J. Agr. Sci. Tech. (2012) Vol. 14: 493-503

Investigating the Researchers' Attitude and the Obstacle Hampering Nanotechnology Development in the Agricultural Sector of Iran

R. Maghabl[1], M. Chizari[1*], S. M. Khayyam-Nekouei[2], and M. Tabatabaei[2]

ABSTRACT

Nanotechnology has been shown to have promising roles in the development of various industries including the agricultural sector. The primary purpose of this study was to investigate the researchers' attitude and the obstacle hampering the development of nanotechnology in the agricultural sector of Iran. The population of this study consisted of researchers in national research centers/institutes (N= 187) during the biennium, 2009-2010. Proportional stratified random sampling was used for sample selection in the study (123). A questionnaire was developed and its validity was evaluated by a panel that consisted of the experts in the Nanotechnology Committee of the Ministry of Agriculture, Iran, and the faculty members of Tarbiat Modares University. A pilot test was conducted to determine the reliability of the questionnaire and Cronbach Alpha coefficient was confirmed for the scales of the questionnaire (α= 0.92). The results of this study showed that the respondents' attitude toward the significance of nanotechnology was in the range of adequate to excellent level (92%, accumulatively). On the other hand, among the 37 obstacle variables investigated, 5 factors were found to account for 69.89% of the variance of obstacle variables. These included budget hindrance, instructional difficulties, management problems, research problems, and relative-informative hardships.

Keywords: Agriculture, Development, Nanotechnology, Obstacle.

INTRODUCTION

Food security and sustainable development are important challenges faced by people all around the world (Berger, 2007; Lewies, 2009). Agricultural technology development is necessary to deal with the food shortages and the increasing population (Sadatenoori and Khodayari, 2005). Agricultural technology system is considered as all the individuals, groups, organizations and institutions engaged in the production, development, and promotion of new technologies in the agriculture sector (Kaimowite, 1999). In general, in this system, the extension subsection has fundamental functions such as: (a) technology transfer; (b) consultancy, and (c) facilitating learning (Agbamu, 2000). The stages involved in the development of a technology includes: technology production, testing, adaptation and adjustment, integration, and technology dissemination and, ultimately, the acceptance and publication of the technology. In the agriculture sector, the research institutions are responsible for technology development and the agricultural extension handles technology testing and proceeds till the technology is published (Hosseini, 2002).

Among various novel technologies such as biotechnology, nuclear technology, and information technology, nanotechnology has been nominated as the technology of the 21st century, and is expected to play enormously

[1] Department of Agricultural Extension and Education, Faculty of Agriculture, Tarbiat Modares University, P. O. Box: 336-14115, Tehran, Islamic Republic of Iran.
[*] Corresponding author; e-mail: mchizari@modares.ac.ir
[2] Agricultural Biotechnology Research Institute, Tehran, Islamic Republic of Iran.

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

important roles in different fields of science (Berger, 2007; Shatkin, 2008). Nanotechnology is defined as the creation and utilization of materials, devices and systems through the control of the properties and structure of materials at nanometric scales (Hellsten, 2007). In addition, nanotechnology is a new and exciting field of research, in particular due to its applications in molecular biology and cell biology (Prassana, 2006). It has been anticipated that in the very near future nanotechnology will have direct and indirect effects on the development of various branches of science (Berger, 2007). Obviously, nanotechnology could play a significant role in the agriculture sector and in providing food security for the world's growing population (Shatkin, 2008). The agricultural sector has been considered by many as one of the most important areas benefiting the nanotechnology's achievements. Nanotechnology, owing to its unique features, is well capable of transforming the food industry and agriculture. Moreover, it has also been proven to have promising applications in early detection of diseases and preventing losses (Iranian Initiative Nanotechnology, 2005).

While many definitions for nanotechnology exist, the National Nanotechnology Initiative (NNI) of Iran classifies a research under "nanotechnology" only if it involves the followings:

1). Research and technology development at the atomic, molecular or macromolecular levels, at the scale of approximately 1-100 nanometers.

