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AGRICULTURAL BIOTECHNOLOGY AND DEVELOPING COUNTRIES: THE CASE OF THE TURKISH COTTON SECTOR

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ABSTRACT

This thesis describes and analyses the present situation for agricultural biotechnology in Turkey and relates the situation in Turkey, as a developing country, to the global situation for biotechnology in agriculture. The thesis describes and analyses present and future applications of biotechnology in Turkey with special emphasis on the Turkish cotton sector. Emphasis is also put on the preconditions necessary for introducing modern biotechnology in the Turkish cotton sector.

In order to describe and analyse the innovative environment in the Turkish cotton sector with respect to biotechnology, the national system of innovation approach is used as a conceptual framework. The systems of innovation approach is based upon interactive learning theories and evolutionary economical theory. The process of innovation is at the centre of analysis in the approach, and the basic assumption is that innovation and technological change are the foundation of economical growth.

By using the national system of innovation approach as a conceptual framework, the application of biotechnology to the Turkish cotton sector is analysed in a national context, where nation specific factors are taken into account.

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1. INTRODUCTION

1.1. The Objective of the Thesis

The objective of the thesis is to describe and analyse the present situation for agricultural biotechnology in Turkey and relate the situation in Turkey, as a developing country[1], to the global situation for biotechnology in agriculture. The thesis will specifically focus upon the situation of the Turkish cotton sector with respect to plant biotechnology, and is a socio-economical study of the innovative environment in the Turkish cotton sector, with special emphasis on the developments of biotechnology in this sector.

Biotechnology is a science based technology, which demands for strong R&D capacity. This high requirement for scientific input has resulted in knowledge generation only in a few industrialised countries (Gozen, 1997). The developments in biotechnology, which started as basic research in public research organisations, has followed a tendency towards increasing dominance of the private sector. Commercialisation accompanied the development of biotechnology from the very early stages, initially by small venture capital firms and later by multinational corporations in expectations of substantial profits (Gozen, 1997: 111).

As for many developing countries, the level of biotechnological activities is low in Turkey. Modern biotechnology in Turkey is primarily at the research level, with very few examples of commercial applications. The most widespread research activities on the field of biotechnology in Turkey is in plant biotechnology, however, the capabilities reached is quite low by international standards, and there is very little diffusion of the technology in agriculture (Gozen, 1997).

When applying agricultural biotechnology to developing country agriculture the characteristics particular to modern biotechnology must be taken into consideration. These characteristics include high development costs, new demands for financial and managerial resources, opportunities for international collaboration, the possibility of negative public perception and increasing needs for laws and regulations related to biosafety and intellectual property rights (Cohen, Falconi and Komen 1999). Taking these considerations into account,

[1] See classification of the Turkish economy in Appendix. The intention of the thesis is not to address the situation for all developing countries. Taking into account the broad and differing group of countries referred to

the thesis will describe and analyse the present and future applications of biotechnology in Turkey, with special emphasis on the Turkish cotton sector. The main question posed is:

- What are the preconditions necessary for introducing modern biotechnology in the Turkish cotton sector?

1.2. The Theoretical Framework

In order to describe and analyse the innovative environment in the Turkish cotton sector the national systems of innovation approach will be used as a conceptual framework. The systems of innovation approach is based upon interactive learning theories and evolutionary economical theory. The process of innovation is at the centre of analysis in the approach, and the basic assumption is that innovation and technical change are the foundation of economical growth. The national system of innovation approach will be used as a conceptual framework for describing and analysing the innovative environment in the Turkish cotton sector, and for analysing the preconditions necessary for introducing modern biotechnology in this sector. In order to describe the situation for biotechnology in the cotton sector, the biotechnological innovation system in Turkey will also be described on a more general level and related to the innovation system in the cotton sector. The global situation for biotechnology in agriculture will also be related to the described innovation system.

1.3 Methodology

The analysis is descriptive in its form, evaluating the nature of an innovation system, the actors involved in the system, and the relations between the various actors. In order to perform such a descriptive analysis the collected data are both quantitative and qualitative.

The quantitative data are primarily used for descriptive purposes related to portray the picture of modern biotechnology globally and in Turkey, the distribution of GM crops on a global scale, the situation for science and technology in Turkey and the situation for cotton on a global scale and in Turkey. The qualitative data are used in the description of the various actors and the relations between them. The qualitative data are also used to describe various factors that influence the innovation systems like regulations and laws, the national economy, international agreements and national policies.

The sources used are both primary and secondary. The primary sources has been collected by performing informal interviews with representatives of the actors in the innovation

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as having a developing economy, some aspects of the addressed theme that may apply to many developing countries in general, and to Turkey in particular, will be pointed out.

systems. The secondary sources are all based on written documents gathered from scientific publications, official documents, information brochures, reports and abstracts. Information on the World Wide Web have also been used as secondary sources.

The description and analysis of the innovation system in the Turkish cotton sector are based, to a large extent, on informal interviews with representatives of different actors in the system. The extensive use of interviews as sources of information is caused by a combination of language barriers and few available written sources on the field. There are only limited scientific studies that have been addressing the issue of biotechnology in Turkey, and only a few of these are available in English. Other written sources like official documents, government policies, reports and information brochures are only rarely available in English and the ones that exist in English probably cannot give a complete picture of the situation in the cotton sector and for biotechnology in Turkey. Consequently, informal interviews have been used as important sources of information about the various actors in the innovation system, their activities with respect to research, development and distribution, and about the relations between the various actors in the system.

When using informal interviews as important sources, the danger of not getting objective information has to be taken into account. However, in an analysis where the communication between people and the relations between the various actors is focused upon, the subjective opinion of the people in question will be relevant.

1.4. The Structure of the Thesis

The analysis of the biotechnological innovation system in Turkey will be conducted on two levels, a macro level and a micro level.

Chapter 2 will be outlining the theoretical framework, describing the background of the national system of innovation approach and outlining a conceptual framework for integrating biotechnology in a national system of innovation approach.

Chapter 3 will be describing the biotechnological innovation system in Turkey on a macro level, where national policies, the general level of biotechnology in Turkey, the education system, national and international laws and regulations and the financial environment will be taken into account.

Chapter 4 will be describing the biotechnological innovation system in the Turkish cotton sector on a micro level, where emphasis will be put on the individual actors in the system as well as the relations between them.

Chapter 5 will summarise the thesis and outline main arguments an policy implications.

2. THEORETICAL FRAMEWORK

2.1. Introduction

The description and analysis of the Turkish cotton sector will be conducted by using the national system of innovation approach. The "systems of innovation" is a new approach for studying innovation and technical change that has emerged during the last decade (Edquist, 1997: 1). It is an economical approach placing innovation at the centre of analysis when analysing how the process of innovation influences economical growth. The basic assumption is that innovation and technical change is the basis of economical growth. The national system of innovation approach is based upon interactive learning theories and evolutionary economical theory.

2.2. The Systems of Innovation Approach

In the systems of innovation approach innovation refers to a process rather than a single event. Innovations are new creations of economic significance, either radically new or as new combinations of already existing knowledge (Edquist, 1997:19). An innovation might be radical or of an incremental character and the innovation process might result in new or improved products but also in organisational improvements or improvements of production methods. In other words, the outcome of the innovation process does not necessarily have to be a tangible product but can result in a wide range of improvements or changes that causes technical change. Technical change or technological development as a consequence might be both tangible or intangible, products or processes. The innovation process is a complex process involving interactive connections between several actors. The complexity of the process involves emergence and diffusion of knowledge elements and the transformation of these into new products and production processes. The innovation process does not follow a linear path starting from research followed by applied research, the development of new products and finally the diffusion of these products. The innovation process is rather looked upon as a complicated process involving several actors interacting in complicated feedback mechanisms involving science, technology, learning, production, policy and demand (Edquist, 1997:2). The innovation process is time consuming and almost never occur in isolation performed by a single actor. In the system of innovation approach the process of innovation is looked upon by using a system approach, where the system involves all of the actors that participate or influence the innovation process in any respect.

The systems of innovation approach is not considered a formal and established theory, but rather as a conceptual framework for the study of innovation and technological change and their role in economical development. Although the systems of innovation approach is not considered an established theory, its development has been influenced by different theories of innovation such as interactive learning theories and evolutionary theories (Edquist, 1997: 5). The relation to interactive learning theories has especially been developed by Bengt Åke Lundvall and the IKE group at Aalborg University. Innovation should be considered as a process rather than as a single event. The innovation process is considered as an interactive process. It is assumed that knowledge is the most important resource and that learning is the most important process (Lundvall, 1992:1). The essence of interactive learning theories is that the overall innovation performance of an economy not only depends on how specific organisations like firms and research institutions perform individually, but also on how they interact with each other and other actors in the economy. Innovation is regarded as an interactive process where complicated feedback mechanisms and interactive relations between different actors is necessary for the innovation process to occur successfully. Knowledge is also a factor that is highly validated, and knowledge is distributed through relations and interactions within the system.

Many innovation theories are based on the neo-classical argumentation in economical theory that the maximisation of profit is the base of the innovation process when it comes to generation and diffusion of innovations. In the systems of innovation approach it is taken into account that some of the actors and institutions involved in the innovation process are not primarily governed by profit seeking motivations. These actors may be governmental non-profit organisations like public universities or public research laboratories. Legal conditions, rules and norms will also significantly affect the innovation process when non-profit and profit oriented actors in the economy interact with each other in the innovation process. Nelson and Winter propose that it can be understood as an evolutionary process based upon the evolutionary theory in biology (Edquist, 1997: 6). In the biological evolutionary theory novelties are brought into the system as mutations in the genotypes, here referred to as innovations. The innovations are selected in the system by the market in a market selection process, which is analogue in the approach to the natural selection process performed by the environment in biological theory. There is considerable randomness in the system, where the selection process performed by forces in the market is not always based on “the optimal solution”, because various factors or actors are influencing the selection process. As a result the system never reaches a stage of equilibrium because the various actors and factors in the market will go through continuos changes. The process is also time consuming because the process through which new technologies are screened, selected and implemented takes considerable time. The fact that the systems of innovation approach places technological change at the very centre of focus also differs from neo-classical analysis, where technological change is treated as an exogenous factor.

The systems of innovation approach is open towards several interpretations and can be used in various contexts depending on the nature of the innovation system that is investigated. The actors that are relevant for a specific innovation system can be identified depending on the circumstances and the nature of the system. The nature of the system, the actors involved and the circumstances will consequently vary from case to case. Although they all have the system approach in common, the framework of analysis or the perspective may vary depending on the theoretical approach. The systems of innovation approach may be supranational, national, or subnational and at the same time they may be sectoral within all of these geographical demarcations (Edquist, 1997:12). This means that the level of analysis is determined by the geographical or sectoral boundaries that are defined as the framework of the system. The system might be limited at the national level, at the regional level or at a sector level to mention some possibilities. Whether a system should be spatially or sectorally delimited depends on the object of study (Edquist, 1997:12). At the supranational level an innovation system can be global or include a part of the world like for instance the European Union. An innovation system may also be national, where the boundaries of the system is limited to a nation context. The regional level refers to an innovation system where the boundaries of the system is limited to a certain geographical region. When talking about a sectoral approach, the geographical dimension is not as important because the framework of the innovation system is defined at the technological level by studying a specific sector. This approach may include a part of an international system, a national system as well as a regional system depending on the sector of study.

2.3. The National System of Innovation Approach

The expression “national systems of innovation” was first published by Christopher Freeman in his book on technology policy and economic performance in Japan (Freeman 1997). In the early 1990s two major books on national systems of innovation were published

(Edquist, 1997:3). One of these books was edited by Bengt-Åke Lundvall (1992) and the other was written by Richard Nelson (1993). Following the publications of these books several publications where the concept of national systems of innovation is used have been written by various authors. The approach is now widely used in academic circles and in policy contexts by national governments and by international organisations like the European Union and the OECD (Edquist, 1997:3).

The book by Nelson entitled *National Systems of Innovation: A Comparative Study* (1993), is first an foremost empirically oriented and includes case studies from fifteen different countries using the national system of innovation approach. The book uses these empirical case studies to enlighten the approach. The book edited by Lundvall, *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning* (1992), is more theoretically oriented than the book by Nelson. One of the aims of the book is to demonstrate the need for an alternative economical theory that puts interactive learning and innovation at the centre of analysis (Lundvall, 1992: 1).

The national system of innovation approach connects the system of innovation approach to nation specific factors by limiting the boundaries of the system to a national context. The basic assumption in this approach is that nation specific factors like the institutional setting and the cultural context have to be taken into account when considering an innovation process and that these factors varies between different nations. It is emphasised that interactive learning and innovation is at the centre of analysis and that these processes cannot be analysed without taking the influence of the national environment into consideration. Lundvall says that:

> *It is assumed that learning is predominately an interactive, and therefor, a socially embedded process which cannot be understood without taking into consideration its institutional and cultural context (Lundvall, 1992:1).*

When determining in detail which sub-systems and social systems that should be included in, or excluded from the system Lundvall (1992) argues that this is a task involving both historical analysis as well as theoretical considerations. It is also argued that the actors that constitute the system will depend upon the context and for this reason the system of innovation must, to a certain degree, be kept open and flexible regarding which sub-system should be included and which processes should be studied (Lundvall, 1992:13). This implies that there is not one single approach to the national system of innovation that is the only legitimate one. However, Lundvall defines some elements or actors that might be important for the system. The focus upon national systems reflects the assumption that national economies differ regarding the structure of the production system and regarding the general institutional set-up. Basic differences in historical experience, language, and culture will be reflected in the internal organisation of firms, interfirm relationships, the role of the public sector, the institutional set-up of the financial sector, and R&D intensity and organisation (Lundvall, 1992:13). It is also emphasised that the relations between the different elements are just as important as the elements themselves. The importance of the internal organisations of firms is grounded on the importance of firms in the development process of innovations. In this respect the organisation of the flow of information and the learning process affect the innovative capability of the firm. The interfirm relationships are important objects of study according to Lundvall (1992) because competition and cooperation between firms affect the direction of a national innovation system. The public sector also influences the direction of the national innovation system according to Lundvall (1992) because its direct support of science and development, its standards and regulations influence the rate and direction of innovation. It is emphasised that the public sector is also an important user of innovations developed in private firms. The differences between different countries with respect to the financial system are also argued to affect the national system of innovation as well as the competencies, resources and organisation of the R&D system. Lundvall (1992) also points out the important role of the national education and training system.

Even though the national system of innovation approach is defined within a national context it is pointed out by Lundvall (1992) that the process of innovation is not localised exclusively inside national borders. The innovation process might be influenced by outside factors like multinational corporations, international cooperation between different organisations and the increasing openness in information flow across national borders. The fact that the national system of innovation is an open system is underlined and factors influencing the system do not necessarily have to be found inside a national context (Lundvall, 1992:15).

The national system of innovation approach can be looked at either from a broad perspective or from a narrow perspective. The broad perspective includes all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring (Lundvall, 1992: 12), meaning that all factors or actors in the economy that might influence the system, either directly or indirectly, is incorporated in the system. This perspective is in correlation with the theoretical framework presented by Lundvall (1992). The narrow perspective will only include actors that are directly involved in the innovation process. This would imply direct involvement in the organisation and sustainability of research, development, introduction, improvement and diffusion of new products and processes within a national economy (Freeman, 1997:312).

According to Lundvall (1992) the sharp boundaries of the system cannot be defined absolutely and the sub-system and elements constituting a specific case study will vary from case to case depending on the circumstances of the specific context. Although every case study will be different indeed, this vagueness in the definition of the boundaries of the system might cause conceptual problems when applying the approach in a study situation. According to Charles Edquist:

> *One way of specifying "system" is to include in it all important economic, social, political, organisational, institutional, and other factors that influence development, diffusion, and use of innovations. Potentially important elements cannot be excluded a priori if we are to be able to understand and explain innovation. Provided that the innovation concept has been specified, the crucial issue then becomes one of identifying all those important factors (Edquist, 1997:14)*

If the broad perspective on national systems of innovation is taken as the point of reference the system is open to all relevant actors and factors in the economy that might influence the innovation process, and the intention in the approach is that all of these actors should be taken into consideration. When using this broad perspective of the national system of innovation approach, the problem with identifying the boundaries of the system and the important actors in the system will probably arise because of the vagueness of the definition of the boundaries of the system. About these issues Edquist says:

> *In addition none of the major authors provide a sharp guide to what exactly should be included in a "(national) system of innovation"; they do not define the limits of the systems in an operational way. (...), both Nelson and Lundvall explicitly state that the boundaries are unspecific (Edquist, 1997:27)*

Another vagueness that might cause problems for the interpretation of the national system of innovation approach is the concept of institutions. The concept of institutions play a key role in all definitions of systems of innovation, but the concept of institutions is not always very clearly defined. The definition presented by Bjørn Johnson will be used in this thesis; *institutions are sets of habits, routines, rules, norms and laws, which regulate the relations between people and shape human interaction* (Johnson, 1992:26). There is made a distinction between formal and informal institutions. Formal institutions are codified like laws, whereas informal institutions are more tacit and must be indirectly observed by the behaviour of people and organisations (Edquist and Johnson, 1997: 50). Examples of formal institutions might be patent laws or governmental regulations while common law, customs, traditions, work norms, norms of cooperation, and practices might be examples of informal institutions. The relation between institutions and interactive learning is quite clear considering the definition of institutions as factors regulating the relations between people. Communication and interactions between people are the very base of interactive learning, and will clearly be influenced by relevant institutions.

