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Survey of Impact of Production and Adoption of Nanocrops on Food Security

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***Abstract*—**Perspective of food security in 21 century showed shortage of food that production is faced to vital problem. Food security strategy is applied longtime method to assess required food. Meanwhile, nanotechnology revolution changes the world face. Nanotechnology is adequate method utilize of its characteristics to decrease environmental problems and possible further access to food for small farmers. This article will show impact of production and adoption of nanocrops on food security. Population is researchers of agricultural research center of Esfahan province. The results of study show that there was a relationship between uses, conversion, distribution, and production of nanocrops, operative human resources, operative circumstance, and constrains of usage of nanocrops and food security. Multivariate regression analysis by enter model shows that operative circumstance, use, production and constrains of usage of nanocrops had positive impact on food security and they determine in four steps 20 percent of it.

***Keywords*—**adoption, food safety, food security, nanocrops

I.INTRODUCTION

ACCORDING to the United Nations, about 800 million people in the world are suffering from food shortage and the number of people below poverty line has increased dramatically.New forecasts showed that by 2020 over a billion people would live below poverty line. In the past decades, the emergence of first-generation technology in agriculture leading to green revolution have resulted the transition from traditional agriculture to industrial agriculture. In this period quantity and quality of agricultural products improved significantly, although this success was accompanied with excessive use of resources in the agricultural sector [6].

The 2001 Human Development Report [12] of the UN Development Program clearly illustrates the important roles of science and technology in reducing mortality rates and improving life expectancy in the period 1960–1990, but it did not emphasize nanotechnology specifically. In a report released in early 2005 [13], the UN Task Force on Science, Technology and Innovation (part of the process designed to assist UN agencies in achieving the UN MDGs) addresses the potential of nanotechnology for sustainable development.

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The MDGs are eight goals that aim to promote human development and encourage social and economic sustainability [11]. In 2000, all 189 member states of the UN committed to achieve the MDGs by 2015. The MDGs are: (i) Eradicate extreme poverty and hunger; (ii) Achieve universal primary education; (iii) Promote gender equality and empower women; (iv) Reduce child mortality; (v) Improve maternal health;(vi) Combat HIV/AIDS, malaria, and other diseases; (vii) Ensure environmental sustainability; and (viii) Develop a global partnership for development.

Science and technology alone are not the answer to sustainable development challenges. Like any other science and technology waves, nanoscience and nanotechnology are not “silver bullets” that will magically solve all the problems of developing countries; the social context of these countries must always be considered. Nevertheless, science and technology are a critical component of development[8].

Agriculture is the backbone of most developing countries with >60% of the population reliant on it for their livelihood. As well as developing improved systems for monitoring environmental conditions and delivering nutrients or pesticides as appropriate, nanotechnology can improve the understanding of the biology of different crops and thus potentially enhance yields or nutritional values. In addition, it can offer routes to added value crops or environmental remediation. However, it is evident more than any time that there is need for application of new technologies in agriculture sector. During the last decade, the world witnessed an unprecedented growth in developing of nanotechnology. Today, nanotechnology as an interdisciplinary technology can play a leading role in overcoming problems in agriculture. The prediction is that nanotechnology will transform the entire food industry changing the way food is produced, processed, packaged, transported and consumed [6]. Nanotechnology has a wide-ranging application in all stages of production, processing, storing, packaging and transporting of agricultural products. Nanotechnology has the potential to revolutionize agriculture and food systems. Agricultural and food systems security, disease treatment delivery system, new tools for molecular and cellular biology, new material for pathogen detection, protection of environment and education of the public and future workforce are examples of the important links of nanotechnology to the science and engineering of agriculture and food systems[9]. Nanotechnology has been described as the new industrial revolution and both developed and developing countries are investing in this technology to secure a market share.