2). Creating and using structures, devices and systems that have novel properties and functions because of their small and/or intermediate size.

3). Ability to control or manipulate at the atomic scale (National Nanotechnology Initiative, 2000).

Despite the importance of investment in research and development, public understanding and attitudes towards a new and emerging technology could have a profound impact on the scope and application of the technology. An erroneous understanding or lack of common sense regarding a specific technology, leads to negative reactions by the public towards that technology (Acray, 2003; Knight and Pierce, 2003; Friedman and Egold, 2005). Bainbridge (2002) in a study entitled "public attitudes toward nanotechnology" found that about 60% of the respondents believed that nanotechnology was useful for mankind, while less than 1% believed otherwise by considering nanotechnology as a threat to the mankind. In a different study, Macoubrie (2005) investigated the public attitude towards nanotechnology and reported that most of the respondents (80%) had little knowledge about nanotechnology. Among the remaining 20% who had enough knowledge about nanotechnology, 85% believed that benefits derived from the development of nanotechnology were more than the risks involved and considered it as a complementary part of other technologies. On the other hand, the anxieties expressed by the respondents' were environmental safety and legal risks about the development of nanotechnology.

Semwanga (2004) studied the promoting factors in accepting the emerging agricultural technologies. The obtained results indicated that the government policy, providing technical consultancy programs, infrastructure development, and access to the markets and educational policies for purchasing and the consumption of new products are among the most important factors in the dissemination and acceptance of the emerging agricultural technologies. In order to investigate the problems and challenges faced regarding the nanotechnology development and the low level of public awareness and understanding regarding its benefits and potentials, Mize (2005) conducted a study and highlighted that the lack of expert human resources, financial support, legal infrastructure, and international standards were the most important barriers for nanotechnology development. Shatkin (2008), also looked into some other factors hampering nanotechnology development i.e. environmental safety and health aspects of nanotechnology, and emphasized that international participation in nanotechnology risk assessment, management, and

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

development as well as establishing processes to study the international participation and efforts for understanding the effects of nanotechnology on health and the environment would help to well address the above-mentioned concerns.

Currently, different authorities express concern that, despite the general importance of nanotechnology and the fact that it was introduced into the agriculture sector of Iran six years ago, sufficient knowledge and full understanding of the concept of nanotechnology and its applications is still lacking among the major players in this sector. Undoubtedly, this matter has led to a delay in the development of nanotechnology and taking full advantage of its unique potentials and capabilities to revolutionize the agricultural industry. Having considered the importance of this issue, the primary purpose of the present research was set to investigate the attitude of selected agricultural researchers of Iran towards nanotechnology and the factors hampering its development. The more specific objectives of the study were to:

1). Describe personal and occupational characteristics of researchers serving the national research centers/institutes in Iran;

2). Identify the most important communication channels for researchers to get acquainted with nanotechnology;

3). Prioritize the researchers' attitude towards nanotechnology;

4). Identify and prioritize the obstacles hampering the nanotechnology development in agriculture;

5). Conduct the factor analysis for the identified obstacles.