By using this definition of institutions a clear distinction is made between institutions and organisations. Organisations are defined as formal structures that are consciously created with an explicit purpose (Edquist and Johnson, 1997: 47). Organisations are actors in the system, like firms, that participate in the innovation process. As Edquist and Johnson express it*; the organisations are the players and the institutions are the rules* (Edquist and Johnson, 1997: 57). Examples of organisations might be universities, regulatory agencies, patent offices, research institutes and firms. Organisations are strongly influenced, coloured, and shaped by institutions (Edquist and Johnson, 1997: 59). The institutions are guiding the "behaviour" of organisations by formulating the formal and informal rules for their "actions". On the other hand, organisations are also influencing the development of institutions by being actors that are behaving according to certain institutions, they are in many respects also the actors that might change the nature of certain institutions, e.g. informal institutions like work manners or practices. In this respect certain organisations might also be directly responsible for creating institutions like for instance standard setting organisations or regulatory organisations.

Both institutions and organisations are important elements in an innovation system, and because of the influence that they have on each other it might be useful to make a distinction between the two. Another reason for making this distinction is to make the use the concepts easier in a case study situation.

2.4. Biotechnology in a National System of Innovation

Carlienne Brenner (1997) has created a conceptual framework for "Biotechnology in the context of a national system of innovation" that will be referred to in this thesis. This conceptual framework is taken from a policy brief paper created at the development centre of the OECD as a study concentrating on developing a framework for biotechnology policy for agriculture in developing countries. The policy brief is based on a number of country studies (Colombia, India; Kenya, Thailand, and Zimbabwe) as well as analysis of donor-funded biotechnology projects and programmes (Brenner, 1997:3).

Brenner has integrated agricultural biotechnology in the framework of a national system of innovation in order to relate agricultural biotechnology to a national context. She has created a system consisting of a network of units, systems and subsystems which interact to generate, exchange and distribute knowledge (Brenner, 1997:11). The nature, frequency and intensity of linkages and flows of technology and information between the different units and sub-systems within the system are emphasised.

This biotechnological innovation system consists of three main units: Agricultural research, technology development and technology diffusion. These units are linked together through the research system, the production system and the distribution system, which are defined as sub-units. The interactions and close relations between the different units and sub-units in the system are extremely important and should be present between all units and sub-units in the system in an ideal situation. All the units in the system are also connected through the financial system and the regulatory framework that exists both nationally and internationally.

Agricultural research may include basic, applied and adaptive research, where adaptive research refers to the process where the technology is adapted to local conditions (Brenner, 1997: 11). Adaptive research may be important in agricultural research where local ecological and production conditions have to be taken into consideration for successful application of new products. In principle, close interaction is necessary between the research and farming communities and among research, farming and industry both in identifying the major production or other problem areas to which research should give priority, and in providing feedback on the acceptability or appropriateness of technology products generated by the research community and industry (Brenner, 1997:12). The actors in agricultural research may be both public and private actors.

Technology development is referred to as the process where successful research is developed into tangible products (Brenner, 1997). The development process may include large scale field testing, seed multiplication or setting up a pilot plant (Brenner, 1997:12). Product development may also include both public and private actors. According to Brenner (1997) the development process only includes the development of tangible products. According to Lundvall (1992) the innovation process includes the development of both tangible as well as intangible products. Intangible products might be new production methods or organisational innovations that are not tangible products, but still products that can be sold.

Technology diffusion refers to the process where new technology is distributed to the consumers as final products (Brenner, 1997) [2]. This diffusion process may include various actors in the distribution system that may be both public and private.

Many different public and private actors interact between the research phase, the product development phase and the diffusion phase. This may also include non-profit organisations and non-governmental organisations (NGOs).

The financial and regulatory environment both at the macro-level and at the micro-level influences all the different units, sub-units and actors in the system. The macro-level includes macro-economic policies and international agreements, whereas the micro-level includes science and technology policies, levels of investment, environmental policies, agricultural policies and the national regulatory framework.

Brenner points out the importance of technological capabilities as an essential precondition for a country's ability to generate technology appropriate to a particular economic and socio-cultural environment (Brenner, 1997:10). According to Bell and Pavitt technological capabilities consist of the resources needed to generate and manage technical change, including skills, knowledge and institutional structures and linkages (Bell and Pavitt, 1997: 89). The technological capabilities of the various actors in the innovation system will be investigated in terms of skills, knowledge and experience. In addition , the institutional and financial environment relevant for the innovation system in the Turkish cotton sector will be looked at.

The conceptual framework of Carlienne Brenner will be used as a tool to draw the boundaries limiting the system and to define the main actors in the system when applying the

[2] In the diffusion process the products that are distributed to the consumers are tangibleaccording to Brenner, whereas they might be both tangible or intangible according to Lundvall (Lundvall, 1992)

national system of innovation approach to biotechnology in the Turkish cotton sector. As already pointed out one of the problems with the national system of innovation approach might be to define the boundaries of the system as well as defining the actors when applying the approach to a specific case study. This framework created for biotechnology policy for agriculture in developing countries will be used as a point of reference in the analysis of the Turkish cotton sector and the experiences and considerations gathered in the country studies of the project will be referred to in this study.

2.5. Brenner`s Conceptual Framework from a Theoretical Point of View

In this section, the conceptual framework created by Carlienne Brenner (1997) will be looked at from a theoretical point of view, where basic concepts pointed out in the theoretical review on national systems of innovation are related to Brenner's conceptual framework.

2.5.a. Broad or Narrow Perspective

The conceptual framework of Carlienne Brenner (1997) as it is presented is first and foremost looking at the national system of innovation using a narrow perspecvtive. The system that is sketched out is concentrated on the actors that are directly involved in the innovation process, that is the actors involved in agricultural research, technology development and technology diffusion, the research system, production system and distribution system, and the financial system and regulatory system. The interactions and relations between the different units, sub-units and actors in the system are highly emphasised, and these interactions and relations might be looked at by taking into account informal institutions like habits, customs and local ways of cooperating in addition to formal institutions like for instance laws and regulations. Brenner (1997) does not, however, mention the importance of taking factors like culture, history and language into consideration when outlining the framework of the system.

2.5.b. Boundaries and Actors

In the framework created by Brenner (1997), the boundaries and actors that constitute the system are outlined quite specifically. The system consists of three main units (agricultural research, technology development and technology diffusion), three sub-units (the research system, the production system and the distribution system) and all of the units and sub- units are embedded in the financial system and the regulatory environment. In the theoretical review the elements or actors that were sketched out as a general framework for a national innovation system were the internal organisations of firms, interfirm relationships, the role of the public sector, the institutional set-up of the financial sector , and R&D intensity and organisation. Brenner`s framework (1997) is open to the incorporation of all of these actors pointed out by Lundvall (1992). The internal organisations of firms, the interfirm relationships and the R&D intensity and organisation can be included in the research system, the production system and the distribution system. The role of the public sector and the institutional set-up of the financial sector can be incorporated in the financial system and the regulatory environment, as well as in the different units and sub-units.

2.5.c Interactions and Interactive Learning

The relations and interactive relations between the different units, sub-units and actors in the conceptual framework created by Brenner are highly validated. Many different public and private actors and institutions interact between the research phase, the product development phase and the ultimate diffusion of new technology to final users (Brenner, 1997: 13). In accordance with the theoretical framework of national systems of innovation presented by Lundvall (1992), interactivity between the different actors is one of the major issues to be focused upon.

2.5.d Institutions and Organisations

In Brenner`s framework (1997), the concepts of institution and organisation are not clarified. She does, however, not use the definition of institutions that is presented by Johnson (1992), but uses the term institutions about for instance universities, which would be defined as organisation in the Johnson`s definition. *While in the United States and other industrialized countries, seeds industries have been in private hands for some time, public agricultural research institutions (such as the Land Grant Universities in the United States) have played a key role in R&D* (Brenner, 1997: 13).

Throughout this thesis, Johnson`s definition of institutions and organisations will be used.

2.5.e. Openness of the System

As pointed out by Lundvall (1992) the innovation system is not localised exclusively inside national borders although the national system of innovation approach is defined within a national context. The national system of innovation approach is an open system, which is also influenced by actors localised outside the national borders of the system. In the framework created by Brenner (1997) the increasing openness in the agricultural innovation system is underlined. Interaction and feedback in the research, technology development and diffusion process occur not only at micro-level, between units forming part of the system, or at national level, but also at regional and international levels (Brenner, 1997: 13).

2.6. Conclusion

The national system of innovation approach will be used as a conceptual framework for describing and analysing the biotechnological innovation system in the Turkish cotton sector. Although the focus of the thesis is on a sectoral level, the national system of innovation approach will be preferred to a sectoral system approach. The biotechnological innovation system in the Turkish cotton sector will be analysed in the light of a national context, where the influence of national organisations and institutions will be focused upon. The influence of an international context will also be taken into account.

The analysis will be conducted on two levels. In chapter 3, the biotechnological innovation system in Turkey will be described on a macro level, where national policies, the general level of biotechnology, the education system, national and international laws and regulations, and the financial situation in Turkey will be taken into account.

In chapter 4, the biotechnological innovation system in the Turkish cotton sector will be described. The analysis will be more focused upon the individual actors on a micro level, and the relations and interactions between the various actors will be emphasised.

3. THE BIOTECHNOLOGICAL INNOVATION SYSTEM IN TURKEY

3.1. Introduction

Modern biotechnology is science based and knowledge intensive, with high demands for R&D input. Substantial investments of human and financial resources is necessary in order to perform R&D on the field. As a consequence, modern biotechnology has almost exclusively been developed in a few industrialised countries (Gozen, 1997).

In order to keep up with the developments in industrialised countries and to fill the technology gap between the industrialised countries and developing countries on the field, many developing countries are investing in modern biotechnology. However, when integrating modern biotechnology to the R&D systems in developing countries there are several factors specific to modern biotechnology that needs to be taken into account.

As already mentioned, modern biotechnology is knowledge intensive and science based. This implies that new demands for human, financial and managerial resources are needed (Cohen, Falconi and Komen, 1999). It must also be taken into account that on a global scale biotechnological research is becoming more and more international in character with increasing international relations and collaborations in addition to an increasing dominance of the private sector (ibid). Modern biotechnology is in many respects a contested technology and the challenge of possible negative public perception of biotechnological activities should be considered (ibid). Modern biotechnology is also challenging the institutional setting through international agreements with new demands for biosafety regulations and strengthening of intellectual property rights (ibid).

This chapter will be concentrated on describing the biotechnological innovation system in Turkey on a national level. The national situation for Turkey will be related to the characteristics particular to modern biotechnology and the situation for developing countries in this context. The biotechnological innovation system in Turkey will be described by focusing on human resources with respect to knowledge, experience and skills in research and development, the education system and public perception of biotechnology related issues. The organisation of science and technology (S&T) and the priority settings for S&T in Turkey will be described and related to the situation for biotechnology in the country with respect to organisation and priority settings. The institutional setting relevant for biotechnology at the international and national level will be described, and the financial environment will also be taken into consideration by relating the financial situation in Turkey to the funding situation of biotechnological activities.

3.2. Modern Biotechnology on a Global Scale

Two of the most distinguishing characteristics of modern biotechnology are that biotechnology is an extremely science based technology, and that the commercialisation of the technology has tended towards an increasing dominance of the private sector. Although both private and public interests are involved in biotechnology, US based multinational companies constitute the strongest group of technology actors especially in the development and diffusion of the technology (Gozen, 1997: 125). Initially, biotechnology in industrialised countries was developed in the laboratories of the universities or public research institutes and commercialised by small companies, but the small companies have been largely bought up by transnational corporations (TNCs) and the share of the small companies in biotechnology research is much lower than that of the TNCs (Gozen, 1997: 126). This trend towards increasing privatisation of technology actors can partly be explained by the strengthening of intellectual property legislation, which increases the possibility for profits on biotechnological inventions (Persley and Doyle, 1999). Intellectual property litigation may also be part of the explanation for the increasing dominance of TNCs. The first patents that were granted on biotechnological inventions in the US were so broad that the private companies began suing each other (ibid). The easiest way to settle some of the disputes was through mergers and beginning in 1996, a wave of mergers occurred between private companies involved in biotechnology R&D (ibid).

3.3. The Science and Technology (S&T) system

When describing the biotechnological innovation system in a national context, the national priority settings for S&T in general, and the priority settings for biotechnology in particular will influence the innovation system. In this respect the organisation of the national priority setting and implementing bodies will be described. Lundvall (1992) points out the role of the public sector as one of the factors that will influence a national innovation system. When describing a technology where the private sector is dominant on a global scale, the role of the public sector is especially relevant. The S&T system refers to the organisation of the priority setting and implementing bodies of S&T in Turkey.

3.3.a Priority Setting and Implementing Bodies of S&T in Turkey

The Supreme Council of Science and Technology (BTYK) established in 1983 is the highest organ responsible for setting long term S&T policies in Turkey (TUBITAK, 2000). The long term science and technology policies for Turkey is outlined in a policy document covering ten years at the time. The last S&T policy document was set for the period 1993-2003. The Council is accountable to the Prime Minister, who acts as its chairman

The Scientific and Technical Research Council of Turkey (TUBITAK) established in 1963 is financially and administratively autonomous. TUBITAK is responsible for undertaking, coordinating and sponsoring basic and applied research in Turkey and for setting up institutes to work in this field (ibid). The Council also assists the Government in formulating the national research policy in positive sciences (ibid). TUBITAK founded the Marmara Research Centre (MRC) in 1972 to undertake basic and applied research in fields like materials and chemical technologies, information technologies, biotechnology and genetic engineering, food sciences, energy systems and environment, earth and marine sciences through its seven institutes (ibid). TUBITAK also coordinates, promotes and sponsors research on basic and applied sciences through its research grant committees.

The Higher Educational Council (YOK) established in 1982 is in accordance with law No. 2547 of 1981, responsible for planning, coordination and policy priorities for higher education in Turkey (TUBITAK, 2000: 3) . Research funds are distributed to the universities by YOK which means that research undertaken at universities are directly or indirectly determined by this state organ (Gozen, 1997:169).

Turkish Academy of Sciences (TUBA) established in 1993 is a scholarly society attached to the office of the Prime Minister (TUBITAK, 2000). The Academy has administrative and financial autonomy and its objective is to stimulate and encourage interest in research, spread scientific methods and thinking and improve the social status and prestige of scientists and researchers (ibid).

Technology Development Foundation of Turkey (TTGV) was founded by the joint efforts of private and public sectors in 1991, through a Loan Agreement signed between the Republic of Turkey and the World Bank (ibid). The objective of TTGV is to contribute to strengthening the competitiveness of Turkish industry on the international market (ibid).

3.3.b. The Five-Year-Development Plans

Turkish policy on scientific and technical research is defined every five year in the "Five Year Development Plan" by the State Planning Organisation (DPT), which reports directly to the Prime Minister (TUBITAK, 2000). All of the three most recent Five-Year-Development Plans have mentioned biotechnology as a high priority field for R&D.

The 6th Five-Year-Development Plan (1990-1994)

In the 6th Five-Year-Development Plan, biotechnology was stated on the top of the priority technology areas for which necessary support was to be provided for R&D activities (Gozen, 1997:184).

The 7th Five-Year-Development Plan (1996-2000)

Biotechnology is mentioned as a main priority field of investment In the 7th Five-Year-Development Plan together with five other research areas namely, information technology, space research, materials, and industrial and generic technology (7th-Five-Year-Development Plan: 77).

The 8th Five-Year-Development Plan (2001-2005)

In the 8th Five-Year-Development Plan priorities are formulated in favour of strengthening Turkey's general technological capacity in new technologies in the form of investing in human capital, infrastructure and public-private relations.

In Article 1199 in the 8th Five-Year-Development Plan (2001-2005) it says that it is essential to gain international competition potential through scientific and technological development, in order to be a knowledge-based society (TUBITAK, 2000: 5). It is stated in Article 1200 that the necessary physical and human infrastructure will be developed in order to improve the level of scientific and technological research which influences economical and social development as well as growth (ibid). The amount devoted to R&D in terms of GDP will be increased to 1.5 % from 0.49 % in 1997 and the number of researchers will be raised from 8.2 per 10 000 inhabitant (1997) to 20 at the end of the Plan (ibid). In Article 1203 it is written that human capital will be regarded as a strategic resource and education policies will be set up to bring up human capital adaptable to new technologies (ibid). In Article 1206 it is also stated that university-public-private partnership initiatives will be encouraged and supported (ibid).

