Research Trends of Agricultural Faculties in Turkey and the World: Bibliometric Analysis of Web of Science, 1996-2011[*]

Türkiye ve Dünyadaki Ziraat Fakültelerinin Araştırma Eğilimleri: 1996-2011 Yıllarının Bibliyometrik Analizi

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Abstract

In this research, agricultural information structure and emerging trends are visualised with social network analysis from 1996 to 2011; similarities and differences between the researches of agricultural research institutions (universities) abroad and in Turkey are detected. Moreover, whether agricultural research policies determined by these institutions, councils and scholars had effects on the researches carried out in agricultural researches were determined. Comparing the agricultural policies in Turkey through the subjects of the publications in Web of Science (WoS), some priorities in agricultural research policies have increased in time. Especially, the water resources (2-3% increase) out of natural resources, biotechnology (4% increase) and environmental sciences (4% increase) more often take place in agricultural policies and alike, number of publications on these subjects has gradually increased. While there is a significant percentage of publication on biochemistry, molecular biology, genetics and heredity, microbiology and cell biology in agricultural faculties in other countries, the percentage of the publications in these fields is much lower in Turkey. According to the subject category, while the researches on agriculture, plant and food science in Turkey gradually decreased, the ones on chemistry, environmental sciences, biochemistry, biotechnology and molecular biology increased. This shows that more special and different subjects on agricultural researches started to be carried out.

Keywords: *Bibliometrics; informetrics; social network analysis; agricultural research policies; keyword co-occurence; agricultural research trends.*

Öz

Bu araştırmada 1996-2011 yılları arası tarımsal bilgi yapısı ve gelişmekte olan eğilimler sosyal ağ analizi ile görselleştirilmiş ve Türkiye ve yurt dışı tarımsal araştırma kurumlarının araştırmaları arasında benzerlikler ve farklılıklar belirlenmiştir. Ayrıca çeşitli kurum, kurul ve akademisyenlerin belirlediği araştırma politikaları konularının yürütülen araştırmalara etkisinin olup olmadığı ortaya konmaya çalışılmıştır. WoS'da yer alan Türkiye adresli yayınların konuları tarımsal araştırma politikaları ile karşılaştırıldığında, belirli bazı öncelikli alanlarda yayın sayısı artmıştır. Özellikle araştırma politikalarında yer alan doğal kaynaklardan su kaynakları (%2-3 artış), biyoteknoloji (%4 artış), çevre bilimleri (%4 artış) konularında yayın sayısı zamanla artmıştır.

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Bu makale yazarın *Türkiye'de ziraat fakültelerinin tarımsal araştırma eğilimleri: 1996-2011 yıllarının bibliyometrik analizi* başlıklı tezinden (Besimoğlu, 2015) türetilmiştir.

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Yurt dışı ziraat fakültelerinde biyokimya, moleküler biyoloji, genetik ve kalıtım, mikrobiyoloji ve hücre biyolojisi konularında önemli oranlarda yayın bulunmaktayken, Türkiye'deki kurumların bu konularda yayın oranları daha düşüktür. Konu kategorisine göre Türkiye'deki ziraat fakülteleri yayınlarında tarım, bitki, gıda bilimi ve teknolojisi konuları düşüş gösterirken; kimya, çevre bilimleri, biyokimya, biyoteknoloji ve moleküler biyoloji konularındaki yayın sayısı artmaktadır. Bu da tarım disiplininde daha özel ve disiplinlerarası araştırmalarla farklı konularda çalışmaların yapılmaya başlandığını göstermektedir.

Anahtar Sözcükler: *Tarımsal araştırmalar; bibliyometri; enformetri; sosyal ağ analizi; tarımsal araştırma politikaları; anahtar sözcük ortak-görülme; tarımsal araştırma eğilimleri.*

Introduction

Information society development and approaches have paved the way for fundamental change in society, economy and industry. This new approach which is based on knowledge rather than in a more classic or coventional sense has been effective in all areas of life. Accessing information and production of new knowledge have gained importance day by day. Individuals and societies have developed new technologies by using information and become superior in economic field. In this context, information has led to new approaches for the development of agriculture and agro-based industry. Thus, producing new knowledge along with utilization of that knowledge has become important nowadays. As is in all fields, producing new knowledge is realized through technological development and innovations and this applies to R&D activities in agriculture as well.

Examining the role of agriculture in Turkey's economy will be useful prior to stating the knowledge production and R&D activities. Agricultural sector's economic share in Gross Domestic Product (GDP) in 2013 is 7.1% (TUIK, 2013). This is a proof that agriculture has still a significant share in Turkey's GDP. In National Agriculture Convention (Ulusal Tarım Kurultayı, 2006) agricultural sector was addressed as a whole and several solutions to the problems were supplied. The importance of introducing producers in knowledge and technology and advancing R&D and technology for agricultural development to solve the productivity problems were emphasized in solutions. Therefore, it can be said that knowledge/information production and R&D activities in agriculture are the issues to be examined in more detail. In 2012, the share allocated to R&D activities in all areas was 0.92% of GDP. If we look at it in a more detailed way, we see that the spending of commercial business is 2,003 million $, and the public is 488 million $ and the higher education institutions is 1,950 million $ (TUIK, 2013). So this shows that 43.9% of R&D spending which is a high ratio is allocated to higher education institutions. Therefore, the effectiveness of R&D activities of universities is also among the issues to be investigated.

The charactheristics of research in agriculture are different from other disciplines. Most of the applications and research in agriculture vary depending on human, nature and technical environment. Aras and Oren (2000, p. 5) stated that agricultural research generally depends on natural and ecological conditions vary from region to region and national and regional agricultural R&D research are practiced because the material which is used is living. Therefore, when compared with agricultural research in different countries, great differences as well as similitaries may be found. These differences are related to variables mentioned above.

Analyzing scientific publications qualitatively and quantitatively, evaluating and comparing them with the researches abroad can be an important source of data for decision makers in this area. The studies to be carried out can make it possible to examine the characteristics of scientific research studies published in agricultural disciplines, to present an outline of the specific case studies in this area and to allow us to make more accurate evaluations towards future.

Between the years of 1996-2011, agricultural research and targeted subjects were determined by State Planing Organization's (SPO) development plans, TUBITAK -The

Scientific and Technological Research Council of Turkey - Supreme Council of Scientific and Technology's (TUBITAK-SCST)- suggestions-policies, Food, Agriculture and Livestock strategy documents, TUBITAK's commissions programs, scholars' views. These documents are prepared for directing agricultural research and R&D. However, how much of these determined policies were performed or what proportion of the work on specified topics was realized have not been investigated yet. Whether wanted/suggested agricultural researches that were determined by these commissions or authorized institutions were in line with the ones by agricultural faculties was not controlled.

In this research, structure of agricultural information and emerging trends are visualised with social network analysis; similarities and differences between the researches in foreign and Turkish agricultural research institutions (universities) are detected. Moreover, whether agricultural research policies determined by these institutions, councils and scholars had effects on the researches carried out in agricultural researches were determined. In this way, decision makers in agriculture can see current state of researches and they can evaluate the researches more accurately.

Related Studies

There has been a lot of studies which covers only one subject or special areas of agriculture discipline in the literature. But there have been few studies in the literature which analysed agricultural publications or used bibliometric methods on agricultural researches as whole and broadly. So it is worth mentioning these studies, methods and findings in detail considering their contribution to our research.

Lichtfouse et al. (2010) analysed subject trends in the journal of *Agronomy for Sustainable Development* in their study The articles that were the most cited between 1999-2000 in the journal, the most searched subjects in the website of the journal and the articles downloaded at most in 2009 were examined. The most cited topics are soil carbon and climate change on the findings. Other highly cited topics are agroindicators, alternative crop management, pest control, fertilization, biodiversity, pollutants, pesticides. However, emerging topics from 2007 are transgenic plants and biofuels. In this research, the most searched queries in the website of this journal were also compiled profiles of each subject drawn between 1999-2009. For example, "crop rotation" has constantly increased since 2003. "Organic farming" has showed a steep increase since 2004. On the other hand, the topic of "genetically modified" which emerged after 2008 has attracted attention. While agricultural forestry was decreasing from 1999 to 2003, after that year it became an increasing trend between 2003 and 2009. However, the most emerging topics have been biofuels, genetically modified crops, conservation agriculture, sociology, organic farming, carbon sequestration, phytoremediation, biodiversity.

In addition to journal-based research, there have also been studies on the impact and the numbers of scientific publications. The researches on 33 European countries' agrifood publications in *WoS* database were examined and findings obtained were compared with different countries and continents. In this study, it is emphasized that it is necessary to evaluate the current situation of the researches on agriculture, agrifood and global problems. As a result, it is found that there is a correlation between economic power and agrifood landscape. Publication numbers and citation rates of the countries which allocate more resources for agricultural research are higher than other countries. 41%, 29% and 30% of the articles about agrifood research belong to Europe, USA and rest of the world respectively. United States' average citation per paper is about 30% higher than that EU-33 countries (Borsi ve Schubert, 2011). When an assessment is done among European countries; it is understoond that countires such as UK, Germany, Spain, France and Holland have more citations. Nevertheless, findings indicated that certain European countries have more impact on some fields; for example, France in plant breeding, biotechnology and animal health and welfare, Spain in animal production and

husbandry. The countries including Belguim, Croatia, Greece, Holland, Portugal, Spain and Turkey have high share in national S&T on the fields of management of natural and biological resources, animal production and husbandry (European Agrifood Research Landscape, 2008).

In another research, scientific publications indexed in *AGRICOLA* and *Science Citation Index-Expanded* (*SCI-E*) among 1991-2005 which have "agriculture" and "Africa" in their keywords were analysed. Data obtained from both databases were analysed according to their kind of documents, year of publishing, subject categories, country, journal, language, collaboration of authors. The most researched domains in agriculture in Africa were environmental science, plant/crop production and [agriculture] economics (Ocholla ve Onyancha, 2006).

Hasan (2010) analysed bibliometric data such as the publication numbers, authors, institutions, the journals which were most published ones and subject distribution of publications which were addressed by India and that were indexed in *AGRICOLA, AGRIS, CAB* ve *FSTA* between 1990 and 1999. Also a comparison of bibliometric indicators was made with World and India's. According to results; plant diseases, plant breeding and genetics, plant production, fertilizers and other amendments are the forefront researches in India (Hasan, 2010).

There are also researches which analyse the place of agriculture discipline within general literature by bibliometric methods and aim to demonstrate their different features and characteristics. Gazni, Sugimoto and Didegah (2011) investigated the cooperation between institutions and countries based on data from 2000-2009 in *Essential Science Indicators (ESI)*). In agricultural sciences, multiauthored publications rose from 79% in 2000 to 88% in 2009. Moreover, the ratio of researches carried out in multi-institutional collaborations in agriculture increased from 35% in 2000 to 43% in 2009.

Besides, there have been several studies used similar methods on social network analysis or mapping/visualization (Cheng and Wang, 2011; Lee and Su, 2010; Lv et al., 2011; Su, 2012; Su and Lee, 2010; Yoon, Lee and Lee, 2010).

In a scientometric study, Turkey's relative citation[1] impact in disciplines and contribution to the World were examined. As a result of the study, it is found that Turkey's relative citation impact is 0.72 in agriculture and it is under the average of world (Al, 2009). This rate that is below 1 means low relative citation impact.

Methodology

In this study, bibliometrics and social network analysis were used. *Bibexcel* was used for determining the subjects of publications of agricultural institutions. *Bibexcel* is a tool for bibliometric analysis and designed to calculate statistics.[2] *Gephi* was used for social network analysis. G*ephi* is a visiualization and exploration software for various graph, network and data analysis.[3] Information about method is explained in detail -in the doctoral dissertation (Besimoğlu, 2015, pp. 48-49). In this research, data tables in the appendix of dissertation was used as well.

Research Scope

The main objectives of the research are to analyse agricultural researches at the universities in 16 years to see whether the results obtained are in line with the agricultural research policies in Turkey and to compare them with researches abroad:

- Agricultural research policies that are given in SPO's developement plans, Food, Agriculture and Livestock Ministry's strategic documents, TUBITAK's research

[1] Relative citation impact is the value calculated by dividing the average citation rate per paper to world average citation rate in a relevant subject in a certain time (Al, 2009, p. 3).
[2] See also http://homepage.univie.ac.at/juan.gorraiz/bibexcel/
[3] See also https://gephi.org/

programs, TUBITAK-SCST policies/decisions, scholars' opinions, articles etc. from 1996 to 2011 in Turkey (outlines of the major goals and priorities in the key documents on agricultural research policies in Turkey can be found in the section below),

- Scientific agricultural publications addressed in agricultural faculties in Turkey and published in journals abroad in *WoS* database from 1996 to 2011 (7,183),
- Scientific publications (152,358) which are addressed in agricultural faculties, schools, colleges, universities in *WoS* database abroad from 1996 to 2011 were examined and necessary comparings and evaluations were made in the research scope.

Data Sets

The publications addressed in Turkey's agricultural faculties in *WoS* are the first data set and the ones originated from abroad agricultural faculties in *WoS* are the second data set. The search queries used for the two data sets are as below:

The query for foreign agricultural faculties: Address=(Fac Agr OR Sch Agr OR Coll Agr OR Agr Univ*) Refined by: DOCUMENT TYPES: (ARTICLE OR PROCEEDINGS PAPER) [excluding] Countries/Territories=(TURKEY)

The query for the publications addressed in *WoS* (Turkey): ADDRESS (Fac Agr OR Ziraat Fak) AND ADDRESS: (Turkey OR Turkei OR Türkiye) Refined by: DOCUMENT TYPES: (ARTICLE OR PROCEEDINGS PAPER) AND [excluding] SOURCE TITLES: (TURKISH JOURNAL OF VETERINARY ANIMAL... etc.). Turkey-based journals (which are analysed as national data set in doctoral thesis) are excluded because they are indexed in the national database (Besimoglu, 2015a; Besimoglu, 2015b).

Publications of agriculture faculties adressed in Turkey and abroad are analysed in three different periods as 1996-2001, 2002-2006 and 2007-2011. The tables of subject terms which are obtained from the bibliometric analysis are placed in Appendix 1. Detailed tables of subject terms can be seen in Besimoglu's (2015) doctoral thesis.