MATERIALS AND METHODS

The present research consisted of two phases. The first phase was accomplished by a semi-structured interview in order to collect the viewpoints of the experts of the Nanotechnology Committee of the Iranian Ministry of Agriculture on the inhibitory variables in the development of nanotechnology in the agricultural sector of Iran. The second phase of the study was carried out by a survey method. The population of this study included the researchers who were involved in the recent theoretical or practical agricultural research programs related to nanotechnology. These scholars (N= 187) had sufficient information and knowledge on nanotechnology and its various applications and were serving the Iranian national research centers/institutes during the biennium, 2009-2010. The "proportional stratified random sampling technique" was used to select 123 researchers out of the population (187) from 22 Iranian national research centers/institutes as a sample for the present study (n= 123). The sample size was determined as described by Krejcie and Morgan (1970). In constructing a suitable questionnaire, previously reported documents such as those published by Rezaei (2008) and Soltani *et al*. (2002) were reviewed. Moreover, the viewpoints of the experts of the Nanotechnology Committee were taken into consideration. The constructed questionnaire consisted of two sections. The first part of the questionnaire was related to information on the characteristics of the researchers involved, including their gender, age, educational background- and level, academic rank and the number of joint research projects conducted in collaboration with universities. The second part of the questionnaire was oriented toward gathering data on prioritizing the researchers' attitudes towards nanotechnology as well the factors hampering nanotechnology development in the agricultural sector of Iran. In order to characterize the researchers' level of attitude, the following formula based on the Interval of Standard Deviation from the Mean (ISDM) was applied and a four-level distribution was obtained (Senanayake, 1991): (Poor= A: Minimum score≤ A< Mean score-St.dev.; Adequate= B: Mean score-St.dev.≤ B< Mean score; Good= C: Mean score≤ C< Mean score+St.dev.; Excellent= D: Mean score+St.dev.≤ D< Maximume score). A set of 37 questions

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

was designed in order to identify and prioritize the factors holding back nanotechnology development. To achieve that, Likert's scale ranging from 1 to 5 was used. Content and face validity of the instrument was accomplished by a panel that consisted of the experts of the Nanotechnology Committee of the Ministry of Agriculture and the faculty members of Tarbiat Modares University in Iran. A Cronbach Alpha coefficient was achieved for the whole questionnaire (α= 0.92).

RESULTS AND DISCUSSION

The findings of the study are presented and discussed below in the order of the research objectives.

Objective One

The first objective of the study was to describe the personal characteristics of the selected researchers of the national research centers/institutes. As shown in Table 1, most respondents were male (84.6%) and the maximum age of the responders was 56 years. More than 72.4% of the responders held a Master of Science degree and the rest were PhD holders. Twenty-six percent of the respondents were in the field of plant protection. Almost 53% of the respondents were of mentor academic rank. Most researchers (78.9%) had conducted less than five research projects in collaboration with the universities.

Objective Two

The results obtained for prioritizing the communication channels used by the researchers to get acquainted with nanotechnology showed that the most important channels were, respectively: internet (30.9%), scientific seminars (27.6%), and radio and television (15.4%), as shown in Table 2. This finding is in agreement with the results of the research conducted by the National Public Viewpoints Studies and Assessment Center (2004) and Bainbridge (2002).

Objective Three

The attitudes of the agricultural researchers were investigated in order to determine the level of their attitude towards nanotechnology. The obtained results revealed that 49% of the studied researchers had a good or excellent attitude towards nanotechnology and only 9.7% had a poor level of attitude towards nanotechnology (Table 3). Similar findings were obtained elsewhere by Social Research Association (2004), Canadian Biotechnology Secretariat (2005) and Besley *et al.* (2008).

The results of prioritizing the researchers' attitudes towards nanotechnology revealed that two variables including: "nanotechnology is able to increase the productivity" and "Nanotechnology is called another industrial revolution" were of the highest priorities (Table 4). This finding was in full agreement with the results obtained previously by Knight and Pierce (2003) and Friedman and Egold (2005).

Objective Four

To determine the significance of each variable as the variables negatively influencing the development of nanotechnology in the agriculture sector of Iran, the mean and standard deviation were used (Table 5). The results of prioritizing the hampering factors showed that the lack of laboratory equipment and related hardware used for carrying out research in nanotechnology and the lack of expert human resources and trained specialists in the field of agricultural nanotechnology are the most important barriers for the nanotechnology's development in the agriculture sector. This finding was

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

Table 1. Demographic data (n= 123).

