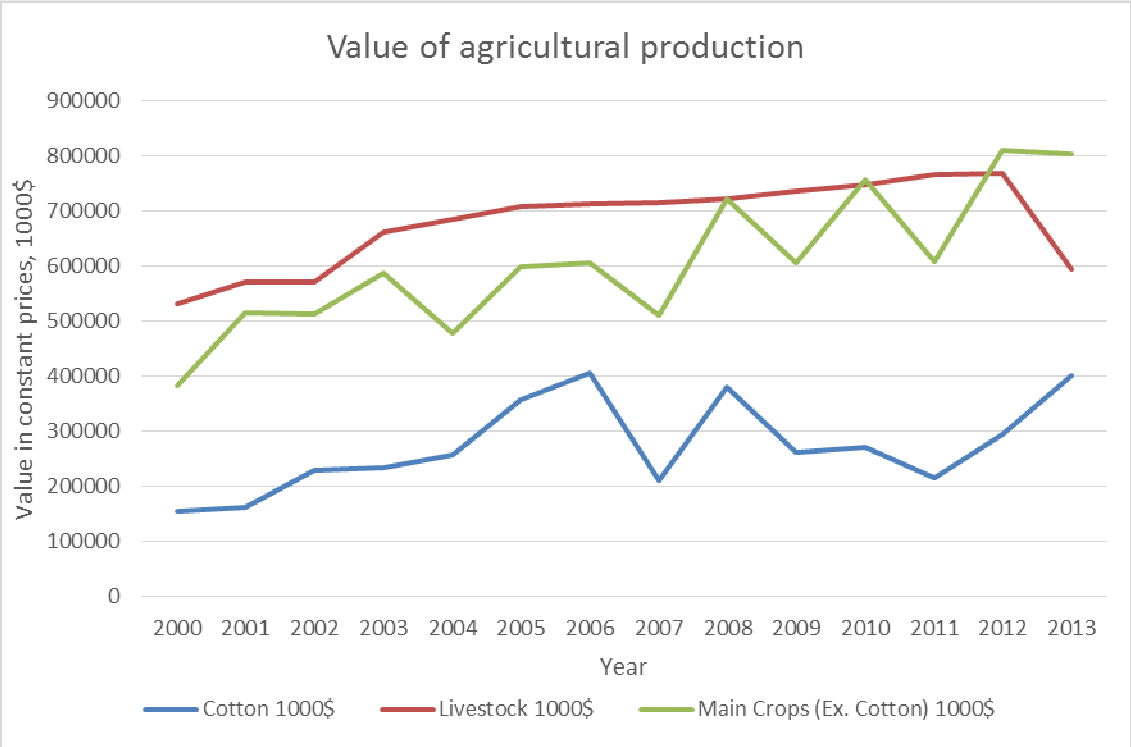

Figure 7: Value of agricultural production in Burkina Faso in constant prices, 1000$ (source: own elaboration according to data from Worldbank.org)

The Burkina Faso economy relies heavily on agricultural sector and mining. In the beginning 2011, Burkina Faso faced upheaval caused by political situation which had an influence in many areas including the judicial system, army, police, administration as well as agriculture that was affected by the above mentioned turmoil but also climate issues such as several droughts. They were the main cause of lower output of this sector,

which dropped by 12% (Refirer et al. 2014). This situation can be observed in fig. 7, where the significant fall in crop production is demonstrated. Surprisingly, the problems did not affect livestock production, and even GDP remained growing, annually at 5% (Worldbank.org).