Analysed Data Fields

Fields that were analysed are given in Table 1. Keywords and *WoS* Subject Categories are examined in both data sets. However, subject terms are searched from *CAB Direct* database and then processed into data file for publications addressed in Turkey. Publications which do not have keywords and subject terms are given in Table 1. There are no publications that have not *WoS* subject category in both data sets.

(Table 1): Analysed Data Fields

	***WoS* World Agricultural Faculties**			***WoS* Agricultural Faculties in Turkey**					
		Keywords			**Subject Terms**			**Keywords**	
Periods	**n**	Absent	Absent %	**n**	Absent	Absent %	An*	Abssent	Absent%
1996-2001	39,085	13,192	33.75	404	60	14.85	344	178	44.04
2002-2006	43,744	11,424	26.11	2,272	274	12.05	1998	467	20.55
2007-2011	69,529	14,222	21.70	4,507	572	12.69	3935	565	12.53

*Analysed number of publications

Social Network Analysis

Keyword co-occurrence networks are prepared by method of social network analysis for keywords that are sub-level identifiers.

Network's most influential concepts and their relationship with each other can be visualized by the social network analysis. Concepts/actors are defined as nodes and relationship between concepts as edges. Thus, the structural characteristics of the network,

efficient/influential concepts and relationships can be more clearly understood with network analysis. To detect most influential concepts, betweenness centrality measure is used. Betweenness centrality represents how often it appears on the shortest path between two random nodes in network. In other words, it is the degree of presence of each concept among other concepts in the network. For example, betweenness centrality measure of the word of genotype is found high in many network figures. It is because genotype is more presented among other concepts in our study. In this context, the concepts whose betweenness centrality is high are more influential in that network. There isn't any certain degree or acceptable value of betweenness centrality score. The interpretations and comments are made according to the comparison of value of the nodes. In order to understand the structure of the network, average path length and modularity class values are used in this study. Average path length is a measure of the average path taken to connect to any other of the two randomly selected nodes (Newman, 2010; Paranyushkin, 2011). The lower number of average path length represents the more interconnected network. Modularity class indicates that it can be used in order to detect distinct communities within the network. Some nodes in the community can be allocated into modularity classes by having a more intense connection. Thus, while more connected concepts can be classified together, others which have less dense connections can be distincted from them (Paranyushkin, 2011). It indicates that there are nodes in the network that are more densely connected between each other than with the rest of the network.

Keyword co-occurence network values which are formed from social network analysis can be seen in the Appendixes (See Appendix 2-7). Co-occurence file (.net) is prepared first in *Bibexcel.* Before the visualization of social network analysis is formed, keywords in the data sets are standardized (Besimoglu, 2015, pp. 150-151). For example; words such as "rice", "Oryza sativa L", "Oryza sativa L." are merged as "rice". Standardization of keywords are made based on the CAB Thesaurus.

Limitations of Research

The data of the study include publications from 1996 to 2011 in *WoS*, but publications were included into the above-mentioned years and indexed until 2012 (last data was downloaded in June 2012).

Subject Outline of Agricultural Research Policies in Turkey

In this part, outline of the agricultural research policies that were divided into three periods of 1996-2001, 2002-2006 and 2007-2011 are given.

For the starting, year 1996 and next five years, 1994 and next years are taken into consideration. For instance, considering that "Turkey's Public Agriculture Research Program" (2005) that was issued in 2005 will be reflected in the research for 2006 and next years, comparisons were made. As a result of comparisons, percentage increase/decrease in the priority subjects was examined. There is no threshold about how effective the stated policies are. For this reason, evaluations are made for percentage changes of the topics of publications according to periods. Moreover, comments should be made by considering the unique characteristics of agricultural discipline, Turkey's existing scientific knowledge on this field and socio-economic conditions.

Agricultural Research Policies: 1996-2001

Concrete policies were not determined in this period. The most important document that gave direction to agricultural research policies was *1995 Development Plan* in this period. *Seventh Development Plan* which is prepared by SPO emphasized concentrating on biotechnology research in agriculture (DPT, 1995).

SCTS's policies and decisions should also be taken into account. SCST has set the policy on these subjects by publishing "Turkey's Science and Technology Policy: 1993-2003" on 3rd Febuary, 1993. With regard to agriculture, giving priority to biotechnology research has come into prominence in this document. (TUBITAK-BTYK, 1993). In the 2nd meeting of SCST, focusing on R&D activities in related to genetic engineering and biotechnology, environmental friendly technologies were proposed (TUBITAK-BTYK, 1997).

In addition to SPO and SCST, authorities and scholars suggested views about agricultural researches in Agricultural Engineers Technical Congresses. The major policies of the 1996-2001 periods are summarized as follows:

- Researches for conservation and development of soil and water resources,
- The impacts of water and soil pollution, biological and agricultural protection methods on plant and animals about environment and ecology,
- Biotechnological researches for plant breeding, plant-soil-climate-water relations on plant production,
- Animal production and husbandary: livestock breeding and animal gene resources on livestock production,
- Food processing and additives in related to food safety on agricultural products.

Agricultural Research Policies: 2002-2006

During this period, agricultural research policies were examined in more detail. Especially priorities and objectives on agriculture are expressed more clearly in SPO *Eight Development Plan, Ad-Hoc Commitee Reports, TUBITAK (2003) Vision 2023 - Agriculture-Food Panel and SCST meetings.*

TUBITAK Vision 2023 Science and Technology Forecast Project is one of the most important documents giving direction to science and R&D activities. In this report, Turkey's situation, 2003-2023 period and the basic tendencies and driving forces, strong and weak points, opportunities and threats, future vision, roadmap of Science-Technology-Innovation policies are identified. Priority technologies and the roadmap are outlined as below:

- Developing new geneotypes: Molecular breeding techniques, in vitro and in vivo, embryo production, embryo transfer, tissue culture techniques, modern biotechnology;
- Seed producing and breeding (Plant and animal): seed, seedling, sapling production;
- Characterization and preservation of gene resources: identification and registration of gene resources, establishment of second gene bank;
- Processed product diversity, food processing methods and procedures;
- Food security and safety: Food quality management, economy, processing, packaging, preservation, genetically modified organisms (GMO) research;
- Development of equipment and structures in agricultural, forest, food and fishery products, and domestic mechanization and structures of production systems: in crops maintenance, harvest, preservation, processing;
- Activation of protection, control and treatment techniques, and combat against and integrated control of disease-pests: 2013-2017 decreasing the use of pesticides, vaccine and hormone production, applied and industrial on bio-pesticides;
- Evaluation and development of natural resources and wild life: benefiting economically from rich plant variety, identification of endangered varieties in ecosystem;
- Development and dissemination of information technologies like remote sensoring and early warning system in agriculture and forestry: development of GIS, remote sensing, software and information systems.

Based on the review of other documents, the suggested general topics that should be emphasised on agricultural research between 2002 and 2006 can be summarized as below:

- Using environmental friendly agricultural production systems and methods to protect ecological life,
- Biotechnological methods in agriculture,
- Seed production,
- Animal and plant breeding (resistant to climate conditions, diseases and pests),
- Yields of animal products,
- Identification and preservation of natural (plant and animal) genetic resources.

Agricultural Research Policies: 2007-2011

The period between 2007-2011 is the one that is determined in most detailed and most clearly way. The macro targets in agricultural industry are stated as *Ninth Development Plan for 2007-2013* (DPT, 2006) and *Strategic Plan* (Tarım ve Köyişleri Bakanlığı - Ministry of Agriculture and Rural Areas, 2010).

In this context, the research, conservation and evaluation of Turkey's biological diversity and genetic resources (fields about environment - p. 74 article 459), R&D activities on biotechnology (R&D and innovation - p. 75 article 482), high value-added animal husbandry, animal breeding, combat with diseases and pests, fodder breeding, (Agricultural efficiency - p. 79 article 506) are the subjects to come to fore (DPT, 2006).

The most important document of this period which was prepared as a result of meetings with universities, ministry, private sector, TUBITAK's institutions and related stakeholders in 2005 is "*Turkey Public Agriculture Program*" (Tarım ve Köyişleri Bakanlığı, 2005).

The chapter A of this program contains the primary topics of the researches that have priority. In the program, there will be a need for the researches on developing animal breeds that are adaptable to environmental conditions and have high yields. In the field and horticultural crops, R&D studies on development of species that are resistant to environmental conditions, stress, disease and pests of exploring genetic potential of plants; production of seed, seedling, sapling technology are emphasized. Combat with pests via biological methods are the other important researches underscored. In the natural resources, the subjects of identification, information gathering, conservation and sustainable utilization of soil and water resources; and river basin water management researches are significant. It is suggested to detect soil pollution (heavy metals, pesticides, hormones, organic compounds, radioactive wastes, salinity, alkalinity) and develop methods for amendment. Researches on plant and animal genetic resources, identification, conservation and registering genetic resources are other suggested topics. It was stated that the researches on food safety and quality in food science should be developed. The researches on rural development, agricultural policies analysis, agricultural information systems, agricultural extension, agricultural cooperations and organizations are the ones that should be focused in agricultural economics.

Some policy differences and similarities are realized between three periods in overall picture. Biotechnology and animal and plant breeding topics are constantly the research priority in all three periods. After the first term (in 2002-2006 and in 2007-2011) to protect environment and ecosystem low-input farming (pesticides, fertilizer etc.) policies are more common. In the last period, policies changed by moving beyond the identification of natural resources towards management and conservation. Also organic farming, transgenic plants, GMO, seed technology, biological control, plant resistance to various factors (disease, pests, climate etc.) became more important in the last period.

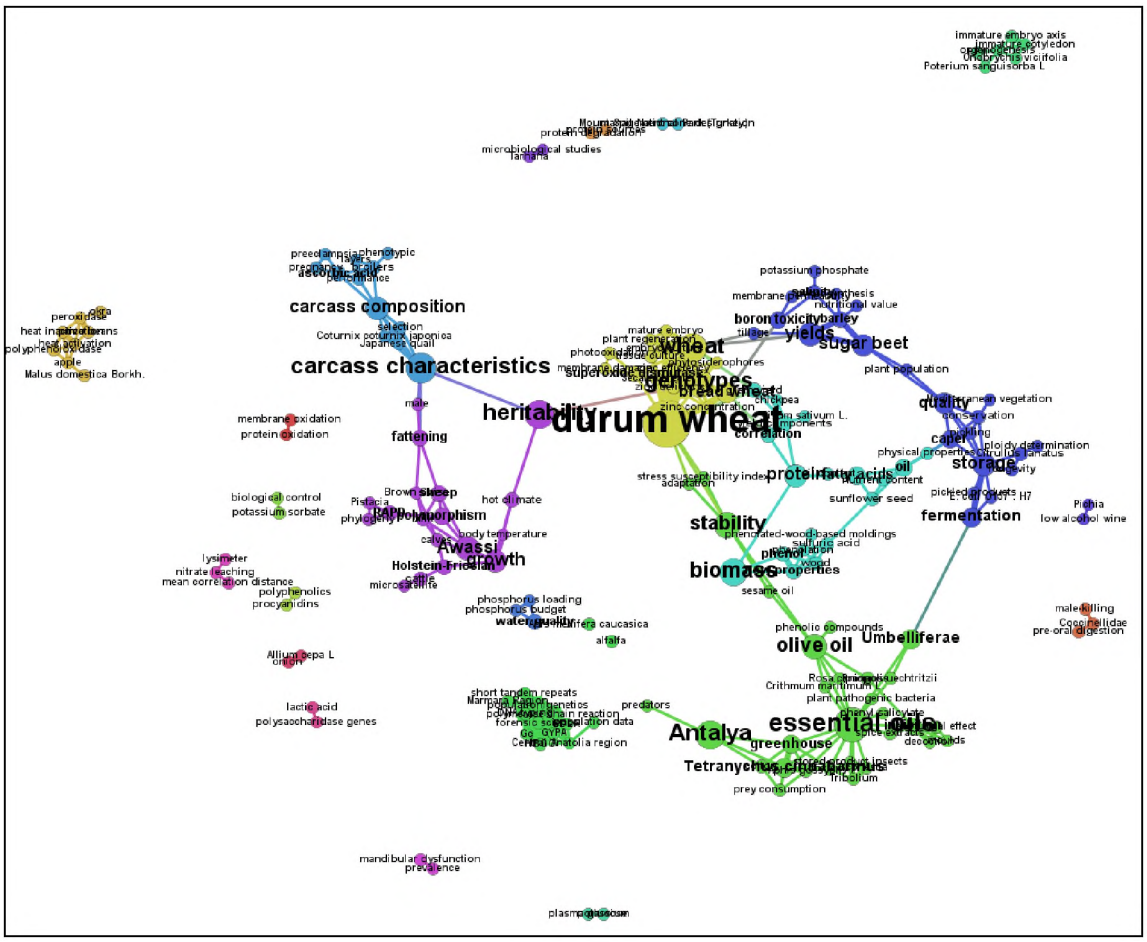
Findings

Subject Analysis of Agricultural Faculties in Turkey

Publications of agriculture faculties in Turkey were analysed via social network analysis in the periods of 1996-2001, 2002-2006 and 2007-2011.

Subject Analysis of Agricultural Faculties in Turkey between 1996-2001

In Figure 1, keywords of publications in Turkey between 1996 and 2001 are visualised. The keywords of this period have a scattered structure according to the figure. Fewer publications with diverse subjects caused less connection. The network of nodes and edges are 177 and 325 respectively. It can be said that the 1996-2001 period has a dispersed structure due to the number of fewer publications that caused appointed keywords to be fewer.