Personal and occupational characteristic		Frequency	Percent
Gender			
	Male	104	84.6
	Female	19	15.4
Áge			
	Less than 35 years old	26	21.1
	36-40 years old	41	33.3
	41- 45 years old	30	24.4
	46- 50 years old	20	16.3
Education level			
	Masters	89	72.4
	PhD	34	27.6
Education background			
	Animal Sciences	15	12.2
	Food Industry	20	16.3
	Plant Protection	32	26
	Agriculture	26	21.1
	Gardening	15	12.2
	Other course	15	12.2
Academic rank			
	Professor	3	2.9
	Associate Professor	2	2
	Assistant Professor	43	42.2
	Instructor	54	52.9
Number of the joint research projects conducted in collaboration with universities			
	Less than 5	97	78.9
	6-10	17	13.8
	11-15	2	1.6
	More than 15	7	5.7

Table 2. The communication channels used by the researchers to get acquainted with nanotechnology in order of their importance.

Rank	Familiarity channel	Frequency	Percent
1	Internet	38	30.9
2	Scientific seminars	34	27.6
3	Radio and television	19	15.6
4	Internal journals	11	8.9
5	Friends and colleagues Sessions	8	6.5
6	Foreign journals	6	4.9
7	Newspapers	4	3.3
8	Satellite networks	3	2.5

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

Table 3. The distribution of the studied researchers according to their levels of attitude towards nanotechnology.

Attitude level	Frequency	Percent	Cumulative percent
Poor	12	9.7	9.8
Adequate	51	41.3	51.2
Good	45	36.8	87.8
Excellent	15	12.2	100
Total	123	100	

Table 4. Prioritizing the researchers' attitude towards nanotechnology.

Variables	Mean	Standard Division	Rank
Nanotechnology is able to increase productivity.	4.16	0.59	1
Nanotechnology is called another industrial revolution.	4.08	0.99	2
Nanotechnology could lead to accelerate the development of sustainable agriculture.	4.03	0.89	3
Nanotechnology is capable of converting the other technologies.	3.98	0.68	4
Nanotechnology is able to accelerate the progress in the developing countries.	3.96	0.96	5
Nanotechnology can increase the quality and length of life.	3.94	0.85	6
Nanotechnology could revolutionize many industries to the extent that new industries will be created.	3.93	0.86	7
Nanotechnology is one of the best technologies in the twenty-first century.	3.93	0.68	8
Nanotechnology can prevent the environmental pollution.	3.88	0.87	9
Nanotechnology may increase inequality between the developing and the developed countries.	3.4	1.05	10
Nanotechnology is able to integrate the education in science, technology and social sciences.	3.26	0.72	11
Nanotechnology is capable of eliminating poverty.	3.13	0.89	12
Some nanoparticles have toxic effects on human health.	2.64	0.99	13
Preventing the development of nanotechnology is essential.	1.83	1.03	14

n= 123; Scale: 1= Against; 2= Completely against; 3= No opinion; 4= Agree, 5= Completely agree.

supported by previous studies (Aigrain and Mumentaler, 2006; Rezaei, 2009).

Objective Five

In order to reduce the number of research variables and determine the share of each inhibitory factor in nano-agriculture, the factor analysis was used. The performed calculations showed that the internal consistency of data to be used in factor analysis was suitable (KMO= 0.734) and Bartlett Pearson (1653.54) was significant at 1% level. In this study, 5 factors with special values higher than 1 were extracted based on the Keiser criterion (Table 6).

After performing factor rotation by the varimax method, the research variables were classified into 5 factors (Table7). The factor analysis could limit the 56 obstacle variables to 5 factors of financial barriers, educational difficulties, management problems, research problems, and relative-informative hardships covering about 69.89% of the variance observed for the obstacle variables. As for the results of factor analysis, difficulty in financing for commercializing of nanotechnology plans, lack of sufficient funding available in the agricultural research centers in the field of nanotechnology, and

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

Table 5. Prioritizing the factors hampering the nanotechnology development in the agriculture sector of Iran.