7.5 Cotton production

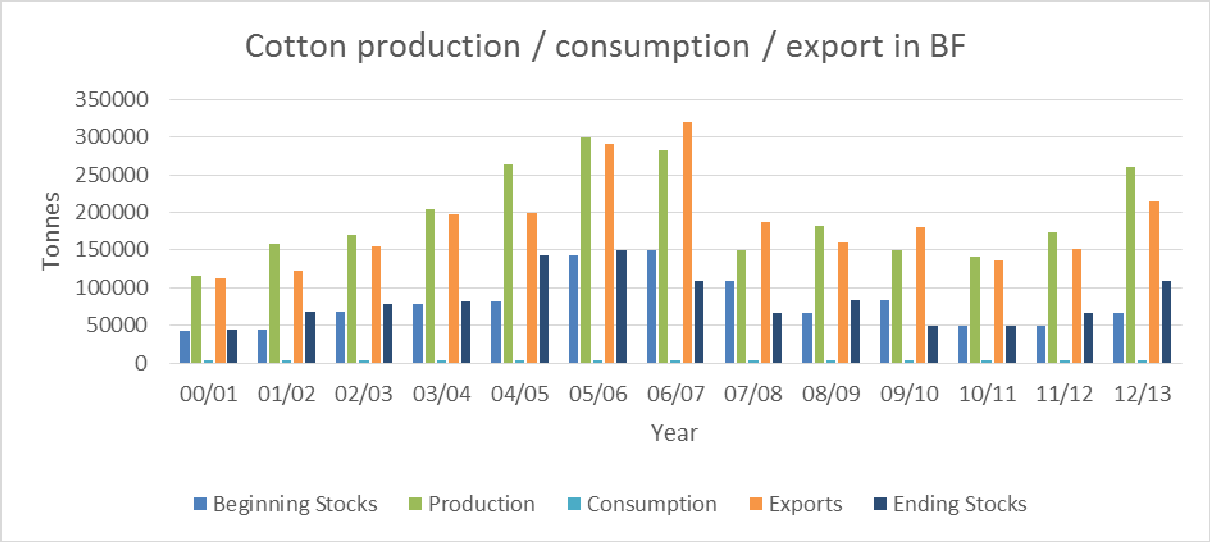

Figure 8: Cotton production, consumption and exports in Burkina Faso (source: own elaboration based on data from ICAC)

The data from figure 8 show that majority of cotton production is exported the same year as it is produced. Unsold cotton is stocked and sold later. As for domestic consumption, only a small amount (approximately 4,000 tons per year) is consumed within the country. From the figure above, a significant fall in overall cotton production in 2007/2008 can be observed. This decrease was due to several reasons, i.e. bad weather conditions, decrease of purchasing prices and increased inputs. (OECD, 2008) Due to this situation, farmers began in larger scale cultivate food crops, as seen in figure 6.

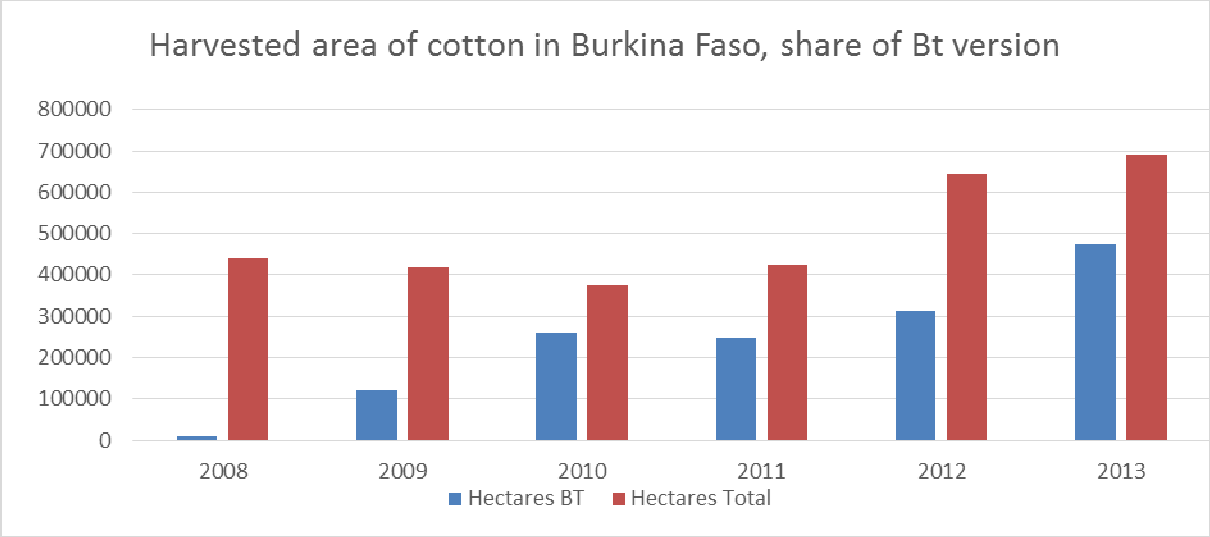

Figure 9: Harvested area of cotton in Burkina Faso, share of Bt version (source: own elaboration based on data from Isaaa.org)

In figure 9, the share of Bt cotton in terms of harvested area is compared to conventional cotton. Despite the fact, that cotton industry was in crisis between 2007 and 2011, production of Bt cotton kept rising right from its implementation in 2008. In 2013, 69% of all cotton acreage was genetically modified.