(Figure 1): Keyword Co-occurence Network of *WoS* Agriculture Faculties in Turkey, 1996-2001 (See Appendix 2 for options)

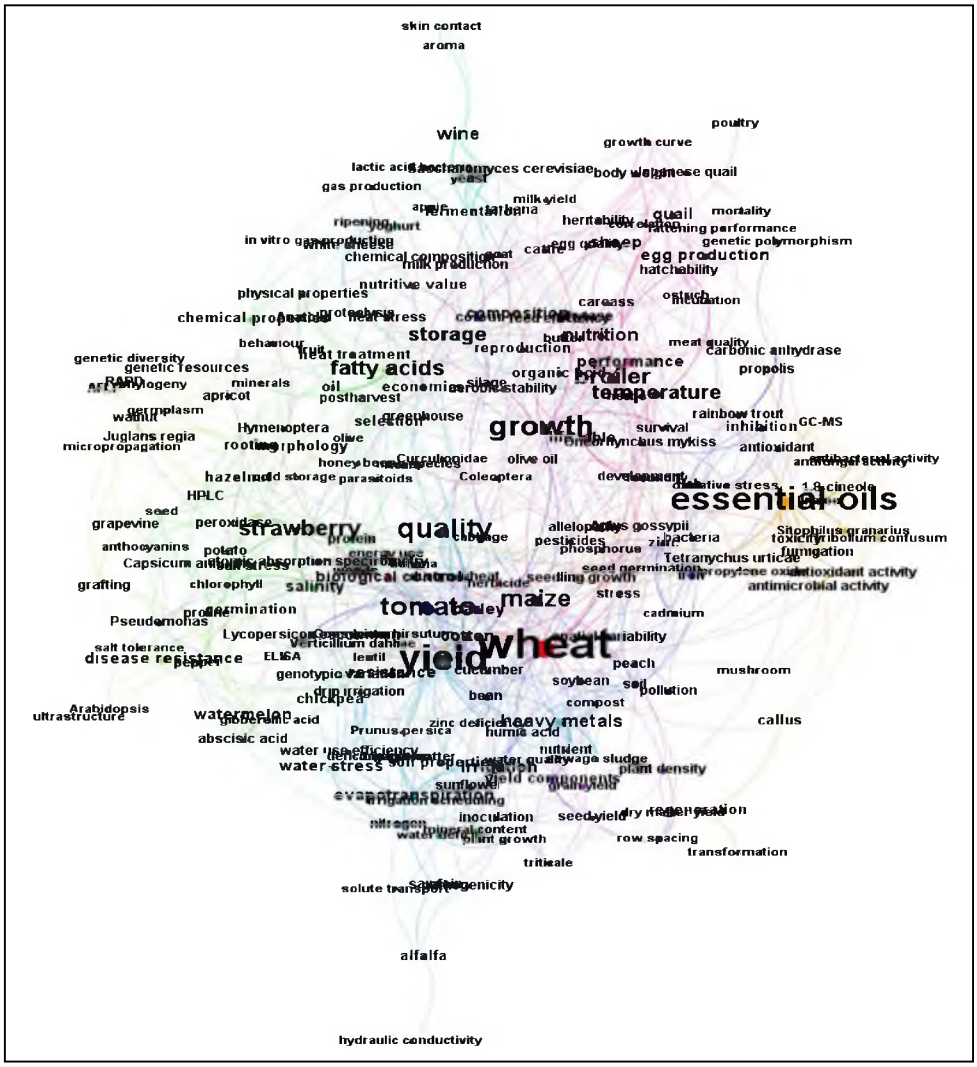
Network average path lenght (APL) is 5,061. The low measurement of APL within the network indicates that keywords are more connected to each other. However, in the period of 1996-2001, the average path lenght is high, and keywords' connection is low when we compare with other periods. In SNA low connection means there are low connection and edges in the graph. As you will see the next graphs (Figure 2 and 3) there are more edges and connection. Therefore APL value of the Figures below are more connected when we compare with *WoS* Agricultural Faculties of Turkey 1996-2001 period (Figure 1).

In the period of 1996-2001, the most prominent concepts in the keywords' network are *durum wheat*, *essential oils*, *carcass characteristics* and *heritability*. On the other hand,

biomass, *carcass composition*, *genotypes*, *olive oil* are important terms in different communities. Network is comprised of 23 modularity class due to few numbers of publication and various researches. *Stability*, *toxicity*, *inhibition*, *cotton*, *sugar beet* and *greenhouse* in plant researches are considered to be different important keywords.

Subject Analysis of Agricultural Faculties in Turkey between 2002-2006

In the period of 2002-2006, there are 222 nodes and 803 edges in the network. On the other hand, this period average path lenght is 2,918. This number is less than previous period, and shows us there are more connections between nodes. Having more publications and keywords than the previous period has an impact on the results (Figure 2).



(Figure 2): Keyword Co-occurence Network of *WoS* Agricultural Faculties in Turkey, 2002-2006 (See Appendix 3 for options)

The keywords which have high betweenness centrality measure in the network are respectively; *wheat*, *yield*, *essential oils and growth*. Topics on plant and animal *growth, quality, essential oils* are on the rise, and are researched about certain product or living.

Nine modularity classes are detected as a result of network analysis. The *storage*, *fermentation of products*, *lactic acid bacteria* and *postharvest activities* are prominent issues about food science. (Turquoise community)

In Figure 2, that communities are grouped as *broiler, quail, sheep, cattle* in purple community, and they indicate the highest betweenness centrality for living beings. From the Figure 2, it is understood that *growth, nutrition, performance, heritability, temperature, hatchability and feed efficiency* are focused on for these living beings. Blue edges with 17,49% ratio is the biggest group. In this group, *yield, quality, heavy metals, irrigation, evapotranspiration, water stress, organic acid, soil properties* are influential concepts. Being one of these concepts on the figure as bigger ones show that irrigation and soil researches on plants are done.

Bright green group has the research subjects such as *salinity, heat treatment, chemical properties, genotype variation, salt stress. Strawberry, potato, chickpea* etc. are researched as crops.

There are the researches on *essential oils, composition, regeneration, seed germination, antioxidant* activity in the yellow community which is distinct in the network

Biological control, resistance, pesticides, herbicides are influential terms in related to plant protection. Another community represented as green (Appendix 3: group no 7) has the concepts of *strawberry, fatty acids, salinity, heat treatment, germination oil* etc.

During this period, *antioxidant, pollution, toxicity* are concepts which gained relatively importance as compared to the previous period. *Morphology, biodiversity, genetic resources, RAPD, rooting, germplasm* (red community) are keywords that have not been seen in the previous period, but appeared in the period of 2002-2006.

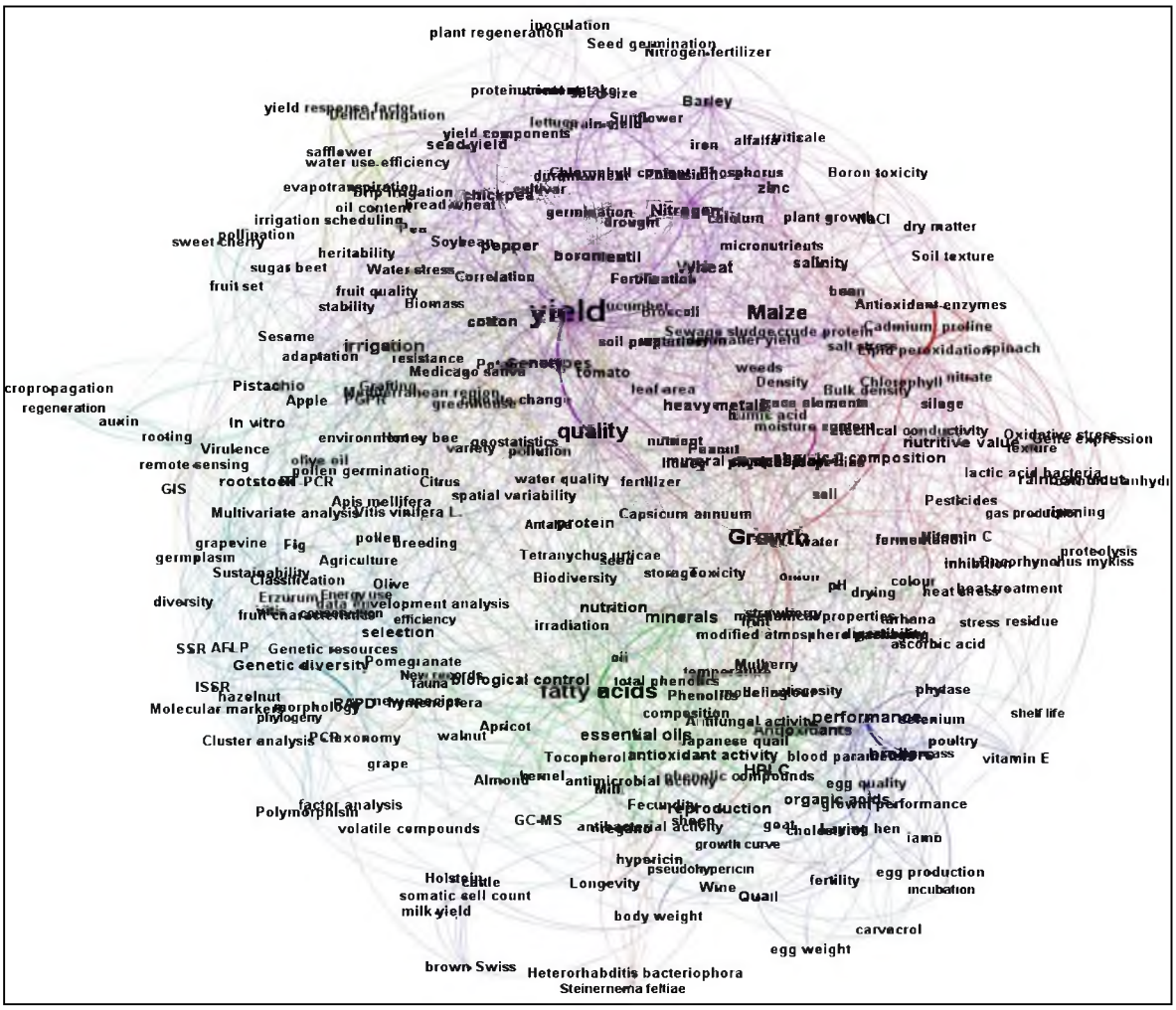
Subject Analysis of Agricultural Faculties in Turkey between 2007-2011

Keywords co-occurence network of publications of agricultural faculties in Turkey from 2007 to 2011 is visualized in Figure 3. There are 285 nodes and 1995 edges in the network. This indicator shows us there are more connections compared to the previous periods.

"*Turkey*" has the highest betweenness centrality value in the network. But it is excluded from the network visualization because it represents only location names. Because evaluations are made through subject terms in the network and publications with Turkey address are already examined in this part, extracting the keyword of "Turkey" from the network does not affect the importance of subject terms but increases the visibility of them in the network. But "Turkey" word is not only a location name and is an animal too. This situation is a limitation for national data sets.

The most influential words in the network are *yield, growth, fatty acids, quality, maize and wheat*. These words indicate that the researches related to the yield, quality and growth of crops and animals have intensified. The collabortative works with *cotton, tomato, seed yield, maize, chickpea, sunflower* aremore salient/prominent.

In this period, *climate change, heavy metals, salinity, trace elements, toxicity, biodiversity, genetic resources* are the keywords that gained importance in comparison with previous period in the network. Moreover, in this period, the increase of importance of the words such *as heavy metals, toxicity* shows that the researches related to environmental pollution increased. The studies on *biological control, antioxidants, antioxidant activitiy* that are seen in the previous periods continued in this period. The research methods such as remote *sensing, molecular markers PCR, AFLP, SSR* were the subjects that emerged for the first time in this period. *Soil characteristics, nutrition, fertilizing, mineral composition* related to soil science were salient/prominent too.



(Figure 3): Keyword Co-occurence Network of *WoS* Agricultural Faculties in Turkey, 2007-2011 (See Appendix 4 for options)

The keywords related to the animal science in network analysis are grouped as dark blue community. The researches on *broilers, cattle, the growth of quail and sheep, performance, fatty acids, egg quality* and *reproduction* in livestock production are prominent.

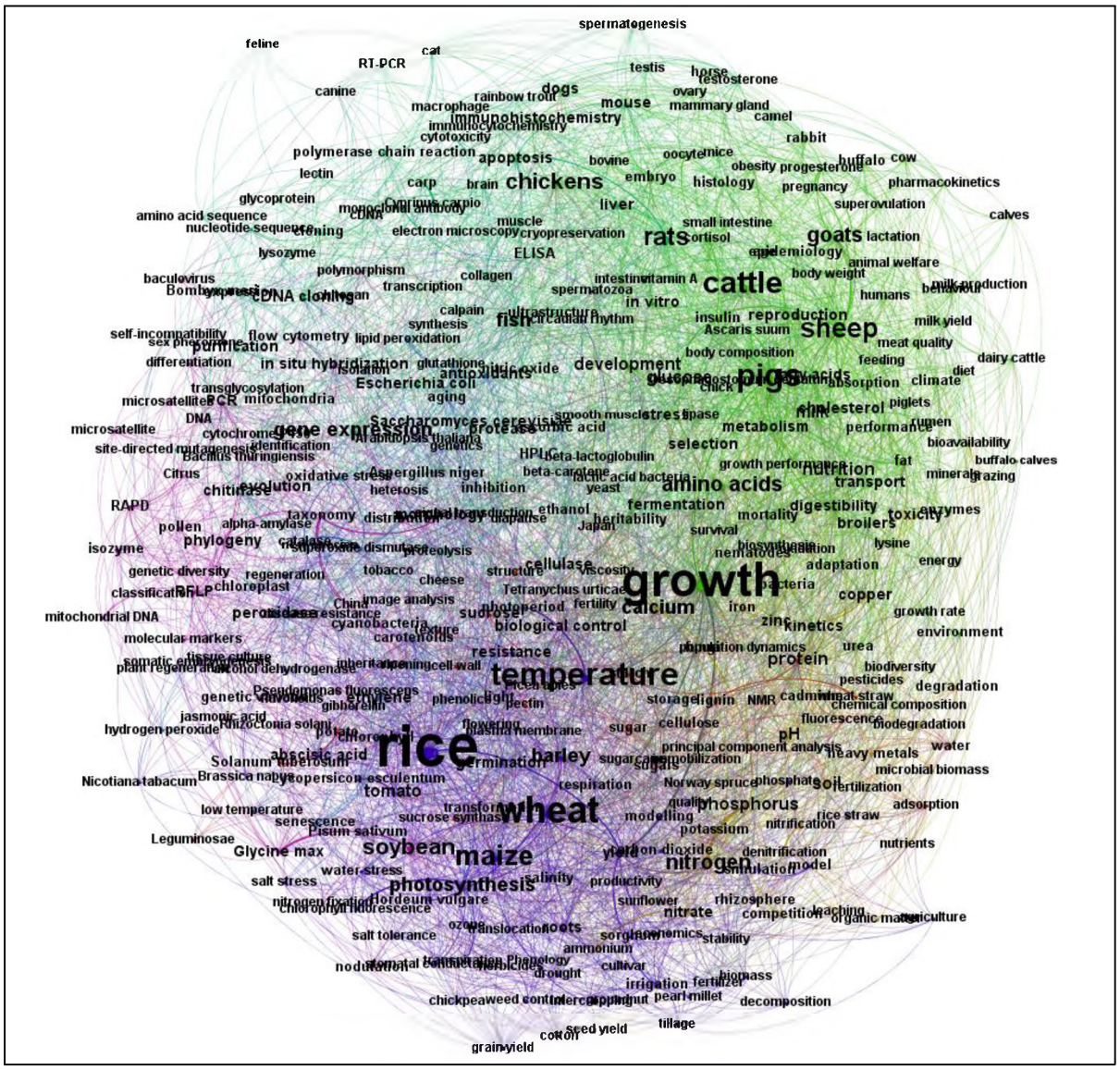
The words of *in-vitro, selection, rootstock, RAPD, genetic diversity* and *breeding* are in turquois group (Appendix 4: Number 7) as the most influential ones.

