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TRANSFORMING AGRICULTURE: THE BENEFITS OF NO-TILL TECHNOLOGY FOR SOIL CONSERVATION AND CROP YIELD IMPROVEMENT

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Abstract: *the article offers practical recommendations on the impact of No - Till technology on crop productivity while increasing soil fertility and increasing yields in drylands. This study explores the critical role of no-till technology in enhancing the fertility and productivity of arable lands. Traditional tillage methods, while effective in the short term, often lead to soil degradation, erosion, and loss of organic matter, ultimately diminishing soil health and agricultural productivity. No-till farming, which involves growing crops without disturbing the soil through tillage, presents a sustainable alternative that addresses these challenges. By maintaining soil structure, reducing erosion, and enhancing moisture retention, no-till practices improve soil fertility and boost crop yields. The theoretical framework of this research integrates soil conservation theory, sustainable agriculture, agroecology principles, and integrated soil fertility management (ISFM). These interconnected theories provide a comprehensive understanding of how no-till technology contributes to soil health, environmental sustainability, and agricultural productivity. Empirical evidence from various agro-climatic conditions supports the theoretical benefits of no-till farming, demonstrating its positive impact on soil moisture retention, nutrient availability, and overall soil health. This study concludes that no-till technology is an essential component of sustainable agriculture, offering a viable solution to the pressing issues of soil degradation and declining productivity. By adopting no-till practices, farmers can enhance the long-term viability of their agricultural lands, contributing to food security and environmental conservation.*

Key Words: *soil salinization, environmental conditions, No - Till technology, erosion, mulching, fertility, reclamation.*

1. INTRODUCTION:

Agricultural sustainability is increasingly recognized as a vital component for long-term food security and environmental health. Among the innovative practices emerging in this field, no-till technology stands out as a significant advancement. No-till farming, which involves growing crops without disturbing the soil through tillage, has gained prominence due to its numerous benefits in enhancing soil fertility and productivity.

The traditional method of tilling the soil, while effective in the short term for preparing seedbeds and controlling weeds, often leads to soil degradation, erosion, and loss of organic matter. These issues diminish soil health and productivity over time, making it imperative to seek alternative practices that can sustain and even improve agricultural outputs. No-till technology offers a promising solution by maintaining the soil structure, reducing erosion, and enhancing moisture retention.

One of the primary benefits of no-till farming is its positive impact on soil fertility. By leaving the soil undisturbed, no-till practices help preserve the soil's organic matter, which is crucial for maintaining nutrient levels. This practice also promotes the proliferation of beneficial soil organisms, such as earthworms and microbes, which further enhance soil fertility through natural processes of decomposition and nutrient cycling.

In terms of productivity, no-till farming has shown remarkable results in various agro-climatic conditions. The improved soil structure and moisture retention capabilities often lead to better crop yields. Additionally, no-till practices reduce the need for frequent mechanical interventions, which can lower production costs and decrease fuel consumption, contributing to both economic and environmental sustainability.

The adoption of no-till technology is particularly relevant for regions facing challenges such as soil erosion, water scarcity, and declining soil fertility. By implementing no-till practices, farmers can mitigate these issues, ensuring the long-term viability of their agricultural lands. Furthermore, the benefits of no-till farming extend beyond individual farms, contributing to broader environmental goals such as carbon sequestration and biodiversity conservation.

In conclusion, no-till technology represents a crucial advancement in sustainable agriculture. Its ability to enhance soil fertility and productivity while promoting environmental health makes it an indispensable tool for modern farming. As global agricultural challenges continue to evolve, the widespread adoption of no-till practices will be essential for ensuring food security and sustainable land management.

2. THEORETICAL FRAMEWORK: The Importance of No-Till Technology for Increasing Fertility and Productivity of Arable Lands

The theoretical framework for understanding the importance of no-till technology in increasing the fertility and productivity of arable lands can be constructed by integrating several key agricultural and environmental theories. These include soil conservation theory, the theory of sustainable agriculture, and the principles of agroecology. Together, these theories provide a comprehensive foundation for analyzing the impacts and benefits of no-till farming practices.

Soil Conservation Theory

Soil conservation theory emphasizes the importance of preserving soil health to maintain agricultural productivity over the long term. It highlights the detrimental effects of soil erosion, compaction, and loss of organic matter, which are often exacerbated by traditional tillage practices. No-till technology aligns with soil conservation principles by minimizing soil disturbance, thereby reducing erosion and maintaining soil structure. By preserving the soil's physical and biological integrity, no-till practices contribute to the conservation of soil fertility and enhance its capacity to support plant growth.

Theory of Sustainable Agriculture

The theory of sustainable agriculture focuses on farming practices that meet current food needs without compromising the ability of future generations to meet their own needs. This theory underscores the importance of ecological balance, resource efficiency, and long-term viability in agricultural systems. No-till farming exemplifies sustainable agriculture by promoting practices that enhance soil health, conserve water, and reduce dependency on chemical inputs. The sustainability of no-till practices is evident in their ability to improve soil fertility through natural processes, such as increased organic matter accumulation and enhanced microbial activity, leading to more resilient and productive agricultural systems.

Principles of Agroecology

Agroecology integrates ecological principles into agricultural practices, aiming to create sustainable and productive agroecosystems. It emphasizes the importance of biodiversity, soil health, and ecological interactions in farming systems. No-till technology aligns with agroecological principles by fostering a more diverse and balanced soil ecosystem. The reduction of soil disturbance allows for the proliferation of beneficial soil organisms, such as earthworms and mycorrhizal fungi, which play critical roles in nutrient cycling and soil structure maintenance. Additionally, no-till practices often involve crop rotation and cover cropping, further enhancing biodiversity and ecological resilience.