When it comes to biotechnology, the 8th Five-Year-Development Plan (2001-2005) mentions biotechnology as a high priority field of research and investment. In article 1207 it says;

> *R&D activities in advances application fields, such as biotechnology and genetic engineering, information and communication technologies, new materials, space science and technologies, nuclear technology, marine sciences, mega sciences and clean energy, will be supported (TUBITAK, 2000: 6)*

Biotechnology is also mentioned in article 1214, which states that industrial parks in advanced fields like biotechnology and genetic engineering will be supported (TUBITAK, 2000: 6).

3.3.c. Science and Technology Policy

The national S&T policy is defined every ten years by the Supreme Council of Science and Technology (TUBITAK, 2000). The last ten year national policy for S&T was set for the period 1993-2003. At the meeting of 3rd February 1993, the Supreme Council of S&T emphasised the determinant role of S&T with respect to the national economy, the sustainability of economical growth, the upgrading of the standard of living and international competitive advantage (TUBITAK, 2000: 6).

Turkish Science and Technology policy 1993-2003

In the national policy for S&T for the period 1993-2003 enhancement of intellectual capacity of the country is mentioned as a goal as well as an upgrading of the R&D ability of the country in new technologies (TUBITAK, 2000). In this respect the number of R&D personnel shall be increased to 15 per 10 000 inhabitants compared to 7.5 in 1992 (TUBITAK, 2000: 7).

In the Turkish S&T plan for 1993-2003 there was a project called “Project for a Leap Forward in Science and Technology” which was also included in the 7th Five Year Development Plan. This project proposed seven specific fields of investment in order to create a concrete base for enhancing the S&T capability of the country. One of these fields of investment is R&D in genetic engineering and biotechnology and project based applications (TUBITAK, 2000: 5).

3.3.d. Priorities for Biotechnology in a National Context

Policy makers devising strategic approaches for the use of biotechnology in a country, need to determine what resources are to be required within the context of national capabilities (Cohen, Falconi and Komen, 1999). In Turkey, S&T policies started to be emphasised in the government plans and programs in the early 1990s (Gozen, 1997:176). In the 6th Five-Year-Development Plan (1990-1994) targets were set to increase the number of research personnel to 15 per 10 000 of the population by doubling the number of university posts and to raise the magnitude of R&D expenditures to 1 % of the GNP (Gozen 1997: 176). As can be seen from the most resent Five-Year-Development Plan (2001-2005) and from the latest national policy for S&T (1993-2003), the goal set in the 6th Five-Year-Development Plan (1990-1994) has not been realised. In the 8th Five-Year-Development Plan the target has been raised to 20 per 10 000 inhabitants, although none of the previous goals have been realised. The same tendency can be seen for the target set with respect to R&D expenditure. In the 6th Five-Year-Development Plan the target expenditure of 1 % of GNP was set to be realised within the period 1990-1994. In 1997 the expenditure was still only 0.49 % of GNP. The target for R&D expenditure in the 8th Five-Year-Development Plan was set at 1.5 % of GNP.

Biotechnology has been set out as a main field of investment with respect to R&D in the 6th, 7th and the 8th Five-Year-Development Plans. Incentives are outlined to strengthen the S&T capabilities in Turkey. These are to be realised in the form of development of the necessary physical and human infrastructure, education policies focused on improving the level of human capital needed to adopt new technologies, strengthening of university-private-public partnership initiatives, and upgrading of the R&D ability by increasing the number of R&D personnel, according to the priorities set. Although the policy making organs for S&T in Turkey identifies a need for strengthening the national S&T capabilities, the incentives are vague. Strengthening of the national capabilities in biotechnology is not specifically mentioned, and consequently specific priorities are not set for determining how national technological capabilities in biotechnology can be strengthened.

Starting in 1993 there was, however, a strategic targeting project financed by TTGV with the objective of specifying priority crops and their properties for plant biotechnology research and applications in Turkey (Gozen, 1997: 194, after Gozen et al, 1995). This project aimed at collecting the opinion of relevant technology actors in Turkey with respect to biotechnology through interviews in addition to identifying the needs of local farmers and consumers and international trends on the field (ibid). The project investigated 38 priority crops according to the following criteria: increase in production, increase in domestic prices, increase in world prices, export share, regional concentration an cultivated area (ibid). Tissue culture and genetic engineering were the biotechnological techniques that were considered with respect to: suitability of the crop for the technique, probability of obtaining favourable results, duration of research, cost of physical infrastructure required, availability of the technology abroad and the importance of agricultural problems involved in the production of the crop (ibid). When the attributed values were calculated, the ranking of the priority crops for genetic engineering was found to be; tomato, tobacco, sugarbeet, corn, potato, pears, watermelon, cucumber, melon, and cotton, when the top ten is mentioned. The project mentioned the potential of using genetic engineering as a means to improve fibre length in cotton.

3.4. Modern Biotechnology in Turkey

This section will describe the national capabilities in Turkey in biotechnology with respect to human resources, the education system and the public and the private sector.

3.4.a Human Resources

Biotechnological research in Turkey is mainly concentrated on plant protoplast fusion, monoclonal antibodies, embryo transfer, enzyme technology, plant cell culture and plant tissue culture (Gozen, 1997: 179). These are all relatively simple biotechnological techniques. The most widespread research is in plant biotechnology where plant tissue culture is dominant (ibid). In 1997 it was estimated that the total number of researchers working in biotechnological research did not exceed 300 (Gozen, 1997: 181). This was a low number compared to international standards in 1997(ibid).

For more recent estimates, a report written on biotechnology in Turkey was written in connection with a symposium for biotechnology and biosafety held at the Hacettepe University in Ankara in October 2000. This symposium report is also indicating the low level of human resources in biotechnology in Turkey. The report says that it is only in the period of the last fifteen years that the importance of modern biotechnology has been realised in Turkey (Kolankaya, 2000). The report also says that the studies made in the field of biotechnology are in general in the scope of classical biotechnology (i.e. not using modern biotechnological methods) and these studies are mostly participating in research projects at the universities (Kolankaya, 2000, after Ozcengiz, 1996). The level of biotechnological research in Turkey has not yet come to a stage where independent biotechnological knowledge is produced as seen in many developed countries (Kolankaya, 2000).

3.4.b. The Educational Level of Biotechnology in Turkey

In resent years there are some universities in Turkey like Hacettepe University, Middle East Technical University, Bilkent University, Bosphorous University, Ankara University, Gazi University, Akdeniz University, Istanbul Technical University that offer higher education in biotechnological fields, most of which are in post-graduate level (Kolankaya, 2000). The Ministry of Education, YOK and TUBITAK have been supporting students for going abroad for biotechnological studies in under-graduate and graduate levels.

3.4.c. Organisation of R&D in the field of Biotechnology in Turkey

Biotechnological research is almost exclusively performed in the public sector in Turkey. The biotechnological research performed in Turkey is performed in some universities, at the Marmara Research Centre and at some research institutes administered by the Ministry of Agriculture and Rural Affairs (Kolankaya, 2000). Up until now, the private sector has not been performing biotechnological research in Turkey. Industrial firms using biotechnological techniques are also very few, therefor the private sector does not contribute significantly to the research performed in the biotechnological field in Turkey (ibid).

The national technological capabilities in biotechnology on a general level can be characterised as weak. Most of the biotechnological research performed in Turkey is using relatively simple techniques, there are relatively few researchers involved, and in addition there are relatively few organisations offering higher education on the field. The knowledge, skills and experience that do exist, however, is localised in the public sector.

3.5. Public Perception of Biotechnology in Turkey

Modern biotechnology is a contested technology in many respects. On a global scale issues related to biosafety, environment, patents and ethics are widely debated. When investigating the biotechnological innovation system the public perception of biotechnology might influence the system on various levels. Ordinary people are the consumers of many of the products produced by using modern biotechnological techniques and are the determining factor with respect to market demand of these products. The consumers may also influence the political agenda related to the regulating process on the field. Lundvall (1992) argues that learning, which is the basis of innovation, cannot be understood without taking the cultural context into consideration. The public perception of biotechnology can be said to reflect a cultural context. Biotechnology is a science based technology and the public perception of aspects related to this technology is dependent upon factors like access to information about the technology, the level of education among ordinary people and the political agenda.

The general knowledge about biotechnology and related issues are not significant in Turkey (interview at the General Directorate of Agricultural Research (GDAR), Department of Field Crops, 2001). Until now, there has been a lack of informative sources for people outside the scientific community about biotechnology. The Ministry of Agriculture and Rural Affairs (MARA) has identified public awareness as one of the issues to be focused upon in relation to establishing biosafety regulations and a biosafety control system (The Ministry of Agriculture and Rural Affairs, 1999). The media seldom addresses issues related to biotechnology like environmental aspects, human health and GMOs and ethical issues related to the use of modern biotechnological techniques (interview at the GDAR, Department of Field Crops, 2001). Although the knowledge about and focus on biotechnology and related issues are scarce in Turkey there are a few NGOs that have addressed the issue publicly. These are the Organic Farmers Association (ETO), the Consumers Rights Association and Turkish Nature Protection Association.

The Consumers Rights Association is an association focusing upon consumer rights and health issues. In this context the organisation have addressed the issue of imported food that is genetically modified or that have genetically modified ingredients. The Consumers Rights Association has arranged a symposium in Mars 2000 called “Genetics, Ecological Foods and Consumer Rights”, and they also held a press conference in relation to this symposium (interview at the Consumers Rights Association, 2001).

The Organic Farming Association (ETO) has not specifically addressed the issue of genetically modified organisms in any campaign, but they are in principle against the introduction of GMOs in Turkey and participated in the mentioned symposium as opponents of GMOs in Turkey (interview with the President of ETO, 2001).

Turkish Nature Protection Association has not address the issue of GMOs in any campaign but the association has published some articles on the issue of GMOs and biodiversity (interview at the Turkish Nature Protection Association, 2001).

In October 2000 there was a symposium addressing the issues related to biosafety and biotechnology arranged by the Ministry of Agriculture and Rural Affairs, the Ministry of Environment and The Turkish Biotechnology Association entitled: “Biotechnology and Biosafety 2000”.

In October the same year there was an industrial workshop entitled: “Biotechnology; opportunities and challenges” at Sabanci University. Among the participants were representatives from the Technology Development Foundation of Turkey (TTGV), The Turkish Academy of Sciences (TUBA), some universities and representatives from domestic and private firms engaged in for instance the seed business.

The lack of public awareness with respect to biotechnology and related issues can probably be explained by the limited distribution of biotechnological activities and limited distribution of biotechnological products in Turkey. Informative sources available dealing with biotechnology and related issues are scarce. This applies both to governmental and non-governmental sources. The lack of information and political focus upon these issues probably influences this lack of awareness among the public.

3.6. The Institutional Set-up

This section will be concentrated on formal institutions that might influence the biotechnological innovation system in Turkey, with particular emphasis on national and international institutions related to intellectual property rights and biosafety.

Lundvall et al. (1992) argue that learning cannot be understood without taking into consideration the institutional and cultural context. According to Johnson’s definition institutions are sets of habits, routines, rules, norms and laws, which regulate the relations between people and shape human interaction (Johnson, 1992:26).

When applying modern biotechnology to the research systems in developing countries, there will be new demands for the institutional set-up (Cohen, Falconi and Komen, 1999).These new demands will particularly involve the need for establishing institutions related to biosafety and intellectual property rights (ibid). Turkey is taking part in several international agreements and conventions that may influence the development of the biotechnological innovation system in the country. Turkey is currently in the process of establishing national regulations in the field of biotechnology, and several international agreements and conventions are likely to influence the establishment of these national regulations. International agreements and conventions that will be mentioned as relevant for the national regulative process on the field are TRIPs, UPOV and EPC, CBD and the Cartagena Protocol, in addition to aspects related to Turkey's relationship with the European Union.

3.6.a. The TRIPs Agreement

The Uruguay Round Agreement on Trade Related Aspects of Intellectual Property (TRIPs) was signed in April 1994 under GATT (The General Agreements of Tariffs and Trade) and came into force on the 1st of January 1995. As a member of WTO (The World Trade Organisation) Turkey is taking part in this agreement. The agreement ensures patent protection to all product and process inventions in almost all spheres of technology with its Article 27. The TRIPs agreement makes intellectual property rights (IPRs) an indispensable part of international trade law, and every country have to enact IPR regimes consistent with the agreement in order to be a part of the system (Gozen, 1997: 151). When relating the agreement to biotechnology there are several aspects that are relevant. Biotechnological inventions are to be protected under patent law, but according to Article 27.3.b plants and animals can be excluded from patent protection. The article also says, however, that plant varieties must be protected by either patents or a *sui generis* system. This so-called *sui generis* system refers to another type of system than patents to ensure plant breeders' rights. The UPOV agreement is such a *sui generis* system applied to the protection of new varieties of plants (will be referred to later).

Developing countries were not required to apply the provisions of the TRIPs agreement before five years after the agreement came into force except for general provision of non-discrimination (Gozen, 1997:152). For product patents on pharmaceutical and food stuff, including biotechnology, developing countries may benefit from a transitional period of ten years (ibid). This means that Turkey has to apply product patents for biotechnology within ten years after the TRIPs agreement came into force.

Turkey has met the requirements addressed in the TRIPs agreement by various measures. Relevant measures for the biotechnology field and for the protection of plant varieties are the establishment of the Turkish Patent institute in 1994 and a new patent law in 1995. Turkey became a member of the European Patent Convention in 2000, and has prepared a draft for legislation related to plant breeders`s rights following the UPOV criteria.

3.6.b. The European Patent Convention

Turkey became a member of the European Patent Office (EPO) on the 1st of November 2000, and is a part of the European Patent Convention. The European Patent Organisation was established by the Convention on the Grant of European Patents signed in Munich in 1973.The European Patent Convention (EPC) is an intergovernmental regime that established a uniform patent system in Europe.

For patent applications and patents concerning biotechnological inventions Rule 23.b. in the European Patent Convention says that the relevant provisions of the Convention shall be applied and interpreted in accordance with the EU-Directive 98/44/EC of 6th of July 1998 (from the web pages of EPO). According to Rule 23.c biotechnological inventions can be patented if they concern:

> *(a) biological material which is isolated from its natural environment or produced by means of a technical process even if it previously occurred in nature; (b) plants or animals if the technical feasibility of the invention is not confined a particular plant or animal variety; (c) a microbial or other technical process, or a product obtained by means of such a process other than a plant or animal variety (Directive 98/44/EC Rule 23.c)*

In principle, no patent can be obtained for plant varieties, only for inventions related to them (Commission of the European Communities, 2000: 23). Plant varieties are covered by a specific regulation which includes breeders` and farmers` exemption, however, EPO has indicated that patents on plants and animals are not excluded by EPC (ibid). This issue is controversial and has caused debate among the members of the Convention.

3.6.c. The International Union for the Protection of New Varieties of Plants (UPOV)

UPOV, The International Union for the Protection of New Varieties of Plants, was created in 1961 and unites several countries under a common regime to protect the interests of plant breeders (from the web page of UPOV). UPOV offers common rules for the recognition and protection of the ownership of new varieties by plant breeders and can be said to stimulate private sector plant breeding. The original UPOV convention has been subsequently revised in 1972, 1978 and 1991 (ibid). All members today are either party to the 1978 or the 1991 Act. The Act of 1978 was closed to further accession in April 1999. The UPOV Act of 1991 has restricted some of the rights in the 1978 version, and this Act is more similar to a patent protection system which means that the rights of the plant breeders are strengthened. In the 1991 revision farmers are restricted in the use of harvested seeds, and breeders are given certain rights over material breed from protected materials and stronger rights over products grown with protected seeds (GRAIN, 1998).

There are 45 members of UPOV today. Turkey is currently not a member of UPOV, but in 1994 Turkey applied for membership. The application was not considered, however, because an added article to a law and a decree of implementation procedures were not found satisfactory in terms of international standards for establishing PBR legislation in a country (Gozen, 1997: 218). According to the European Custom Union Agreement signed in March 1995, Turkey was to ensure PBRs and become a member of UPOV before 1999 (ibid) . This has not been realised although the Turkish Ministry of Agriculture and Rural (MARA) affairs has been working on the subject since the application for UPOV membership was refused in 1994. MARA has prepared a new draft legislation for plant breeder's rights in Turkey based upon the UPOV criteria. This draft was first prepared in 1999 (Ministry of Agriculture and Rural Affairs, 1999). After being revised, the draft legislation is still waiting for approval in the Parliament (interview at the GDAR, Department of Field Crops, 2001). This implies that Turkey has so far failed to fulfil the obligation set in the European Customs Union. According to the GDAR, however, the establishment of plant breeders` rights is seen as an urgent need and will hopefully be approved by the Parliament within a short period of time (ibid).

