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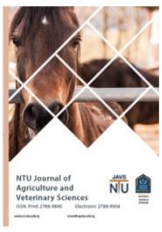
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The reality of wheat production irrigated by supplementary irrigation in Nineveh Governorate for the 2023-2024 production season (challenges and solutions)

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A B S T R A C T

Studies and research indicate a decline in the efficiency of irrigation water use in the cultivation of wheat crops irrigated by supplementary irrigation in Nineveh Governorate for the 2023-2024 production season, as a result of farmers' tendency to waste water, The majority of water is used for agricultural purposes to improve the efficiency of irrigation water use on the farm and thus reduce waste in its use. This research article aims to study the reality of wheat crop production irrigated by supplementary irrigation in Nineveh Governorate for the production season 2023-2024 and to clarify the challenges facing farmers and appropriate solutions for them.

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Introduction

Wheat is one of the most important crops in Iraq, both in terms of production and consumption. A portion of the wheat available for consumption is imported from outside Iraq. Despite Iraq's wheat production, it only constitutes one-third of the total supply of this crop [1]. Wheat is a winter crop, whether it depends on irrigation or rain, which is what the northern governorates of Iraq, especially Nineveh Governorate, often depend on. As for the central and southern regions, they depend on irrigation from rivers [2]. Its cultivation is concentrated around the Tigris and Euphrates river basin, and the governorates located in western Iraq do not play a significant role in wheat production. Therefore, the issue of developing and modernizing the agricultural sector is of exceptional importance, as it is the sector responsible for providing the country's food requirements for the population, in addition to providing the industrial need for raw materials [3]. Rain-fed farms in Iraq are classified as arid and semi-arid regions, in addition to the loss of water due to the use of traditional irrigation methods. Farmers tend to waste irrigation water due to their incorrect perceptions of the crop's water needs, their expectations of the amount of rainfall, as well as the lack of legislation and laws necessary for managing water resources, All of this had a negative impact on the production of grains (wheat) and the efficiency of water use as well [4], as the area of rain-fed lands in Iraq amounts to a total of 14.6 million dunums, divided in terms of the annual rainfall rate into guaranteed rainfall (more than 450 mm) its area is 1.8 million dunums, representing 12%, and its rainfall is almost guaranteed (350-450 mm), with an area of 4.4 million dunums, representing (30%), and its rainfall is not guaranteed (100-350 mm), with an area of (8.4) million dunums, representing (58%). Rain-fed agriculture is the main source of wheat production in Iraq [5]. Statistics indicate that about 85% of wheat production occurs under rainfed conditions over the past four decades, but wheat productivity in this region is very low [6]. This decline in grain productivity rates has led to a decline in self-sufficiency rates achieved in the main grain crops in Iraq, because agriculture consumes between 80% and 90% of available water for irrigation purposes, any water savings must come from the agricultural sector, which primarily requires increasing the efficiency of water use. Therefore, the focus is on producing more output with available water resources or using less water to produce the same levels of output achieved. In Iraq, wheat production is concentrated in the rain-fed region, which is highly vulnerable to fluctuating climatic conditions. Therefore, grain production will also be vulnerable to these fluctuations and instability [7]. Rainwater is the main source of food production in such environments, and it is generally noted that annual rainfall rates are much lower than the water requirements of crops for economic production, The soil water reserve in the root zone is often insufficient to meet the water needs of crops during the growing season [8]. Modern technology, through its various means, has contributed to making important positive changes in raising the productivity of available and limited production elements, especially in rain-fed agriculture [9]. Supplementary irrigation or fixed and pivot sprinklers is one of the techniques that add quantities of water to rain-fed crops during times when rain does not provide sufficient moisture for the plants to grow normally, with the aim of improving and stabilizing the crop yield [10], in light of the unstable production conditions of rain-fed agriculture, which is the main source of wheat production, and the deterioration of productivity in many agricultural systems that suffer from fluctuating rainfall rates, many farmers have turned to the application of supplementary irrigation technology to secure the water needs of crops. Reducing dependence on rain and reducing risk [11]. Improving the efficiency of irrigation use is a vital factor for its use and improving wheat production in Nineveh Governorate, which suffers from a large food gap [12] Supplementary irrigation technology has been recently introduced and its use in agricultural activities has positive effects in increasing and stabilizing production, improving water use efficiency, and increasing farm income. Therefore, we find that most developed countries have adopted this modern method as a means of developing the productivity of their other components, and reaching to raise the productivity and production of this important strategic crop. [13] ,Nineveh Governorate is one of the most important agricultural regions in Iraq, contributing significantly to wheat production, a strategic crop upon which the country's food security depends. However, farmers in the governorate face the problem of low productivity of wheat grown under sprinklers. This negatively impacts economic returns and agricultural production. This study aims to analyze the causes of this problem and propose practical solutions to improve productivity and increase the efficiency of using available resources. [14]