Subject Analysis of Agricultural Faculties in the World

The keywords of the publications that are addressed in agricultural faculty, college, school and university in *WoS* are examined by social network analysis method according to the indicated three periods.

Subject Analysis of Agricultural Faculties in the World between 1996-2001

The keywords of the publications of various agricultural faculties in the world are visualised by social network analysis method in Figure 4.



(Figure 4): Keyword Co-occurence Network of *WoS* World Agriculture Faculties 1996-2001 (See Appendix 5 for options)

Keyword co-occurance file is formed by the keywords whose threshold value is 28 and over in the social network analysis. There are 354 nodes and 4,993 edges in this network formed within this framework. The network is seperated into 7 communities by the value of 0.35. The most influential keywords in the network generally are *rice, growth, wheat, temperature, pig* and *cattle*.

Animal science researches are roughly grouped in green cluster. The researches such as *growth, gene expression, development, stress, amino acids* on the animals such as *cattle, sheep, pig* are more visible/influential.

The studies such as *germination, photosynthesis, resistance, modelling related to rice, wheat, soybean, maize* are realized in the second big group, dark blue cluster. In this group, there are terms such as *irrigation, biomass, disease resistenace, genetic variation* that have relatively low betweenness centrality value.

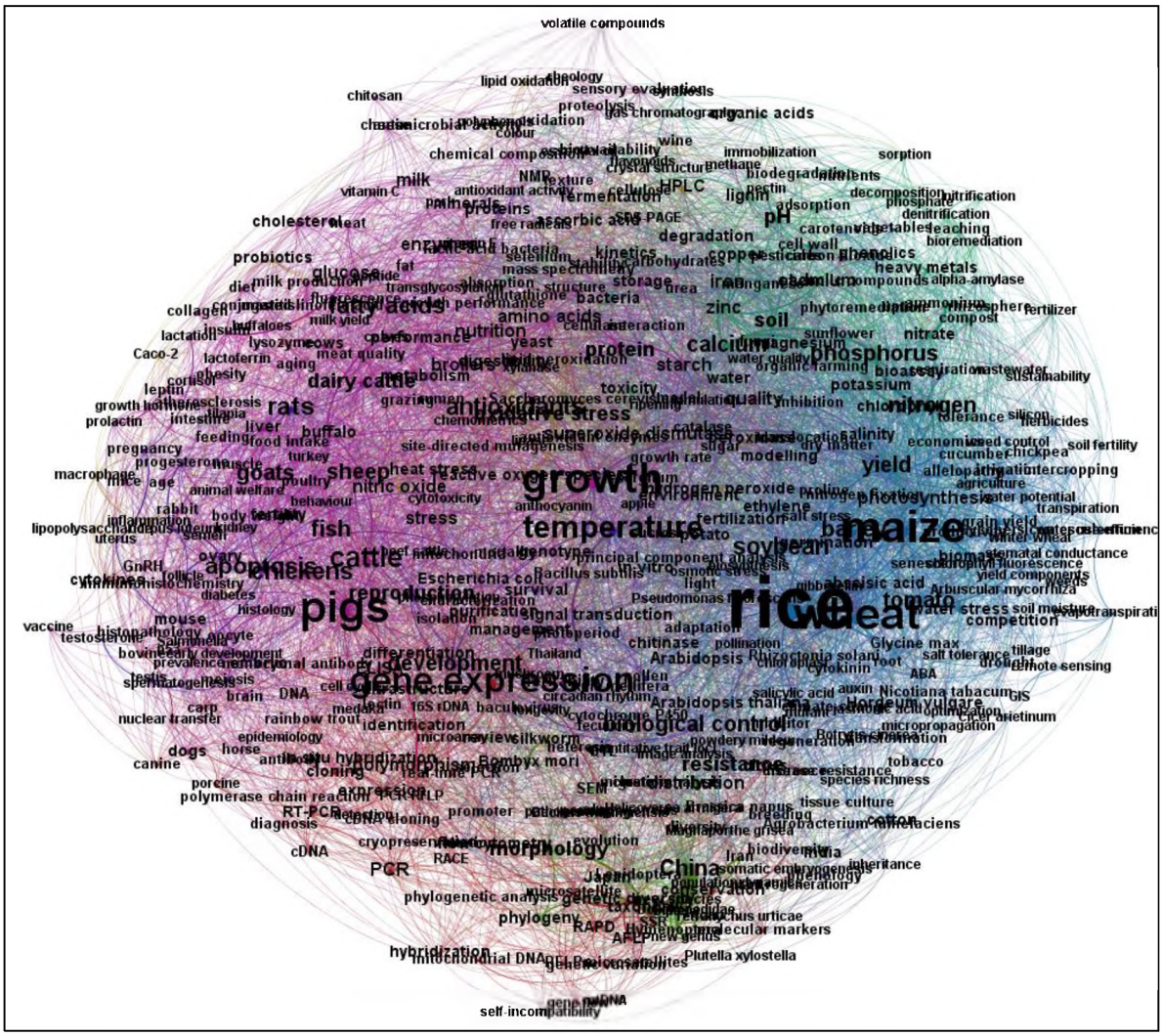
When the Turquois group is examined, it has been seen that a subject network which compromises the terms that are much different from the subjects researched in Turkey is met. In this community there are private researches on the mice and rats or some tissues and enzyms. A*poptopis, cellulase, cDNA cloning, fermentation* and *purification* are given as examples for these terms.

The words that define various researches such as *biological control, morphology, phylogeny, PCR, RFLP, RAPD, genetic variation, DNA, polymorphsim*, *genetic diversity* are intensified in Purple Group.

The other communities have grouped the relatively less betweenness centrality value terms. For example, the publications that include *soil*, n*itrogen, copper, zinc, ferrum, phosphorus, toxicity, heavy metals* are in yellow community.

Subject Analysis of Agricultural Faculties in the World between 2002-2006

In this period, the network of 43,744 publications that agricultural faculties made and keyword co-occurance files (.net) that had the keywords between range of 30 and over are visualised. There are 457 nodes and 8,052 edges in this network. In this context, it can be said that there are interdependent and dense relationship figures between keywords. Average path lenght (2.078) is less than that of previous period. This shows that there is a network in which words are more interdependent.



(Figure 5): Keyword Co-occurence Network *of WoS* World Agricultural Faculties, 2002-2006 (See Appendix 6 for options)

The most influential keywords were *maize, wheat, growth, gene expression, cattle* and *pig* in the period of 2002-2006. It can be seen that there are details about network and other important concepts when the examination is based on communities.

The widest group is purple in the network. The studies that are directed to *growth, reproduction, protein, fatty acids, amino acids, nutrition, metabolism, stress* and *performance* on the animals such as *cattle, pig, sheep*, and *broiler* in this group are carried out.

Second biggest group (blue) is formed by crop researches being linked. There are *(rice, wheat, soybean, maize, barley, tomato* are the most influential keywords) crop researches on *genetic, resistance, photosynthysis, salinity, germination, hereditary* in this community.

The studies on plant chemistry such as *nitrogen, calcium, phosporus, pH, cadmium, ferrum* are in group turquoise. These words are directed to the plant nutrition relating to soil sciences. Moreover, in this group, there are the concepts such as *biological degradation, irrigation, organic acids, heavy metals, toxicity*. In this period, the concept of *organic agriculture* is more salient/prominent in the network.

The keywords that are in group red include very special terms which have technics of researches of biochemistry, molecular biology, genetics etc. related to plant and animals. The words such as *PCR, doning, expression ELISA, RAPD, flow cytometry in situ hybridization, purification, identification, genetic diversity, hybridization, cDNA cloning, DNA* show the most researched subjects in this group.

There is a green group that has tight links in the network. In this group, the tight linking of the terms such as *temperature, development, morphology, distribution, taxonomy, diversity* etc. with the geographical names of *China* and *Japan* points that regional and study subjects are close to each other.

Subject Analysis of Agricultural Faculties in the World between 2007-2011 Years

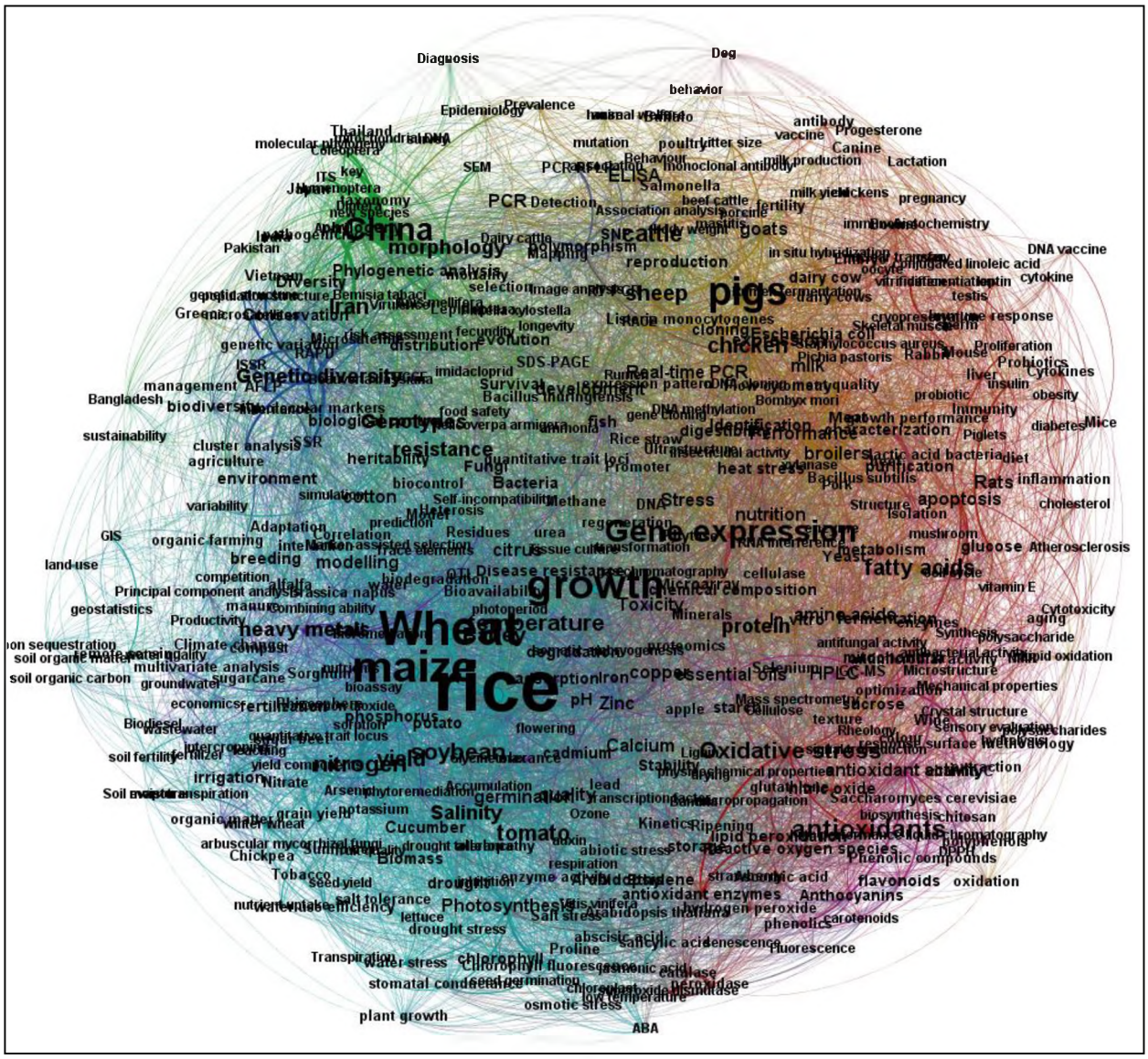
There are totally 69,529 publications in *WoS* between 2007 and 2011. This measurement reflected themselves into the network calculations. There are 447 nodes and 10,890 edges in the network. In examined periods based on these results, the period of 2007-2011 had the highest number of nodes and edges in networks of the publications of *WoS* agricultural faculties.

The most influential words in network are *rice, pig, wheat, maize, growth, China, gene expression, cattle, antioxidants, oxidative stress* and *temperature*. Determining of these words with network analysis more clearly presents the structure of agricultural researches and concepts that are related to each other. The distribution ratios of researches on subjects shows what is studied mostly. Network analysis presents which words have key role in network or relationships of the words to other researches. For example, *nutrition, growth* or *genetic* researches are mostly related to animal researches. The networks are divided into 8 different modularity classes.

As the network details are examined, it is seen that the biggest community is the group which stands for turquise color. In this community, the most influential words are *rice, soybean, tomato, citrus* and *cotton*. In these crops, the researches on *temperature, nitrogen, genotypes, quality, germination, phytosyenthesis, biomass, breeding, disease resistance, drought, QTL, organic agriculture, remote control* are carried out. In the network, the terms such as *organic agriculture, biocontrol* are relatively less (middle and lower ranks) salient/prominent.