3.6.d. The Impact of Stronger Patent Protection Systems on Biotechnological Inventions in Developing Countries

International agreements and conventions like TRIPs and EPC forces the contracting parties to enact patent protection systems for biotechnological inventions. On a global scale the trend towards intellectual property protection has influenced the increase of private sector R&D in biotechnology, and the private sector industry has greatly centralised to become a global oligopoly dominated by MNCs (Barton, 1999). In developing countries, the strengthening of intellectual property right (IPR) regimes may restrict the access to technology. It is likely to think that strong biotechnology patents in the industrialised countries have negative impacts on the adoption of the technology in the developing countries as they are limiting their access to the technology and its products, although increasing their access to knowledge (Gozen, 1997: 154). In developing countries where the scientific capacity often is at a low level, the possibilities for innovating in biotechnology is often limited. The present patent system favours those countries that have a strong innovation base (Perseley and Doyle, 1999).

The lack of IPR regimes in many developing countries has constrained the private sector from investing in developing countries (ibid). The main benefit of patents for developing countries may be in attracting foreign companies to the country (Gozen, 1997: 155). However, one of the preconditions for developing countries to benefit from foreign companies on their home markets is that they are getting access to knowledge and experiences possessed by the foreign companies. Foreign company activities have to be effectively regulated in order to balance the reciprocal gains and to benefit from technology transfer (ibid).

Turkey has established stronger patent protection systems for biotechnological inventions by becoming a member of the EPC in 2000, and by being in the process of establishing plant breeders` rights. The effect of stronger protection systems for intellectual property is yet to be seen in the Turkish situation.

3.6.e. The Convention on Biological Diversity (CBD)

The Convention on Biological Diversity was signed at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. CBD has three main goals; the conservation of biodiversity, to ensure sustainable use of the components of biodiversity, and to ensure that the sharing of the benefits arising from the commercial and other forms of utilisation of genetic resources is done in a fair and equitable way (from the web page of CBD). The CBD was signed by over 150 governments in 1992. At the time of writing (May, 2001), 180 countries have ratified the agreement and are parties of the Convention. Turkey is a Party of the Convention since the 14th of February 1997.

The Convention addresses issues related to access to genetic resources. By Article 15.1. the sovereign rights of States over their natural resources is recognised. The Article states that the authority to determine access to the genetic resources within a State lies upon the national governments and is subject to national legislation. This is further addressed later in the Article. In Article 15.7. it says that the results of research and development and the benefits arising from the commercial and other utilisation of genetic resources shall be shared in a fair an equitable way with the Contracting Party providing such resources.

The national authority over genetic resources might be relevant in a country where foreign companies are performing R&D and applying for patents on national genetic resources. In such a situation the national regulative framework in the country where the genetic resources are situated is important. Contracting Parties to the agreement have recognised national authority to regulate access to the national genetic resources. National regulations should ideally address the issue of national genetic resources, in order to secure them from exploitation.

The Regulation on the Collection, Storage and Use of Plant Genetic Resources of 1992, is the regulating the genetic resources of plants in Turkey. Taking into account the new regulative framework related to patents established in Turkey, the regulative framework for plant genetic resources should be considered in correlation to the new established patent laws in Turkey.

3.6.f. The Cartagena Protocol

The Cartagena protocol on Biosafety was adopted under CBD, and seeks to establish a global framework for managing the safe production and use of biotechnology. The objective of the Cartagena Protocol is to contribute to ensuring an adequate level of protection in the field of safe transfer, handling and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements (from Article 1 of the Cartagena Protocol). The protocol applies the precautionary principle, which allows governments to decide whether they want to accept imports of living modified organisms (LMOs) based upon the precautionary principle (from the web pages of CBD). This would imply that any feared risks that is causing a governmental decision of not allowing a LMO to cross the national border does not have to be proven by scientific evidence (as the TRIPs agreement demands). Their decision should be communicated to the world community via the Biosafety Clearing House, a mechanism set up to facilitate the exchange on and experience with LMOs. In addition, commodities that may contain LMOs are to be clearly labelled as such when being exported. Stricter Advanced Informed Agreements procedures will apply to seeds, live fish, and other LMOs that are to be intentionally introduced into the environment. In these cases the exporter must provide detailed information to each importing country in advance of the first shipment, and the importer must then authorise the shipment. The aim is to ensure that recipient countries have both the opportunity and the capacity to assess risks involving the products of modern biotechnology (ibid). The protocol will enter into force when 50 governments that are already Parties to the Convention on Biological Diversity have signed and ratified the agreement. Turkey signed The Cartagena Protocol on the 24th of May 2000, but has not ratified the agreement yet.

3.6.g. Turkey and the European Union

Turkey made its first application to join the European Economic Community (EEC) in 1959, shortly after the creation of the EEC in 1958. This resulted in an agreement between EEC and Turkey, the "Ankara Agreement", which entered into force on the 1st of August 1964. The Ankara Agreement involved the establishment of a customs union to be realised in three phases, which would bring about integration between Turkey and EEC. This Custom Union was fully adopted in December 1995 with decision 1/95. At the Helsinki meeting on the 10th and 11th of December 1999 Turkey was officially recognised as a candidate state for membership in the European Union without any preconditions.

As a basis for the negotiations about Turkish membership the EU Commission makes annual regular reports about the situation in Turkey with respect to membership. The first annual report for Turkey was made in 1998. In the 3rd Regular Report (2000), the lack of regulations in relation to genetically modified organisms (GMOs) among others is mentioned;

> *Since the last Regular Report no evidence of progress in adopting the acquis is apparent in areas such as air quality, waste management, water quality, nature protection, industrial pollution control and risk management, chemicals, GMOs, ozone depleting substances, nuclear safety and radiation protection. (...) Turkish legislation as regards genetically modified organisms is not aligned with the acquis (EU Comission, 2000 "3rd Regular Report from the Commission on Turkey's Progress Towards Accession" 2000)*

The part related to GMOs in the document is related to the EU acquis, which is a document by the EU Council about priorities for the candidate country's harmonisation reforms. This means that the adoption of the changes required is not a precondition for opening accession negotiations, but only for membership.

3.6.h. The National Regulation System in Turkey for Biosafety

The first initiative for the establishment of national regulations on the field of biotechnology came in August 1997 when the Supreme Council of Science and Technology decided that that there should be established rules regulating biotechnological activities in Turkey (interview with the Legal Advisor of the Biotechnology Committee, 2001). The process of establishing these rules was to be coordinated by TUBITAK as a cooperative project between the Ministry of Health, the Ministry of Agriculture and Rural Affairs, the Ministry of Environment, the Ministry of Industry and Commerce, and the Advisory Institute of Foreign Trade (The Ministry of Agriculture and Rural Affairs, 1999). The first meeting of this working group was held in February 1998, where it was decided that that the regulations on these fields should be based on the prevailing EU regulations (interview with the Legal Advisor of the Biotechnology Committee, 2001).

The Supreme Council of Science and Technology, which is the responsible organ for the establishment of safety regulations in the field of biotechnology, has proposed an establishment of a High Council for Biotechnology (ibid). In the 8th five year development plan (2001-2005) Paragraph 1227 says that this High Council of Biotechnology should be established (interview at DPT, 2001). This Council shall assist the preparations for decisions on all biotechnology related activities and actions, which would include the establishment and application of necessary regulations on the field.

According to The Ministry of Agriculture and Rural Affairs (MARA) a regulation including; *principles of use, handling, release and marketing of genetically modified organisms and products thereof*, as well as, *regional and national needs for the safe development, use, transfer and handling of GMOs,* shall be established (Ministry of Agriculture and Rural Affairs, 1999). On the 19th of September 1997 regulations on the registration of genetically modified plants entered into force (ibid). The next year a directive on the principles of field trials for genetically modified plants was elaborated by MARA and entered into force on the 14th of May 1998 (ibid).The directive applied to all genetically modified plants both imported or locally developed (ibid).The directive was amended in May 1999 and the 1999 version is the currently prevailing version of the directive. The objective of the directive is; *to identify rules in order to give trial permission for the plants with novel traits modified by using plant biotechnological methods* (Directive of Field Trials of

Transgenic Plants, 1999). The directive identifies rules for application, evaluations and measures to be taken during trials.

A project for setting up a biosafety system funded by the State Planning Organisation is currently being prepared and developed (interview at the GDAR, Department of Field Crops, 2001). The project will have to phases. The first phase is concentrated on strengthening the research capacity in the field of biosafety, and will include setting up laboratory facilities in different universities and research institutes and training and education of personnel to conduct the research (ibid). The Marmara Research Centre will be the main location for research on the DNA level, whereas Hacettepe University will have the main responsibility for toxicity and allergenic tests related to human health (ibid). Several agricultural universities will perform tests related to the environmental impacts of the tested varieties (ibid). The second part of the program will involve setting up a control system for the implementation of the biosafety regulations. This year (2001) is the first year of the project and has only been concentrated on the first phase of the project. The main problem in the first phase of the project has been the organisation of the different research organisations involved with respect to cooperation and working together in a biosafety system (ibid). At present, research in connection with the ongoing field trials has been done by signing contracts from case to case. The second phase of the project, which involves the control system for the implementation of the regulations will most probably be started next year (ibid).

Under the auspices of TUBITAK a group called the Biotechnology Committee has also been established. The tasks of this committee is to monitor the activities of international organisations with respect issues related to biotechnology and to assist in setting the priorities and policies for biotechnology in Turkey (interview at TUBITAK, 2001)

3.6.i The Current Situation for Biosafety in Turkey

At present there are no biosafety regulations in the field of biotechnology except for the described directive on field trials for genetically modified organisms. This directive was developed as a response to pressure from foreign companies wanting to introduce genetically modified seeds into the Turkish seed market (interview at the GDAR, Department of Field Crops, 2001). Imports, release and application of genetically modified organisms in Turkey are not allowed, but apart from the Directive on Field Trials of Transgenic Plants, there are no control of imports of commodities, release into the environment or application on the market with respect to genetically modified organisms (ibid) In June 1999, however, The Ministry of Environment through a circular warned all prefectures regarding unauthorised use and planting of genetically modified plants (interview with the legal advisor of the Biotechnology Committee, 2001).

The process of establishing the institutions necessary for a regulative framework related to biosafety, and to build the capacity needed to manage and implement these institutions is a time consuming process, in need of financial, human, scientific, physical and legal resources. The 3rd Regular Report of the EU Council mentioning the lack of a regulations related to GMOs, might exert some political pressure on the Turkish authorities, which again may speed up the process of establishing a functioning regulative framework for biosafety.

3.7. The Financial Environment

Modern biotechnology is a science based technology in constant demand for both human resources in the form of knowledge, skills and experience and physical resources in the form of equipment and long term financial investments. In order to secure inputs of human as well as physical resources a stable financial environment will be favourable. In this respect the national financial environment is likely to influence the biotechnological innovation system.

Before 1980 Turkey followed a political path based on having a closed economy. Custom tariffs and other taxes protected the internal market. However, starting from the early 80s reorganisations were made for opening the Turkish economy to foreign markets and for sustaining the industrialisation based on exports, especially in the fields of foreign trade and foreign exchange. Privatisation implementations were started in 1984 in order to restructure the share of the private sector in the market. In the Seventh Five year Development Plan (1996-2000) it is stated that public services should be concentrated in the fields of education, health and social security (from the web page of the Ministry of Foreign Affairs)

The Turkish economy went through a crisis in 1994 (ibid). High inflation and devaluation of the Turkish Lira resulted in difficult economic conditions. High inflation has been a continuos problem for the modern Turkish economy and an economic crisis also struck the Turkish economy in November 2000 (ibid). Just 11 months into a three year programme aiming at stabilising the inflation rate a severe banking crisis blew up accompanied by a massive capital outflow. The crisis revealed a number of important stress points in the programme, located in the vulnerability of the banking sector and the sensitivity of foreign confidence to a widening current account deficit against the background of delays to the structural reform programme (OECD, 2001). An emergency package of 7.5 billion US$ led by the IMF (International Monetary Fund) tried to normalise the situation and the Government reaffirmed its commitments to privatisation and banking reforms in order to stabilise the inflation rate (ibid). The situation seemed to stabilise in early 2001, but confidence in the programme was not really restored despite government pronouncements and the support from the IMF (Bibbee, 2001). In February 2001 a new crisis struck the Turkish economy and the Government decided to float the Lira which meant the end of the exchange rate-based stabilisation programme (ibid). The 2001 Spring Forecast made by the European Union on the economic situation for the accession candidates for membership in the Union describes the situation as follows;

> *Compared to the Commission's autumn forecast, Turkey's economic prospects for this and next year have changed dramatically. While during last year Turkey was rather successful in reducing inflationary pressures, the lack of political determination on addressing structural reforms eroded market confidence in the programme and led to significant capital outflows which cumulated in the eruption of two financial crises within only 3 months (General Directorate of Economic and Financial Affairs, Economic Reform Monitor, Issue 2001/2).*

The Turkish authorities are currently (April 2001) preparing a new economic programme, which will probably contain measures on how to address the revealed weaknesses of the Turkish banking system and to continue with the dis-inflation process (General Directorate of Economic and Financial Affairs, 2001).

During the past year Turkish economy can be described as very unstable. The crisis in November 2000, and the crisis in February 2001, has caused the economical environment to be very insecure, and the inflation rate is high.

Biotechnology is a knowledge intensive as well as capital demanding and time consuming technology. The biotechnological products and processes which are being generated are increasingly costly and, requiring high levels of scientific capability and skills, and increasingly sophisticated and expensive equipment (Brenner, 1997: 25). Biotechnological research and development needs human capital, in terms of knowledge, skills and scientific experience, and long term financial investments to finance equipment and basic research.

In Turkey, where human capital is limited, investments in education and training of scientists and technical personnel will be needed. An unstable and insecure economical environment is likely to affect the innovative environment for biotechnology in a negative direction. Developing scientific capabilities in terms of human capital will require long term policies and investments. Biotechnological research in terms of basic research is also capital demanding in the sense that it does not produce instant results in the form of products. The investments made in that kind of research will consequently have to be in the form of long term investments.

In as situation where inflation rate is high, equipment bought from abroad will be more expensive. When it comes to biotechnological research in Turkey, equipment often have to be bought from abroad because of the lack of a domestic biotech-industry (interview at the Hacettepe University, Biology Department, 2001).

3.8. Conclusion

In the case of modern biotechnology in Turkey, research and development is at a relatively low level with low scientific capacity when it comes to human resources, and few universities offering education on the field .

The activities performed in the field of biotechnology in Turkey are almost exclusively performed in the public sector, meaning that the state is the strongest actor in the biotechnological innovation system. Modern biotechnology has been identified as one of the main fields of investment when it comes to new technologies by government policies, although the priority goals set in this respect has been far from being realised up until now. The private sector is close to being absent from the scene when it comes to R&D in modern biotechnology in Turkey, which can be said to be in correlation with the low level of industrial R&D in general in Turkey. It can be suggested that one of the reasons for this absence of actors from the private sector can be explained by the weak institutional set-up in relation to biotechnological activities. In the case of plant biotechnology, which is the most widespread field of biotechnology in Turkey, the lack of plant breeders` rights might have the effect of hindering establishment of the private sector on the field. In a situation where new plant varieties cannot be protected, the conditions are not favourable for private companies trying to make profit out of new inventions. The low scientific capacity is another factor that makes the conditions unfavourable for private investments in biotechnological activities.

The role of the public sector is strong in the biotechnological innovation system in Turkey, being the sector where most of the biotechnological activities are situated up until now. Being in this position the public sector, through governmental incentives, can influence the development of the biotechnological innovation system by stimulating and strengthening the necessary conditions in the system. The major weaknesses in the system can be described as the weak institutional set-up, the low scientific capacity in the form of human resources, the educational system, the lack of informative sources for improving public awareness on the field and the unstable financial environment.

4. THE BIOTECHNOLOGICAL INNOVATION SYSTEM IN THE TURKISH COTTON SECTOR

4.1 Introduction

Agricultural growth is essential for fostering economic development and feeding growing populations in most developing countries (Hazell and Ramasamy, 1991: 1). Agricultural biotechnology offers opportunities for new methods in agricultural diagnostics, plant virus and insect resistance, novel biocontrol agents, as well as genetic marker and mapping techniques as an aid to conventional plant breeding (Brenner, 1997: 7). Prospects are set for biotechnology to enhance plant resistance to pests, disease and stress, but also for agricultural biotechnology to offer the potential for more sustainable methods for plant protection and production by decreasing the dependence on agro-chemicals in production (ibid).

Agricultural biotechnology does, however, also represent potential risks that must be taken into account when introducing this technology to developing country agriculture. These risks involve ethical considerations, potential environmental effects of releasing genetically modified organisms (GMOs) into the environment, potential effects to human health, the potential danger for small farmers and poor consumers in developing countries to become dependent on private TNCs and issues related to intellectual property rights.

