The opinions of agricultural researchers on the current and potential applications and impacts of nanotechnology on Egyptian agriculture

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ABSTRACT

Nano Technology (NT) is a recent and impactful innovation with various applications that enhance agricultural practices. The success of extension efforts led by Egyptian Agricultural Researchers (EARs) depends on their awareness of NT applications. This awareness is crucial for encouraging farmers to apply NT effectively, leading to improved agricultural productivity, increased farm income, and enhanced food security.

The main objective of the study was to explore Egyptian Agricultural Researchers' (EARs) opinions on Nano Technology (NT) and its current and potential contributions to Agricultural Production and Marketing (AP&M). Specific objectives included understanding EARs' perspectives on NT and its impacts on various aspects of AP&M, such as improving access to inputs, modernizing processes, reducing transportation costs, maximizing economic returns, and promoting environmentally friendly practices.

Data were collected from 79 Egyptian Agricultural Researchers (EARs) representing different Agricultural Research and Educational Institutions using an online questionnaire. The questionnaire, tailored to meet the study objectives, included inquiries about respondents' characteristics and their opinions on various aspects related to the meaning,

current applications, and potential uses of Nano Technology (NT) in Egyptian agriculture.

The most important results of this study are:

The respondents reported a considerably high knowledge of the meaning of NT:

- Their opinions encompassed various current and potential contributions of NT,
- Their opinions included NT several current and potential contributions in improving farmers':

Access to production and marketing inputs and services,

Modernizing processes and services of performing production and marketing activities,

Minimizing the costs of agricultural activities and services, and,

Maximizing farming economic net returns and enhancing environmental protection.

Keywords: Nanotechnology, Agricultural Researchers, Egyptian Agricultural, Sustainable Development Strategy

Introduction

The Egypt's high interest in applying NT also reflects the serious Research and Development (R&D) programs and projects to achieve the Egypt vision 2030, of the Sustainable Development Strategy . According to this vision (SDS 2030): by 2030, the new Egypt will achieve a competitive, balanced, diversified and knowledge based economy, characterized by justice, social integration and participation, with a balanced and diversified Agriculture ecosystem, benefiting from its strategic location and human capital to achieve sustainable development for a better life to all Egyptians.

Egypt faces significant challenges in food security due to overpopulation, limited natural resources, and the adverse effects of climate change, compounded by health, political, and economic issues such as the COVID-19 pandemic and conflicts. As a result, there is an urgent need to modernize agricultural production and marketing to address food security, making it a top strategic priority for Egypt.

Nano Technology (NT) emerges as a modern innovation with the potential to contribute significantly to improving food security by enhancing agricultural processes. The growing interest among Egyptian Agricultural Researchers underscores its alignment with the goals of SDGs 2030, focusing on eradicating poverty, reducing hunger, building resilient infrastructure, promoting sustainable industrialization, and fostering innovation.

Effective application of NT-based devices, practices and interventions, for improving agricultural production and marketing activities requires high awareness among EARs in addition to efficient extension programs and activities to help farmers in timely and proper adoption of NT applications.

Consequently, EARs' awareness about the current and potential NT applications determine the success of their extension efforts to encourage and help farmers to timely and properly apply these applications for improving agricultural productivity, increasing their farming income and achieving food security in addition to improving the quality of rural life.

As reported by Mittal et al, (2020), in the current scenario, it is an urgent requirement to satisfy the nutritional demands of the rapidly growing global population. Using conventional farming, nearly one third of crops get damaged, mainly due to pest infestation, microbial attacks, natural disasters, poor soil quality, and lesser nutrient availability. In this regard,

nanotechnology has contributed to the agro-technological revolution that has imminent potential to reform the resilient agricultural system while promising food security. Therefore, nanoparticles are becoming a new-age material to transform modern agricultural practices.

NT, according to Ansari, (2023), has provided a path for increasing food availability and developing new agricultural products, particularly by minimizing nutrient losses from fertilizers and improving food yield through pest and nutrient management. Nano fertilizer improved seedling vigor index, increased reserve food-mobilizing enzyme activities, increased antioxidant enzymes, decreased lipid peroxidation, stimulated chlorophyll content, and effectively enhanced crop yield by promoting source activity.