7.6 Yields

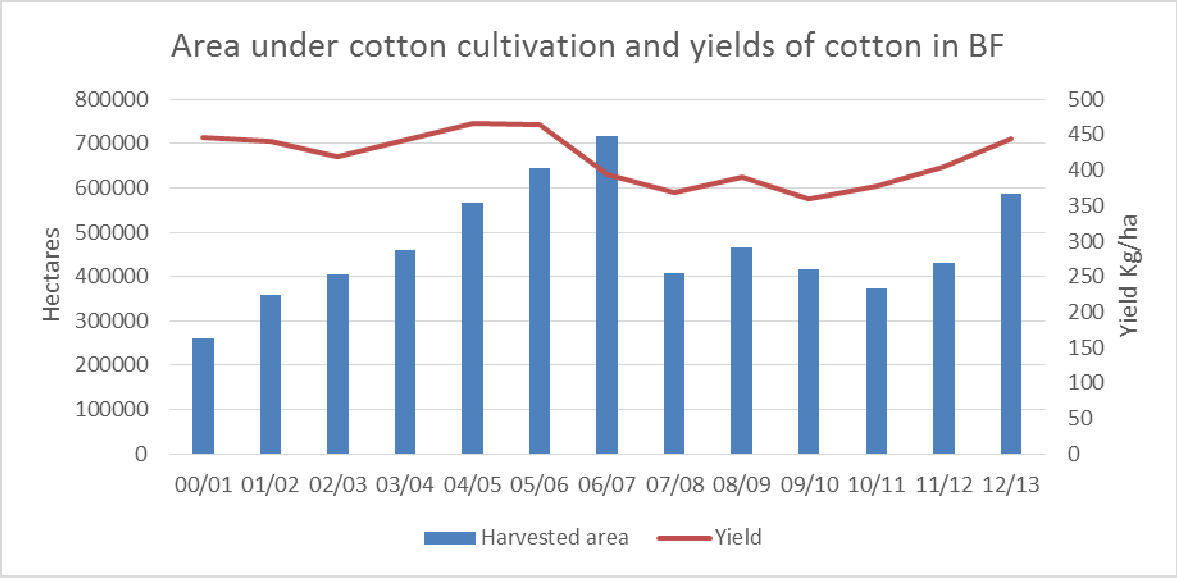

Figure 10: Area under cotton cultivation and yields of cotton in Burkina Faso (source: own elaboration based on data from ICAC)

Yields are one of the most important indicators of agronomic production. In figure 10, several important figures can be processed. In 2000 / 2001, cotton planted area covered around 300,000 ha. As mentioned in chapter 6.4.1., at that time Burkina Faso faced significant problems with pests, mainly with Helicoverpa armigera. However, no significant changes in yields occurred till 2007, when the problems with the weather, governance and social protests together with low cotton market prices and higher price of pesticides caused a significant decline in yields.

7.7 Bt cotton yields advantage

As demonstrated in table 1 comparison shows conventional and Bt cotton yields. Bt cotton (Bollgard II) generates in an average 18% higher yields than conventional cotton. Vitale also states, that yields differ depending on growing zones – the highest yields were reached by Faso Cotton (36,6%), followed by SOFITEX (16,5%) and SOCOMA (14,3%)

Table 1: Comparison of Bt cotton and conventional cotton yields (source: own elaboration according to Vitale, 2010)

Cotton version	Yields kg Ha $^{-1}$
BG II	1,178
Conventional	997
Avarage yield	1,087
BG II yield advantage %	18,2

7.8 Use of pesticides and fertilizers

One of the most important reasons why Bt cotton has been adopted in Burkina Faso was to lower the pesticide inputs. It has a significant impact not only on total input costs, but also on the land fertility so it is beneficial for both farmers and the whole economy. As demonstrated in figure 11, overall use of pesticides decreased significantly in 2010, after Bt cotton began to predominate over conventional cotton. According to Vitale J.