This chapter will be concentrated on describing the biotechnological innovation system in the Turkish cotton sector and on relating this innovation system to the global situation for agricultural biotechnology. By restricting the boundaries of the innovation system to a more limited system, the analysis will be performed with a micro perspective compared to the analysis performed in the previous chapter. This will allow for more emphasis to be put on the specific individual actors in the innovation system and the relations between these actors.

The conceptual framework will be based on Brenner (1997) as outlined in chapter 2. In the conceptual framework of Brenner (1997) the innovation system is divided into three major units namely; research, technology development and technology diffusion. These three units are connected through the research system, the production system and the distribution system. The innovation system is functioning within the confines of a regulative and financial environment.

4.2 The Global Picture of Transgenic Crops

This analysis of agricultural biotechnology in the Turkish cotton sector will be concentrated on transgenic crops, also called genetically modified (GM) crops, and specifically on the developments of GM cotton in Turkey.

The first significant commercial sowings of transgenic crops took place in 1996, almost exclusively in the US (CEC, 2000: 10). Since 1996, the land under cultivation has rapidly expanded and reached 41.5 Mio ha sown in 1999 (ibid). As can be seen from table 1, the major countries when it comes to commercial sowings of GM crops are the US, which accounts for 70 % of the world wide sowings in 1999, followed by Argentina (14 %) and Canada (9.7 %) as the major actors. The other countries growing transgenic crops on a commercial scale in 1999 were China (3.1 %), Brazil (2.8%), Australia (0.7%), South Africa (0.4%), Mexico (0.12%) and Europe (0.03%{Spain, France, Portugal, Romania, Ukraine}).

The major transgenic crops grown are soybeans, maize, cotton and canola. As can be seen from table 2, soybeans accounted for 52,5 % of the sown transgenic crops in 1999, whereas corn accounted for 27.2%, cotton 9.4 %, rapeseed 8.4% , tobacco 2.4 % and potatoes accounted for 0.1 % of the transgenic area sown in 1999.

4.3. Transgenic Cotton on a Global Scale

Turkey is the sixth country in the world when it comes to the major cotton producing countries in the world. As can be seen from table 3, the major cotton producing countries in the world are China, followed by the United States, India, Pakistan, Uzbekistan, Turkey Australia and Brazil in 1999/2000.

In 1999 transgenic cotton accounted for 12% of the total amount of cotton grown in the world with an area of 3.92 million hectares grown with transgenic cotton (CEC, 2000: 17). As can be seen from table 4, the cotton producing countries growing transgenic cotton on a commercial scale are the US, China, Australia, South Africa and Mexico.

Cotton is engineered genetically for several different traits. Most of the GE cotton has been genetically engineered to be resistant to herbicides (more than 40 %), GE cotton that has been engineered to be resistant to certain insects (one third of the transgenic cotton), and the rest of the genetically engineered cotton grown commercially contains both genes (more than 20 %) and are thus resistant to both herbicides and insecticides (CEC, 2000: 18).

Herbicide resistant cotton is the result of inserting an herbicide resistant gene into the cotton genome. The transgenic cotton crops containing the herbicide resistant gene will have a growth-regulating enzyme that is immune to the effects of the active ingredients in the herbicide and therefor allows the herbicide to be applied to the crop without affecting the transgenic cotton at the same time as it kills the weeds in the field (CEC, 2000: 13).

Insect resistant cotton is produced by inserting genetic material from the bacteria *Bacillus thuringiensis* (Bt) into the cotton seed genome. The Bt gene is coding for a protein that is toxic to the insects bollworm and budworm, which is a great threat to cotton crops many places in the world (ibid). Transgenic cotton with inserted genetic material from *Bacillus thuringiensis* is often called Bt cotton.

Genetically engineered cotton with improved quality traits is the new generation of GM cotton to be developed (ibid). Engineering of these kinds of traits is often more difficult because normally more than one gene controls the trait (polygene traits) and consequently more than one gene have to be modified. Despite these difficulties a lot of research is being performed on the area. Traits that are under research are colour, fibre quality, draught resistance to mention some examples (ibid).

4.4. The Turkish Cotton Sector

In Turkey there have been no commercial applications of transgenic cotton up until now.

Cotton is of great economical and social significance for Turkey. It is the basis of a national textile industry, and provides the raw material for a wide range of industries employing millions of workers in production, ginning, trading, manufacturing of fibres and in the processing of seeds and its products (Eksi, 2001). The exports of textile and clothing (leather and fur clothing not included) reached to an amount of 9948 million $ in 2000, which represents 35.8 % of the total export in Turkey (from the web pages of the Turkish Ministry of Foreign Affairs).

Cotton has been cultivated in Anatolia since the 6th century, but the broad cultivation of cotton started during the time of the Seluk and Ottoman Empire (Eksi, 2001). Major improvements were achieved in production after the establishment of the Turkish Republic in 1923. In 1932 the total production of cotton was 20 200 metric tons, however, it was first after World War II that the production really increased because of larger planting areas and the introduction of new cotton varieties imported from abroad (Eksi, 2001: 1).

As can be seen from table 5 the production in 1951 was 149 900 metric tons of lint. The production has increased considerably from 1951 until 2000. In 2000 the production was 739 500 metric tons, although the planted area of cotton has been almost the same throughout the period. In 1951 the planted area was 641 800 hectares, whereas the production area was 669 000 hectares in 2000, hence there has been an significant increase in yield performance. This radical increase in yield performance is the result of new high yielding varieties, better irrigation techniques and an increase in the use of fertilisers, insecticides and fungicides, in addition to the application of better and more efficient farming techniques (Eksi, 2001: 1).

Although the yield performance has increased dramatically in the last 50 years, Turkey has been importing considerable amounts of cotton fibres since the 1992/93 season. This is related to improvements in the textile industry and Turkey has gone from being a cotton exporting country to being a cotton importing country (interview at the GDAR, Department of Field Crops, 2001).

The cotton growing areas in Turkey are divided into four regions, which all have different climatic and production conditions. The four regions are; the Aegean region, the Cukorova region, the South-eastern region and the Antalya region (Eksi, 2001: 2)

The Agaean region is the main cotton growing area in the western part of Turkey, representing 34 % of the total growth area for cotton (ibid). The main characteristics of this region are low insect and pest populations, high yield and good fibre quality (ibid).

The Cukorova region represents 17 % of the cotton growing area in Turkey (ibid). This region used to be the main cotton growing area in Turkey, but in the last eight or ten years pest infestations have become a serious problem. The major pests are White fly (*Bemisia tabaci*) and pink bollworm (*Pectinophora gossypiella*) (ibid). The pest problems are causing the number of pesticide and insecticide spray rounds to sometimes exceed 8 to 10 times during a season and as a result the number of cotton planting areas has decreased drastically (ibid).

The South-eastern region is the region having the largest cotton planting area representing 46 % of the total planting area in Turkey (ibid). This region has the highest yield of the four regions and has no serious pest problems (ibid). It has a hot climate with low humidity. The South-East Anatolian project (GAP) is a major governmental agricultural project for irrigating a large area between the Tigris and Euphrates rivers in order to make the land productive for agriculture. The project involves 22 dams and 19 hydroelectric power plants (ibid). Cotton will be one of the beneficiary crops among others from the project. Earlier estimates suggested that cotton production would go up by 118 % after the project was completed (ibid).

The Antalya region is the smallest cotton growing region in Turkey representing 3 % of the growth area (ibid) . The planting area has fallen by 50 % in the last decade. The growing conditions are similar to the Cukorova region with severe pest problems (ibid).

4.5. Cotton Research and the Cotton Research System

When describing cotton research conducted in Turkey both basic, applied and adaptive research will be taken into consideration. Adaptive research may be especially important in agriculture because agricultural products needs to be suitable for local agro-ecological conditions and for local production methods (Brenner, 1997).

4.5.a. Cotton Research in Turkey

In Turkey, there are mainly four types of organisations performing cotton research, namely governmental research institutes, universities, the Marmara Research Centre and the Cukorova Advanced Agricultural Research and Development Institute administered by TUBITAK, and private companies.

There are six governmental research institutes administered by the Ministry of Agriculture and Rural Affairs (MARA) to undertake cotton research (Eksi, 2001). These research institutes are situated in different geographical regions in Turkey, and are responsible for the cotton research performed in the region where they are located. Nazilli Cotton Research

Institute, situated in the Aegean region is the largest cotton research institute in Turkey. This particular institute is the only one out of the six which is concentrated on cotton research only. Nazilli Cotton Research Institute has an overall role in Turkish cotton research, by performing cotton research with significance for all of the cotton growing regions in the country (ibid) . The remaining five regional research institutes located in Adana, Antalya, Sanliurfa, Kahramanmaras and Diarbakir (ibid). They are all special research institutes for cotton research although they do research on other crops as well. In addition to the regional cotton research institutes other governmental research institutes also performs cotton research. Some special institutes like Soil and Water Management Institutes, Plant Protection Institutes and Regional Research Institutes carry out occasional cotton research programs on special topics (ibid). The cotton research performed at the governmental research institutes is mostly in the form of applied and adaptive research.

There are some universities that undertake cotton research on various topics on a small scale (Eksi, 2001). The universities are autonomous when it comes to research policies and the research performed at the universities are primarily in the form of basic research although some applied research is also performed at the universities.

The Marmara Research Centre (MRC) is administered by TUBITAK and was established to undertake basic and applied research through its seven institutes. The Genetic Engineering and Biotechnology Research Institute (RIGEB), is performing a few research projects related to cotton (interview at MRC, RIGEB, 2001). RIGEB is at the forefront of modern biotechnological research in Turkey, and the main research organisation involved in cotton research where modern biotechnology is integrated. These cotton research projects are all in the form of basic research and some of the projects are performed in collaboration with Cukorova Advanced Agricultural Technology Research and Development Institute (ibid).

Some private companies are conducting cotton research, but on a very limited scale. There are some private firms performing adaptive field trials for imported seeds as well as for fertilisers, fungicides, pesticides and insecticides often in collaboration with the governmental research institutes (Eksi, 2001). The opportunities for the private companies to perform research are normally very limited. They are not in possession of either technical equipment or human and financial resources to be able to perform research at a large scale (interview at the GDAR, Department of Field Crops 2001).

4.5.b. The Cotton Research System

The cotton research system is dominated by the public sector, where the governmental research institutes are the dominant actors (interview at the GDAR, Department of Industrial Crops, 2001). The GDAR is responsible for setting the overall policies for agricultural research. The priorities for agricultural research are outlined every five years in the Five-Year-Master Plan for agricultural research in Turkey (ibid). The Five-Year-Master Plan is a priority list where the research budget of the GDAR is allocated according to the priorities decided by the GDAR (ibid). In addition to a priority list among the different agricultural areas, each agricultural area also has a five-year-master plan or priority list for the research that is considered most important in that specific agricultural area (ibid). The projects proposed by the research institutes are evaluated by the GDAR according to the relevance with the five-year-master plan. In the case of cotton, a technical advisory committee for field crops evaluates the projects according to the cotton master plan. If accepted by this committee, the Research Council evaluates all of the accepted projects (by different technical advisory committees) according to the Five-Year-Master Plan and allocates the funding according to the priorities in the master plan and the agricultural research budget (ibid).

The second Five-Year-Master Plan (2001-2005) for agricultural research is based on an assumed research grant budget of 5 million US$ over five years (GDAR, 2001). According to the master plan for 2001 to 2005, industrial crops which is the area where cotton belongs, has the second highest priority among the research areas. The five research areas with highest priority are; 1) large domestic animals, 2) industrial crops, 3) cereals, 4) forage crops & pastures, and 5) fruit & viticulture (ibid). The research grant budget estimated for industrial crops are 12 % of the total budget for agricultural research (ibid). Cotton has a high priority among the industrial crops and will receive approximately 10 % of the research budget directed to industrial crops (interview at the GDAR, Department of Industrial Crops 2001).

The priorities set by the GDAR for cotton research is visualised in the Five Year Master plan for cotton and the funding of cotton research is based upon this Master Plan. In the Master Plan for the period 2001-2005 the overall development goal is; *to meet the needs of the country in cotton production, to improve the quality and to reduce production costs* (GDAR, 2001). The master plan also sets out an overall research goal which is ; *improvement of the varieties with high yielding ability and suitable quality for different uses, and to* *develop proper agronomic techniques for the improved varieties to fit in a sustainable agricultural system* (ibid). In order to achieve these overall goals the master plan identifies 16 specific strategies listed in table 7.

The research priorities set by the GDAR apply in principle to all cotton research projects performed in the public sector in Turkey (interview at the GDAR, Department of Industrial Crops, 2001). Still, only the governmental research institutes are directly influenced by these priorities because of the funding system. The governmental research institutes are funded from MARA, the universities are funded through university funds distributed by YOK, and the MRC is funded from TUBITAK. The GDAR points out that there is a problem with collaboration and coordination between basic and applied research caused by the funding system. The universities, which are performing mainly basic research, and the governmental research institutes, which perform mostly applied research, are funded from different sources. The administrative gap between these different research organisations can make the coordination between the different research projects difficult when the objective is collaboration between basic and applied research projects (ibid).

It is important to integrate biotechnology policies with agricultural policies, and the implementation of biotechnology in the agricultural system should be clearly defined (Brenner, 1997: 14). When looking at the research policies set out for biotechnology in general, the strategic targeting project for specifying priority crops that was started in 1993, financed by TTGV, is an attempt of integrating biotechnology policies in the agricultural priority system. As stated earlier, cotton was ranked as number ten in this project with respect to being a priority crop for genetic engineering.

When looking at the priorities set for cotton research by the GDAR in the Five Year Master Plan for cotton research, research on transgenic cotton crops is mentioned as one out of sixteen strategies that will be supported financially in order to achieve the research and development goals set out. This might imply that cotton research using modern biotechnological techniques has a good potential for being financed by the Government. It also implies that the use of biotechnological techniques in cotton research is being focused upon by the policy making authorities in Turkey and that the use of modern biotechnological techniques is integrated in the strategies set for cotton research.

Despite the priority policies set by the policy makers where biotechnology is integrated in the strategies set for cotton research, modern biotechnological techniques are only rarely integrated in cotton research in Turkey. In September 2000 there was a joint workshop and meeting of the Inter Regional Cooperative Research Network on Cotton in Adana organised by FAO, (Food and Agriculture Organisation of the United Nations), ICAC (International Cotton Advisory Committee), the University of Cukorova and Cukorova Cotton Research and Application Center. There were research institutes participating from Turkey, Israel, Greece, Egypt, France, Iran, Bulgaria, Uzbekistan, Azerbaijan and the US. Several cotton research projects were presented in the fields of cotton breeding, variety trials, growth regulators, plant growth modelling, water management, integrated pest management, cotton fibre varieties, biotechnology and economy (Inter-Regional Cooperative Research Network on Cotton, 2000). The papers presented by Turkish scientists represent many of the fields where cotton research in Turkey today are concentrated. The presented papers addressed issues like nutrition, pests and growth variables, which are closely related to the problems facing the cotton farmers when growing cotton. At the other hand the presented papers also addresses research issues like fibre quality, the relation between cotton production and economical output, as well as policies and cost structure of the cotton yarn sectors in Turkey (Inter – Regional Cooperative Research Network on Cotton, 2000).

The participating Turkish scientists were all representing the public sector, underlining the fact that cotton research is almost exclusively performed in the public sector. The participants from Turkey were representing universities, governmental research institutes and MRC. The issues addressed in the abstracts were covering a broad range of aspects related to cotton growth and production. Biotechnology was integrated in three of the presented projects. Two of these projects are ongoing research projects where modern biotechnological techniques are integrated in cotton crop improvement. Both of these research projects are performed at MRC in cooperation with University of Cukorova and Cukorova Cotton Research and Application Centre, which is one of the regional cotton research institutes administered by MARA.

One of these research project named "Cotton Crop Improvement Against Fungal Pathogens through Genetic Engineering" has as its objective to obtain resistance against an important fungal disease on cotton in Turkey named *Verticillum dahlia* through genetic engineering (Inter – Regional Cooperative Research Network on Cotton, 2000). The main goal of the project is to induce anti fungal genes into the cotton genome in order to make the cotton express toxic proteins against the fungus (interview at MRC, RIGEB, 2001). According to the project description, the resistance of genetically engineered cotton plants to disease is likely to reduce the production cost, improve yield and quality, and promote environmentally friendly farm practises (Inter – Regional Cooperative Research Network on Cotton, 2000). This project is also performed with assistance from the Biology Department at the University of Istanbul.