Nanomaterials protect plants against pathogens by inhibiting microbial growth, inducing innate plant immunity, and delivering pesticides and micronutrients. Furthermore, Nano Particles (NPs) improve stress tolerance by reducing abscisic acid, regulating gibberellin acid, and improving seed germination.

The use of NT-based applications could significantly enhance the production and processing of foods and the quality of products, which will improve human health and well-being if handled and governed effectively.

As reported by He, et al (2019), the rapid development of NT has been facilitating the transformations of traditional food and agriculture sectors, particularly the invention of smart and active packaging, Nano sensors, Nano pesticides and Nano fertilizers. Efforts are still needed to strengthen public awareness and acceptance of the novel Nano enabled food and agriculture products. Nanotechnology offers a plethora of opportunities, by providing a novel and sustainable alternative in the food security and agriculture sectors.

They concluded that NT exhibits promising potentials to be widely utilized in every aspect of food industry and security. This is based on limited knowledge obtained mainly from labs. The practical application of nanotechnology and marketing nanomaterial based product remains uncertain, considering the poor capability to control properties and interaction of materials at nanoscale, as well as the unclear environmental effect and almost vacant toxicity database.

Public shows low awareness to food NT while their attitude is tunable depending on the way nanotechnology is used and advocated. The conflict seems to be that public wants to be informed on the status of food nanotechnology (especially development of related novel products) while food manufacturers prefer the opposite since their technology is confidential.

Abbotts (2018) highlights that Nanotechnology (NT) is a crucial factor for boosting agricultural production by enhancing nutrient efficiency and improving plant protection practices. The study highlights Nanotechnology's role in addressing agricultural challenges by improving crop varieties, enhancing plant protection, and monitoring plant growth. It emphasizes NT's potential to advance the agricultural sector through innovative applications, boosting global crop production to meet future demands. Ongoing applications include Nano nutrients, improved crop productivity, plant protection using herbicides and pesticides, Nano-packaging, and Nano sensors, showcasing the promising contributions of NT to agricultural development.

As reported by Upadhyay et al, (2021), agricultural activities can be sustained directly by NT, by reducing the effects on crops, plants, animals, and human health. There has been significant progress in nanotechnology in various fields of agriculture, like crop improvement, disease diagnosis, insect-pest management, monitoring soil health, etc. Nano-derived devices

(Nano-sensors, nanoparticles) are widely used in plant breeding and genetic transformation of crops to develop improved varieties through appropriate breeding programs.

As reported by Upadhyay et al, (2021), This technology has the potential to revolutionize the agriculture and food system because of its substantial and diversified applications. Even though this technology has brought out a significant change in agriculture, such advancements have also raised challenges and safety concerns about the practical use of nanotechnology.

Clunan et al (2014), identified the following key findings and recommendations:

- Nanotechnology is a general-purpose technology that is contributing to the ongoing revolution in information and communications technologies, microelectronics and robotics.
- Awareness of nanotechnology advances is hindered by the questionable comparability and quality of existing indicators on nanotechnology research and development.
- Based on available data, the United States remains the leader in nanotechnology. Other Asian countries, including China, are expanding and improving their Nano technological base.

As reported by Yousef et al (2023,) the advantage of NT as an alternative for the management of insect pests is increasing efficiency against target organisms and low toxicity of Nano pesticides to non-target organisms, highlighting the insufficient collateral environmental damage were reported in this work. It also provides selective, targeted, and long-term-controlled release of formulated nanomaterial. So, using nanotechnology for insect pest management is considered environmentally sustainable and an excellent insect control strategy in green agriculture.

They concluded that NT has the potential to transform existing technologies in various fields, including pest control, as it has shown an outstanding ability to manage the release pattern of pesticide-active ingredients, making them more effective for long-term functionality and overcoming agricultural runoff and residual pesticide accumulation issues.

As a result, it is possible to conclude that nanotechnology can give green and ecofriendly alternatives for pest management that do not harm the environment. Consequently, NT is considered one of the promising and emerging fields that can potentially alter the current situation of the agriculture and food sector with the aid of recently developed approaches.

