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Research article

Identification of Challenges in commercialization agricultural biotechnology in Iran as perceived by agricultural experts

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ABSTRACT
The main purpose of this study was to identify challenges in commercialization agricultural biotechnology in agriculture sector of Iran. The total population was all agricultural experts working in research institutes through Iran. 170 agriculture experts were selected using random sampling technique as sample of the study. Principal component analysis was applied as main statistical technique to analyze the data. The findings revealed that six factors containing 22 variables determined about 61.7 percent of variance of challenges in agricultural biotechnology commercialization in agriculture sector.

Keywords: Challenges, Biotechnology, Commercialization, Agricultural Biotechnology, Iran.

INTRODUCTION
Science and technology are seen as important determinants for survival and growth of companies, regions and nations and are related to new theories of economic development, technological change and industrial innovation (Knol, 2004). Everything in life has its benefits and risks, and genetic engineering is no exception. Much has been said about potential risks of genetic engineering technology, but so far there is little evidence from scientific studies that these risks are real. Transgenic organisms can offer a range of benefits above and beyond those that emerged from innovations in traditional agricultural biotechnology. Following are a few examples of benefits resulting from applying currently available genetic engineering techniques to agricultural biotechnology (Wieczorek, 2003). The original investment in basic science research has delivered truly incredible dividends. Through the creation of highly skilled jobs and contribution of billions of dollars to western economies, biotechnology provides the promise to vastly improve the quality of life. The new knowledge generated by investment in biotechnology research has led to a bounty of potential applications for improvement of health, which are being explored for commercial purposes by the biotechnology industry. This success can be attributed to the collaboration between industry and academia (Tonukari, 2004).

According to the study by Burgeat & Tangermann, (2003), policy and infrastructure requirements needed to ensure that biotechnology will benefit rural communities such as:

- Capacity to generate, adapt, and/or negotiate access to biotechnology innovations;
- Capacity to generate good quality animal and plant germplasm where biotechnology can be used;
- Ability to identify and prioritize critical problems affecting the rural poor that may be addressed by biotechnology;
- Existence of a technology and information delivery system;
- Existence of a rational (science-based), transparent and expedient biosafety regulatory system;
- Ability of the public sector and the international agricultural research centers to negotiate and promote private-public partnerships in an environment where biotechnologies for resource poor farmers can be considered public goods.

As with other rapidly developing technologies, the issue of intellectual property rights is a significant one in considering commercialization. Problems can arise when university or government researchers are seen to be getting too close to industry 'know-how' and when industry wishes to have exclusive rights (Tegart, 2003).

Based on the study by FAO (2011), a further constraint in developing countries is the limitation of capacity to generate, adapt or utilize potentially beneficial biotechnologies due to limitations in agricultural research systems. Such limitations include:

- absent or inadequate policies for agricultural R&D at government and institutional level (Spielman, Hartwich and von Grebmer, 2007);
- poor scientific, political and public awareness of the opportunities and risks of different crop biotechnologies (Gressel et al., 2004; Cohen, 2005; Pender, 2007);
- inconsistent policy and regulatory regimes regarding issues such as IPR enforcement, the protection of plant and animal health, biosafety, food safety and bioethics (Diao et al., 2008; Stein and Rodriguez-Cerezo, 2009);
- deficiencies in economic and physical infrastructures (including trade markets) that impede farmer ability to capitalize on new biotechnologies (Murphy, 2007a; Diao et al., 2008);
- the weaknesses of research institutions that do not allow efficient implementation of research projects;
- Insufficiently educated/trained human resources and the lack of appropriate incentive schemes for capacity building, the retention and motivation of staff through competitive career development opportunities.

The shortfall in the number of patents is primarily due to work either having little commercial value (and thus not worth being protected), or the difficulty of assessing its value. One lesser cause is that research work does not lead to patents because it is derivative or insufficiently original. In this case, a gap between academia and industry can account for a significant part of the answer (Crawley, 2007).

For a high-technology innovation to successfully reach the market, a company's commercialization team must identify, obtain, combine, and manage needed technological knowledge. The innovation must be developed into a product, which must then be manufactured, marketed, and distributed. Ongoing success with subsequent commercialization attempts can be facilitated by a growth strategy that exploits economies of joint costs and scale. Furthermore, an innovation can be successful if the innovation team or company can adhere to their learning paths and create and maintain a good network (Chandler, 2005). Additionally, the team must not only concentrate on a niche market but also focus on a wider (potential) market because a niche market may not be able to sustain the product in long run (Slater & Mohr, 2006).

The study by Al Natsheh et al. (2015) revealed that the following factors need to be considered during technology commercialization:

- novelty and clear added value

- technology functionality
- a non-complicated first set of products
- product certification/accreditation
- the right team
- sufficient capital
- a good business model
- a proper manufacturing plan
- ongoing updates and product maintenance

Meyers (2009) believe that to realize the benefits of knowledge and to receive returns from these investments, the resulting innovations or inventions must be sold, or commercialized. Indeed, commercialization is an important contributor to economic growth (Tahvanainen & Nikulainen, 2011), and it makes technology available to end users. In essence, commercialization is an exchange of know-how for money (Speser, 2008).