Rank	Variables	Mean	Standard Division
1	Lack of laboratory equipment and related hardware used for carrying out research in the field of agricultural nanotechnology	4.31	0.85
2	Lack of expert human resources and trained specialists in the field of agricultural nanotechnology	4.3	0.82
3	Lack of a comprehensive plan by the ministry of science and technology to promote and develop nanotechnology as a branch of science in the universities	4.18	0.95
4	Lack of sufficient funding for agricultural research centers in the field of nanotechnology	4.09	0.88
5	Insufficient infrastructure related to intellectual property system in the field of agricultural nanotechnology	4.08	0.87
6	Lack of a suitable educational program to increase awareness in the agriculture sector	4.06	0.85
7	Lack of support to establish mechanisms ready to undergo financial risks in agricultural nanotechnology	4.02	0.87
8	Financing difficulties for commercializing the nanotechnology outcome	3.98	0.98
9	Forfeiture of loan grants to support research activities	3.89	0.91
10	Brain drain of nanotechnology specialists and loss of opportunities	3.88	0.83
11	Administrative and bureaucratic obstacles	3.85	0.89
12	Lack of infrastructure for evaluating the safety and quality of agricultural products in the field of nanotechnology	3.85	0.8
13	Lack of knowledge and mistrust of the managers of the ministry of agriculture about the potentials of nanotechnology	3.84	0.89
14	Lack of financial support from the private and active companies in the field of agricultural nanotechnology	3.83	2.96
15	Lack of demand-oriented agricultural research in nanotechnology	3.83	1.08
16	Lack of attention to appointing right directors to manage nanotechnology research in country	3.83	1.01
17	Lack of deep understanding of the importance and capacities of nanotechnology and its applications in agriculture among the authorities of the agricultural organizations	3.82	1.1
18	Lack of sufficient knowledge and understanding among the managers of the agricultural research centers regarding nanotechnology	3.78	0.9
19	lack of centers in order to market the agricultural products based on nanotechnology	3.78	0.66
20	Lack of a strong information communication network between researchers in the field of nanotechnology in agriculture	3.77	0.89
21	Insufficient access to scientific information related to nanotechnology among the agricultural researchers	3.77	0.76
22	Deficient number of expert faculty members in the field of nano-agriculture	3.74	0.76
23	Weak distribution of information about the importance of nanotechnology in agriculture	3.7	0.89
24	Lack of the private sector' support and their presence in the development of agricultural nanotechnology	3.7	0.85
25	Instability in the official management and development of new technologies	3.68	1.18
26	Lack of national standards for nanotechnology products	3.69	0.74
27	Lack of practical capabilities in nanotechnology researches especially in the agricultural sector	3.67	0.81
28	Lack of suitable management system to evaluate the projects related to nanotechnology	3.61	1.09
29	Lack of effective communication between the active ministries in the field of nanotechnology	3.6	1.08
30	Lack of supporting systems, such as growth centers and technology parks in the field of nano-agricultural	3.59	1.03
31	Lack of awareness about nanotechnology among agricultural researchers	3.58	0.78
32	Lack of legal and judicial infrastructure for the development of nanotechnology in agriculture	3.53	0.87
33	Lack of foreign investment in the field of agricultural nanotechnology	3.5	1.15
34	Lack of support in terms of providing risk funds for financing nanotechnology in agriculture	3.49	0.87
35	Lack of coordination between different nanotechnology-related committees of the ministry of agriculture	3.48	4.06
36	Interdisciplinary nature of nanotechnology	3.3	0.835
37	Lack of effective communication between the development staff and the nanotechnology committees in the ministry of agriculture	3.25	1.16

n=123; Scale: 1= Very low; 2= Low; 3= Moderate; 4= High, 5= Very high.

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

Table 6. Extracted factors whit Eigenvalue Criterion, percentage of variance criterion and cumulative percent frequency variance.

Factors	Eigenvalue Criterion	Percentage of variance criterion	Cumulative percent frequency variance
1	4.364	18.541	18.541
2	3.708	16.121	34.662
3	2.955	12.847	47.509
4	2.640	11.479	58.988
5	2.509	10.908	69.896

Table 7. The related variables to each obstacle factors and the rate of factor loading obtained by the rotation matrix.