Jiang et al. (2021), reported that with the rapidly changing global climate, the agricultural systems are confronted with more unpredictable and harsh environmental conditions than before which lead to compromised food production. Thus, to ensure safer and sustainable crop production, the use of advanced Nano technological approaches in plants (phytonanotechnology) is of great significance. An amended comprehension of the communications between crops and nanoparticles (NPs) can improve the production of crops by enhancing tolerance towards environmental stresses and optimizing the utilization of nutrients.

As reported by Deva (2022), the application of smart and active packaging, Nano sensors, Nano pesticides, and Nano fertilizers, as well as the rapid development of NT, has expedited the transformations of traditional food and agriculture industries. Metal nanoparticles have been produced for a variety of applications, including food quality and safety, crop development, and environmental monitoring.

`NT is used in agriculture to provide agrochemicals and nutrition, as well as insecticides, Nano-scale carriers, smart packing, Nano sensors, and nutritional deficiency monitoring. Nanomaterials are likely to become more

widely used in agriculture in the future, increasing human and environmental exposure to these materials.

Regulation and legislation are also important in regulating nanoparticle manufacturing, processing, application, and disposal. Public understanding and adoption of revolutionary Nano-enabled food and agriculture products still need to be improved.

As illustrated in figure (1), nanoparticles applications in agriculture quality improvement, NT could facilitate a wide-spectrum of agricultural production functions, including: monitoring agro ecosystems, seed germination, minimizing soil and groundwater pollution, pest and disease control, weed control, crop nutrition, improving postharvest quality,

These functions could be reflected, as demonstrated in figure (2), in several services, devices and processes that could enhance food security. These services, devices and processes include: delivery of fertilizers, insect pest management, micronutrient supply, Nano herbicides, Nano fungicides and Nano sensors.

The study problem and objectives

The agricultural sector is one of the most important sectors in the Egyptian economy which is considered as a driving force for activating other economic sectors in addition to its significant contribution in the GDP. Agricultural research contributes effectively to modernizing Egypt's agricultural production and marketing activities to enhance food security, through coping with latest technological innovations, such as NT, which is increasingly becoming an important and urgent priority.

NT has considerably high applicability potentials to upgrade and facilitate all the agricultural inputs, processes, activities and products. Examples of the useful applications of NT include Nano fertilizers and Nano

pesticides for improving agricultural productivity and the quality of agricultural products.

However the potential negative effects of using NT-based applications need to be assessed and highly considered by all stake holders sharing the agricultural business. EARs awareness and opinions about the meaning, the current and potential applications and impacts of NT, as a relatively new innovation, need to be assessed.

Therefore, the problem of this study was to investigate the EARs' awareness and opinions concerning the meaning or the concept of NT and its current and potential applications and impacts on different areas and activities of Egyptian agricultural production and marketing.

As a relatively new innovation, it needs to be evaluated by answering the following questions:

1-What is the concept of nanotechnology from the perspective of the respondents?

2. What are the respondents' opinions about the current and potential contributions of nanotechnology to facilitating the various fields of agricultural production and marketing?

Objectives

The main objective of this study was to identify the concept, the current and potential applications of NT from the point of views of the EARs' (the Agricultural Scientific Research Community) in Egypt Through the following sub-objectives:

1- Identify Respondents' opinions concerning the concept or the meaning of NT

2- Identify the EARs' opinions on the current and potential contributions of NT in facilitating the following areas of agricultural production and marketing :

a) facilitating and Improving farmers' access to production and marketing inputs and services,
b) Modernizing different processes and services of performing production and marketing activities,
c) Minimizing costs of different activities and services during the production and marketing processes (such as transporting agricultural commodities, products and services),
d) Maximizing the farming economic net returns,
e) Enhancing environmental protection through developing environment friendly innovations, services and practices

Methodology

The study was carried out across various agricultural educational and research institutions, encompassing agricultural colleges and research centers associated with the Agricultural Research Center under the Ministry of Agriculture and Land Reclamation. These entities, serving as sources of modern technology and innovations, play a crucial role in tailoring technology to meet the needs of stakeholders, fostering its adoption and application to boost production and productivity.