The second biggest group in the network is yellow community. The terms whose betweeness centrality is the highest in this community are *pig, cattle, broiler* and *sheep*. In this context, it can be said that this community groups livestock researches. The subjects of *PCR, performance, nutrition expression ELISA real-time PCR, milk, heat stress, polymorphism, aminoacids* and *reproduction* related to these animals are researched. *Gene cloning, cDNA cloning* are the terms that are in lower rank in terms of betweeness centrality in this group.

The words such as *gene identification, antioxidants, oxidative stress, apostosis, heat stress, antioxidant enzymes, metabolism* and *flow cytometry* are linked to the red group. Moreover, it is found in this group that there are various researches on *mice*, *rats* and *rabbits* that are experimental animals.



(Figure 6): Keyword Co-occurence Network of *WoS* World Agricultureal Faculties, 2007-2011 (See Appendix 7 for options)

The purple links show that there is mostly strong relationship between soil and plant nutrition researches. The words such as *heavy metals, toxicity, copper, degradation, environment, residues, water, risk assessment biodegradation, fertilizers* are forefront in this group. It can be said that the researches in this group are concentrated on soil-environment-pollution.

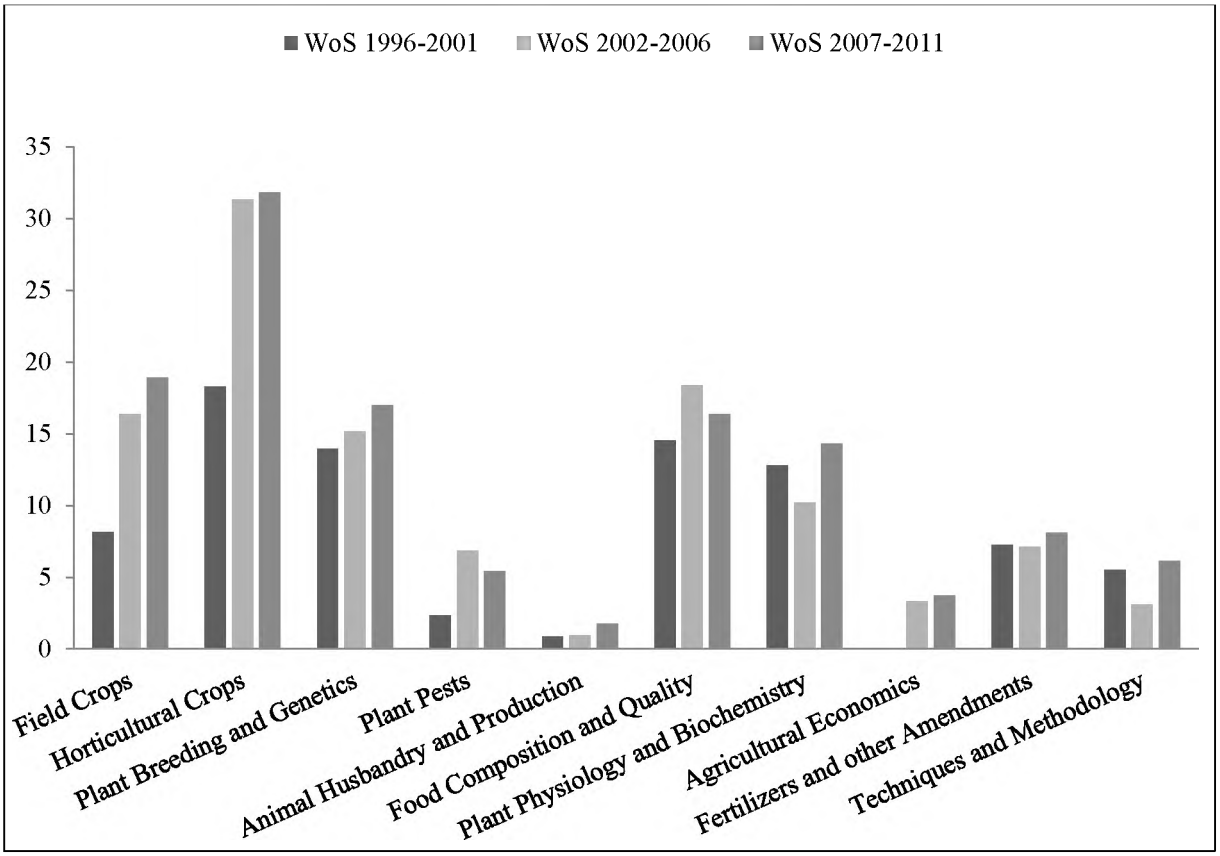
The words such as *HPLC, essential oils, antioxidant activity, characterization, purification* and *phenolic* are interrelated / have relationship in light purple group (Group 1).

The green community shows there is a link between the names such as *China, Japan* and the words such as *morpholgy, distribution, diversity* and *evolution*. The dark blue words, *genetic diversity, conservation, biodiversity, microsatellite, RAPD* in small groupings are more influential. Even if the words such as *resistance, biological control* in dark green (Group 7) are not mostly chosen, they bring the researches related to plant protection together.

Comparison of Data of *WoS* Subject Categories according to Periods

When the subject terms of the publication addressed in *WoS* agricultural faculties of Turkey are examined, it is seen that the most researches carried out are on horticulture (Figure 7).

Especially, in the periods of 2002-2006 and 2007-2011 the researches in this subject were over 30%. While the researches on field crops were 8% in the first period, they increased to 18% in the last one. There are a large number of researches and an increasing trend on plant breeding and genetic. While there was no research in the first period, the ratio of doing research in agricultural economics increased to 3%. As the researches on food increased to 18% in the period of 2002-2007, they decreased to 16.39% in the last one. The researches on plant physiology and genetics increased towards the last periods. The researches on molecular biology increased to 5.13% in the last period (Figure 7). The researches on animal breeding and genetics decreased towards the last period (1%). Subjects words of publications of agricultural faculties addressed in Turkey are given in Appendix 1 according to periods.



(Figure 7): Comparison of Subject Terms of Agriculture Faculties in Turkey according to the periods (%)

The differences between the research areas of *WoS* publications of agricultural faculties in Turkey and abroad are given in Figures 8 and 9, according to the periods.

According to these results, it can be said that most of the studies in Turkey are on agriculture. However, while as the rate of agricultural publications in the periods of 1996-2001 and 2002-2006 is 41%, it decreased to 32.33% in the last period. The decreased rate of agricultural publications (Agriculture, food science and technology and plant sciences) is distributed to other subjects (Biotechnology, chemistry etc.) in the same period. Moreover, it must be considered that the changes in the *WoS'* indexing policies cause these differences. Agricultural publications abroad are 24-25% in each period.

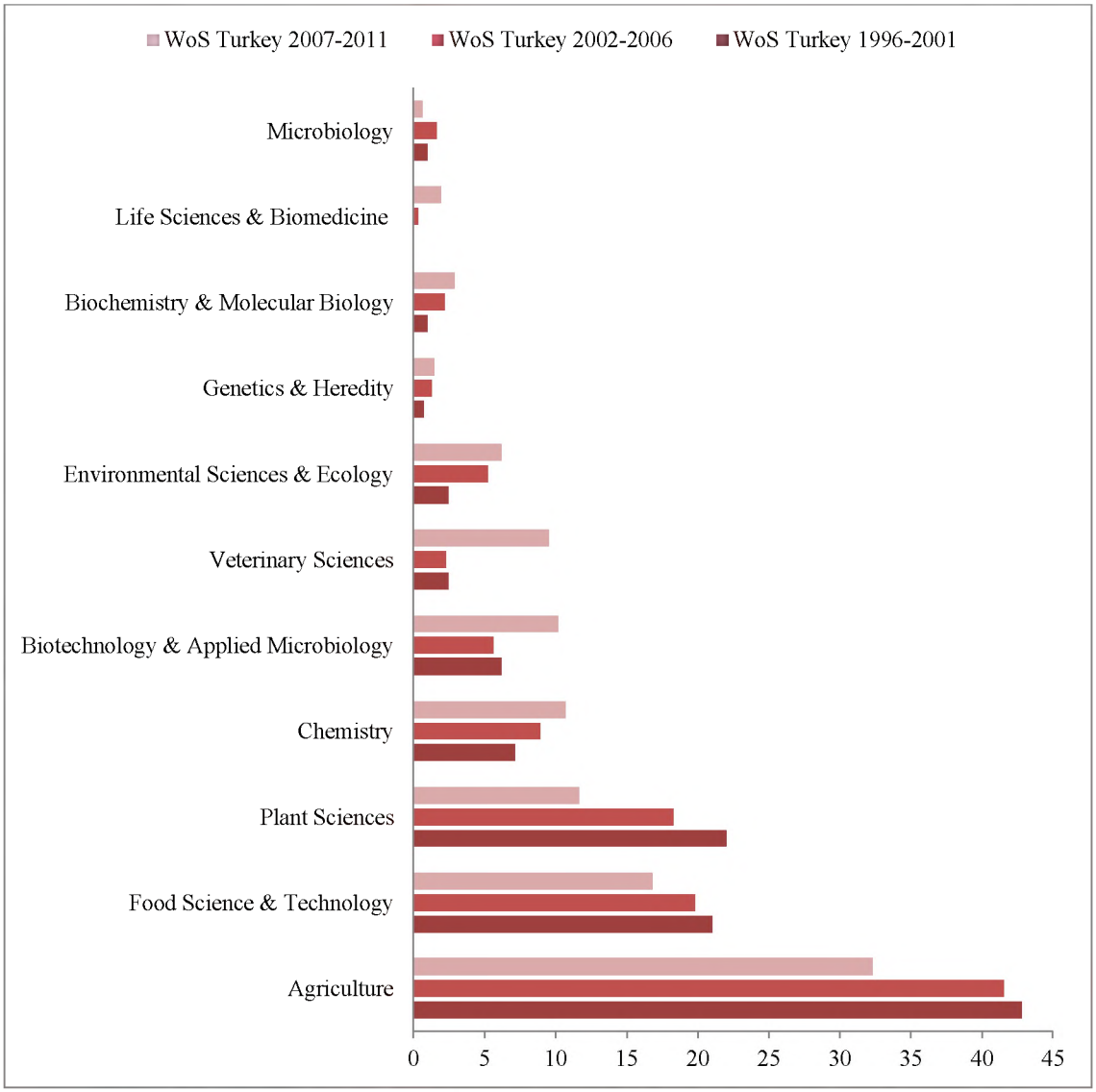
The important part of the resarches in Turkey is on food science and technology. However, the number of researches in this area decreased to 16.86% in the periods of 2007-2011. The rate of publications on these subjects is 10% abroad.

As the researches in plant science are considered, especially in the last period, this subject is researched equally in agricultural faculties of Turkey and abroad.

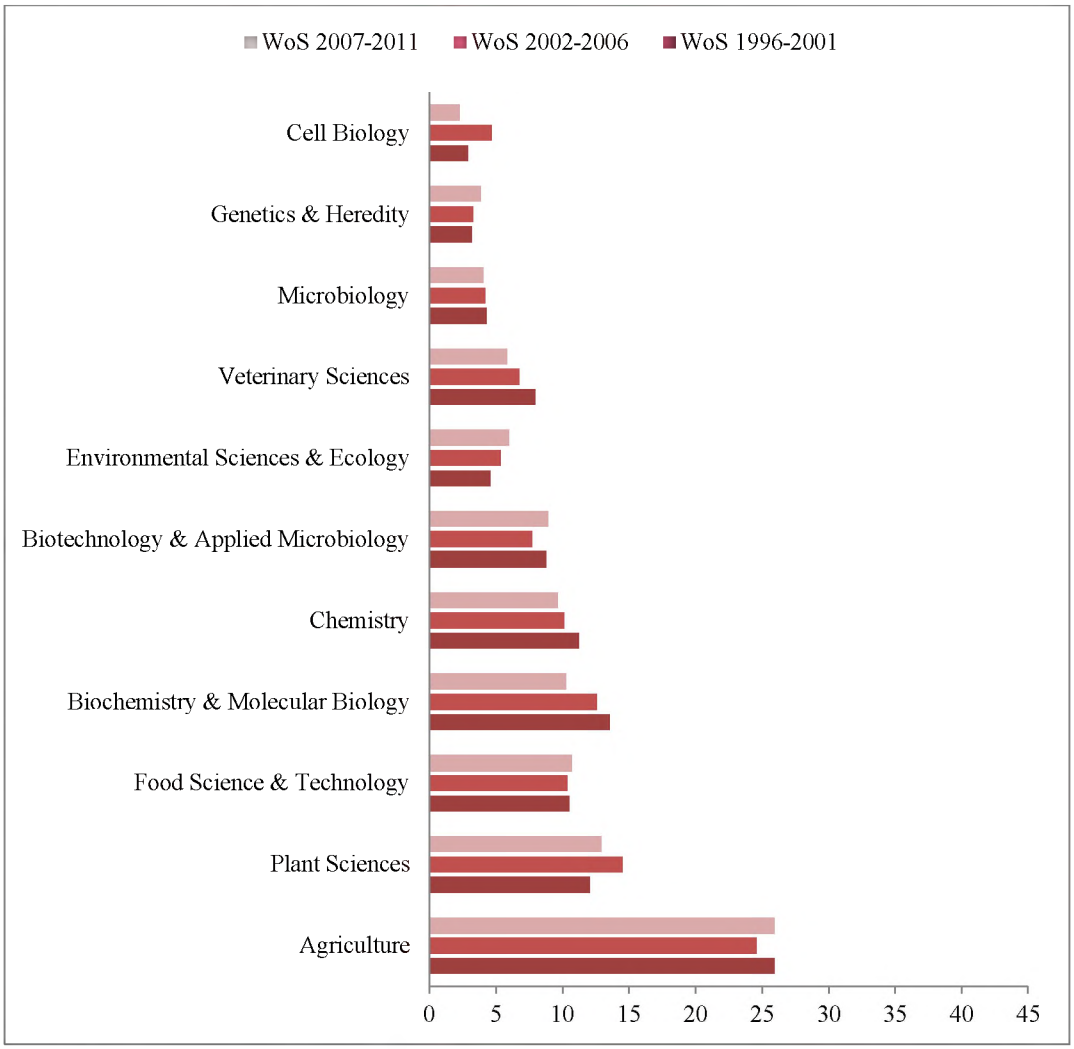
Biotechnology and applied microbiology subjects addressed in Turkey are the ones whose rates increase highly. While the research rate is 6% in the first two periods, it increased to 10.18% in the last period. An increase on the subjects of environmental sciences and ecology occured alike. While the publication rate in this field is 2.48% in the period of 1996-2001, it increased to 6.21% in the period of 2007-2011. Moreover, it is found that there is an increasing trend on the field of chemistry towards the last period (1996-2001: 6.19%, 2007-2011: 10.74%).