(2010), the need of pesticide application during the Bt cultivation process was reduced from 6 sprays in case of conventional cotton to mere 2 sprays as for Bt cotton.

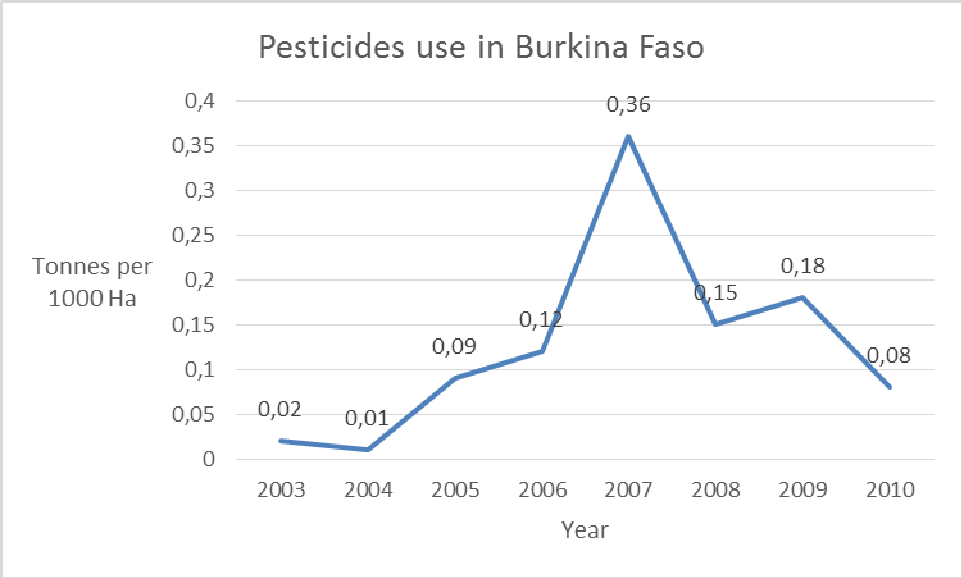

Figure 11: Pesticide use in Burkina Faso (source: own elaboration according to data from Faostat.fao.org)

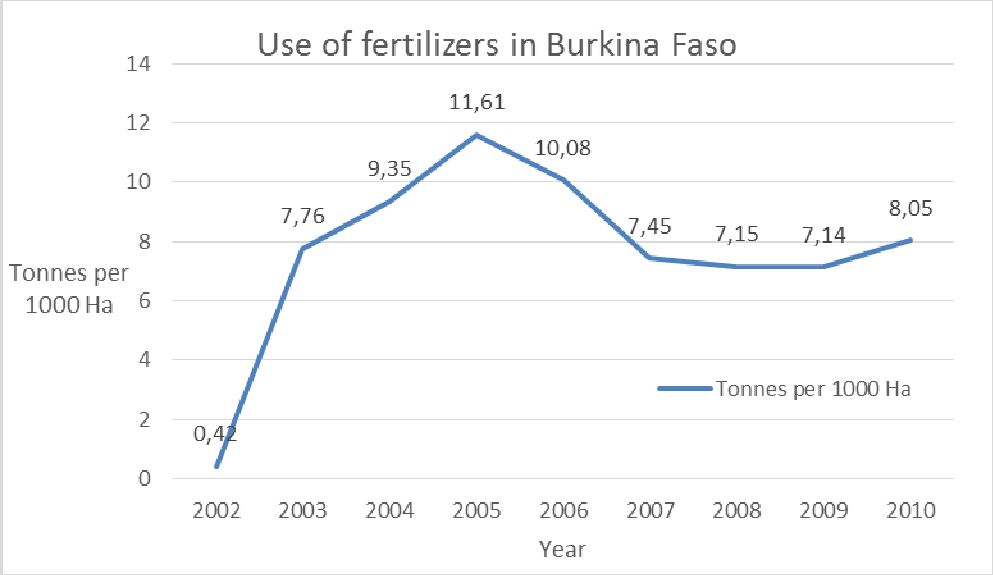

Figure 12: Use of fertilizers in Burkina Faso (source: own elaboration based on data from Faostat.fao.org)

As seen in figure 12, the use of fertilizers did not change after implementation of Bt cotton. This is also demonstrated in table 2, where approximately same amounts of fertilizer inputs can be observed.