Data were collected using an electronic questionnaire form. This questionnaire involved sets of questions covering two main parts. The first part included the following personal characteristics of the respondents: age, educational qualification, scientific specialization, attendance at training programs in NT, place of training of respondents in NT, and topics of these training programs.

The second part covered respondents' opinions on the meaning of NT and their views on the potential uses of NT in facilitating the following agricultural production and marketing processes and activities: improving farmers' access to production inputs; modernizing various processes and services for production performance and marketing activities; reducing the costs of various activities and services during the production and marketing processes; maximizing the net agricultural economic return; and enhancing environmental protection.

The questionnaire form was presented to a group of 10 specialists in the field of NT in order to ensure its validity to achieve the study objectives. This group included experts of the uses of NT in agriculture, encompassing those involved in generating it as a novel technology, conducting experiments utilizing it, or teaching it at universities.

Frequency and percentages were used in presenting it Results. The study was conducted in June and July 2023.

The purposive study sample included 79 EARs from different Agricultural Educational and Research Institutions, including Faculties of Agriculture (25 staff members from different technical departments), and different Research Institutes of the Agricultural Research Center, the Ministry of Agriculture and Land Reclamation (35 researchers), in addition to 19 Nano experts from the Faculty of Nano. The respondents were asked about their opinions concerning the concept or the meaning of NT, their sources of information about NT. They were also asked about their opinions about the following:

- Current and potential contribution of NT in facilitating and improving farmers' access to production and marketing inputs and services,
- Modernizing different processes and services of performing production and marketing activities,

- Minimizing the costs of different activities and services during the production and marketing processes,
- Maximizing the farming economic net returns,
- Enhancing environmental protection through developing environment friendly innovations.

The Respondents' personal characteristics were:

As shown in table (1), the EARs respondents' characteristics could be summarized as follows:

A) Age: Relatively high proportions of the respondents (78.5%) are from middle and old age (35 years and above), compared with only 21.5% from young age (less than 35 years).

B) Educational Qualification: The majority of the respondents (88.6%) are highly qualified, since around 34% has M.Sc. university degrees, and 54.4% has a Ph.D. degree, compared with only 11.4% with the first university degree (B.Sc.).

C) Scientific Specialization: The respondents represent 6 different specializations, namely: plant protection (29.1 %), plant pathology (27.8 %), plant physiology (21.5 %), biological control and biotechnology (13.9 %), in addition to vegetable production and biochemistry (3.8 %, for each).

D) Attending Training Programs in NT: Considerable proportion of the respondents (63.3%) reported that they have attended training courses in NT. However, more than one third (37%) did not attend such training.

E) Place of respondents' training in NT: More than one half (around 56 %), of the respondents reported that they have attended NT training programs both inside and outside Egypt, compared with a relatively low

proportion (19%), who attended these programs inside Egypt only and 25% who attended these programs outside Egypt only.

F) Topics of training attended by the respondents: Topics of training covered several areas related to the use of NT in agriculture. These areas were reported by the respondents as follows: How to get the advantages of Nano Sciences (33.8 %), NT applications in Agriculture (27.9%), NT uses in Agriculture (26.5 %) and Impacts of using NT (11.8 %).

Results and Discussion

1) Respondents' opinions concerning the concept or the meaning of NT

The respondents' understanding of, and knowledge about, NT were reflected in their self-reported points of views about the meaning or the concept of NT as a modern technology. As shown in table (2), these points' pf views could be summarized as follows:

A -NT is the branch of technology that deals with dimensions and tolerances of less than 100 nanometers, especially the manipulation of individual atoms and molecules, as reported by (69.6%) of the respondents,

B-Nano is a unit prefix meaning one billionth. Used primarily with the metric system, this prefix denotes a factor of 10^{-9} or 0.000000001. It is frequently encountered in science and electronics for prefixing units of time and length,(41.7%).