The economic importance of wheat crops in Iraq

Wheat is one of the most important strategic crops in Iraq, playing a pivotal role in the national economy by providing food security, supporting the agricultural sector, and reducing dependence on imports. The following is a detailed account of the economic importance of wheat in Iraq [15]

1. Achieving food security:

Wheat is the main component of the Iraqi diet, as the state relies on it to produce flour used in making bread, which is the basic food for the

population [16]. In addition, the government provides the wheat crop as part of the ration card items in order to continue providing bread products at reduced prices to all individuals or consumers. [17].

2. Reducing imports and achieving self-sufficiency:

Iraq tends to import large quantities of the wheat crop in order to cover the needs of consumers, but supporting local production and expanding the cultivation of the wheat crop leads to reducing dependence on foreign markets, and thus contributes to reducing the trade deficit and reducing pressure on the state budget. In addition, reaching levels that achieve self-sufficiency in the wheat crop leads to reducing Iraq's exposure to global price fluctuations and crises. [18]

3. Supporting the national economy:

Wheat production contributes significantly to the agricultural gross domestic product, which leads to the growth, development and expansion of the agricultural sector in general. This also provides sources of income for locally produced farmers and enhances the agricultural economy in rural areas (villages and countryside) by increasing agricultural commercial activity [19].

4. Employing labor and supporting rural areas:

Farmers work extensively in cultivating and producing the wheat crop in large quantities, starting with planting the seeds (wheat crop) and passing through the harvesting operations and then marketing. This provides job opportunities (employing the workforce) and contributes to raising the standard of living in the agricultural areas that are characterized by its production. This means supporting, developing and expanding the cultivation of wheat crop, which contributes to improving agricultural infrastructure, such as water and irrigation networks and then storage. This is what supports and enhances agricultural development in rural areas [20].

5. Investing in food industries:

In Iraq, the wheat crop is used in many food industries, such as the production of flour, various pastries, pasta, etc., which leads to the support and development of its manufacturing sector. Also, the increase in locally produced quantities of the wheat crop reduces production costs in the food industry and makes it more competitive in different markets [21].

6. Supporting economic stability:

Iraq's reliance on receiving and purchasing wheat from farmers at prices suitable for them contributes to supporting them to expand and develop its cultivation. The stability of wheat production also contributes to the stability of the prices of flour, bread, and other wheat products, which reduces economic pressures on the final consumer[22].

7. Using Wheat in the Livestock Sector

The animal feed production industry sector depends on the locally produced quantities of wheat, and any increase in local production contributes to supporting and developing the livestock sector and reducing the costs of imported feed, as well as enhancing local production of meat, dairy, and animal products, thus significantly supporting comprehensive food security. [23]

8. Improving the Utilization of Water and Agricultural Resources

Supporting the development and expansion of modern irrigation methods, such as drip or sprinkler irrigation, contributes to increasing the productivity of the wheat crop while reducing water consumption, despite Iraq's reliance on river water to grow wheat to a large extent, with some challenges related to water scarcity due to climate change and water policies in neighboring countries. [24]

9. The Role of Wheat in International Trade Relations

Iraq is still considered an importer of wheat, but supporting the development of local wheat production may enable it to export surpluses to global markets in the future. A strong wheat-based industry could enhance Iraq's chances of signing trade agreements with other countries. [25]