Nanotechnology solutions to agriculture and food systems:

_ Delivery of nutritional functions (micronutrients and bio-active compounds) through food matrix

_ Protect nutritional stability in the environment

_ Synthesis of chemical for agriculture

_ More effective chemicals and biodegradable

_ Food preparation and conservation

_ Sensors and control

_ Smart delivery systems

_ Nano tags (traceability)

_ A new platform for new developments[7]

The impact of nanotechnology in the food industry has become more apparent over the last few years. Nanofood is defined the nanotechnology techniques or tools that are used during cultivation, production, processing and packaging of the food [6].

Currently, one of the major challenges in many developing countries is issue of food security. Despite the actions taken to reduce world hunger, little progress has been achieved. For example in developing countries during the last decade, there was only one percent reduction in the number of people who were suffering from malnutrition.

Since the adoption of Millennium Development Goals in September 2000, implementation of economic reforms to reduce poverty has become a critical strategy in the world. In 2005, a wide range of measures to reduce poverty and hunger has been undertaken in the areas of agricultural development and food production in rural areas. In line with the UN Millennium Development Goals, several new strategies and solutions to reduce the hunger to improve productivity in agriculture sector and to change the food chain system has been proposed [6] cited a report from Helmuth Kaiser Consultancy (2004) predicted that the nanofood market will surge from 2.6-20.4 billion USD by 2010. This report suggests that with >50% of the world population, the largest market for nanofood in 2010 will be Asia.

Nano-technology has a great potential in all aspects of agriculture, processing, packaging and even monitoring of food production and farming activities. However, the full potential of nanotechnology in the agricultural and food industry has still not been realized [6].

Scott and Chen (2003) pointed out to the role nanotechnology in food security of the United States. For instance, nanotechnology holds the potential that the food supply of United States can be carefully monitored and protected. It is important to point out that producing healthy food and increasing the availability, affordability and accessibility of food for world population now become a growing challenge in the coming decades. Although, agricultural nanotechnology offer tremendous impacts on increasing production and eventually enhancing the food security in the developing countries but there are numerous challenges, risks, erroneous ideas and beliefs which impede its progress and development.

As in the case of any complex technology impacting wide range of processes and developments, the nature and extent of positive and negative impact will depend on the choice of the technique, place and mode of its application, ultimate use of the product, concerned policies and regulatory measures[10]. In terms of food security, nanotechnology can play an important role in improving the quality and quantity of food produced. Therefore, it is necessary to remove the impediments faced by farmers and provide basic information to enable the spread of nanotechnology. This would enable nanotechnology to be part of a comprehensive development strategy for agricultural sector. Developing countries such as Iran have adopted their own nanotechnology programs with a specific focus on agricultural applications. The Iranian Agricultural ministry is supporting a consortium of 35 laboratories working on a project to expand the use of nanotechnology in agro sector. The ministry is also planning to hold training programs to develop specialized human resources in the field [6].

In the year 2001, the Iran presidential technology cooperation office initiated a smart move in the field of nanotechnology. Through these efforts, nanotechnology gained national priority in the country and in 2003, the Iranian Nanotechnology Initiative was set up with the aim of pursuing the development of nanotechnology.

In recent years, Iran has shown a great improvement in area of nanotechnology especially in publishing ISI papers. At the end of the third quarter of 2009, Iran was ranked 15th having published 919 ISI papers in this field.

The attitudes and interests of stakeholders involved in national public debates on the risks and benefits of agricultural technology are having a significant influence on public opinion as well as public policy outcomes in developed and developing countries [1].

Given a key role that agricultural specialists such as researchers in influencing farmers to adopt agricultural innovation, their views on individual innovations may be critical for overall adoption [11].

The research question for this study is: what are the perceptions of researchers about the role of nanotechnology on achieving food security? The overall purpose of the study was to examine the perception of researchers about the role of nanotechnology in achieving food security.