C-Nano materials describe, in principle, materials of which a single unit is sized between 1 and 100 nm. Nanomaterials research takes a materials science-based approach to nanotechnology, leveraging advances in

materials metrology and synthesis which have been developed in support of microfabrication research, (44.3%),

D-Nanotechnology refers to the branch of science and engineering devoted to designing, producing, and using structures, devices, and systems by manipulating atoms and molecules at nanoscale,(26.6%),

E-Nanotechnology is the term given to those areas of science and engineering where phenomena that take place at dimensions in the nanometer scale are utilized in the design, characterization, production and application of materials, structures, devices and systems, (6.3%).

2) Opinions the EARs' on the current and potential contributions of NT in facilitating the following areas of agricultural production and marketing

a) Facilitating and improving farmers' access to production and marketing inputs and services,

As shown in table (3), the respondents reported different opinions on how NT contributes to facilitating and improving farmers' access to production and marketing inputs and services. These opinions could be demonstrated as follows:

- Making production inputs more accessible to small farmers, as reported by (69.6%) of the respondents,
-Create more efficient supply systems, (69.6%),
- Raising the level of knowledge of agricultural production requirement, (54.4),
- Creating new tools and technologies that can help improve communication and information sharing among producers, distributors and consumers, (30.4%),
- Providing small farmers with more accessible new NT-based practical solutions to the agricultural production and marketing problems, (6.3%),

b) Modernizing different processes and services of performing production and marketing activities

As shown in table (4), the respondents reported different opinions on how NT applications contribute to modernizing and facilitating different processes and services of performing production and marketing activities. These points of views could be summarized as follows:

-Maintaining product quality during export, (72.2%),

- Nanotechnology applications can be used to improve fuel efficiency in vehicles and agricultural machinery, (44.3),
- The crop tolerates post-harvest operations such as sorting, packing, transportation, and resistance to storage diseases, (41.8),
- Many NT applications have the property of extending the life of the agricultural product, (26.6),
- Finding practical solutions to the problems facing agriculture and farmers, (12.7%) ,
- Treating diseases that threaten plants, (8.9%).

c) Minimizing the costs of different activities and services during the production and marketing processes

As shown in Table (5) the respondents' reported several opinions on how nanotechnology innovations contribute to minimizing costs of different activities and services during the production and marketing processes. **These opinions were as follows:**

- By using nanotechnology in the low-cost fertilization stage with the same effectiveness as traditional materials, production costs are considerably reduced, (22.8%), (13.9%),
- Minimizing costs of transport through the development of new, lighter materials.

- Reducing the size of agricultural products to reduce their volume in transportation with the same efficiency, (16.5%).
- Nanotechnology innovations in fertilizers are lighter and thus save the number of transportation times/ Use in limited quantities, (13.9%),
- Minimizing costs of transport through the development of new, lighter materials, (13.9%),

d) Maximizing the farming economic net returns:

As shown in table (6), the respondents reported different opinions on how NT applications contribute to increasing / minimizing the net return from agricultural production and marketing activities. These points of views could be summarized as follows:

- Improving food self-sufficiency to reduce food imports, (64.6%),
- NT applications can help farmers increase productivity per feddan (62.2%),
- Improving crop characteristics and quality (49.4 %),
- Increase exports for the provision of hard currencies, (44.3%).

e) Enhancing environmental protection through developing environment friendly innovations, services and practices

As shown in table (7), the respondents reported several opinions on how NT contributes in enhancing environmental protection through developing environment friendly innovations, services and practices.

These opinions could be summarized as follows:

- NT applications help reducing the need to use pesticides, (51.9 %)
- NT monitoring devices help farmers resist drought, (30.8%).
- NT monitoring devices help farmers resist pests, (30.8%),

- NT monitoring devices help farmers determine the physiological state of the crop, the appropriate time to add fertilizers, and the time of harvest, (30.8%),
- Improving the efficiency of using agricultural resources, (21.5%),
- NT overlaps in many industrial, medical, agricultural, and water purification and pollution control applications. (18.98 %),
- NT resolutions help reduce the utilized amounts of pesticides and fertilizers, with greater efficiency. (18.1 %)
- NT applications save fertilizers, and NT applications save and reduce the needed amounts of pesticides, (13.9 % for each)

Conclusions and recommendations

Considerably high awareness among EARs, about NT, was revealed by the study. The EARs' self-reported NT-based applications, devices and materials, that could facilitate agricultural production and marketing functions and activities, reflect their high enthusiasm to utilize and get the best advantages of this new technology.