The other research project performed at MRC named "Characterisation and Expression of Metal Induced Genes in Cotton Grown in Southern Region of Turkey" has as its objective to induce genes in cotton plant which are tolerant to toxic heavy metals (ibid). Toxic heavy metals and cations can accumulate in the cotton plants causing damage to the quality of the cotton crops. The projects is aiming at improving the quality of cotton crops by introducing transgenic cotton crops with better tolerance towards heavy metals (ibid).

The use of modern biotechnological techniques in improvements of agricultural crops has two major objectives, to improve production or to improve the product quality (Paillotin, 1998). In production improvements of agricultural crops, research is focused upon tolerance to herbicides and pests, resistance to pathogens, and adaptations to limiting growth conditions (ibid). In product quality improvement, the research will be focused upon improving the quality traits of the crop as an end-product (ibid). For cotton crops examples of the latter might be traits for improved fibre quality like the strength or the colour of the cotton fibres. The ongoing cotton research projects with integrated biotechnological techniques described above belongs to the first category where the objective is to improve the conditions for production. This objective is in correlation with some of the goals set for research and development in the Master Plan for cotton research. In the Master Plan variety improvement for cotton crops resistant to diseases and pests are mentioned, as well as research on the effect on biotic and abiotic stress conditions.

The third research project is a cooperative project between Cukorova Research Institute, the Department of Field Crops at the University of Cukorova and the Department of field Crops at the Mustafa Kemal University. The project is called "Applicability of Biotechnological Techniques in Cotton Improvement", and has as its objective to discuss present and future applications of biotechnological techniques in cotton improvement (Inter – Regional Cooperative Research Network on Cotton, 2000). In the abstract, insect and herbicide resistant transgenic cotton cultivars are mentioned as examples of applications that might reduce production costs and improve the cotton quality (ibid). This projects has not been finalised, but in the future it might be helpful for integrating biotechnology in cotton research policies.

Starting in 1998, some foreign companies have been conducting field trials of transgenic crops in collaboration with governmental research institutes (MARA 1999) . The transgenic crops that have been tested are cotton, maize and potato (ibid), and the foreign companies were TNCs (interview at the GDAR, Department of Field Crops, 2001). The field trials of the transgenic varieties were performed and controlled by governmental research institutes, while the foreign companies provided the transgenic seeds that were tested (ibid). The testing of these crops involved three phases namely; the evaluation of the project, field tests and laboratory tests (ibid). In 1998, two herbicide resistant varieties and two insect resistant varieties were tested (MARA 1999). In 1999, one herbicide resistant variety was tested, one variety resistant to herbicides and insects, and one variety with insect resistance were tested (interview at the GDAR, Department of Field Crops, 2001). Two transgenic cotton crop varieties were tested in 2000; one variety with herbicide resistance and one variety with insect protection were tested (ibid). The tests for the different varieties were all tested in several locations. The report with results of these tests have not been finalised at the time of writing.

A group called the EU-US Biotechnology Consultative Forum was formed in June 2000 with the objective of considering the full range of issues of concern in biotechnology in the United States and in the European Union with specific focus on the use of biotechnology in the context of agriculture and in particular on biotechnology with respect to plants (The EU-US Biotechnology Consultative Forum, 2000: 4). The final report of this Forum outlines some potential risks and benefits often mentioned in relation to GM crops as follows;

> *The ability to engineer herbicide resistant plants may allow the use of relatively environmentally benign agrochemicals and facilitate the implementation of non-till agriculture. Pest and pathogen resistant crops may decrease the application of indiscriminately toxic chemicals that kill beneficial insects and harm other non-target organisms (The EU-US Biotechnology Consultative Forum, 2000: 11).*

Examples of potential risk are also mentioned;

> *Herbicide resistant crops entrench farmers` reliance on chemical weed control, rather than encourage more diverse weed control tactics. Pests may quickly evolve resistance to GM pest-resistant crops, making them ineffective. The evolution of resistant pests to GM Bt crops may even cause traditional Bt insecticide sprays, relatively safe pesticides used by both conventional and organic farmers, to lose their efficacy against certain pests (The EU-US Biotechnology Consultative Forum, 2000: 11).*

These are only examples of potential benefits and risks often mentioned in relation to GM crops. Many other examples could have been mentioned both with respect to benefits and risks of GM crops. The scientific community on a global scale have not reached a consensus with respect to agreeing upon the scientific evidence related to potential risks and benefits of GM crops on the environment.

There are also concerns about the potential effects related to human health when GM crops are used as human food or feeding material for animals used as human food. For these concerns about potential harmful effects of GMOs the situation is quite similar with respect to reaching a consensus among scientists on the field.

A report from the Commission of the European Communities (CEC) (2000) has tried to asses the profitability of GM crops compared to conventional crops. It says in this report that GM crops are expected to allow for cost-savings through reduced insect and weed control/or to achieve higher yields (CEC, 2000). It also says that the effective profitability of a GM crop can only be properly assessed on the basis of several years of cultivation and commercialisation because of the number of factors that have an impact on profitability like yearly fluctuations in yield and prices and developments on the supply and demand side (ibid). The report consequently does not give any definite answers to the profitability question of GM crops. It does, however, point out some points related to these crops (HT soybeans and Bt corn are used as main examples). The main effect of HT crops are the convenience effect, which implies flexibility of herbicide application and labour requirements (ibid). Insect resistant crops have a potential for decreased insecticide input, however the effectiveness depends on growing conditions (ibid).

In Turkey, the questions related to potential benefits and risks of GM crops are currently being discussed by Turkish authorities in connection to the performed field trials of GM crops. The lack of scientific consensus on the issues related to risks and benefits of GM crops makes such a discussion difficult with no obvious answers. It will probably be important to decide upon potential benefits and risks on a case to case basis. When it comes to GM cotton, the cotton growing regions in Turkey are all very different in character, representing a wide range of different aspects that will have to be taken into account at the ecological, economical and socio-cultural level. An application that may be beneficial in one region may be potentially deleterious in another. According to the report of the EU-US Biotechnology Consultative Forum, environmental effects of GM crops should be decided upon on a case to case basis because of the complexities of environmental issues and the wide range of potential applications of the technology (EU-US Biotechnology Consultative Forum, 2000).

4.5.c. Relations Between the Actors in the Research System

Brenner (1997) points out the importance of establishing contacts between scientists involved in biotechnology research and scientists involved in agricultural research. RIGEB at MRC is at the forefront of biotechnological research in Turkey and the relations between RIGEB and Cukorova Agricultural Research Institute suggests that there have been established contacts between cotton researchers and the biotechnological research community The present relations between cotton researchers and the biotechnological research community are relatively limited for the moment, only including Cukorova Agricultural Research Institute, but it might contribute to integrating modern biotechnology in cotton research especially if further relations are encouraged.

Agricultural biotechnology is becoming increasingly global in character, and for developing countries with limited research capacity foreign relations may be important. Linkages with external sources of information, technology and possible capital are important when introducing biotechnology to developing countries (Brenner, 1997: 22). The inter-Regional-Research-Network on Cotton is an example of established linkages and relations across national borders. This research network might represent a good source of information and knowledge when it comes to sharing experiences connected to biotechnology integrated in cotton research and development.

Country experiences suggests that regional collaboration in biotechnology has been most successful thus far in the policy arena (Brenner, 1997: 23). The Inter-Regional-Research-Network on Cotton is such a regional collaboration network, where collaboration might be stimulated both nationally and internationally. Regional collaboration workshops can also be arranged in a national context bringing scientists from various national research communities together. The workshop on biotechnology and biosafety held in Ankara in 2000, is an example of such a gathering.

Close interaction is necessary between the research and farming communities, and among research, farming and industry, both in identifying the major production or other problem areas to which research should give priority, and in providing feedback on the acceptability or appropriateness of technology products generated by the research community and industry (Brenner, 1997: 12). According to the GDAR there are scarce relations between the public research community and the farmers, as well as between the public research community and the private seed industry (interview at the GDAR, Department of Field Crops, 2001). When integrating modern biotechnological methods in the cotton research system the actual demand in the market, the problems on the level of the farmers and perceptions of the consumers and the general public about the technology should ideally be taken into consideration already at the research level in order to perform research that might result in products adjusted to the market.

4.6. Technology Development and the Production System

Technology development refers to the activities which translate successful laboratory work into tangible products[3] (Brenner, 1997: 12). The production system will be looked at here as a system including the actors involved in technology development. The tangible products that will be considered in the production system will primarily be cotton seeds, and when relating the production system to modern biotechnological techniques the development of transgenic seeds and genetically modified crops will be focused upon[4].

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[3] Brenner is limiting the development process to include only tangible products. According to Lundvall the innovation process might include both tangible and intangible products. When considering the use of modern biotechnological techniques in agriculture intangible products might be just as important, if not even more important than tangible products. The use of biotechnological processes in research as a means to improve breeding techniques (using genetic screening with genetic markers) is one out of many example of how biotechnological processes can be used in agricultural research without resulting in transgenic products. The analysis of the development process will, however, only include tangible products because of the limited space available for analysis and because transgenic seeds are currently the most widespread biotechnological products in the Turkish cotton sector.

[4] There are other products that might have been relevant to consider (like bio fertiliser, disease free planting materials, bio pesticides etc.). The analysis of the technology development process will be limited to include only seeds since they are the most widespread biotechnological products currently present in the Turkish.

4.6.a. The Global Picture

As already mentioned, US based multinational companies (MNCs) constitute the strongest group of technology actors on a global scale, especially in the development and diffusion of biotechnology products (Gozen, 1997: 125). In the agri-biotech business, the picture is similar, however in the agri-biotech business there is a concentration of the actors involved in agricultural biotechnology and the actors involved in crop protection (agro-chemicals). According to RAFI (Rural Advancement Foundation International), the ten top agro-chemical companies accounted for 80 to 90 % of the market in agro-chemicals in 1997/98 (CEC, 2000: 26).The seven major companies in the agro-biotech business were the same companies as the seven major companies in the agro-chemicals business when comparing sales figures in 1998 (CEC, 2000: 25). These multinational companies are AgrEvo, Monsanto, Novartis, Rhone-Poulenc, Astra-Zeneca, DuPont and Dow Chemicals (ibid).

In the early 90s the concentration of the seed sector was not as high as for agro-chemicals (CEC, 2000. 26). The development of biotechnology has, however, increased the concentration rate in the seed sector. The commercialisation of GM seeds that began in 1996, resulted in a series of mergers, acquisitions and alliances between gene providers and some of the major seed companies (ibid). Many of the major agri-biotechnology companies now have access to the seed market in which they can market their biotechnology products (ibid).

4.6.b. The Turkish Situation

Traditionally, seed production was exclusively controlled by the public sector in Turkey, and the legal framework concerning production and distribution of seeds was tightly controlled by the state. In 1984 a Decree dated July 8 put forward a new framework for seed imports where the control of imports was handed over to the Ministry of Agriculture and Rural Affairs, and allowed for facilitated credits and credit rates on imports (Gozen, 1997: 214 after Resmi Gazete, 18963). The Decree of December 19, 1985 on the Encouragement of Seed Industry allowed the establishment of a private seed industry in Turkey (Gozen 1997: 214, after Resmi Gazete, 18963). The establishment of the seed industry was encouraged by the liberalisation of seed prises, subsidises on sales prices, and subsidised credit rates. In 1988 the Decree of December 23 lifted custom duties on seed imports (Gozen, 1997, after Kun 1989). In 1986 the Plant Variety and Seed Certification Centre (VRCC) was established administered by the Ministry of Agriculture and Rural Affairs. VRCC is the responsible organ for the registration of new plant varieties in Turkey and for the performance of variety trials (VRCC, 1999).

Seeds are defined in four categories in Turkey according to the Law NO: 308 on Seed Registration, Control and Certification, namely breeder, pre-basic, basic and certified seeds (ibid). Breeder seeds are developed at public research institutes and agricultural faculties, basic seeds at agricultural research institutes and agricultural enterprises, and certified and controlled seeds are produced by public and private sector seed organisations besides nucleus farms (ibid). The certified seeds produced are distributed to farmers through governmental research institutes, agricultural credit cooperatives and private firms (ibid). Only the certified seeds can be distributed commercially.

From 1964 to 1995, 21 cotton varieties were registered in Turkey (ibid). These varieties were all domestically developed cotton varieties registered by governmental research institutes (20 varieties) and agricultural universities (one variety) (ibid). In 1995 the first cotton variety was registered by a private company. From 1995 to 1999, 18 new cotton varieties were registered (ibid). Out of these, 13 varieties were registered by private companies and 5 varieties were registered by governmental research institutes (ibid). From 1999-2001 8 new varieties have been registered. 6 varieties were registered by private companies and 2 varieties were registered by governmental research institutes (VRCC, 2001). All of the cotton varieties registered by private companies are imported varieties, whereas the cotton varieties registered by public research organisations are all domestically developed varieties.

The registration of a new seed variety requires that the seeds in question are in possession of some basic criteria determined in Law NO: 308. Imported seed varieties must be tested in field trials before being registered, and the applicant for the new variety must be a research/breeder institute registered in Turkey (VRCC, 1999). Imported seed varieties registered in another country must be tested in one year of agricultural field trials in three different locations for adaptation and performance tests (ibid). Imported seed varieties not registered in another country must be tested in field trials for a minimum of two years at a minimum of three different locations (ibid). If the documented criteria are not satisfactory, this period may be extended to three or four years. After starting field trials the variety must be registered by the government within four years (ibid).

4.6.c. The Production System

The major actors in seed production in Turkey are the governmental research institutes and private companies. The governmental research institutes perform applied and adaptive research and the development of new cotton varieties with improved qualities is one of the main objectives in public cotton research performed at the governmental research institutes (Eksi, 2001). When looking at the registration of new cotton varieties from 1995 to 1999, the dominance of the public sector when it comes to registration of new cotton varieties is diminishing. In this period private companies have been registering a larger number of new varieties than public sector organisations. The period from 1999 to 2001, also follows this trend where private companies are registering a larger number of new varieties than public sector organisations. It is important to point out, however, that all of the new cotton varieties registered by private companies are imported varieties, while the varieties registered by public research organisations are all domestically developed. This would imply that the private firms are only performing adaptive research in the form of field trials of imported varieties, whereas the public research organisations, almost exclusively represented by governmental research institutes, are developing new cotton varieties through R&D in Turkey.

Currently in Turkey there exists no applied research on developing transgenic cotton seeds. The limited research that is being performed by using modern biotechnological techniques in cotton research (by the Marmara Research Centre in cooperation with a governmental research institutes) is at a very early stage and can be characterised as basic research (interview at RIGEB, MRC, 2001). There are, however, being performed field trials with transgenic cotton seeds as outlined in the section describing the research system. The field trials started in 1998, and the trials are conducted with the purpose of testing imported transgenic cotton seeds for the effects on the environment as well as effects on human health. The transgenic seeds were imported by private firms, and the field trials are performed and controlled by governmental research institutes. The private firms importing the transgenic seeds were Turkish branches of multinational companies (interview at the GDAR, Department of Field Crops, 2001).

4.6.d. The Relations Between the Actors in the Production System

Interactions and feedback mechanisms between public research institutes and agricultural producers, or between the public sector and industry are important for a well functioning innovation system when biotechnology is to be integrated in the agricultural system (Brenner, 1997:17). Generally the relations between the cotton research community and the farmers are weak in Turkey (interview at the GDAR, Department of Field Crops, 2001). Incentives to strengthen such relations might be favourable for ensuring a demand in the market of the final products.

The relations between the public sector and the private sector are limited when it comes to cotton seed production and development of new cotton varieties according to the VRCC (interview at VRCC, 2001). The development of new cotton varieties is primarily performed by governmental research institutes and occasionally by universities. The governmental research institutes have a solid capacity and tradition for cotton breeding and development of new cotton varieties. The private sector, represented by private companies, on the other hand does not have a tradition for performing cotton research except for adaptive field trials of imported varieties. However, the private seed industry is increasing with more and more new cotton varieties being registered by private companies in Turkey. According to the VRCC, the relations between the public sector and the private sector are limited when it comes to cotton seed production and development of new cotton varieties (interview at VRCC, 2001). Incentives to strengthen the relations between the public and the private sector might be favourable for the innovative environment. The major share of biotechnological products in the cotton seed sector is represented by imported transgenic cotton seeds imported by private companies, although these transgenic seeds are not allowed for the commercial market. The field trials that have been performed on these transgenic seeds have been undertaken as a collaborative project between governmental research institutes and private companies because of the obligation from MARA of such trials being performed at governmental research institutes. This incentive might serve as a first step in establishing stronger and more extensive relations between the public and the private sector in the production system of cotton seeds.

4.7. Technology Diffusion and the Distribution System

Technology diffusion refers to the process where the consumers adopt new technology (Brenner, 1997). New technology may be considered both as processes and techniques as well as end-products. Biotechnology may be a set of tools or techniques, often complementary to other techniques, or it might be end-products. New technology will be considered here as end-products in the form of transgenic cotton seeds[5]. In this respect, the traditional distribution system for cotton seeds will be described and some aspects relevant for a possible distribution system of transgenic cotton seeds will be reflected upon. A distribution system will be looked at as a system involving the actors in the technology diffusion process, and the relations between these actors.