The most increasing rate in agricultural faculty publications is in veterinary sciences. It is known that the publications that are included into the field of zootechnical departments are at the same time in the scope of livestock production. The increasing rate of these publications in the last period reached to 9.56%.

However, there are differences on research subjects between the publications originating from abroad agricultural faculties and Turkey. Especially the researches on biochemistry and molecular biology, microbiology, genetics and hereditary are more searched subjects abroad based on the data obtained.



(Figure 8): Comparison of Subject Categories in *WoS* for Turkey (%)



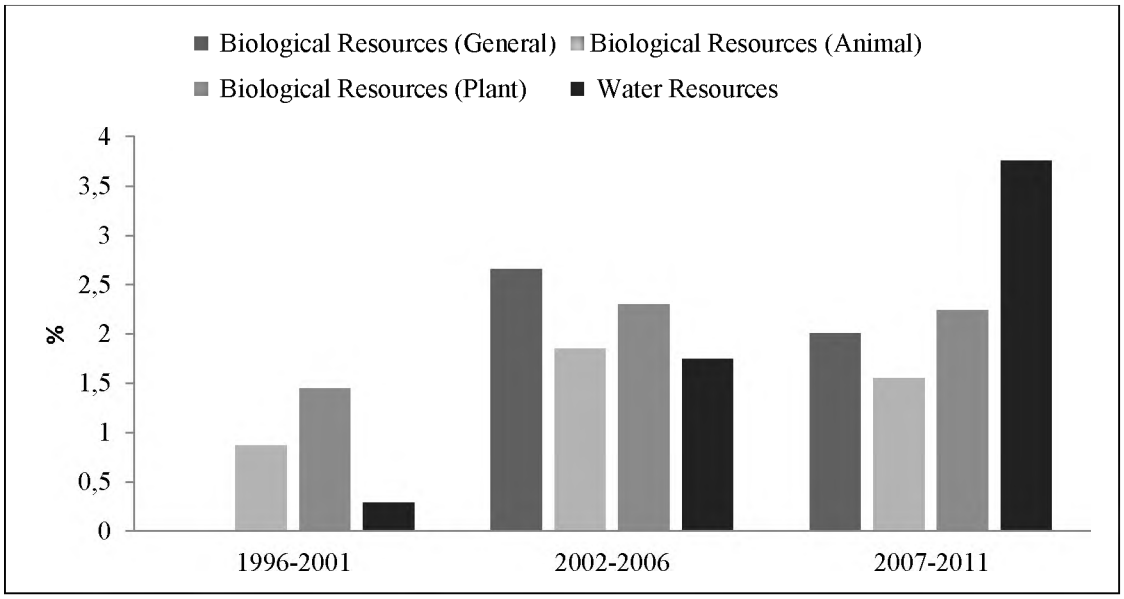
(Figure 9): Comparison of Subject Categories in WoS for the World (%)

Comparison of Agricultural Research Policies with the Research Findings

In this part of the study, the research findings obtained by bibliometric analysis of the publications addressed in Turkey will be compared to the agricultural research policies. Whether the determined and targeted agricultural policies are macthing with the scientific publications will be investigated. The subject terms in publications, *WoS* subject categories and keywords are evaluated, and the results are compared according to periods and subject distributions in policies. There is no certain ratio or targeted percentage in subjects and priorities in agricultural policies. Therefore, inferences and comments are made by looking only at the increasing or decreasing rates in the previous period and differences. When subjects compared in three periods, it should be noted that the increases are only small rate on over all publications.

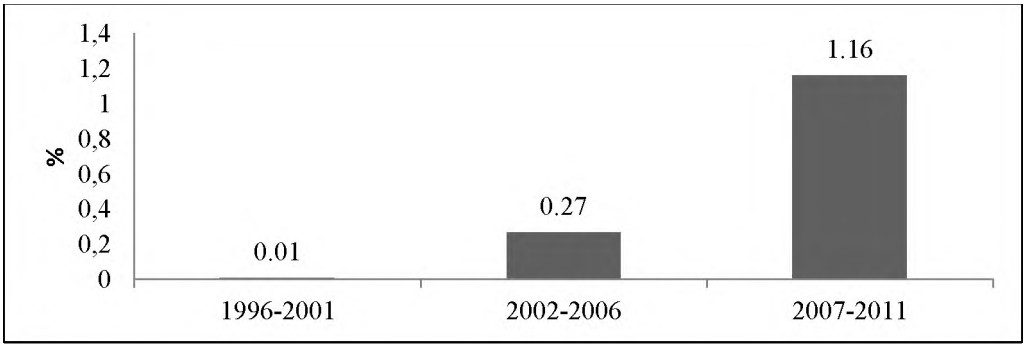
Natural resources are the main subject that should be priority and concentrated on. There are policies in first two periods towards the identification, determination and protecting natural resources, and management of them in the last period. The rate of publications for the data obtained from bibliometric analysis for three periods is given in Figure 10. The rate of 0.29% on water resources in the first period increased to 3.76% in the last period. While there is no publications on biological resources (general) in the first period, researches increased to 2.01% in the last period. While there is 2% increase in water resources, the researches on plant and animal resources did not increase much (Figure 10). It is understood that determined policies

have partly or less impact on publications. Since the researches on soil resources are fewer, they are not represented in the figure.



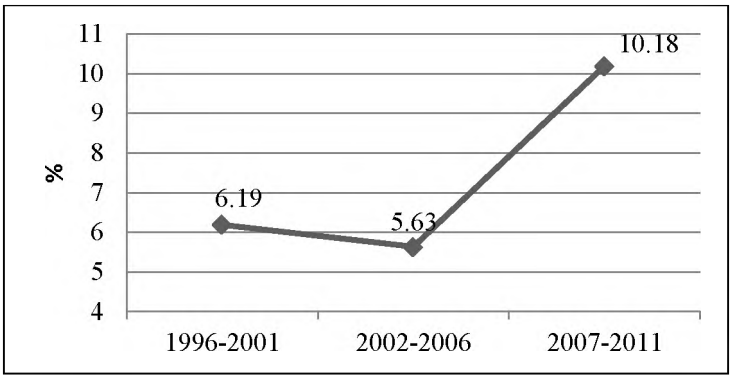
(Figure 10): Natural Resources Subject Terms (%)

One of the subjects that is in agricultural policies and whose publication number increased is the preserving of the genetic diversity. Especially in the last period, the data indicates that more researches on the preserving genetic diversity were done comparing to the previous periods (Figure 11). The researches on this subject increased much more in the period of 2007-2011. Even so, the over all rate on this subject is small (only %1) in all publications.



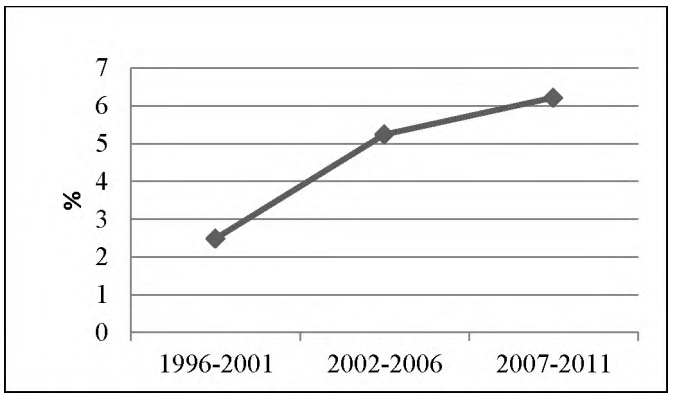
(Figure 11): Genetic Diversity *WoS* Keywords According to the periods (%)

Focusing on biotechnological methods in agriculture in every period and concentrating on such researches are main policies. In findings chapter, the researches on biotechnology and applied microbiology increased towards the last period. Biotechnological methods are used in the most part of the researches on plant and animals considering *WoS* subject category (Figure 12).



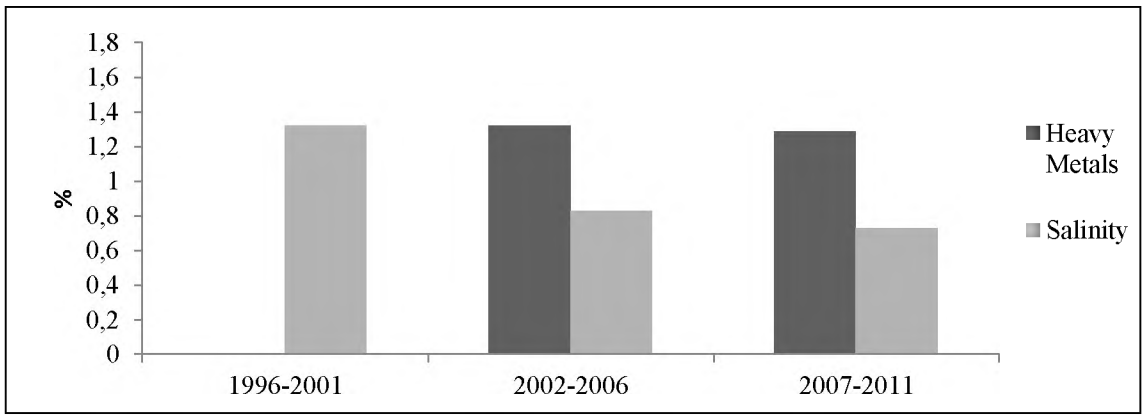
(Figure 12): Biotechnology and Applied Microbiology Subject Category (%)

The policies for environmental pollution, ecology and wastes take place in the relevant documents in every three periods. There are policies for protection of environment in the development plans and strategic documents in the first two periods. These policies impacted researches and the number of publications on environmental sciences and ecology increased to 6.21% in 2007-2011 (Figure 13). In the period of 2007-2011, environment, ecology and agricultural ecological regions are the prominent subjects in research policies. In this context, it can be said the realization level of these targets can be followed in the future periods.



(Figure 13): Environmental Sciences and Ecology Subject Category (%)

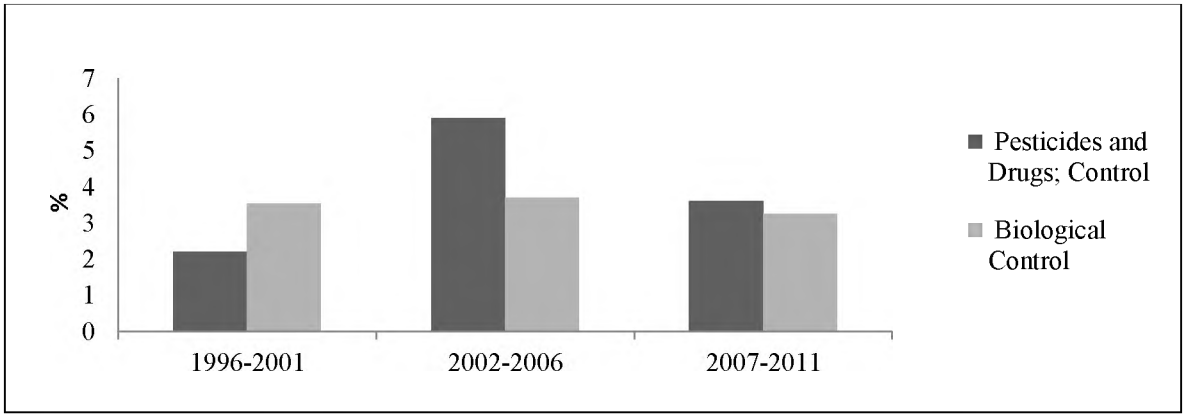
The other research subjects are heavy metals and salinity based on environmental pollution. The researches on this subject occur constantly in Figure 14. The number of researches on these subjects is 1% in general distribution, even if they have increased in years.



(Figure 14): Heavy Metals and Salinity – Environmental Pollution and Sciences (%)

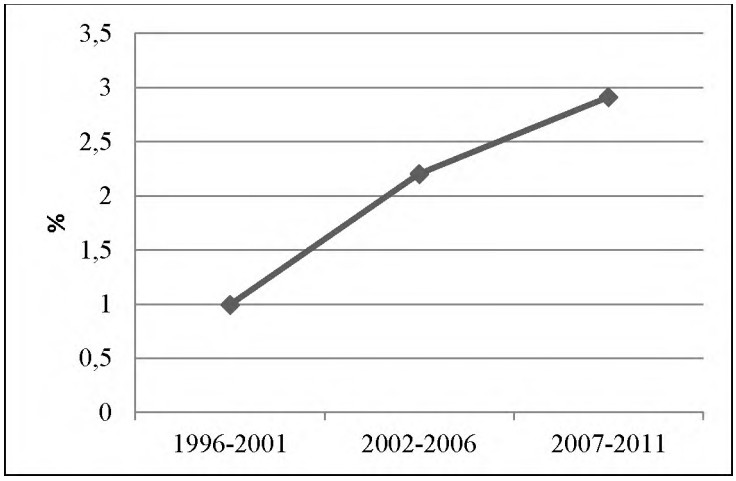
The other subject title in the documents with regard to agricultural policies is biological control and pesticides. It is suggested that in agricultural policies, less input (disease, pests-pesticides-

and herbicides) in agriculture should be used especially in the first period. In addition to that, it is stated that biological control (biological control in plant protection) methods should be developed.