Based on these results, the following recommendations could be suggested:

1) Collaborative research and extension programs and activities are urgently needed for linking Egyptian agricultural producers with latest developments and safe utilization of NT-based applications.

2) Conduct workshops, seminars, or training sessions to enhance the knowledge of farmers, stakeholders, and researchers regarding the applications and potential benefits of NT in agriculture.

3) Examples of the current NT-based applications, in different agricultural production and marketing processes and activities, need to be surveyed

to acquire sufficient knowledge about practical lessons of success and/or failure on the use of NT.

4) A code of conduct of using NT-based applications in agriculture, need to be developed, discussed and agreed upon by different stakeholders in the agricultural production and marketing business.

5) Invest in collaborative efforts between the scientific community, agricultural experts, and technology developers to ensure that NT applications address specific needs and challenges in agriculture.

6) Encourage public-private partnerships to accelerate the adoption of NT in agriculture by providing incentives for companies to invest in research and development.

7) Conducting comprehensive field studies to evaluate the awareness levels of diverse agricultural professionals regarding the presence and potential applications of (NT) in advancing Egypt's agriculture is crucial. This initiative should involve clearly defined objectives, identification of target audiences such as farmers, extension workers, researchers, policymakers, and educators, and the creation of tailored surveys and questionnaires

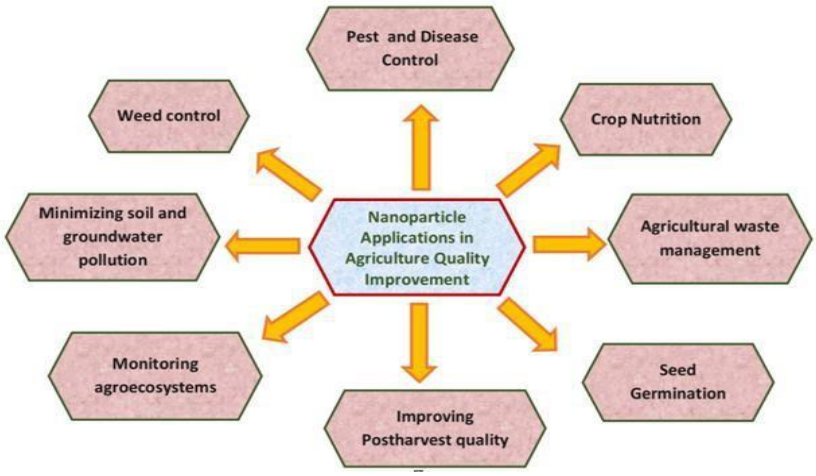
- Communication and Information Sharing:

8) Emphasize the role of NT in improving communication and information sharing among farmers, distributors, and consumers. Develop platforms or tools that facilitate efficient exchange of information.

9) Establish networks or forums where farmers can share their experiences with NT applications, creating a community that supports each other in adopting new technologies.

First: figures

Figure no.1:Nanoparticles applications in agriculture quality improvement



Source: Devra, (2022).

Figure no.2:NT resolutions that **could** enhance food security

Source: Allam, (2023).

Second: Tables

Table no.1:Distribution of the respondents according to their characteristics

Characteristics	Frq.	%
Age (years):		
Young (less than 35)	17	21.5
Middle (35- 55)	35	44.3
Old (56 and above)	27	34.2
Educational Qualification:		
B.Sc	9	11.4
M.Sc	27	34.2
Ph.D	43	54.4
Scientific Specialization:		
Vegetable Production	3	3.8
Plant physiology	17	21.5
Biochemistry	3	3.8
Plant pathology	22	27.8
Plant protection	23	29.1
Biological control & Biotechnology	11	13.9
Attending Training Programs in NT:		
Yes	68	63.3
No	11	36.7
Place of training:		
Inside Egypt only	13	19.1
Outside Egypt only	17	25.0
Both inside and outside Egypt	38	55.9
Training Topics:		
How to get advantages of Nano Sciences	23	33.8
NT applications in Agriculture	19	27.9
NT uses in Agriculture	18	26.5
Impacts of using NT	8	11.8