So regarding to the importance of biotechnology commercialization in agriculture sector, it is essential to identify its challenges and problems. The purpose of this study is to outline the challenges perceived by agricultural experts in commercialization biotechnology in Iran.

MATERIALS AND METHODS

The current study was carried out in Iran to identify the challenges of commercialization biotechnology in agriculture sector from the viewpoints of agricultural experts working at the research institutes through Iran. Having knowledge and information or practical experience on challenges facing biotechnology was considered as a criterion for selecting these respondents. Applying random sampling technique, 170 agriculture experts were selected. The data were collected through a well-structured questionnaire.

Data were collected through a structured questionnaire from respondents. The questionnaire was based on the published literature on related topics in Iran and other countries. To evaluate face and content validity of the instrument, the questionnaire was assessed through expert judgment. It was modified according to comments and suggestions of the early respondents. Cronbach's alpha coefficient, a measure of internal consistency, was used to estimate the reliability of the survey questionnaire. This coefficient ranges in value from 0 to 1 and it was found to be 0.87 for main scale of the questionnaire indicating an acceptable level of reliability. The researchers received formal permission to collect data through the Ministry of Agriculture in Tehran, and a formal letter of introduction and permission to proceed was provided.

In this research, descriptive and inferential statistics were used to analyze the collected data. Descriptive statistics included frequency values and inferential statistics included exploratory factor analysis technique. The main objective of this technique is to classify a large number of variables into a small number of factors based on relationships among variables. For this purpose 28 variables were selected for the analysis. To determine the appropriateness of data and measure the homogeneity of variables about challenges of biotechnology commercialization from the viewpoints of agricultural experts in Iran, the Kaiser-Meyer-Olkin (KMO) and Bartlett's test measures were applied. These statistics show the extent to which the indicators of a construct belong to each other. KMO and Bartlett's test obtained for these variables show that the data are appropriate for factor analysis (table 1). The Kaiser criterion also was utilized to arrive at a specific number of factors to extract. Based on this criterion, only factors with Eigen-values greater than one were retained.

Findings: Agriculture experts who participated in the study ranged in age from 27 to 58 years. The mean age of respondents was 38.6 years. 86.3% of experts were male and the rest (13.7) were female. Experts were asked to report their scientific and educational degree: 45.2% of respondents were post graduate; 30.6% were assistant professor; 15.7% had associate professor degree; and 8.5% were professor. 43.8% of respondents had a master's degree and 56.2% had completed PhD degree. Also experts were asked to indicate the number of years of job experience that they possessed. Years of job experience ranged from 3 to 30 years (M=13.5; SD=7.1).

In current study, from all 28 variables, 22 variables were significantly loaded into six factors. These factors explained 61.69 percent of total variance in challenges of agricultural biotechnology commercialization. According to the Kaiser criterion, six factors with eigen-values over one were extracted. The eigen-values and percentage of variance explained by each factor are shown in table 2. Eigen-values drive the variances explained by each factor. Sum of squares of factor's loadings (eigen-values) indicates the relative importance of each factor in accounting for the variance associated with the set of variables being analyzed.

Table 1- KMO measure and Bartlett's test to assess appropriateness of the data for factor analysis

KMO	**Bartlett's test of sphericity**	
0.838	Approx. chi	square Sig.
	$3.813 * 10^3$	0.000

The percentage of trace (variance explained by each of the five factors) is also shown in table 2. The traces for factor 1 through 6 are 14.27, 12.86, 11.45, 9.14, 7.59 and 6.38 respectively. The total percentage of the trace indicates how well a particular factor accounts for what all the variables together represent.

This index for the present factors shows that 61.69 percent of the total variance is represented by the variables contained in the factor matrix.

Table 2- Number of extracted factors, eigen-values and variance explained by each factor

Factors	**Eigen-value**	**% of variance**	**Cumulative % of variance**
1	3.956	14.27	14.27
2	3.594	12.86	27.13
3	3.312	11.45	38.58
4	2.497	9.14	47.72
5	2.238	7.59	55.31
6	1.586	6.38	61.69

The Varimax rotated factor analysis is shown in tables 3-8. In determining factors, factor loadings greater than 0.50 were considered as to be significant.

As anticipated, the first factor accounts for 14.27 percent of variance and 5 variables were loaded significantly. These variables were presented in table 3.

Table 3- Variables loaded in the first factor using varimax rotated factor analysis

Name of factor	**Variables loaded in the factor**	**Factor loadings**
Infrastructural Challenge	No flexibility of labor laws and trade regulations for biotechnology business start-up	0.513
	Weakness in commercial laws and tax policies related to innovative activities	0.522
	Lack the necessary context for the activities of foreign investors in the biotechnology field	0.611
	Lack of appropriate mechanisms to secure investment in R&D activities	0.662
	Weakness of the political and economic infrastructures for biotechnology development in agriculture	0.785

A relevant name for this on loading's pattern is "infrastructural challenge". Eigen-value of this factor is 3.956, which is placed at the first priority among the challenges for biotechnology commercialization in agriculture sector in Iran.