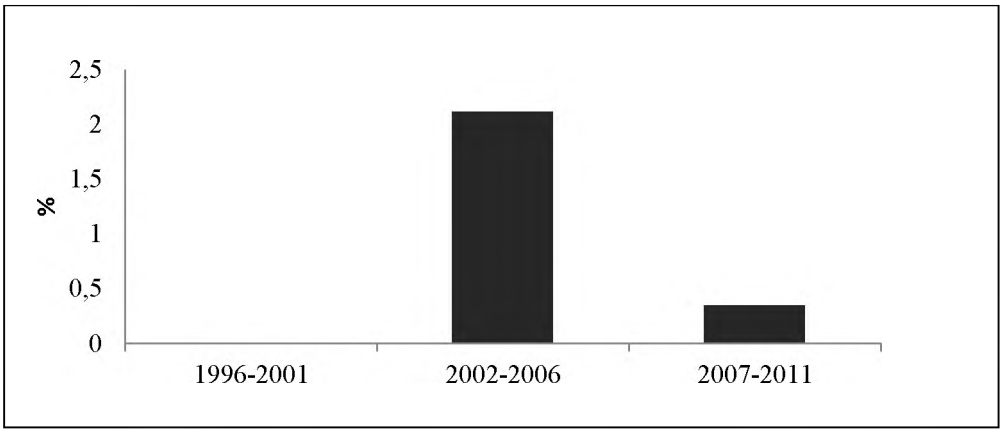
(Figure 15): Biological Control - Pesticides and Drugs; Control

Though less input using in agriculture takes place in policies, the researches on pesticides used for plant protection are still common. The researches on biological control are about 3%. While it is stressed that the researches on biological control in agricultural policies should be carried out, the increase in the rate of these publications on this subject has not occured (Figure 15).



(Figure 16): Biochemistry and Molecular Biology Subject Category (%)

The policies on biochemistry and molecular biology that was stated in SPO, TUBITAK and Public Program are summarized in moleculer biology, biotechnology and genetic engineering (SPO, 2002-2006), the various microbiological and biochemistry tests to detemine the microorganisms (2007-2011). The data with regard to the subject show that the increase rate of the publications on biochemistry and molecular biology subjects addressed in agricutural faculties in Turkey in *WoS* data base is low (Figure 16). But topic has shown rising trend.

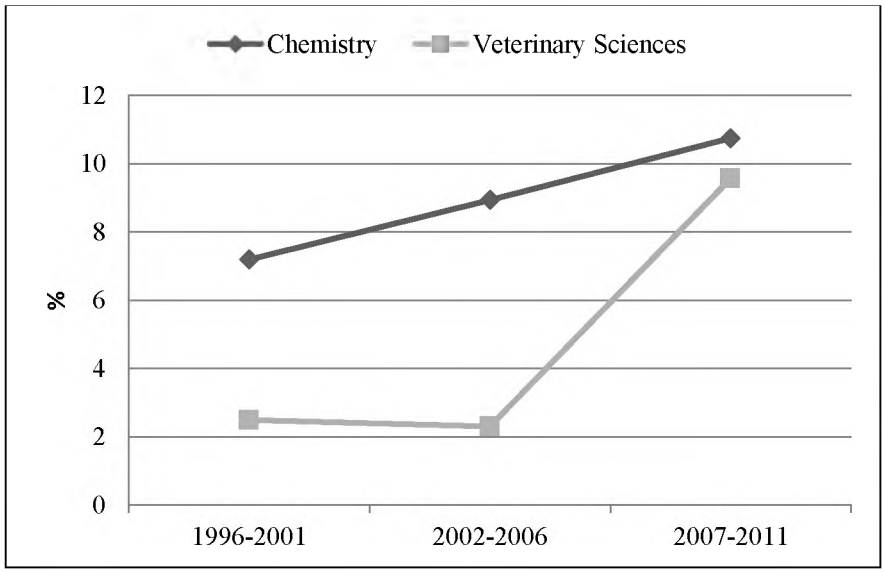


(Figure 17): Organic Farming Keywords (%)

The suggestions about doing researches on organic agriculture often took place in agricultural policies especially in the last periods. The results of the study show that while there is no research addressed in Turkey in the first period, organic agriculture took place in the researches after 2002. Despite that, the researches' rate on organic agriculture is in low levels in general (Figure 17).

In this part of the study, the subjects that are not in agricultural resaerch policies but increased in the agricultural faculty publications take place. It is estimated that these subjects increase depending on the world trends and other factors.

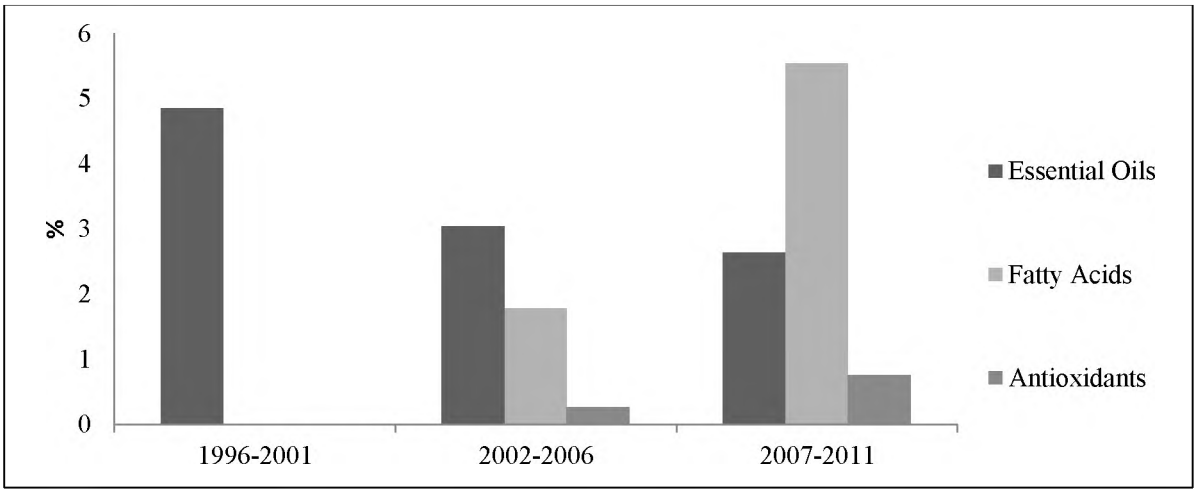
For example, while chemicals and veterinary subjects are not in agricultural policies, there is an increase in the number of researches on this subject. The cause of this increase can be explained by the increase in the world general research trends especially on the subject of chemistry. Thus, it is understood from the findings that the researches on chemistry are done significantly in abroad institutions' publications.



(Figure 18): Chemistry and Veterinary Sciences

In this context, agricultural faculties in Turkey have increased their researches on this subject based on the global trends. The increase in the publications on veterinary can be explained by the fact that the academicians doing researches on livestock production prefer these journals that make publications on this subject. One of the reasons of these journals being preferred is the desire of academicians taking place in *WoS*, which is one of the important

criteria in promotion in academic level. Moreover, the expanding of *WoS* and its indexing several new journals after 2007 are some of the reasons of this increase (Figure 18).



(Figure 19): Other Subjects Keywords (%)

Certain number of researches on determining the plant composition in agriculture and plant resources, biological diversity, protecting natural resources are carried out. Even if essential oils (drugs, food, cosmetics and perfumes etc,) are not in agricultural policies, they took place in the researches by 4.86% in the first period, 3.04% in the period of 2002-2006 and 2.64% in the last period. Similarly, the studies on finding antioxidants materials in foods and plants took place in researches in the last period (1996-2001: 0,01% 2002-2006: 0,27% 2007-2011: 0,76%,) more than previous ones. There is an increasing trend on fatty acids in the last period (Figure 19).

Conclusion

In this study, the agricultural publications addressed in agriculture faculties' subjects are analysed and the researches that are done outside of the agricultural faculties are not included. With the subject analysis, whether the priority research policies/R&D fields/subjects determined are reflected onto the researches are tried to be examined. In this context, the researches on agriculture are examined both in national and international scope, trends and the developing fields are determined.

Comparing the agricultural policies in Turkey with the subjects of the publications addressed in agricultural faculty, it is seen that the priorities in agricultural research policies has increased in time. Especially, the water resources (2-3% increase) out of natural resources, biotechnology (4% increase) and environmental sciences (4% increase) take place more in agricultural policies and alike, number of publications on this subjects have gradually increased. Plant breeding and genetics (14-16% levels) are researched in every period. In this context, it is found that the researches with regard to agricultural policies are done partly in some subjects.

The researches on *biological control* are about 3% based on agricultural policies with low input use. The studies on *pesticides* are about 3%. In this context, even if there are policies based on low agricultural input use, the studies on *pesticides* for plant proteciton have continued. *Organic agriculture* increased to 2% in the period of 2002-2006 and decreased in the period of 2007-2011. However, because there is no research done in the first period, it is the increasing subject towards the last period.

While there are publications significantly on biochemistry and molecular biology (>10%), genetics and herditary (>3%), microbiology (>4%), cell biology (>2%) in agricultural faculties abroad, the publications on these subjects (biochemistry and molecular biology 1-3%, genetics and hereditary: 1-2%), microbiology: 0,5-1%), cell biology: 0,5%) are much less in Turkey.

In network visualization, some research technics are in forefront. Some research technics that are used in abroad researches are not sufficiently used in Turkey. Animals (mouse, rat and rabbit etc.) related to biochemistry and molecular biology, genetics sciences based on tissue and enzymes are among these technics. Although the keywords like *polymorphism, doning, ELISA, flow cytometry, in situ hybridization, identification, apoptosis, cellulase, in situ hybridization, cDNA cloning DNA* are more common in foreign publications, this kind of research technics in publications of Turkey are much less.

According to the subject category, while the researches on agriculture, plant and food science gradually decreased, the ones on chemistry, environmental sciences, biotechnology, biochemistry and molecular biology increased (see Figure 8). This shows that more special and different subjects on agricultural researches have started to be carried out.

The terms like genetic resources and genetic diversity increased in the publications of the period of 2002-2006. In the period of 2007-2011, the terms such as *essential oils, genetic diversity, antioxidants* (and *antioxidant activities, enzymes*), *heavy metals, toxicity, biodiversity, pollution, climate change* were on rise. The terms of *genetic resources, rootstock, morphology, biological control, genotype*, and *genetic identification* are the researches that are constantly carried out in every period.

Forming and planing agricultural research policies are necessary for the agricultural development. However, making policies and determining targets alone are not enough. Investigating how much of it reached to these targets and evaluating the feedbacks of conducted study on the subjects should be considered in the next policy studies. Therefore, it is useful to examine the agricultural publications in detail. Also impact of these publications' subjects should be researched.

33 universities in Turkey have an agricultural faculty. The policies on transferring interscholastic humanpower and funds can be determined by establishing an upper comission which consists of competent scientists in agricultural faculties. Moreover, this comission can contribute to TUBITAK and SPO about determining policies, supporting these policies and collaboration. This comission can suggest priorities, targets and the subjects of R&D and innovations, and can give direction to the policies to allocate the humanpower, funds and incentives for universities.

References

Al, U. (2009). Türkiye'nin göreli atıf etkisi üzerine bilimetrik bir çalışma. *Bilgi Dünyası*, *10*(2), 231-244.

Aras, Y. ve Ören, M. N. (2000). Türkiye'de tarımsal araştırma politikaları organizasyon yapısı ve uygulamaların değerlendirilmesi. *Alatarım*, *1*(2), 4-11.

Besimoglu, C. (2015a). Türkiye'deki ziraat fakültelerinin tarımsal araştırma eğilimleri: *1996-2011 yıllarının bibliyometrik analizi.* Yayımlanmamış Doktora Tezi, Hacettepe Üniversitesi, Ankara.

Besimoglu, C. (2015b). Türkiye'deki ziraat Fakültelerinin tarımsal Araştırma eğilimleri: 1996-2011 yılları Yaşam Bilimleri Veri Tabanı yayınlarının bibliyometrik analizi. *Bilgi Dünyası*, *16*(2). doi:10.15612/BD.2015.499

Borsi, B. and Schubert, A. (2011). Agrifood research in Europe: a global perspective. *Scientometrics*, *86*(1), 133-154.

Cheng, Bo. and Wang, M. (2011). Co-occurrence analysis of domain knowledge in e-learning enabled workforce development. *International Journal of Continuing Engineering Education and Life Long Learning, 21*(1), 87-102. doi: 10.1504/ijceell.2011.039696

DPT. (1995). *Yedinci Beş Yıllık Kalkınma Planı 1996-2000*. Ankara: T. C. Başbakanlık Devlet Planlama Teşkilatı.

DPT. (2006). *Dokuzuncu Beş Yıllık Kalkınma Planı 2007-2013.* Ankara: T. C. Başbakanlık Devlet Planlama Teşkilatı.

European Agrifood Research Landscape. (2008). *Agri-Food Research in Europe: Mapping report Bibliometric mapping of agri-food research activities in 33 countries and survey of the research capacity in 14 countries*. B. Borsi ve A. Udvardi (Ed.).

Gazni, A., Sugimoto, C. R., and Didegah, F. (2012). Mapping world scientific collaboration: Authors, institutions, and countries. *Journal of the American Society for Information Science and Technology, 63*(2), 323-335. doi:10.1002/asi.21688

Hasan, N. (2010). *Mapping the dynamics of world agricultural research output: a scientometric study*. Saarbrücken: LAP Lambert Academic Pub.

Lee, P. and Su, H. S. (2010). Investigating the structure of regional innovation system research through keyword co-occurrence and social network analysis. *Innovation: Management, Policy & Practice, 12*(1), 26-40. doi: 10.5172/impp.12.1.26

Lichtfouse, É., Hamelin, M., Navarrete, M., Debaeke, P. and Henri, A. (2010). Emerging agroscience. *Agronomy for Sustainable Development*, *30*(1), 1-10. doi: 10.1051/agro/2009055

Lv, P. H., Wang, G. F., Wan, Y., Liu, J., Liu, Q. and Ma, F. C. (2011). Bibliometric trend analysis on global graphene research. *Scientometrics*, *88*(2), 399-419.

Newman, M. (2010). *Networks: An Introduction*. Oxford: Oxford University Press.

Ocholla, D. N. and Onyancha, O. B. (2006). The nature and trends of agricultural research development in Africa: an informetric study. *South African Journal of Library & Information Science*, *72*(3), 226-235.