*(N= 79)

Table no.2: Frequencies and percentages of respondents' opinions regarding the concept or meaning of NT

NT meaning	Frq.	%
NT is the branch of technology that deals with dimensions and tolerances of less than 100 nanometers, especially the manipulation of individual atoms and molecules.	55	69.6
Nano is a unit prefix meaning one billionth. Used primarily with the metric system, this prefix denotes a factor of 10^{-9} or 0.000000001. It is frequently encountered in science and electronics for prefixing units of time and length.	33	41.7
Nano materials describe, in principle, materials of which a single unit is sized between 1 and 100 nm. Nanomaterials research takes a materials science-based approach to nanotechnology, leveraging advances in materials metrology and synthesis which have been developed in support of microfabrication research	35	44.3
Nanotechnology refers to the branch of science and engineering devoted to designing, producing, and using structures, devices, and systems by manipulating atoms and molecules at nanoscale.	21	26.6
Nanotechnology is the term given to those areas of science and engineering where phenomena that take place at dimensions in the nanometre scale are utilized in the design, characterization, production and application of materials, structures, devices and systems.	5	6.3

*(N= 79)

Table no.3: Frequencies and percentages of respondents' opinions regarding on how NT contributes to modernizing different processes and services for facilitating and improving farmers' access to production and marketing inputs and services.

Respondents' opinions	Frq.	%
Creating new tools and technologies that can help improve communication and information sharing among producers, distributors and consumers.	24	30.4
Creating more efficient input supply systems.	55	69.6
Making production inputs more accessible to small farmers	55	69.6
Raising the level of knowledge of agricultural production requirement	43	54.4
Providing small farmers with more accessible new NT-based practical solutions to the agricultural production and marketing problems.	5	6.3%

*(N= 79)

Table no.4: Frequencies and percentages of respondents' opinions regarding on how NT contributes to modernizing and facilitating the performance of production and marketing activities

Respondents' opinions	Frq.	%
Many NT applications have the property of extending the life of the agricultural product.	21	26.6
Nanotechnology applications can be used to improve fuel efficiency in vehicles and agricultural machinery.	35	44.3
Treating diseases that threaten plants.	7	8.9
Finding practical solutions to the problems facing agriculture and farmers.	10	12.7
The crop tolerates post-harvest operations such as sorting, packing, transportation, and resistance to storage diseases	33	41.8
Maintaining product quality during export	57	72.2

*(N= 79)

Table no.5:Frequencies and percentages of respondents' opinions regarding on how nanotechnology innovations contribute to minimizing the costs of different activities and services during the production and marketing processes.

How could NT contribute	Frq.	%
Nanotechnology innovations in fertilizers are lighter and thus save the number of transportation times/ Use in limited quantities.	11	13.9
Minimizing costs of transport through the development of new, lighter materials	11	13.9
By using nanotechnology in the low-cost fertilization stage with the same effectiveness as traditional materials, production costs are greatly reduced	18	22.8
Reducing the size of agricultural products to reduce their volume in transportation with the same efficiency.	13	16.5
Nanotechnology innovations in fertilizers are lighter and thus save the number of transportation times/ Use in limited quantities.	11	13.9
By using nanotechnology in the low-cost fertilization stage with the same effectiveness as traditional materials, production costs are considerably reduced	18	22.8

*(N= 79)

Table no.6: Frequencies and percentages of respondents' opinions regarding on how NT applications contribute to increasing / maximizing the net return from agricultural production and marketing activities.

Respondents' opinions	No	%
NT applications can help farmers increase productivity per feddan	49	62.02
Improving crop characteristics and quality	39	49.4
Improving food self-sufficiency to reduce food imports	51	64.6
Increase exports for the provision of hard currencies	35	44.3

*(N= 79)

Table no.7: Frequencies and percentages of respondents' opinions regarding on how NT contributes to enhancing environmental protection.