The wheat crop in Iraq is considered one of the strategic crops of great importance and affects food security and economic stability in the country, as the expansion of its cultivation represented by improving irrigation techniques, supporting farmers, and increasing investment in related industries can contribute to achieving self-sufficiency and reducing dependence on imports coming from abroad, and this will have a positive impact on the Iraqi agricultural economy. [26]

The Role of Nineveh Governorate in Wheat Production

One of the most important Iraqi agricultural governorates that is distinguished by the production of agricultural crops, especially wheat, is Nineveh Governorate, and it has advantages and factors that make it one of the largest contributors to wheat production at the national level, the most prominent of which are:

1. Vast Agricultural Area

It is possible to expand the cultivation of wheat in Nineveh Governorate due to its possession of large agricultural areas, especially in the areas of Al-Hamdaniya, Tal Afar, and Suha Nineveh. [27]

2. Suitable Climate

Nineveh Governorate is characterized by a moderate to semi-arid climate, with appropriate amounts of rain in the winter, which makes it an ideal agricultural environment for growing and producing wheat, and it depends on intensive irrigation, represented by the increasing number of various fixed and pivot sprinklers.

3. Availability of Fertile Soil

What supports and enhances the productivity of the wheat crop in Nineveh Governorate, both quantitatively and qualitatively, are several features, the most important of which is the type of fertile soil rich in organic matter.

4. Use of Modern Agricultural Technologies

Recently, farmers and peasants producing wheat in Nineveh Governorate began using advanced technologies in the field of agriculture, such as conservation agriculture, advanced irrigation water systems, and improved chemical fertilizers, which led to an increase in productivity in quantity and quality.

5. Government Support

Supporting and encouraging farmers to expand wheat production in Nineveh Governorate has a clear impact for producers, by providing seeds and chemical fertilizers at subsidized prices and ensuring the reception and purchase of wheat crops at appropriate prices.

6. Nineveh's Contribution to National Production

The wheat crop is considered one of the strategic crops of great importance in Nineveh Governorate. This governorate is distinguished by its production and contributes significantly to the gross domestic product, making it a basic pillar of food security in Iraq.

Challenges Facing Wheat Production in Nineveh:

• In some seasons, drought impacts climate change.
• Failure to receive receivables from farmers at the specified times, in addition to other problems
• There is adequate support in rural areas in terms of equipment, improved seeds, etc. [29]

Nineveh Governorate can remain one of the most important governorates or centers producing wheat in Iraq, as it plays a pivotal role in its production, by benefiting from its natural resources and with continued improvements and development in agricultural techniques and government support, [30]

Reasons that contribute to the decline in wheat productivity under sprinklers (fixed and pivotal)

First: Climatic factors

The climatic factors that contribute to the decline in wheat crop production under pivot and fixed sprinklers in Nineveh Governorate are:

1. Weak groundwater recharge and low rainfall amounts

In irrigation with sprinklers (pivotal and fixed), Nineveh Governorate relies partly on the amounts of rainfall to replenish groundwater. Also, in years in which the amounts of rainfall decrease, groundwater levels decrease and the flow to wells decreases. Together, this leads to not achieving sufficiency of the irrigation water used to irrigate and produce the wheat crop, and this contributes to a decrease in productivity. [31]

2. Rising temperatures and increased evaporation

High temperatures in the spring and the end of the winter lead to an increase in the rates of water evaporation from the soil and sprinklers (a large percentage of the water does not reach the roots), which affects the efficiency of irrigation, especially with heat waves that put pressure on the plants.

3. Winter Frost Waves

In some seasons, wheat is exposed to sudden frost waves in the early stages of germination, which can damage leaves and reduce early growth, thus reducing later production.

4. Strong winds and their impact on water distribution

In some cases, strong, dry winds cause uneven water distribution from sprinklers. Water droplets evaporate before reaching the soil, causing some parts of the field to dry out and preventing plants from receiving sufficient water. [32]

It is clear from the above that low rainfall, high temperatures, frost waves, and strong winds are among the most important climatic factors leading to reduced wheat production under sprinklers in Nineveh, calling for improved irrigation management to address these challenges [33].