Paranyushkin, D. (2011). Identifying the Pathways for Meaning Circulation using Text Network Analysis. NodusLab. Retrieved from http://noduslabs.com/research/pathways-meaning-circulation-text-network-analysis/

Su, H. (2012). Visualization of global science and technology policy research structure. *Journal of the American Society for Information Science and Technology*, *63*(2), 242-255. doi: 10.1002/asi.21520

Su, H. N. and Lee, P. C. (2010). Mapping knowledge structure by keyword co-occurrence: a first look at journal papers in Technology Foresight. *Scientometrics*, *85*(1), 65-79

Tarım ve Köyişleri Bakanlıgı (2005). *Türkiye Kamu Tarım Araştırma Programı*. Ankara: Retrived from http://www.tagem.gov.tr/pdf/1007/alankonu.pdf

Tarım ve Köyişleri Bakanlığı (2010). *Stratejik Plan* (2010-2014). Ankara: T. C. Tarım ve Köyişleri Bakanlığı.

TÜBİTAK, BTYK-. (1993). *Türk Bilim ve Teknoloji Politikası: 1993-2003*, Bilim ve Yüksek Teknoloji Kurulu 2. Toplantısı 3 Şubat 1993. Ankara: TÜBİTAK.

TÜBİTAK, BTYK-. (1997). *Türkiye'nin Bilim ve Teknoloji Politikası*, Bilim ve Yüksek Kurulu 3. Toplantısı 25 Ağustos 1997. Ankara: TÜBİTAK.

TÜBİTAK. (2003). *TÜBITAK Vision 2023 Science and Technology Forecast Project: Agriculture and Food Panel Final Report*. July 2003. Ankara.

Türkiye İstatistik Kurumu (TÜİK). (2013). *İstatistiklerle Türkiye=Turkey in Statistics 2013.* Türkiye İstatistik Kurumu, Ankara.

Ulusal Tarım Kurultayı (2006). Ulusal Tarım Kurultayı Sonuç Bildirgesi. Paper presented at the *Ulusal Tarım Kurultayı, 15-17 Kasım 2006*, Adana.

Yoon, B., Lee, S. and Lee, G. (2010). Development and application of a keyword-based knowledge map for effective R&D planning. *Scientometrics*, *85*(3), 803-820.

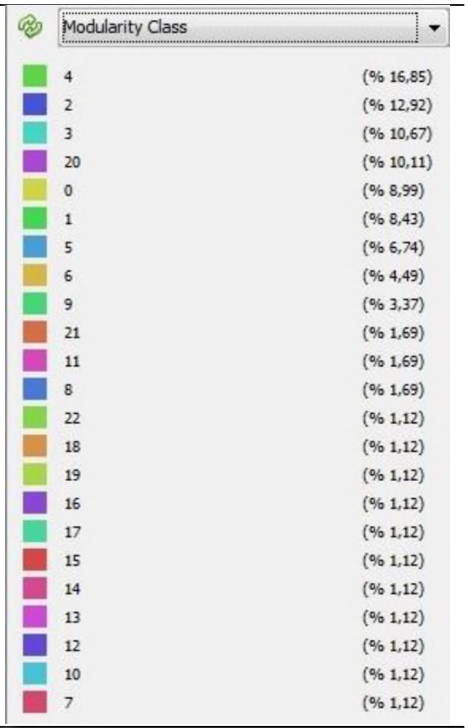
Appendixes

(Appendix 1): Comparison of Subject Terms According to Periods

***WoS* Addressed with Turkey**			
*Sequenced by last periods	**1996-2001**	**2002-2006**	**2007-2011***
Subject Terms	% (n)	% (n)	% (n)
Horticultural Crops	18.31 (63)	31.33 (626)	31.82 (1,252)
Plant Production	11.05 (35)	16.47 (329)	21.37 (841)
Field Crops	10.17 (28)	16.37 (327)	18.93 (745)
Plant Breeding and Genetics	14.53 (48)	15.17 (303)	16.98 (668)
Food Composition and Quality	17.44 (50)	18.77 (375)	16.39 (645)
Crop Produce	11.92 (38)	13.01 (260)	14.51 (564)
Plant Physiology and Biochemistry	13.95 (44)	10.21 (204)	14.33 (403)
Plant Composition	7.27 (25)	8.06 (161)	9.17 (361)
Fertilizers and other Amendments	8.14 (25)	7.11 (142)	8.13 (320)
Techniques and Methodology	5.52 (19)	3.10 (62)	6.15 (242)
Viral, Bacterial and Fungal Diseases of Plants	3.20 (11)	8.86 (177)	6.10 (240)
Non-food/Non-feed Plant Products	5.52 (19)	6.41 (128)	5.51 (217)
Plant Pests	2.33 (8)	6.86 (137)	5.44 (214)
Milk and Dairy Produce	3.44 (35)	7.61 (152)	5.21 (205)
Molecular Biology and Molecular Genetics	0 (0)	3.20 (64)	5.13 (202)
Mathematics and Statistics	2.62 (9)	4.70 (94)	5.06 (199)
Soil Chemistry and Mineralogy	3.49 (12)	4.85 (97)	5.03 (198)
Forage and Fodder Crops	0.87 (3)	3.55 (71)	4.73 (186)
Soil Water Management (Irrigation and Drainage)	1.74 (6)	3.85 (77)	4.52 (178)
Plant Morphology and Structure	0.87 (3)	2.15 (43)	3.99 (157)
Plant Nutrition	12.79 (41)	4.55 (91)	3.91 (154)
Animal Genetics and Breeding	5.52 (11)	3.05 (61)	3.91 (154)
Soil Physics	1.16 (4)	3.75 (75)	3.89 (153)
Animal Nutrition (General)	2.62 (9)	2.80 (56)	3.89 (153)
Water Resources	0.29 (1)	1.75 (35)	3.76 (148)
Agricultural Economics	0 (0)	3.35 (67)	3.71 (146)
Food Processing (General)	2.03 (7)	4.15 (83)	3.71 (146)
Pesticides and Drugs; Control	1.45 (5)	5.36 (107)	3.63 (143)
Food Storage and Preservation	3.78 (13)	4.65 (93)	3.63 (143)

(Appendix 2): Keyword Co-occurance Network of *WoS* Agriculture Faculties of Turkey (1996-2001) - Analysis

Bibexcel .net File	
Co-occurence data	≥1
# of Nodes	**177**
# of Edges	**325**
Gephi Options	**Undirected Graph**
Repulsion strength	600
Attraction strength	10
Maximum displacement	10
Autostabilization strength	80
Autostabilization sensitivity	0.2
Gravity	30
Average Path length	**5,061**
Number of shortest paths	**18480**
Modularity with resolution	**0,792**
Number of Communities	**23**

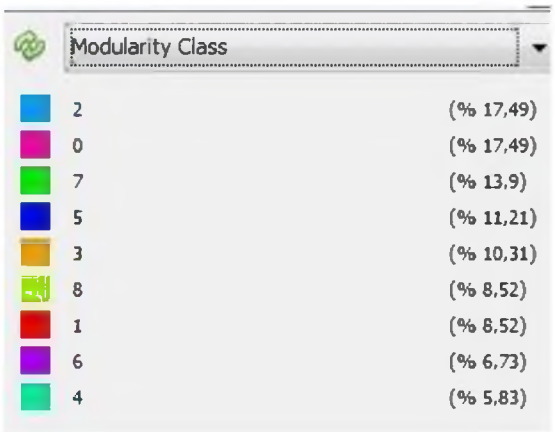


Label	**Closeness Centrality**	**Betweenness Centrality***
Durum wheat	3.289	2944.887
Essential oils	4.4	1832.1
carcass characteristics	5.015	1486.911
wheat	3.652	1377.33
heritability	4.333	1379.449

*Listed by Betweenness Centrality value

(Appendix 3): Keyword Co-occurance Network of *WoS* Agriculture Faculties of Turkey (2002-2006) - Analysis Table

Bibexcel .net File	
Co-occurence data	≥5
# of Nodes	**222**
# of Edges	**803**
Gephi Options	**Undirected Graph**
Repulsion strength	15000
Attraction strength	10
Maximum displacement	10
Autostabilization strength	80
Autostabilization sensitivity	0.2
Gravity	30
Average Path length	**2,918**
Number of shortest paths	**49506**
Modularity with resolution	**0,532**
Number of Communities	**9**

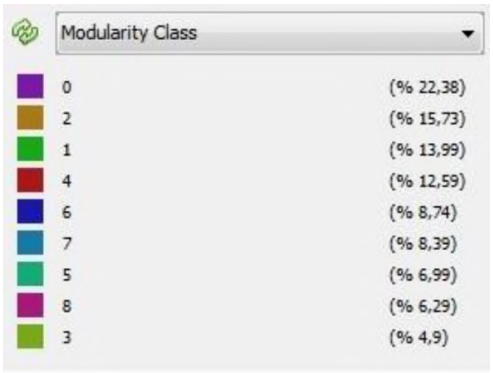


Label	**Closeness Centrality**	**Betweenness Centrality***
Wheat	2.063	3228.407
yield	2.126	2560.88
Essential oil	2.234	2333.213
growth	2.198	1786.261
quality	2.117	1622.742

*Listed by Betweenness Centrality value

(Appendix 4): Keyword Co-occurance Network of *WoS* Agriculture Faculties of Turkey (2007-2011) Analysis Table

Bibexcel .net File	
Co-occurence data	≥8
# of Nodes	**285**
# of Edges	**1995**
Gephi Options	**Undirected Graph**
Repulsion strength	35000
Attraction strength	10
Maximum displacement	10
Autostabilization strength	80
Autostabilization sensitivity	0.2
Gravity	30
Average Path length	**2,36**
Number of shortest paths	**81510**
Modularity with resolution	**0,428**
Number of Communities	**9**

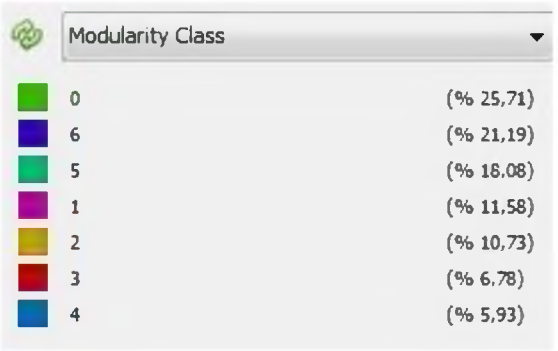


Label	**Closeness Centrality**	**Betweenness Centrality***
yield	1.684	4091.624
Growth	1.839	1987.764
Fatty acids	1.881	1937.096
quality	1.87	1581.434
maize	1.87	1375.718

*Listed by Betweenness Centrality value

(Appendix 5): Keyword Co-occurance Network of *WoS* World Agriculture Institutions (1996-2001) - Analysis Table

Bibexcel .net File	
Co-occurence data	≥28
# of Nodes	**354**
# of Edges	**4993**
Gephi Options	**Undirected Graph**
Repulsion strength	65000
Attraction strength	10
Maximum displacement	10
Autostabilization strength	80
Autostabilization sensitivity	0.2
Gravity	30
Average Path length	**2,102**
Number of shortest paths	**124962**
Modularity with resolution	**0,35**
Number of Communities	**7**

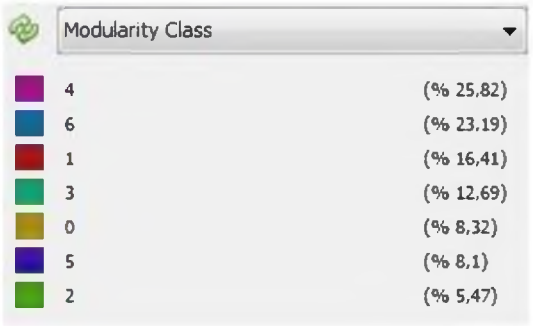


Label	**Closeness Centrality**	**Betweenness Centrality***
rice	1.595	4436.797
growth	1.632	3415.531
wheat	1.671	2338.231
temperature	1.745	1894.964
pigs	1.711	1822.108
Cattle	1.742	1711.263
maize	1.748	1516.368

*Listed by Betweenness Centrality value

(Appendix 6): Keyword Co-occurance Network of *WoS* World Agriculture Institutions (2002-2006) - Analysis Table

Bibexcel .net File	
Co-occurence data	≥30
# of Nodes	**457**
# of Edges	**8052**
Gephi Options	**Undirected Graph**
Repulsion strength	25000
Attraction strength	10
Maximum displacement	10
Autostabilization strength	80
Autostabilization sensitivity	0.2
Gravity	30
Average Path length	**2,078**
Number of shortest paths	**208382**
Modularity with resolution	**0,373**
Number of Communities	7

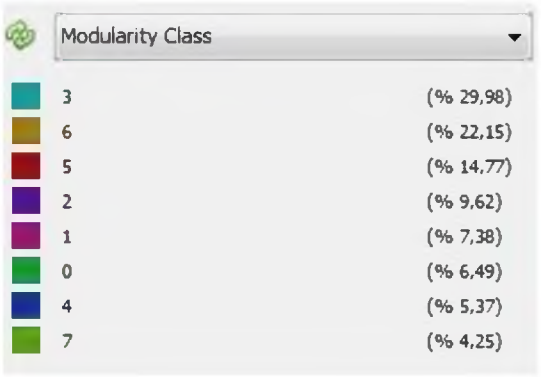


Label	**Closeness Centrality**	**Betweenness Centrality***
Rice	1.555	6718.437
maize	1.656	3504.904
Wheat	1.649	3401.746
pigs	1.691	3380.379
growth	1.682	3293.5
Gene expression	1.759	2514.507
temperature	1.779	1950.088

*Listed by Betweenness Centrality value

(Appendix 7): Keyword Co-occurance Network of *WoS* World Agriculture Institutions (2007-2011) Analysis Table

Bibexcel .net File	
Co-occurence data	≥30
# of Nodes	**447**
# of Edges	**10890**
Gephi Options	**Undirected Graph**
Repulsion strength	25000
Attraction strength	10
Maximum displacement	10
Autostabilization strength	80
Autostabilization sensitivity	0.2
Gravity	30
Average Path length	**1,946**
Number of shortest paths	**199362**
Modularity with resolution	**0,365**
Number of Communities	**8**



Label	**Closeness Centrality**	**Betweenness Centrality***
rice	1.433	5723.065
wheat	1.509	3396.204
maize	1.534	3112.064
Growth	1.583	2803.866
Pigs	1.601	2626.155
china	1.711	1926.059
Gene expression	1.65	1759.229

*Listed by Betweenness Centrality value