II. Materials And Methods

The methodology used in this study involved a combination of descriptive and quantitative research and included the use of correlation, regression and descriptive analysis as data processing methods. The total population for this study was 76 agriculture researchers in the Isfahan Province. Data were collected through interview schedules. A series of in-depth interviews were conducted with some senior experts in the nanotechnology to examine the validity of questionnaire. A questionnaire was developed based on these interviews and relevant literature. The questionnaire included both open-ended and fixed-choice questions. The open-ended questions were used to gather information not covered by the fixed-choice questions and to encourage participants to provide feedback. Measuring respondents attitudes towards role of nanotechnology in food security has been achieved largely though structured questionnaire surveys. The final questionnaire was divided into several sections. The first section was designed to gather information about personal characteristics of respondents. The second section was designed to measure the attitudes of researchers about the role of nanotechnology in achieving food security. The respondents were asked to indicate their agreements with 4 statements by marking their response on a five point Likert-type scale.

The next section explored the impact of nanotechnology on consuming, producing, processing and packaging of agricultural products and four items were presented in a 5 point Likert format with responses from 1 completely disagree to 5 completely agree. Further section dealt with questions about necessary conditions required for application of nanotechnology in agriculture. Seven attitudes were presented in a 5 point Likert format. The last section was designed to measure the attitudes of researchers about constraints in adoption of nanotechnology. The respondents were asked to indicate their agreements with six constraints by marking their response on a 5 point Likert-type scale. The variables and their measurement scale are shown in Table 1. Content and face validity were established by a panel of experts consisting of faculty members at Islamic Azad University, Science and Research Branch and some specialists in the nanotechnology. Minor wording and structuring of the instrument were made based on the recommendation of the panel of experts.

A pilot study was conducted with 20 persons, who had not been interviewed before the earlier exercise of determining the reliability of the questionnaire for the study. Computed Cronbach's Alpha score was 86.0% which indicated that the questionnaire was highly reliable. Dependent variable in the study included achieving food security by application of nanotechnology which was measured by perception of respondents about impact of nanotechnology on four dimensions of food security.

TABLE I
VARIABLES AND THEIR MEASUREMENT SCALE

Variable	Measurement scale
Attitudes about role of nano on achieving food security	Five point likert
Impact of nanotechnology on consuming , producing, processing and packaging of agricultural products	Five point likert
Conditions required for application of nanotechnology	Five point likert
View about constraints	Five point likert

The independent variables in this research study were the impact of nanotechnology on consuming, producing, processing and packaging of agricultural products; condition required for application of nanotechnology and views about constraints in application of nanotechnology. For measurement of correlation between the independent variables and the dependent variable correlation coefficients have been utilized and include spearman test of independence.

III. Results And Discussion

Table 2 shows the demographic profile and descriptive statistics. The results of descriptive statistics indicated that majority of respondents were male with a mean age of 40 years old. More than half of respondents had earned a master degree with major in agriculture and mean average of working experience was 13 years old.

In order to finding the perception of respondents about their attitudes role of nanotechnology in achieving food security, they were asked to express their views. Table 3 shows the respondents' means about the four dimensions of food security. As can be seen the highest mean number refers to the role of nanotechnology in making food products safer (mean = 2.65) and lowest mean number refers to the role of nanotechnology in making food products more accessible (mean = 1.82).

In order to finding the means of respondent's view about the impact of nanotechnology in consuming, producing, processing and packaging the agricultural products, respondents were asked to express their views (Table 4). As can be seen the highest mean number refers to the impact of nanotechnology on producing agricultural products (mean = 2.70) and lowest mean number refers to the impact of nanotechnology on consuming agricultural products (mean = 2.32).