7.9 Comparison of inputs

Table 2 contains a comparison of all inputs. According to this table, costs of overall conventional cotton inputs do not significantly differ from those needed for Bt cotton production. Concerning conventional cotton there is a higher cost for insecticides, while on the Bt cotton side the cost of insecticides is lowered due to its small use. However, this cost is replaced by cost of seed, which are intellectual property of Monsanto and therefore farmers have to buy those every year for a much higher amount of money then farmer buying conventional cotton seeds. As labour and cost of fertilizers and herbicides remains the same for both of the variations, the overall cost of production per hectare is almost the same – more accurate cost of Bt cotton is lightly more expensive, however, this is subtitled with higher yields.

Table 2: Inputs comparison for Bt and conventional cotton (source: own elaboration based on data from Vitale. D, 2010)

Inputs	Costs - $ per ha
Bt cotton - Bolgard II	
Insectides	5,42
Seed cost	62,36
Labor	143,75
Fert & herb	168,29
Total cost	379,83
Conventional cotton	
Insecticides	58
Seed cost	8,88
Labor	142,04
Fert & herb	168,29
Total cost	377,21
Cost comparison: BGII-Conv.	2,62

7.10 Economical advantages of Bt cotton

As mentioned above, due to expensive seeds there is no advantage in terms of production costs. However, thanks to higher yields by approximately 18%, it brings an economical advantage.

Since the implementation of Bt cotton, several studies have been made in order to measure its economic impact. In all studies, Bt cotton made a higher economic profit over conventional cotton. In 2009, the increased cotton income resulting from growing Bt cotton was by average $61,88 / ha. (Vitale, 2010)

Total Bt cotton revenue amounted at $186.9 million until 2012. (Clive, 2014)

CONCLUSION

The introduction of genetically modified plants has brought about important changes for the economies of countries that decided to start with their production. As the majority of these countries are or, until recently, were considered to be developing countries, it is obvious that such production significantly influences the country´s economy, agriculture and environment. This thesis dealt with various aspects accompanying the adoption of genetically modified crops such as the globalization process, its main institutions and the influence of multinational corporations in the developing countries. The crop chosen for further research is Bt cotton. On that account, the conventional cotton, its use and history were described at first in order to explain the reasons for its genetic modification, i.e. the improved qualities concerning pest resistance, herbicide tolerance and thus the increased yields. The country chosen for its Bt cotton production is Burkina Faso because it is one of the most progressive countries in African continent regarding biotechnology and it is actually a leading producer of Bt cotton in Africa.

Cotton is one of the leading crops in developing countries that provide major work opportunities for local citizens. Even though the share of GDP from cotton production is low, it still represents the major share of exports. Efforts that accompany increasing production usually bring negative externalities. Before the introduction of Bt cotton, the farmers in Burkina Faso suffered from the significant production losses due to pests. The biggest influence of Bt cotton adoption concerns the reduction of insecticides. On the other hand, the controversy concerning high prices of modified seeds remains. This fact negates the benefits of lowering the use of pesticides. Nevertheless, owing to higher yields, overall income for farmers producing Bt cotton is significantly higher in comparison with the production of conventional cotton. Environmental impacts cannot be assumed yet as the introduction of Bt cotton is rather new matter and there is a lack of data available on this issue. In my opinion, negative environmental externalities may come as degradation of soil fertility caused by damaged biodiversity in the era of intensive agriculture.

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UN – United Nations

OECD – Organisation for Economic Co-operation and Development International

IMF – International Monetary Fund

WB – World Bank

NGOs – Non-governmental organizations

MNCs – Multinational corporations

FDI – Foreign direct investment

WTO – World Trade Organization

IBRD – International Bank for Reconstruction and Development

GATT – General Agreement on Tariffs and Trade

GNI – Gross national income

LDCs – Least developed countries

GDP – Gross domestic product

Bt – Bacillus thuringiensis

EMS – Ethyl methanesulfonate

DNA – Deoxyribonucleic acid

GM – Genetically modified

GMO – Genetically modified organism

BF – Burkina Faso