Factors	Variables	Factor Loading (Coefficients Rate)
	Financing difficulties for commercializing nanotechnology plans	0.771
	Lack of sufficient funding of agricultural research centers in the field of nanotechnology	0.709
Financial barriers	Lack of support to establish mechanisms ready to undergo financial risks in agricultural nanotechnology	0.708
	Lack of public and private financial supports for the nanotechnology plans	0.682
	Lack of foreign investment in the field of agricultural nanotechnology	0.566
	Weak distribution of information about the importance of nanotechnology in agriculture	0.898
	Lack of human resources and trained specialists in the field of nanotechnology agriculture	0.844
Educational problems	Lack of awareness about nanotechnology among the agriculture researchers	0.768
	Insufficient access to scientific information related to nanotechnology by the agricultural researchers	0.715
	Lack of a suitable educational program to increase the level of awareness of different players in the agriculture sector	0.700
	Lack of knowledge and mistrust of the managers of the ministry of agriculture about the potentials of nanotechnology	0.843
	Lack of sufficient knowledge and understanding among the managers of the agricultural research centers about nanotechnology	0.802
Management problems	Administrative and bureaucratic obstacles	0.800
	Lack of attention in appointing right directors to manage of nanotechnology research in the country	0.758
	Instability in the official management and development of new technologies	0.706
Research problems	Lack of demand-oriented agricultural research in nanotechnology	0.902
	Lack of practical capabilities in nanotechnologies researches especially in the agricultural sector	0.698
	Lack of effective communication between the development staff and nanotechnology committees in the ministry of agriculture	0.673
Informative - communicative problems	Lack of effective communication between the active ministries in the field of nanotechnology	0.612
	Lack of a strong information communication network between researchers in the field of nanotechnology in agriculture	0.573

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

lack of support to establish risk funds for financing nanotechnology in agriculture are the most important financial barriers that were also confirmed by the findings reported by Aigrain and Mumentaler (2006). Results obtained by factor analysis also highlighted the educational problems, management problems, research problems, and information communication problems, which were previously reported by Aigrain and Mumentaler (2006), Hodge (2005), Singh (2007) and Hellesten (2007) as well.

COCLUSIONS

Considering that more than half of the researchers (51%) investigated in the present study had adequate to poor attitudes toward nanotechnology, it is, therefore, recommended to increase their awareness, interests, and attitudes. The information and promotional programs such as distribution of publications and extensional brochures, exhibitions, preparation and broadcasting educational films, etc can be used to accomplish that;

According to the results obtained concerning the ranking of acquaintance mechanisms with nanotechnology, it is suggested to provide researchers with facilities to easily access the Internet at work, in order to increase their awareness and knowledge. Also, regarding the radio and television channels as one of the most potentially informative sources, it is recommended to prepare and broadcast radio and television programs related to agricultural nanotechnology. This can be accomplished through close and dynamic interactions between the Ministry of Agriculture and media;

Concerning the results of the priority of the obstacle factors for the development of nanotechnology in agriculture, it is suggested to fully equip the laboratories to conduct research in agricultural nanotechnology and also dispatch faculty members of the agricultural colleges in the fields to participate in short-term nanotechnology training courses abroad;

As to the results of the factors analysis of hampering factors on the way to develop nanotechnology in agriculture, it is recommended that the necessary policies be adopted quickly for the commercialization of nano-based products in the agricultural sector. This could be achieved by holding training workshops and extension courses to increase the knowledge of the managers on nanotechnology and also by granting loans and funds necessary to help the private research centers in order to get involved in the nanotechnology research projects.

AKNOWLEDGEMENTS

This study was funded by the Nanotechnology Committee of the Ministry of Jihad-e Agriculture of Iran and the Iranian Nanotechnology Initiative. The authors would also like to gratefully acknowledge the support provided by the Agricultural Biotechnology Research Institute of Iran (ABRII).