TABLE II
PERSONAL CHARACTERISTICS OF EXTENSION EXPERTS

Characteristics	Options	values
Sex	Female	14.5%
	Male	85.5%
Age / year	Mean	40
Degree	Master degree	55.35%
Occupation status	Permanent	87.4%
	Contractual	12.6%
Work experience/ year	Mean	13

TABLE III
MEANS OF RESPONDENTS VIEWS ABOUT THE ROLE OF NANOTECHNOLOGY IN ACHIEVING FOOD SECURITY (1 = STRONGLY DISAGREE; 5 = STRONGLY AGREE)

Dimensions	Mean
Make food products more affordable	2.60
Make food products more accessible	1.82
Make food products more available	2.15
Make food products safer	2.65

TABLE IV
MEANS OF RESPONDANTS VIEWS ABOUT THE IMPACT OF NANOTECHNOLOGY IN CONSUMING, PRODUCING, PROCESSING AND PACKAGING OF AGRICULTURE PRODUCTS (1 = STRONGLY DISAGREE; 5 = STRONGLY AGREE)

Statement	Mean ± SD
Consuming	2.32±0.38
Producing	2.70±0.47
Processing	2.67±0.47
Packaging	2.36±0.40

TABLE V
MEANS OF RESPONDENTS VIEWS ABOUT THE NECESSARY CONDITIONS REQUIRED FOR APPLICATION OF NANOTECHNOLOGY IN AGRICULTURE SECTOR (1 = STRONGLY DISAGREE; 5 = STRONGLY AGREE)

Conditions	Mean ±SD
Development potential	3.25±1.047
Private sector participation	1.78±0.645
Production potential	3.14±1.163
Public investment	1.99±0.739
Decreasing the production cost	2.86±1.186
Consumer demands	2.05±1.142
Public awareness	1.57±0.893

The perception of respondents about the necessary condition required for application of nanotechnology was shown in Table 5. The highest mean refers to development potential in agricultural sector (mean = 3.25) and the lowest mean refers to public awareness about nanotechnology (mean = 1.57).

Table 6 shows the means of respondents' views about the constraints in application of nanotechnology. As can be seen from Table 6, the highest mean refers to regulatory constraints (mean = 3.96) and the lowest mean to economic constraints (mean = 3.36).

Spearman coefficient was employed for measurement of relationships between independent variables and dependent variable. Table 7 shows the results which show that there were relationship between perception of respondents about role of nanotechnology in achieving food security as dependent variable and consuming nanotechnology products; producing, processing and packaging agricultural products; necessary conditions required for application of nanotechnology and constraints as independent variables.

Table 8 shows the result for regression analysis by stepwise method. Independent variables that were significantly related to perception of respondents about role of nanotechnology in achieving food security were entered.

The result indicates that 20% of the variances in the perception of respondents about could be explained by the necessary conditions for application of nanotechnology, producing agricultural products, consuming nanotechnology products and constraints in producing nanotechnology products.

TABLE VI
MEANS OF RESPONDENTS VIEWS ABOUT THE CONSTRAINTS IN APPLICATION OF NANOTECHNOLOGY IN AGRICULTURE SECTOR (1 = STRONGLY DISAGREE; 5 = STRONGLY AGREE)

Conditions	Mean ±SD
Education constraints	3.92±1.004
Management constraints	3.92±1.004
Regulatory constraints	3.96±1.026
Environmental constraints	3.77±1.211
Social / cultural constraints	3.39±1.255
Economic constraints	3.36±1.288

The perception of researchers about the role of nanotechnology in achieving food security was discussed in this study. Based on the results of the mean score, researchers did not agree that nanotechnology could help in achieving food security, although they believed this technology could have more impact on affordability and safety of food products than other dimension of food security.

In regard to role of nanotechnology on safety of food products, Dingman (2008) pointed out that many researchers believed the nanotechnology and related food products are safe and causes no harm to human being.

As regression analysis showed, necessary conditions for application of nanotechnology, producing agricultural products, consuming nanotechnology products and constraints in application of nanotechnology caused 21% of variance on the perception of researchers regarding the role of nanotechnology in achieving food security.

Respondents indicated in order to achieve food security by adopting nanotechnology as an appropriate technology, necessary conditions should be established over a period of time. Therefore innovative technologies and applications need to be developed that cater specifically to achieve food security.