Respondents' opinions	Frq.	%
NT overlaps in many industrial, medical, agricultural, and water purification and pollution control applications.	15	8.98
NT applications help reducing the need to use pesticides	4 1	51.9
NT resolutions help reduce the utilized amounts of pesticides and fertilizers, with greater efficiency	15	18.10
NT monitoring devices help farmers determine the physiological state of the crop, the appropriate time to add fertilizers, and the time of harvest.	24	30.8
NT applications save fertilizers	11	13.9
NT applications save and reduce the needed amounts of pesticides	11	13.9
NT monitoring devices help farmers resist drought.	24	30.8`
NT monitoring devices help farmers resist pests	24	30.8
Improving the efficiency of using agricultural resources	17	21.5

*(N= 79)

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آراء الباحثين الزراعيين في التطبيقات الحالية والممكنة لتقنية النانو في الزراعة المصرية

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المستخلص

تكنولوجيا النانو هي المبتكرات الجديدة وذات التأثير العالي والمستخدمة في تطبيقات زراعية مختلفة لتحسين الممارسات الزراعية. ونجاح مثل هذه التطبيقات يعتمد على جهود الباحثين الزراعين المصرين ومدى وعيهم بتطبيقات تكنولوجيا النانو. وهذا الوعي أمر يساهم بفاعلية في تشجيع المزارعين على استخدام تطبيقات تكنولوجيا النانو بفعالية، مما يؤدي إلى تحسين وزيادة الإنتاج الزراعي والإنتاجية، وزيادة دخل المزارع، وتعزيز الأمن الغذائي.

واستكشفت هذه الدراسة آراء الباحثين الزراعيين فيما يتعلق بمفهوم تقنية النانو ومساهماتها الحالية والمتوقعة في تيسير وتحسين أنشطة الإنتاج والتسويق الزراعي المصري. وقد أوضحت الدراسة وجهات نظر الباحثين الزراعيين حول مفهوم النانو واظهرت أيضا المساهمات الحالية والمتوقعة لتحسين الوصول إلى مدخلات الإنتاج والتسويق وتأثيراتها على الجوانب المختلفة للعمليات الزراعية، وتقليل تكاليف النقل، وزيادة صافي الدخل وتعزيز الممارسات الصديقة للبيئة.

وتم جمع البيانات من عينة عمدية من مختلف المؤسسات البحثية والتعليمية الزراعية مكونة من 79 من الباحثين الزراعيين. وتم جمع البيانات بالاستبيان من خلال الإنترنت. وقد تم تصميم هذا الاستبيان وعرضه على 10 خبراء ثم اختباره مبدئيا للتأكد من صلاحيته لتحقيق أهداف الدراسة. وتضمن الاستبيان مجموعة من الأسئلة على جزئين أساسيين الأول يتعلق بخصائص المبحوثين والثاني يتعلق بأراء المبحوثين في معنى مفهوم تقنية النانو والإسهامات الحالية والمتوقعة لهذه التقنية الحديثة في تسهيل وتحسين أنشطة وعمليات ومراحل الإنتاج والتسويق الزراعي في مصر.

وتلخصت أهم نتائج الدراسة كالتالي:

تبين ارتفاع معرفة المبحوثين عن معنى ومفهوم تكنولوجيا النانو وقد اشتملت الآراء على: مساهمات متنوعة حالية ومحتملة للتكنولوجيا النانو، وإمكانية تحسين وصول المزارعين إلى المدخلات

والخدمات الإنتاجية والتسويقية، وتحديث العمليات والخدمات الزراعية المتعلقة بالأنشطة الإنتاجية والتسويقية، وتقليل تكاليف هذه الأنشطة والخدمات الزراعية وتحقيق صافي العوائد الاقتصادية للزراعة وأيضا تعزيز حماية البيئة.

الكلمات المفتاحية: النانوتكنولوجي، الباحثون الزراعيون، الزراعة المصرية، استراتيجية التنمية المستدامة