REFERENCES

1. Acray, B. 2003. Nanotechnology Faces GM-style Backlash. *J. IEE Review,* **49(3)**: 12-17 ,
2. Agbamu, J. 2000. Agricultural Research-Extension Linkage System: An International Perspective. Agricultural Research and Extension Network, Department International Development, Uk. Available On line at: http://www.google.com/url?sa=Dandq=http://www.odi.org.uk/networks/agren/papers/agrenpaper_106.pdfandusg=AFQjCNHZchEvzVftQ7xjCIg3v0EAo7zgoA
3. Aigrain, J. and Mumenthaler, C. 2006. *The Risk Governance of Nanotechnology: Recommendations for Managing a Global Issue*, *J. Nano Letters,* 4(6): 1079 -1083.
4. Bainbridge, W. S. 2002. Public Attitudes toward Nanotechnology. *J. Nanotechnology Research,* **4(2)**: 561-570.
5. Berger, M. 2007. Truly Green Nanotechnology-growing Nanomaterials in

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

Plants. Available On line at: http: //www.nanowerk.com/spotlight/spotid=2105 .php
6. Besley, J., Victoria, L., Kramer, A. and Susanna, H. 2008. Expert Opinion on Nanotechnology: Risks, Benefits, and Regulation. *J. Nanotechnology Research*, **10(2)**: 45-51.
7. Canadian Biotechnology Secretariat. 2005. *International Public Opinion Research on Emerging Technologies: Canada-US Survey Results*. Retrieved September 9, 2005. Available Online at: http://www.bioportal.gc.ca/English/View.asp?pmiid=524&x=720
8. Friedman, S. and Egold, B. 2005. Nanotechnology: Risks and the Media. *IEEE Tech. Soc. Magazine*, **24 (4)**: 5-11.
9. Hellsten, E. 2007. The European Nanotechnology Strategy: Environmental and Health aspects. *J. Nanosciences and Nanotechnologies.,* **6(2)**: 502-513.
10. Hodge, G. 2005. Nanotechnology as the Next Big Business. *Moans Business Review Business.,* **13 (2)**: 119-132.
11. Hosseini, S. J. 2002. *Booklet of Appropriate Technology Selecting and Assessing.* Islamic Azad University, Science and Research, PP. 152-158. (In Persian).
12. Iranian Initiative Nanotechnology. 2005. *Iranian Action Plan for Nanotechnology Development*. Retrieved May 13 2005. Available Online at: http://www.nano.ir (In Persian).
13. Kiamowite, D. 1999. *The Evaluation of Links between Research and Education* 4th Edition, Holt Bart and Winston, Inc. Orland, Florida, PP. 101-112
14. Knight, H. and Pierce, J. 2003. To Kill a Technology. *Journal of Engineer*, **291 (1)**:24-29.
15. Krejcie, R. V. and Morgan, D. W. 1970. Determining Sample Size for Activities. *Educ. Psychol. Measurement*, **1 (30)**: 608.
16. Lewies, J. B. 2009. Foresight Nanotechnology Challenges. Available Online at: http://www.foresight.org/challenges/
17. Macoubrie, J. 2005. Informed Public Perceptions of Nanotechnology and Trust in Government. *Project on Emerging Technologies at the Woodrow Wilson International Center for Scholars*. Available Online at: http://www.wilsoncenter.org/hndex.cfm?fuseaction=events.event_summaryandevent
18. Mize, S. 2005. The Foresight Nanotechnology Challenges. *Foresight Nanotechnology Institute*, May 2005, Available Online at: http://www.waset.ac.nz/journals/waset/v73/v73-74.pdf
19. National Nanotechnology Initiative. 2000. *A Report by the Interagency Working Group on Nanoscience, Engineering and Technology*. Available Online at: http://www.nsf.gov/about/budget/fy2009/pdf/42 fy2009.pdf
20. National Public Viewpoints Studies and Assessment Center. 2004. *Attitude of Media Expert and Managers about Nanotechnology*. Retrieved April 9 2004. Available Online at: http://www.nano.ir(In Persian).
21. Prassana, B. M. 2006. Nanotechnology in Agriculture, *ICAR National Fellow,* Division of Genetics, IARI, New Delhi-110012. Available Online at: http://www.iasri.res.in/.../10nanotech in Agriculture BM Prasanna 1.2.2007.pdf
22. Rezaei, R. 2009. *Recognition and Analyzing of Fields and Mechanisms for Nanotechnology Dissemination in Agriculture Sector of Iran*. Ph.D. Dissertation, Agricultural Extension and Education Group, Tehran University, (In Persian).
23. Sadatenoori, S. and Khodayari, M. 2005. *Introduction to Nanotechnology*. Nopardazan Publications, 1(1): 18-24. (In Persain).
24. Semwanga, K. 2004. *The Effective Factors on Technology Dissemination and Adoption.* Semwanga Research Ltd, Upper Kololo Terrace, PP. 215-235.
25. Senanayake, R. 1991. Sustainable Agriculture Definitions and Parameters for Measurement. *Journal of Sustainable Agriculture*, **1 (4)**: 7-28.
26. Shatkin, J. A. 2008. *Nanotechnology: Health and Environmental Risks*. CRC Press, *J. Nanoscience*, **2 (6)**: 321-345.
27. Singh, A. 2007. Nanotechnology Skills and Training Survey. *Institute of Nanotechnology*, July 2007, Available Online at: http://www.nano.org.uk/nanomasters/PDFs/SkillsTrainingSurvey.pdf