Second: Soil Problems

Soil problems are among the most important factors leading to decreased wheat production under sprinklers in Nineveh Governorate. The most prominent of these problems are:

1. Soil Salinization

The prolonged use of groundwater for irrigation, especially if it contains a high percentage of salts, leads to the accumulation of salts in the soil. In addition, high salinity contributes to obstructing the roots' absorption of water and nutrients, which leads to reduced and weak plant growth and a decrease in the quantities produced.

2. Soil Fertility Deterioration

The decrease in the use of organic fertilizers and the total dependence on chemical fertilizers contribute to creating a nutritional imbalance in the soil. Repeated cultivation without proper rotation of agricultural crops leads to the depletion of essential nutrients such as nitrogen, phosphorus and potassium.

3. Compaction (soil hardening)

The growth and multiplication of plant roots depends on pores that are large and sufficient to retain water and air, as the repeated use of agricultural machinery and equipment leads to a reduction in these pores and thus weakens the plants' retention of water and air.

4. Wind and water lead to soil erosion

Poor management of irrigation water use leads to the removal of the topsoil, which is characterized

by high fertility, and this leads to a decrease in production, especially in open areas.

5. Soil pH imbalance

High or low pH affects the ability of plants to absorb nutrients, which contributes to a decrease in wheat crop production. [34]

Third: Problems of Irrigation Management with Sprinklers

Among the most important and prominent disadvantages of sprinkler irrigation management are:

1. Poor Irrigation Scheduling

Excessive irrigation results in waterlogging of the soil, reducing the oxygen available to the roots and causing problems such as fungal diseases and root rot. Inadequate irrigation during critical periods (such as flowering and grain filling) also reduces the final yield. [35]

2. Inefficient water distribution by sprinklers

Not distributing water equally to the plants leads to uneven growth in the field. Strong winds also affect the direction of water fall, which leads to creating an imbalance in irrigation in some parts of the field and causing the plants to grow.

3. Use of poor-quality water

The lack of water and nutrients absorbed by the plant is caused by the irrigation water (highly saline) used to irrigate the plant, which leads to the accumulation of salts in the soil.

4. Inefficient traditional irrigation system

The use of old or traditional, undeveloped sprinklers leads to problems with water pressure, which reduces irrigation efficiency. In addition, the blockage of some sprinkler nozzles or openings due to salts (highly salty) or sedimentation leads to an uneven distribution of water, and thus the plants are not satisfied with draining the water necessary for its growth. [36]

5. High Pump Operating Costs

Some farmers are working to reduce irrigation periods due to the high cost of fuel or electricity needed to operate pumps or machines, which leads to a decrease in the quantities produced. [37]

Fourth: Variety and Seed Problems

Variety problems include:

1. The type of intentions is not compatible with the local environment

Cultivation of varieties that are not adapted to the climate of the region (Nineveh Governorate), such as varieties that need a lot of irrigation water or low temperatures, which leads to a decrease in productivity. Some varieties are also unable to tolerate drought or soil salinity, making them more vulnerable to harsh and difficult conditions.

2. Some varieties are not resistant to some diseases

Some fungal diseases, such as yellow rust or powdery mildew, lead to a significant reduction in production quantities. Poor resistance to insects and pests also leads to the need to repeatedly use pesticides, which increases costs and affects the quality of the crops grown.

3. Poor quality of some seeds

What is caused by poor germination rates or low productivity in general is the adoption of traditional seeds that are not genetically improved. Some farmers replant seeds from the previous season, reducing plant vigor due to genetic deterioration. [38]

4. Lack of early-maturing varieties

Some cultivated varieties require a long growing period, making them more susceptible to drought and high temperatures at the end of the season. Early-maturing varieties can be more efficient at utilizing water and avoiding heat stress. [39]

Fifth: Pests and Diseases

Pests and diseases are among the most important causes of decreased wheat production under sprinklers in Nineveh Governorate, affecting plant growth, crop quality, and final yield. The most important of these are:

1. Fungal Diseases

A- Yellow Rust (Stripe Rust):

One of the most dangerous diseases affecting wheat in Nineveh, it causes yellow spots on the leaves, leading to impaired photosynthesis and reduced productivity.

B- Septoria leaf spot:

Causes brown spots on leaves and leads to premature drying, reducing grain set.