In regard to public awareness, the results show that researchers did not agree about impact of public involvement in application of nanotechnology in agricultural sector of Iran. The reason could because the nanotechnology in Iran still is in early phase of development and the findings highlight the need for informing public about the importance of nanotechnology. Nanotechnology has the potential to play a significant role in risk reduction for issues of agriculture and food systems security. The public should be educated that explain the value-added, increased safety and food security due to application of nanotechnology [7].

A regulatory process should ensure the democratic control of and public participation in decision making on nanotechnology and other new technologies. It is recommend the initiation of a wide range of participatory processes to enable direct input from the general public into new technology assessment and determination of priorities and principles for public policy, R and D and legislation [5].

TABLE VII
CORRELATION MEASURES BETWEEN INDEPENDENT VARIABLES AND PERCEPTION OF RESPONDENTS ABOUT ROLE OF NANOTECHNOLOGY IN ACHIEVING FOOD SECURITY

Independent variable	Dependent variable	r	p
Consuming nanotechnology productions	Role of nanotechnology in achieving food security	0.327**	0.004
Producing agricultural products	Role of nanotechnology in achieving food security	0.411**	0.000
Processing agricultural products	Role of nanotechnology in achieving food security	0.259*	0.026
Packaging agricultural products	Role of nanotechnology in achieving food security	0.416**	0.000
Necessary conductions required for application of nanotechnology	Role of nanotechnology in achieving food security	0.332	0.004
constraints	Role of nanotechnology in achieving food security	0.431**	0.000

**p<0.01 , *p<0.05.

TABLE VIII
MULTIVARIATE REGRESSION ANALYSIS (ROLE OF NANOTECHNOLOGY IN ACHIEVING FOOD SECURITY)

Conditions	B	Beta	T	Sig.
Constant	3.309	…..	6.573	0.000
Necessary conductions required for application of nanotechnology	-0.096	-0.378	-2.991	0.004
Producing agricultural products	0.084	0.424	2.879	0.005
Consuming nanotechnology productions	-0.081	-0.439	-3.524	0.001
constraints	0.049	0.320	2.818	0.006

$R^2 = 0.20;$

$$Y = -439/0\ x_1 + 424/0\ x_2 - 378/0\ x_3 + 320/0\ x_4$$

Like any other new technology, public confidence, trust and acceptance are likely to be the key factors determining the success or failure of nanotechnology applications for the food sector. The nanotechnology derived foods are new to consumers and it remains unclear how public perception, attitudes, choice and acceptance will impact the future of such application in the food sector. It is well known that uncertainties and lack of knowledge of potential effects and impacts of new technologies or the lack of a clear communication of risks and benefits can raise concern amongst public [2]. Based on the perception of respondents, the main constraint in application of nanotechnology in agricultural sector was regulatory constraints. The findings reflect an important fact, namely that a sound regulatory and policy environment is a necessary prerequisite for developing and adopting of the nanotechnology in agricultural sector. It is becoming increasingly clear that nanotechnology requires a holistic and tightly integrated regulatory framework for dealing with the range of health, ecological, economic and socio-political issues that this technology raises [9].

VI. CONCLUSION

There are many reasons why we need to be better prepared for the arrival of food and agriculture applications of nanotechnology:

• Experience has shown that any risks or benefits involved with integrating new technologies into food and agriculture processes are greatly magnified given their potentially far-reaching effects on humans, animals, rural communities, and the environment.

• Public perceptions and acceptance of agrifood nanotechnology will greatly influence how widely these applications enter society.

• Food and agribusiness concerns are at the vanguard of commercializing nanotechnology innovations, and their successes or failures could affect future commercialization of nanotechnology products in all industries.

The results demonstrated that success of nanotechnology in helping to achieve food security will depend on the informing population about benefits of nanotechnology and its food related products and in this regard the authorities should provide accurate and on time information. There is no single and appropriate strategy in which nanotechnology could improve the food security and in view of the numerous and varied constraints and opportunities, there is need to develop location- specific strategies.

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