4.7.a. The Distribution System

The most important actors in the distribution system of seeds in the Turkish cotton sector are the farmers cooperatives, governmental research institutes and private companies. Most of the Turkish cotton farmers buy new seeds every year, although some of the small scale cotton farmers also save seeds from their own harvest for planting material (interview at the GDAR, Department of Field Crops, 2001).

The farmers cooperatives are sales cooperatives that allow credits or ensure inputs like fertilisers, pesticides, and seeds directly (interview at Ege University, Department of Agricultural Machinery, Faculty of Agriculture, 2001). They also give technical support via extensions, buy agricultural products, pay partially in advance, process the material and perform marketing of the final products (ibid). For the cotton farmers there are three cooperatives divided by the four major cotton producing areas in Turkey. The farmers cooperatives have supportive roles for the cotton farmers at different stages of both the production process of cotton as well as for the distribution process of agricultural inputs like seeds and chemicals, and consequently they might represent a connection between farmers and seed producers and seed distributors.

Governmental research institutes are important sources of seeds for the cotton farmers. The governmental research institutes are developing new cotton varieties as well as maintaining and multiplying already developed varieties for sale, storage and further development (interview at Nazilli Cotton Research Institute, 2001) . The governmental research institutes also have a role in distributing information to the Turkish cotton farmers about developments in subjects like mechanisation and improvement of cultivation, harvesting, processing and

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[5] This does not mean, however, that biotechnological end-products are considered to be more important than biotechnological processes or techniques. Taking into account the limited space available for analysis, the analysis will be concentrated on the diffusion of transgenic seeds as an example of the diffusion process of biotechnology.

storing methods (Eksi, 2001). This indicates that there are relations between the governmental research institutes and the farmers.

The private seed companies are also distributing cotton seeds to the farmers. They are mainly selling imported seeds to the cotton farmers as well as various chemicals.

4.7.b. The Distribution of Transgenic Seeds

Currently, no distribution of transgenic seeds are allowed in Turkey. MARA is expected to make a decision concerning whether transgenic crops shall be allowed in Turkey or not by the end of 2001 (interview at GDAR, Department of Field Crops, 2001).

When considering biotechnological products like transgenic seeds, MNCs are the only actors in the Turkish distribution system with access to these products (if GM seeds are allowed for the commercial market in Turkey). According to the report made by the Commission of the European Communities (2000), farmers adopting GM crops are confronted with several constraints. GM seeds are often sold in the framework of contracts between the seed company and the farmer, which generally preclude seed savings by farmers (CEC, 2000). This might have an effect on the small scale Turkish cotton farmers, that depend on saving seeds. Some biotechnology firms have developed technologies that render GM crops sterile (CEC, 2000: 31). This technology is often referred to as terminator technology and the objective behind the technology is to force the farmers to buy seeds every year. Some biotechnology firms are also charging a technology fee which makes GM seeds more expensive than conventional seeds (ibid). Both the technology fee and the restriction on seed saving imply increased seed costs for farmers (ibid). The centralisation of the GM seed sector, giving the farmers less seed suppliers to choose from, and the contracts between the farmers and the seed companies might lead to a loss of autonomy for the farmers. Many of the GM seed suppliers are also major actors in the agro-chemicals business, and the GM seeds are often sold as “technology packages” involving both seeds and agro-chemicals (ibid). This might also decrease the autonomy of the farmers.

When moving biotechnological products “from the lab to the farmers” several factors might be relevant for the diffusion process. Information and education might be crucial for the diffusion process. When considering the transgenic seeds that have been tested in field trials in Turkey since 1998, product information and education about production methods will be necessary if these products are to be distributed to the cotton farmers. The herbicide resistant and insect resistant varieties that have been tested have specific principles of usage in cotton production to give optimal yield. The herbicide resistant varieties (DP 5690 RR{herbicide resistant} and DP 20B/RR {both herbicide and insect resistant variety}) are only resistant to certain herbicides, which should be communicated to the farmers. The insect resistant varieties are only resistant to certain insects (green bollworm *Heliotis armigera*, and pink bollworm *Pectinophora gossypiella*) and the crops will probably need application of additional chemicals despite this resistance, to protect against other possible pests (interview at Nazilli Cotton Research Institute, 2001). Informing the farmers about principles of integrated pest management in relation to these products will consequently be necessary. As Brenner says, the production of transgenic crops with resistance to specific pests may require management skills and a level of eduaction on the part of farmers which may be incompatible with the conditions prevailing in many of the production systems in developing countries (Brenner, 1997: 21). This is very likely to be the case in Turkey.

To determine if modern biotechnology may benefit the farmers in developing countries, policymakers at the national, regional and international level need to analyse the problems that are currently constraining agricultural productivity or damaging the environment (Persley and Doyle, 1999). The possible usage value of these transgenic crops in the Turkish cotton sector should be correlated to the actual pest and herbicide problems specifically located to the area of application, and to the use of chemicals in the region in question. Cotton growing regions like the Agean region and the Southeastern region where pests are currently not a significant problem will not have the same potential usage value of insect resistant cotton crops as in growth regions where pests are causing major applications of chemicals to reduce the damage of insects on the crops. The costs related to herbicide usage should also be taken into consideration. The application of herbicide resistant crops is probably only valuable to farmers where the use of herbicides in production are already extensive. In cotton growing regions like the Agean region and the Southeastern region, the use of chemicals is generally very limited, and herbicide resistant crops might not have the same potential usage value as in other regions (interview at Nazilli Cotton Research Institute, 2001). As stated earlier, the evaluation of potential risks and benefits of transgenic crops should be evaluated on a case to case basis, where the factors specific to the region in question are taken into account.

Being a contested technology the implementation of transgenic crops in agriculture should also ideally include information about issues like biosafety, human health and ethical considerations related to the use of modern biotechnological techniques both to the farmers and to the general public. Transgenic crops have been the object of strong public opposition in many countries, and if applied to Turkish agriculture the public as well as the farmers should be informed about potential risks related to the environment and human health. In Turkey the general public awareness about issues connected to biotechnology and GMOs is at a very low level. When considering a scenario where the private sector is dominant in distributing transgenic cotton seeds, there is a chance that the information released on issues related to GMOs will be scarce. Commercial extension systems are generally considered to be more efficient than public extension systems in communicating the information necessary to ensure optimal use and to encourage feedback from the producers, but that in the case of biotechnology the maximisation of profit may come in the way of ensuring the distribution of the necessary information to the consumers and to ensure "the public-good" aspect of biotechnology (Brenner, 1997: 19). A private sector interested in economical output from transgenic seeds as a product is not likely to inform about potential risks related to their products that might result in public rejection. Consequently, it might be important that public extension systems are created as informative channels to both farmers and the general public.

4.8. The Influence of the Regulative Environment

All of the aspects mentioned in chapter 3 related to the regulative environment will apply to biotechnological activities in the cotton sector.

The strengthening of protective systems for IPRs and plant breeders` rights are likely to affect the private seed companies and other private organisations in the cotton sector. If transgenic seeds are allowed for the cotton seed market, the strengthening of these protective measures, where the patenting system of the EPC has already been established and legislative measures for plant breeders` rights are waiting for approval, will probably create a more favourable environment for profit making activities related to biotechnology in the cotton sector.

Convention of Biological Diversity (CBD) is addressing several aspects related to the access to genetic resources. In article 16.3 it says that each contracting party shall take legislative, administrative or policy measures to ensure that the contracting party providing the genetic resources, especially those that are developing countries, shall have access to the technology, including technology protected by patents or other intellectual property rights. The EPC for patent systems and the UPOV protective system for plant breeders` rights are not taking the country providing the genetic resources into consideration. When considering the rich genetic material existing in Turkey with respect to cotton varieties, it will be important for Turkey to protect these genetic resources as well as other national genetic resources with regulations to ensure that they are not being exploited and patented by foreign companies without sharing the outcome of these resources as pointed out in the Convention of Biological Diversity.

The Cartagena Biosafety Protocol addresses the issue of genetically modified living organisms and trade. The Protocol contradicts the WTO in allowing governments to use the precautionary principle when refusing the imports of genetically modified living organisms (LMOs).Genetically modified seeds would fall into the category of LMOs. For the moment Turkey does not allow for imports of genetically modified seeds, but there are no measures taken for controlling whether imported seeds are genetically modified or not. According to the Protocol commodities that may contain LMOs are to be labelled as such. If Turkey ratifies the Protocol labelling has to be addressed in the regulatory framework related to commodities containing LMOs.

4.9. The Influence of the Financial Environment

The influence of the financial environment on the biotechnological innovation system in the Turkish cotton sector will share the aspects pointed out for the biotechnological innovation system in Turkey.

The biotechnological activities in the Turkish cotton sector is primarily conducted in the public sector, which implies that these activities are based upon the public funding system. Taking into account the financial situation in Turkey, which is very unstable for the moment, the available funds for the public R&D system in the cotton sector, as well as in other sectors, might be more limited. According to the State Planning Organisation, the current financial situation will affect the funding situation for many of the planned projects in the Five-Year-Development Plan because of tighter national budgets (interview at DPT, 2001).

Strengthening the relations between the public and the private sectors might contribute to establishing alternative funding mechanisms, where the industry might build up more interest in collaborative projects with public R&D. According to the GDAR there are very few examples of public/private collaborative research projects in the cotton sector (interview at the GDAR, Department of Field Crops, 2001).

4.10. Conclusion

When looking at the biotechnological innovation system in the Turkish cotton sector, the main conclusion to be drawn is that biotechnological activities are not widespread in any of the identified units and sub-units which constitute the system. The biotechnological activities that do take place in the system, however, are almost exclusively performed in the public sector.

When looking at the research system, biotechnology is integrated in the governmental priorities set for cotton research. When looking at the actual research conducted, however, there are only very few projects that involve biotechnology. The few ongoing projects where biotechnological techniques are integrated, are at the level of basic research and very few actors are involved. When it comes to the production- and the distribution-system, biotechnological activities are near to being absent from the scene.

If modern biotechnology shall be integrated in the Turkish cotton sector on a larger scale, the technological capabilities of the various actors needs to be strengthened in the form of skills, knowledge, and experience.

Another aspect which is important if modern biotechnology is to be introduced in the various units and sub-units in the innovation system is the relations between the actors in the Turkish system. Frequent and well-functioning relations and feed-back mechanisms should ideally be present in an innovation system to facilitate the distribution of knowledge and information in the system, and emphasis should be put on the lack of relations among the various actors in the system. This applies especially to the relations between the actors in private sector and the actors in the public sector, which are near to being absent. The public sector has established a functioning innovation system based on tradition and historical experience when it comes to cotton research, production and distribution. The private sector on the other hand has recently appeared on the scene with foreign contacts and access to biotechnology products in the form of transgenic cotton seeds. The private companies do not have a tradition for cotton research in Turkey, and might be strengthened by establishing stronger and more extensive relations with the experienced cotton research system in the public sector. The public sector, on the other hand might receive information on experiences with biotechnological products from abroad if more extensive relations are established. More frequent collaborative projects and relations between the public and the private sectors can also make the funding situation for biotechnology in Turkey more favourable, in the sense that it will not only rely upon public funding systems. If MNCs are allowed to commercialise transgenic seeds on the Turkish market there are, however, some risks that should be taken into consideration. These risks involve a potential danger for a centralisation of the seed sector where there are few actors involved in distribution, which could imply a danger of creating dependency of the farmers towards the MNCs with decreasing autonomy for the farmers.

Another aspect which is important with respect to relations between the various actors in the innovation system, is the relations between the research-, production-, and distribution-systems and the consumers. The acceptance of the market cannot be taken for granted when it comes to a knowledge intensive and contested technology like biotechnology, and objective information about biotechnological products and processes should be communicated to the consumers.

The major weaknesses in the biotechnological innovation system in the Turkish cotton sector can be summarised as follows; inadequate technological capabilities of the actors in the system, weak relations between the various actors in the system in general, especially between the actors in the private and the public sectors and between the consumers and the research-, production- and distribution- system.

5. CONCLUSION

5.1. Summary

On a global scale the biotechnology industry is dominated by US based MNCs, with large R&D departments and substantial human, physical and financial resources available. In Turkey, the existing biotechnological activities are limited and the activities performed are primarily situated in the public sector.

The national S&T policies identify biotechnology as one of the main fields of interest when it come to R&D investments. The R&D performed in Turkey in the field of biotechnology is, however, very limited. The national technological capabilities are at a low level when it comes to human resources, and there are few educational organisations offering education on the field.

The public perception of biotechnology is suffering from a lack of knowledge among ordinary people, and there are few informative sources on the field. The public debate concerning possible risks related to biotechnological applications are consequently near to being absent from the public space.

The institutional set-up related to biotechnological activities is generally weak in Turkey, especially with respect to biosafety regulations. The existing regulative framework can be characterised by increasing IPR protection and a lack of biosafety regulations. International agreements and conventions like the TRIPs agreement and EPC have influenced the establishment of patent regulations in Turkey. Plant breeders` rights have still not been established. There are governmental incentives present for establishing a regulation system for biosafety in Turkey, but this has been a long and time consuming process so far. International agreements like CBD and the Cartagena Protocol have not had the same influential power as TRIPs and EPC.

The financial environment in Turkey can be characterised as unstable with high inflation rates after several economical crises during the last decade.

The agro-biotech business on a global scale has many of the same characteristics as the general biotechnology business. The global market is dominated by MNCs, especially with respect to development and diffusion of biotechnological products. The business is greatly centralised with a few dominating actors, mostly MNCs.

On a global scale, transgenic seeds are mainly sown commercially on the American continent, with the US in the lead followed by Argentina and Canada. In 1999 transgenic cotton accounted for 12 % of the total cotton grown in the world.

In Turkey there are no commercial applications of either transgenic cotton or any other transgenic crops.

When looking at governmental policies, cotton is a priority crop with respect to allocation of governmental funding for research and development. Biotechnology is identified as one out of many strategies for meeting the goals set out for R&D in the cotton sector.

The cotton research system in Turkey is dominated by the public sector. There are only a few examples of biotechnological techniques being integrated in cotton research. The cotton research projects where biotechnological techniques are integrated are all in the form of basic research. The private sector only performs cotton research in the form of limited adaptive field trials for imported cotton varieties.

In Turkey, the public sector has traditionally controlled the seed market, but after a liberalisation of this market the private sector is arriving on the scene. In the market for cotton seeds both the public and the private sector is present with actors in the market. The public sector is represented by governmental research institutes, whereas the private actors are private companies, mostly foreign based companies, selling imported cotton seed varieties.

There are currently no applied research in Turkey where transgenic cotton varieties are developed. There are, however, being conducted field trials of imported transgenic cotton varieties. Foreign private companies have imported the transgenic cotton varieties and are performing the field trials in cooperation with governmental research institutes.

Transgenic seeds are not allowed for commercial distribution in Turkey. The conventional distribution system for cotton seeds is dominated by governmental research institutes selling domestically developed varieties and private companies selling imported cotton varieties.

5.2. Concluding Arguments and Policy Implications

According to governmental S&T policies, biotechnology is intended to be one of the main fields of investments when it comes to S&T investments in Turkey. Cotton is a high priority crop in governmental priorities set for R&D in the agricultural sector, and in the governmental priorities set for cotton research biotechnology is outlined as one of the strategies to be invested in when it comes to governmental funding of public cotton research and development.

Having these governmental policies in mind, one of the main questions to be asked is;
- what are the preconditions necessary for introducing biotechnology in the Turkish cotton sector?

When looking at the situation for biotechnological activities in the Turkish cotton sector this question can be divided into two separate questions where each of them are related to different aspects of the innovation system, namely;
- what are the preconditions necessary for introducing biotechnology in the existing innovation system in the Turkish cotton sector?
- and, what are the preconditions necessary for introducing commercial applications of transgenic cotton seeds in the Turkish cotton sector?

In principle these two questions should not be separated, because the commercial distribution of technology products, in this case transgenic cotton seeds, is an important part of the innovation system. Some preconditions will, however, be pointed out for the second question in particular even though the preconditions mentioned for the first question also will apply for the second question.

Turkey is about to make a decision with respect to whether transgenic seeds shall be allowed for commercial distribution. In this regard it has to be taken into account that the national technological capabilities are at such a low level that domestic development of transgenic seeds is difficult at this stage. In other words, Turkey has take into consideration how to improve the national technological capabilities in the field of biotechnology, and the implications of releasing transgenic seeds on the Turkish market.