C- Powdery mildew:

Appears as a white coating on leaves and stems, weakening the plant and affecting yield. [40]

2. Bacterial and viral diseases

Some viruses, such as wheat dwarf virus, are transmitted by insects such as aphids, leading to stunted plants and small ears. [41]

3. Weeds associated with wheat crops

Weeds are considered one of the most important factors negatively affecting the productivity of wheat grown under sprinkler irrigation systems, as they compete with the crop for resources such as water, space, light, and nutrients, leading to reduced productivity. Studies indicate that weeds can cause a reduction in wheat yield of up to 45% [42].

The most important weeds that grow with wheat crops:

A .Narrow-leaved weeds:

a. Wild oats (Avena fatua): An annual plant that reproduces by seeds, it can reach a height of 90 cm and produces approximately 500 seeds per plant.

b. Wheat (Lolium rigidum): An annual plant that grows between 30-45 cm tall and produces approximately 1,360 seeds per plant.

c. Roeta (Lolium temulentum): A plant similar to wheat but distinguished by the presence of a squash in the seed.

d. Abu Damim (Phalaris minor): An annual plant that can produce approximately 5,000 seeds per plant and is characterized by an erect, branched stem.

B. Broadleaf Weeds:

a. Cephalaria syriaca: A herbaceous plant that reproduces by seeds, reaching a height of 80 cm and producing 1,800-2,000 seeds per plant.

b. Sylibium marianum: A thorny annual plant that can reach a height of 120 cm and produce about 1,300 seeds per plant.

c. Raphanus raphanistrum: An annual plant that can produce about 13,000 seeds per plant, reaching a height of 120 cm.

d. Wild mustard: It is one of the plants that reproduces by seeds. Its height can sometimes reach more than 100 cm and produces about 400 seeds or more per plant [43].

The importance of controlling weeds and weeds in wheat crop fields:

a. Agricultural control:

- ✓ Crop rotation: This helps reduce weed density by planting different crops in successive seasons, limiting the spread of weeds associated with a particular crop.
- ✓ Soil preparation: Ploughing and thinning help eliminate weed seeds and reduce the chance of their germination.
- ✓ Use clean, weed-free seeds from reliable sources.
- ✓ Land fallow: This method is used when the yield per unit area decreases due to the dense spread of weeds. In this case, the farmer plows the land and repeats the plowing several times to combat weeds. This method of weed control is considered expensive because the land in this case has no economic return due to the lack of crops, despite the expense of weed control.

b. Mechanical control:

This is one of the methods of direct weed control. It refers to the mechanical methods that can be used to control and overcome weeds. Mechanical methods that can be used in wheat fields are divided into the following:

1- Tillage

2- Mowing and grazing.

c. Chemical Methods (Chemical Weed Control)

Chemicals are used to control weeds. The chemicals used for this purpose are divided into three main categories, depending on the nature of the pesticide's action and the method of application. Some chemicals used as weed control pesticides are considered general in their toxicity, killing any plant to which they are applied. Others are specialized in their effect, killing a specific type of plant or weed, while not harming the other type (the crop) if the pesticide is applied to both types of plants. [44]

Below are some of the pesticides used in weed control.

First: Typical foliar herbicides:

- ✓ Topic 10%: Apply at a concentration of 200 cm^3 per 10-15 gallons of water per acre, and in the Far East when the weeds reach the 3-5 larval stage.
- ✓ Eloxan (Elomac) 28%: Apply at a concentration of 750 cm^3 per acre, and in the Middle East after the weeds have emerged and reached the 3-5 leaf stage.

Second: Broadleaf herbicides:

- ✓ 2,4-D: Apply at a concentration of 370-400 cm^3 per 50 liters of water, and continue spraying approximately 32 days after emergence and until the wheat plants reach 60 days of age.
- ✓ Panfil 4%: It is used at a concentration of 375 cm^3 per 10-15 gallons of water per acre, when the wheat reaches the branching stage and the bush reaches the 4-6 leaf stage.

d. Biological control:

The use of natural enemies, such as specialized insects or fungi that attack weeds without harming the crop. This method is still under research and development in many regions. [45]

Important Notes:

- ✓ Timing of control: The timing of application of control strategies is critical to ensure their effectiveness and reduce crop damage.
- ✓ Integration of strategies: It is recommended to combine more than one control method to achieve the best results and reduce the possibility of weeds developing resistance to insecticides.
- ✓ Environmental precautions: The potential environmental effects of chemical pesticides must be taken into account, and ensuring that they are used in accordance with recommended guidelines to avoid negative impacts on the environment and public health.