The second factor contains 4 variables relating to "knowledge challenge". The eigen-value for this factor is 3.594 which explain 12.86 percent of the total variance (table 4).

Table 4- Variables loaded in the second factor using varimax rotated factor analysis

Name of factor	**Variables loaded in the factor**	**Factor loadings**
Knowledge Challenge	Lack of technical knowledge in the field of biotechnology in agriculture	0.805
	Lack of adequate knowledge among agricultural researchers and experts about biotechnology potential	0.788

	Lack of academic training related to entrepreneurship and management of risky investments	0.672
	Lack of familiarity in biotechnology policy makers, experts and entrepreneurs with risky investment	0.611

The name assigned to the third factor is "structural challenge". This factor with eigen-value of 3.312 explains 11.45 percent of the total variance of challenges in biotechnology commercialization in agriculture sector (table 5).

Table 5- Variables loaded in the third factor using varimax rotated factor analysis

Name of factor	Variables loaded in the factor	Factor loadings
Structural Challenge	Lack of effective interaction between researchers and investors in biotechnology R&D	0.505
	Lack of an organization for dissemination of entrepreneurship culture among biotechnology experts	0.623
	Weakness of networking between entrepreneurs, researchers and investors in biotechnology R&D	0.609
	Lack of adequate cooperation and interaction among universities and research centers with bio-SMEs	0.718

The forth factor is associated mostly with the variables related to economic challenges. Thus this factor can be named as "economical challenge". These variables explain 9.14 percent of total variance (table 6).

Table 6- Variables loaded in the forth factor using varimax rotated factor analysis

Name of factor	Variables loaded in the factor	Factor loadings
Economical Challenge	Lack of financial resources for investment in R&D activities of biotechnology	0.812
	Inadequate access to government funding for business projects in the field of biotechnology	0.785
	Lack of appropriate infrastructure to finance bio-SMEs and emerging companies	0.621

The fifth factor is associated with the variables related to policymaking. Thus, this factor can be named as "policymaking challenge". The eigen-value for this factor is 2.238, which explain 7.59 percent of the total variance (table 7).

Table 7- Variables loaded in the fifth factor using varimax rotated factor analysis

Name of factor	Variables loaded in the factor	Factor loadings
Policymaking Challenge	Lack of effective governmental approach in attracting business initiatives in biotechnology	0.745
	Lack of comprehensive policies in support of bio-SMEs and start-ups	0.723
	Slow and undesirable Evaluation of biotechnology research projects in the public sector	0.681

The name assigned to the six and last factor is "environmental challenge". This factor with eigen-value of 1.586 explains 6.38 percent of the total variance (table 8).

Table 8- Variables loaded in the first factor using varimax rotated factor analysis

Name of factor	Variables loaded in the factor	Factor loadings
Environmental Challenge	Environmental risks of biotechnology applications in agriculture	0.628
	Safety hazards in the production and use of bio-particles by producers and consumers	0.692
	Lack of health laws and regulations based on biotechnology standards	0.619

CONCLUSIONS

Biotechnology has a major impact on almost all major sectors of industry and represents a major element in the transition from an agricultural-based to a knowledge-based economy. Nevertheless, the development of improved technology for agricultural production and its diffusion to farmers is a process requiring investment and time. In industrialized countries, biotechnology is viewed as an all-pervasive profitgenerating technology and a strategic component of industrial competitiveness. In developing countries, the translation of this science base into commercial business is very much needed. There are so many products imported in several developing countries that can now be manufactured using biotechnology. Moreover, several developing countries have strategic advantages in some natural biological resources that can be exploited for their development. The challenge is to ensure that these ideas are marketable as value-added products (Tonukari, 2004).

Agricultural biotechnology is a collection of scientific techniques used to improve plants, animals and microorganisms. Based on an understanding of DNA, scientists have developed solutions to increase agricultural productivity. Starting from the ability to identify genes that may confer advantages on certain crops, and the ability to work with such characteristics very precisely, biotechnology enhances breeders' ability to make improvements in crops and livestock. Biotechnology enables improvements that are not possible with traditional crossing of related species alone.

Based on the results of this study, challenges of biotechnology commercialization were classified in six main challenges namely: infrastructural challenge, knowledge challenge, structural challenge, economical challenge, policymaking challenge, and environmental challenge. About 61.7 percent of total variance in challenges of biotechnology commercialization was explained by these six factors. Therefore, to commercialize biotechnology in agriculture sector, finding solutions for overcoming these challenges is crucial.

Findings of the study introduced infrastructural challenge as most important group of challenges of biotechnology commercialization agriculture sector. According to the findings, knowledge challenge was placed at the second priority among the challenges for biotechnology commercialization in agriculture sector in Iran. Consequently, the people involved in the commercialization of bioscience & technology do need special education following their scientific degree to develop management skills and understand marketing and financial issues.

Other studied challenges in this study, were putted in four factors namely: structural challenge, economical challenge, policymaking challenge, and environmental challenge. Therefore, the most serious efforts to confront the challenges of biotechnology commercialization should be in the way of these factors.

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