[DOR: 20.1001.1.16807073.2012.14.3.15.9]

28. Soltani, A. M., Ghazinoori, S. S. and Technology Cooperation Office of President. 2002. *TOWS Matrix Application in the Extract National Nanotechnology Strategy in Iran*. (In Persian). Available Online at: http://www.7dar7.blogfa.com

29. 29. Social Research Association. 2004. *Nanotechnology: Views of General Public.* Retrieved August 15 2005. Available Online at: Http://nanotech.org.uk/MarketResearch.pdf

بررسی نگرش محققان و عوامل بازدارنده توسعه فناوری نانو در بخش کشاورزی ایران

ر. ماقبل، م. چیذری، س. م. خیام نکویی و م. طباطبایی

چکیده

فناوری‌نانو به عنوان یک موج تکنولوژیکی جدید از پتانسیل فراوانی برای متحول نمودن صنایع مختلف از جمله بخش کشاورزی برخوردار است. هدف اصلی این تحقیق، بررسی نگرش محققان و عوامل بازدارنده توسعه فناوری نانو در بخش کشاورزی ایران می‌باشد. جامعه آماری این تحقیق، شامل محققین مراکز و موسسات تحقیقات ملی در سالهای ۱۳۸۹- ۱۳۸۸ می‌باشد (N= ۱۸۷). جهت انتخاب نمونه آماری تحقیق، از روش نمونه‌گیری تصادفی متناسب استفاده شد (n= ۱۲۳). ابزار جمع آوری اطلاعات، پرسشنامه بود که روایی آن بوسیله پانلی متشکل از متخصصان کمیته فناوری نانوی وزارت کشاورزی و اساتید گروه ترویج و آموزش کشاورزی دانشگاه تربیت مدرس بدست آمد. آزمون مقدماتی جهت بدست آوردن اعتبار پرسشنامه انجام شد (α= ۰/۹۲). نتایج این تحقیق نشان داد که اکثریت محققان (۹۲ درصد) دارای سطح نگرش مناسب تا عالی نسبت به اهمیت فناوری نانو هستند. تحلیل عاملی توانست ۳۷ متغیر بازدارنده را در ۵ عامل موانع اعتباری - مالی، مشکلات آموزشی، مشکلات مدیریتی، مشکلات پژوهشی و موانع اطلاعاتی- ارتباطی محدود کند که در مجموع ۶۹/۸۹ درصد واریانس تغییرات را تبیین کردند.

[DOR: 20.1001.1.16807073.2012.14.3.15.9]