By adopting these integrated strategies, farmers can reduce the impact of weeds on wheat crops, which contributes to increasing productivity and improving crop quality.

4. Insect Pests

A- Sunn beetle:

It feeds on wheat ears, which reduces the quality of the grain and affects the market value of the crop.

B- Aphid:

It absorbs plant juice and secretes substances that cause honeydew growth, which reduces its production.

C- Wheat cutworm:

It feeds on seedlings in the early stages, damaging plants and reducing plant density.

5. Rodents and Birds

Some rodents, such as mice, feed on grains stored in the soil, which reduces germination rates. Birds, such as starlings, also feed on mature grains, which leads to direct losses in production. [46]

Solutions are proposed to improve wheat crop productivity under sprinklers in Nineveh

Solutions depend on addressing issues related to climate, soil, irrigation, varieties and pests. Below is a detailed explanation of each axis of the solution:

First: Improving the efficiency of sprinkler irrigation management includes:

1. Precisely scheduling irrigation according to wheat growth stages, increasing irrigation during critical periods such as flowering and grain filling.
2- Use soil moisture measuring devices (such as moisture sensors) to ensure that only the required amount of water is provided, while avoiding over- or under-irrigation.
3- Improving the efficiency of water distribution through regular maintenance of sprinklers and ensuring that the nozzles are not clogged.
4- Using smart irrigation techniques, such as variable-pressure sprinklers that adapt to the soil and climate.
5- Planting windbreaks around the fields to reduce water evaporation resulting from strong winds. [47]

Second: Improving the type and fertility of the soil includes:

1. Wash the soil periodically with fresh water to reduce the accumulation of salts, which affects the roots' absorption of water and nutrients.
2. Add organic materials (such as compost or plant residues) to improve the soil structure and increase its ability to retain moisture.
3. Implementing agricultural rotation, where different crops (such as legumes) are grown to improve soil fertility and limit the spread of diseases.
4- Use agricultural gypsum in alkaline soil to improve water permeability and enhance the absorption of nutrients.

Third: Choosing appropriate varieties and improving seeds:

1. Planting improved drought-resistant varieties, such as those that tolerate low water and soil salinity.
2. Choose varieties that are resistant to fungal diseases such as yellow rust and septoria spot to reduce the need for pesticides.
3. Use high quality certified seeds to ensure high germination rates and uniform plant growth.
4. Encouraging the planting of early-maturing varieties to avoid severe heat waves at the end of the season.

Fourth: Effective control of pests and diseases, including:

1. Preventive spraying with fungicides and insecticides during critical stages of plant growth.
2. Using biological control, such as introducing beneficial organisms that feed on harmful insects.
3. Avoid excessive watering because it increases soil moisture, which encourages the spread of fungal diseases.
4. Monitor the fields periodically for early detection of any infection and rapid intervention to prevent the spread of infection.

Fifth: Improving agricultural practices, including:

1. Deep tillage to improve soil aeration and enhance water absorption.
2. Plant wheat at the right time to avoid heat stress at the end of the season.
3. Reducing the use of heavy equipment in the fields to prevent soil compression, which helps improve the roots' absorption of water and nutrients.

Sixth: Supporting farmers and improving infrastructure, including:

1. Providing government support for seeds, fertilizers, and pesticides at subsidized prices to reduce costs for farmers.
2. Updating the electricity networks to ensure that the pumps operate efficiently and without interruption.
3. Establishing agricultural extension centers to train farmers on the latest irrigation and agricultural management techniques.

To improve wheat productivity using sprinklers in Nineveh, irrigation management, soil improvement, selection of resistant varieties, pest control, improved agricultural practices, government support and training are essential. Combining these solutions will increase productivity and achieve agricultural sustainability in the region.