As for the first question, the major weaknesses in the biotechnological innovation system in the Turkish cotton sector are related to inadequate technological capabilities. The low level of technological capabilities can be seen among the actors in the biotechnological innovation system at a national level, as well as among the actors in the innovation system in the cotton sector. If biotechnology is to be integrated in the innovation system in the Turkish cotton sector, several preconditions should be taken into account:

-The R&D capacity needs to be strengthened especially in terms of human resources among all of the actors in the innovation system. This will require that the education and training systems for biotechnological activities are strengthened. When it comes to strengthening of human resources in the field of biotechnology, this will apply to both the actors in the cotton sector and the actors involved in biotechnological activities on a general level in Turkey.

-Biotechnology is integrated in the governmental priorities set for the cotton sector. These policies and priorities are, however, rarely implemented in the R&D activities actually performed. The policies related to biotechnology consequently needs to be implemented on a larger scale if biotechnology is to be integrated in the cotton sector. The implementation of these priorities will probably require a stable financial environment where long term investments are made.

-The institutional set-up with respect to biotechnology needs to be strengthened, especially in relation to establishing a functioning regulatory framework for biosafety. This will imply that both laws and regulations needs to be established in addition to implementing bodies with capacity to control the following up of the established laws and regulations.

- The institutional set-up will also need to be strengthened in terms of management of established IPR protection systems in order to secure national interests, especially with respect to national genetic resources.

- Informative channels for issues related to biotechnology should be established to stimulate public awareness and public debate around biotechnology related issues.

- The relations between the various actors in the innovation system should be stimulated and strengthened in order to secure interactive feedback mechanisms among the various actors in the system. In this respect the relations between the public and the private sector should be encouraged for knowledge distribution and for establishing alternative funding mechanisms for public research. The relations between the consumers and the R&D system is also particularly important in order to assess the demands in the market at an early stage in the innovation process.

- Establishing new relations and stimulating already existing relations to foreign biotechnology research might be favourable for the innovation system

As for the second question related to the preconditions necessary for introducing commercial applications of transgenic seeds in the Turkish cotton sector, there are some particular aspects that will be taken into consideration.

If commercial applications of transgenic cotton seeds are allowed for the Turkish market, the major actors in the market will most likely be MNCs with local branches in Turkey. The potential risks represented by the centralisation of the seed market should be taken into account. The possible centralisation of the seed market where a few actors are dominating the market will involve the possibility for increased dependency of farmers towards the MNCs as a result of their potential dominance in the market. The contracts often established between the seed companies and the farmers with restrictions on seed saving might also cause a dependency relationship. The increased seed prices and the "technology packages" involving both transgenic seeds and chemicals might increase the input price for the farmers. In such a situation the distribution of objective information about the products and their potential risks and opportunities to the farmers will be of crucial importance, in addition to education and information about production methods.

Opening up for technology from abroad might be favourable for the innovative environment and stimulate technological change, but it is important that there is a national capacity to manage technological change, here represented by transgenic cotton seeds. The national technological capabilities will need to be on such a level that the actors in the innovation system can take advantage of the imported knowledge. This will imply that all of the mentioned preconditions outlined in relation to the first part of the question will apply also for the second part of the question. Technology acquired from external sources can only complement local scientific and technological efforts, it cannot be a substitute for the consolidation of national capacities through local knowledge, education and training, or learning-by-doing (Brenner 1997: 10).

LIST OF ABBREVIATIONS

BTYK	The Supreme Council of Science and technology
Bt	Bacillus thuringiencis
CBD	Convention on Biological Diversity
CEC	Commission of the European Communities
DPT	State Planning Organisation
EEC	European Economic Community
EPC	European Patent Office
EPO	European Patent Office
ETO	Organic Farming Association
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GDAR	General Directorate of Agricultural Research
GM	Genetically Modified
GMO	Genetically Modified Organism
GNP	Gross National Product
ICAC	International Cotton Advisory Committee
IMF	International Monetary Foundation
IPR	Intellectual Property Right
LMO	Living Modified Organism
MARA	Ministry of Agriculture and Rural Affairs
MNC	Multinational Corporation
MRC	Marmara research Centre
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
RAFI	Rural Advancement Foundation
R&D	Research and Development
RIGEB	Genetic Engineering and Biotechnology research Institute
S&T	Science and Technology
TNC	Transnational Corporation
TRIPs	Trade Related Aspects of Intellectual Property
TTGV	Technology Development Foundation
TUBA	Turkish Academy of Sciences
TUBITAK	Scientific and Technical Research Council of Turkey
UPOV	International Union for the Protection of New Varieties of Plants
US	United States of America
VRCC	Variety Registration and Certification Centre
WTO	World Trade Organisation
YOK	Higher Educational Council of Turkey

APPENDIX

1. Tables

Table 1: Development of Transgenic Crop Area by Country
(in Mio ha {million hectares))

	1996	1997	1998	1999	1999 in %
USA	1.45	7.16	20.83	28.64	69.1
Argentina	0.05	1.47	3.53	5.81	14.0
Canada	0.11	1.68	2.75	4.01	9.7
China	1.00	1.00	1.10	1.30	3.1
Brazil	0.00	0.00	0.00	1.18	2.8
Australia	0.00	0.20	0.30	0.30	0.7
South Afr.	0.00	0.00	0.06	0.18	0.4
Mexico	0.00	0.00	0.05	0.05	0.12
Europe	0.00	0.00	0.00	0.01	0.05
Total	**2.61**	**11.51**	**28.62**	**41.48**	100

Source: Commission of the European Communities, 2000

Table 2: Development of Transgenic Crop Area by Crop
(in Mio ha {million hectares})

	1996	1997	1998	1999	1999 in %
Soya	0.45	5.04	13.59	21.78	52.5
Corn	0.30	2.61	9.11	11.28	27.2
Rapeseed	0.11	1.42	2.43	3.46	8.4
Potatoes	0.01	0.01	0.03	0.04	0.1
Cotton	0.73	1.43	2.46	3.92	9.4
Tobacco	1.00	1.00	1.00	1.00	2.4
Total	**2.60**	**11.51**	**28.62**	**41.48**	100

Source: Commission of the European Communities, 2000

Table 3: World Cotton Production

(in millions of 480-lb. bales / 1 lb = 0,454 kg)

	1996/97	1997/98	1998/99	1999/00
China	19,3	21,7	20,7	17,6
United States	18,9	18,8	13,9	17,0
India	13,9	12,3	12,9	12,2
Pakistan	7,3	7,2	6,3	8,6
Uzbekistan	4,8	5,2	4,6	5,2
Turkey	3,6	3,7	3,9	3,6
Australia	2,8	3,2	3,3	3,5
Brazil	1,3	1,7	2,1	3,1
Greece	1,5	1,7	1,8	2,0
Syria	1,2	1,6	1,6	1,5
Egypt	1,6	1,5	1,1	1,1
Turkmenistan	0,6	0,9	0,9	1,1
Argentina	1,5	1,4	0,9	0,6
Iran	0,8	0,6	0,6	0,6
Paraguay	0,2	0,3	0,3	0,4
African Franc Zone	0,2	0,2	0,3	0,3
Others	10,1	10,3	9,8	9,1
World Total	**89,7**	**91,8**	**85,0**	**87,3**

Source: USDA (United States Department of Agriculture)

Table 4: Development of Transgenic Cotton Area by Country

(in Mio ha {million hectares})

	1996	1997	1998	1999	1999 in % *
USA	0.73	1.23	2.00	3.25	55
China	0.00	0.00	0.10	0.30	8
Australia	0.00	0.20	0.30	0.30	79
South Afr.	0.00	0.00	0.01	0.02	13
Mexico	0.00	0.00	0.05	0.05	25
Total	**0.73**	**1.43**	**2.46**	**3.92**	**38**

* in % of total cotton production in each country

Source: Commission of the European Communities, 2000

Table 5: Cotton Production in Turkey: Planted Area, Production and Yield

	Planted area In ha	Production in metric tons	Yield in kg/ha
1932	158100	20200	128
1942	234000	77100	238
1951	641800	149900	234
1960	621000	192000	309
1970	527000	400000	758
1980	671000	500000	744
1990	641000	654000	1125
1995	756000	851000	1125
1999	719000	791000	1100

Source: Eksi, 2001

Table 6: Strategies for Research and Development in Cotton

1. Improvements of varieties and appropriate growing techniques that are suitable for sustainable agriculture
2. Improvement of fibre quality by improving new varieties and growing techniques
3. Variety improvement for the GAP region
4. Variety improvement and growing technique improvement that are suitable for machine harvest
5. Variety improvements for developing resistance to diseases and pests
6. Development of low cost growing techniques
7. Adaptive research on cotton for different agro-ecological zones in rotations and second cropping systems
8. Research on the effect of biotic and abiotic stress conditions on cotton
9. Integrated crop management researches
10. Development of germplasm catalogues and databases for cotton
11. Improvement of coloured cotton varieties with high technological properties
12. Improvement of the adoption rates of improved varieties and management techniques by working with extension workers and the private sector to demonstrate their value under commercial farming situations
13. Research on the effect of macro and micro elements on cotton
14. Research on organic cotton production
15. Surveys to find out new problems on cotton production
16. Research on transgenic cotton crops

Source: The General Directorate of Agricultural Research, 2001

2. Definitions

2.1. Biotechnology

The traditional meaning of the word is; *the use of living cells or microorganisms in industry and technology to manufacture drugs and chemicals, break down waste etc.* (Hendersons Dictionary of Biological terms, 1995). In recent years the term often refers to genetic modification of cells and microorganisms and the use of these. When biotechnology is used with the last meaning of the word it is often referred to as "modern biotechnology", "gene technology", or "recombinant DNA technology" and sometimes "genetic engineering"

In this thesis biotechnology refers to the genetic modification of cells and microorganisms by molecular biology techniques, that are not techniques used in traditional breeding and selection, and the use of these.

Agricultural biotechnology refers to the use of biotechnology in agriculture.

2.2. Developing Country

The World Bank's main criterion for classifying economies is gross national income (GNI) per capita. Based on its GNP per capita, every economy is classified as low income (less than $ 755), middle income (subdivided into lower middle $ 756-2955, and upper middle $ 2996-9265), or high income ($ 9266) (from the web pages of the World Bank)

Low-income and middle-income economies are sometimes referred to as developing economies. According to the World bank the use of the term is convenient; it is not intended to imply that all economies in the group are experiencing similar development or that other economies have reached a preferred or final stage of development (ibid).

Turkey is classified as a developing country with an upper-middle-income economy (ibid)

2.3. Genetic Engineering

The manipulation of an organisms genetic endowment by introducing or eliminating specific genes through molecular biology techniques.

2.4. Genetically Modified Organism (GMO)

An organism produced from genetic engineering techniques, including the transfer of functional genes from one organism to another, and from one species to another.

Living modified organism (LMO) and transgenic organism are other terms used in place of GMOs.

2.5. Living Modified Organism (LMO) according to the Cartagena Biosafety Protocol

Any living organism that possesses a novel combination of genetic material obtained through genetic engineering. A living organism is an biological entity capable of transferring or replicating genetic material.

2.6. Transgenic Crops

Crops with plants with inserted genetic material from another organism.

Transgenic crops are also referred to as genetically modified (GM) crops

BIBLIOGRAPHY

Barton, J. H. (1999), “Biotechnology for Developing-Country Agriculture: Problems and Opportunities, Intellectual Property Management”, 2020 Focus 2, Brief 7, IFPRI

Bell, M. and Pavitt, K. (1997), “Technological accumulation and industrial growth: contrasts between developed and developing countries” in Archibugi, D. and Michie, J.(1997) (eds), Technology, globalisation and economic performance, Cambridge University Press, Camebridge

Bibbee, A. (2001), “Turkey’s Crisis” in OECD Observer No.225, March 2001

Brenner, C. (1997), “Biotechnology Policy for Developing Country Agriculture”, Policy Brief No.14, OECD Development Centre, OECD

The Cartagena Biosafety Protocol of January 29th 2000, UN

Cohen, A. Falconi, C. and Komen, J. (1999), “Biotechnology for Developing-Country Agriculture: Problems and Opportunities. Research policy and Management Issues”, 2020 Focus 2, Brief 8, IFPRI

Commission of the European Communities (CEC) (2000), “Economic Impacts of Genetically Modified Crops on the Agri-Food Sector: A First Review”, Working Document Rev. 2, Directorate-General for Agriculture

Directive on Field Trials of Transgenic Plants (1999), Ministry of Agriculture and Rural Affairs, Ankara

DPT (1996), Seventh Five Year Development Plan (1996-2000), Ankara

Edquist, C. (1997), “Systems of Innovation Approaches – Their Emergence and Characteristics” in Edquist, C. (ed), (1997), Systems of Innovation. Technologies: Institutions and Organizations, Pinter, London, pp. 1 - 35

Edquist, C. and Johnson, B. (1997), “Institutions and Organizations in Systems of Innovation” in Edquist, C. (ed), (1997), Systems of Innovation. Technologies: Institutions and Organizations, Pinter, London, pp. 41 – 63

Eksi, I. (2001), “A Brief Report of Cotton Developments in Turkey”, for the 2000/01 ICAC Research Associate Program 7-17 May, 2001, Washington

EU Commission (2000), “Regular Report from the Commission on Turkey’s Progression Towards Acession” chapter 22: Environment, EU, Brussels

The EU-US Biotechnology Consultative Forum (2000) “Final Report”

Freeman, C. (1987), Technology Policy and Economic Performance: Lessons from Japan, Pinter, London

General Directorate of Agricultural Research (GDAR) (2001), "Draft for the Cotton Master Plan (2001-2005), Ministry of Agriculture and Rural Affairs, Ankara

General Directorate of Economical and Financial Affairs (2001), "Spring Forecast: Turkey", Economic Reform Monitor 2001/2, EU, Brussels

Gozen, A. (1997), From Green Revolution to Plant Biotechnology: Technological Change in the Agriculture of Turkey, University of Amsterdam, Amsterdam

GRAIN (1998), "Global Trade and Biodiversity in Conflict", Issue No. 2, GAIA/GRAIN

Hazell, P. B. R. and Ramasamy, C. (1991), "The Green Revolution Reconsidered", Food Policy Statement No.14, IFPRI

The Inter-Regional Cooperative Research Network on Cotton (2000), "Abstracts" from the Joint Workshop and Meeting of All Working Groups 20-24 September, Adana

Johnson, B. (1999), Genetically Modified Crops and Other Organisms: Implications for Agricultural Sustainability and Biodiversity" for the CGIAR/NAS Biotechnology Conference October 21-22, 1999

Johnson, B. (1992), "Institutional Learning" in Lundvall, B-Å. (ed), (1992), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, Pinther Publishers, London, pp. 23 - 44

Kolankaya, N (2000), "Bioteknolojiye Bir Bakis: Dunya ve Turkiye", Biyotenoloji ve Bioguvenlik Sempozyum 23-24 Ekim 2000, Sempozyum Bildirileri, Ankara, pp. 5

Lawrence, E. (ed) (1995), Henderson`s Dictionary of Biological Terms, Longman Singapore Publishers, Singapore

Lundvall, B-Å. (1992), "Introduction" in Lundvall, B-Å. (ed), (1992), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, Pinther Publishers, London, pp. 1-19

The Ministry of Agriculture and Rural Affairs (MARA) (1999), " A Short Report on the Present Situation of Genetically Modified Organisms in Turkey", General Directorate of Agricultural Research, Ankara

Nelson, R.R (ed), (1993), National Systems of Innovation: A Comparative Study, Oxford University Press, Oxford

OECD (2001), "Policy Reassessment in light of the end-2000 financial crisis" OECD Economic Survey of Turkey

Paillotin, G. (1998), "The Impact of Biotechnology on the Agri-Food Sector" in OECD (ed) The Future of Food: Long-Term Prospects for the Afri-Food Sector, Advisory Unit to the Secretary-General, Paris, pp. 71-90

Persley, G. J. and Doyle, J. J. (1999), "Biotechnology for Developing-Country Agriculture: Problems and Opportunities. Overview", 2020 Focus 2, Brief 1, IFPRI

The TRIPs Agreement of January 1st 1995, WTO

TUBITAK (2000), "Information Brochure for the EU-Turkey Sub Committee Meeting 23-24 November, Ankara", Ankara

Variety Registration and Seed Certification Centre (VRCC) (1999), "Information Brochure", The Ministry of Agriculture and Rural Affairs, Ankara

Variety Registration and Certification Centre (VRCC) (2001), List of Registered Cotton Varieties", The Ministry of Agriculture and Rural Affairs, Ankara

INTERVIEWS

(in the order of citation)

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LIST OF WEB PAGES USED AS SOURCES
(in order of citation)

The web pages of the European Patent Office (EPO):

www.european-patent-office.org

The web pages of The International Union for the Protection of New Varieties of Plants (UPOV):

www.upov.org

The web pages of the Convention of Biological Diversity (CBD):
www.biodiv.org

The web pages of the Ministry of Foreign Affairs (Republic of Turkey):
www.mfa.gov

The web pages of the World Bank:
www.worldbank.org