Seventh: Using magnetized water to increase production and reduce the effect of irrigation water salinity

Irrigation water salinity represents a major challenge facing agriculture, especially in arid and semi-arid regions, where high salinity negatively affects the growth and productivity of crops, including wheat. In this context, magnetic water technology has emerged as an innovative solution to reduce the impact of salinity on agricultural crops.

- Magnetized water is water that has been passed through a strong magnetic field, which has changed some of its physical and chemical properties. These changes include increasing the ability of water to

dissolve and reducing their accumulation, which improves the plant's absorption of water and nutrients.

- How does magnetized water reduce salinity in irrigation water?

When water passes through a magnetic field, the arrangement of water molecules changes, which increases its ability to dissolve salts and reduces their deposition on the soil surface or in irrigation systems. This enhances the efficiency of root absorption of water and nutrients, reducing the effect of salinity on plants.

Benefits of Using Magnetized Water

- ✓ Improving the efficiency and properties of the soil: Magnetized water helps reduce and reduce the accumulation of salts on the soil surface, which improves the soil structure and its ability to retain water.
- ✓ Increasing efficiency and improving water use: By improving plant absorption of water, the amount of water used in irrigation can be reduced, which contributes to rationalizing the consumption of water resources.
- ✓ Reducing clogging of irrigation networks: Magnetized water reduces the deposition of salts in irrigation pipes and points, which reduces maintenance problems and improves the efficiency of irrigation systems.

The use of magnetized water is considered a promising technology for reducing the impact of irrigation water salinity on wheat yields. [48]

The Role of Government Agencies and Research Institutions in Supporting Wheat Cultivation

• Supporting Agricultural Extension

1. Providing training programs for farmers on best agricultural practices.
2. Holding extension courses, workshops, and seminars through specialized extension centers to support farmers in selecting varieties and managing resources. [49]

• Improving Agricultural Infrastructure

1. Developing irrigation networks and repairing damaged sprinklers.
2. Providing government support to farmers to purchase modern equipment.

• Supporting agricultural research

1. Enhancing scientific research in the field of improving wheat productivity.
2. Encouraging cooperation between universities, research centers, and farmers to develop innovative solutions. [50][51]

Proposed recommendations that contribute to increasing productivity and achieving agricultural sustainability for wheat grown under sprinklers in Nineveh Governorate:

1. Use advanced irrigation techniques and distribute water evenly through sprinkler maintenance.
2. Irrigate at specific times according to the wheat growth stages (early morning or evening).
3. Regularly test the soil to determine its nutrient requirements.
4. Precisely apply chemical fertilizers based on soil type and crop needs.
5. Plant disease- and drought-resistant wheat varieties.
6. Ensure the use of certified seeds with high germination rates.
7. Preventative spraying with fungicides and insecticides during critical times.
8. Regularly monitor wheat fields to detect weeds and take appropriate measures in a timely manner.
9. It is recommended to implement integrated control strategies that include agricultural, chemical, and biological methods to achieve the best results.
10. Providing training programs for farmers on weed identification and control methods can contribute to improved field management.
11. Select fast-growing varieties to avoid late-season heat.
12. Reduce tillage to conserve moisture and improve soil aeration.
13. Provide government support for fertilizers, seeds, and modern equipment.
14. It is preferable to include all suitable agricultural lands in the agricultural plan, whether or not they have renewable leases, to ensure an increase in the area planted with wheat.
15. All center pivot irrigation farms can become economically efficient if support for modern agricultural production technologies is increased, reducing production costs and increasing allocative and economic efficiency.
16. Work to guide farmers to implement agricultural rotation (crop cycle) by planting summer crops such as mung beans in the autumn season (early June to late August) in order to restore the soil's chemical properties and eliminate salinity, and support them by providing them with fuel for the summer crop or with national electricity, which achieves environmental and economic benefits for farmers.
17. Optimum utilization of agricultural economic resources in Nineveh Governorate and reducing waste, especially water, given that water represents the main axis of agricultural development in Iraq.
18. Conducting soil analysis studies on all agricultural lands to identify areas suitable for wheat cultivation under supplementary irrigation systems, as this analysis reveals the elements and compounds contained in the soil, which leads to optimal use of agricultural resources and increases in production rates.

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