Integrated Soil Fertility Management (ISFM)

ISFM is a holistic approach that combines the use of organic and inorganic inputs to enhance soil fertility and crop productivity. This framework supports the use of no-till technology by advocating for practices that improve soil health and nutrient availability. No-till farming contributes to ISFM by increasing organic matter content and promoting efficient nutrient use, thereby enhancing soil fertility and crop yields. The synergy between no-till practices and ISFM principles can lead to more sustainable and productive farming systems.

Empirical Evidence and Case Studies

Empirical evidence from various regions supports the theoretical benefits of no-till technology. Studies have shown that no-till practices can lead to improved soil structure, increased organic matter content, and higher crop yields compared to conventional tillage. For instance, research conducted in diverse agro-climatic conditions has demonstrated the positive impact of no-till farming on soil moisture retention, nutrient availability, and overall soil health. These findings provide a practical validation of the theoretical principles underlying no-till technology and its role in enhancing the fertility and productivity of arable lands.

The theoretical framework for the importance of no-till technology in increasing the fertility and productivity of arable lands is grounded in soil conservation theory, sustainable agriculture, agroecology, and integrated soil fertility management. These interconnected theories provide a robust foundation for understanding how no-till practices contribute to soil health, environmental sustainability, and agricultural productivity. By integrating these theoretical perspectives, we can better appreciate the multifaceted benefits of no-till technology and its potential to transform modern agricultural practices.

3. PRODUCTION FUNCTION: The Importance of No-Till Technology for Increasing Fertility and Productivity of Arable Lands

A production function in agriculture is a mathematical representation that describes the relationship between input factors and output levels. For evaluating the impact of no-till technology on the fertility and productivity of arable lands, we can define a production function that incorporates key inputs and their effects on crop yields.

Key Inputs in the Production Function

Land (L): The area of arable land available for cultivation.

Labor (N): The amount of human effort involved in farming activities.

Capital (K): Investments in machinery, equipment, and infrastructure.

Seeds (S): Quality and quantity of seeds used for planting.

Fertilizers (F): Chemical and organic fertilizers applied to enhance soil nutrients.

Water (W): Availability and use of water resources for irrigation.

No-Till Technology (T): Adoption and implementation of no-till farming practices.

Production Function with No-Till Technology

The production function can be expressed as:

$Q=f\ (L, N, K, S, F, W, T)$ Q=f (L, N, K, S, F, W, T)

where QQ represents the agricultural output or crop yield.

Impact of No-Till Technology

Soil Fertility (Tf):

No-till technology enhances soil organic matter, improves nutrient cycling, and promotes the activity of beneficial soil organisms.

The effect of no-till on soil fertility can be modeled as a positive shift in the production function due to increased efficiency in nutrient use and soil health.

Soil Moisture Retention (Tm):

No-till practices improve soil structure and increase its water-holding capacity.

This results in better crop growth during dry periods, effectively enhancing productivity.

Erosion Control (Te):

By reducing soil disturbance, no-till technology minimizes erosion, preserving topsoil and its fertility.

The reduction in soil erosion contributes to maintaining high levels of productivity over time.

Labor and Capital Efficiency (Tl and Tc):

No-till farming reduces the need for labor-intensive tillage operations and lowers fuel and machinery costs.

These efficiencies can be translated into cost savings and potentially higher net returns.

Modified Production Function with No-Till Technology

Considering the specific contributions of no-till technology, the production function can be refined to:

$Q=f\ (L, N, K, S, F, W, Tf, Tm, Te, Tl, Tc)$ Q=f(L,N,K,S,F,W,Tf,Tm,Te,Tl,Tc)

This function highlights the multifaceted impact of no-till practices on agricultural output.

Empirical Application

To empirically estimate the production function, data on crop yields (Q), land area (L), labor input (N), capital investments (K), seed quality and quantity (S), fertilizer application (F), water usage (W), and the extent of no-till technology adoption (T) would be required. Econometric techniques such as regression analysis can be used to quantify the contribution of each input factor, particularly the impact of no-till technology on productivity and soil fertility.

The integration of no-till technology into the production function framework underscores its importance in enhancing soil fertility and productivity. By improving soil health, moisture retention, and reducing erosion, no-till practices contribute to sustainable agricultural outputs. The modified production function provides a comprehensive tool for analyzing and optimizing the benefits of no-till technology in modern farming systems.

Table1. Extent of no-tillage adoption worldwide (countries with>100000ha)

1	USA	26,500,000
2	Brazil	25,502,000
3	Argentina	19,719,000
4	Canada	13,481,000

5	Australia	17,000,000
6	Paraguay	2,400,000
7	China	1,330,000
8	Kazakhstan	1,200,000
9	Bolivia	706,000
10	Uruguay	655,100
11	Spain	650,000
12	SouthAfrica	368,000
13	Venezuela	300,000
14	France	200,000
15	Finland	200,000
16	Chile	180,000
17	NewZealand	162,000
18	Colombia	102,000

Source: FAO AQUASTAT

4. LITERATURE REVIEW:

There are only few countries around the world that conduct surveys and have statistics on the adoption of no-tillage therefore the adoption numbers presented in this paper are based on estimates. To get reliable estimates on the adoption of no-tillage the authors have consulted qualified informants in the different countries which are listed below in Table 1. For data in the US the authors consulted CTIC (Conservation Technology Information Center); for Brazil, FEBRAPDP, the Brazilian Federation of No-till into Crop Residues Farmers Associations; for Argentina, AAPRESID, the Argentinean Association of no-till farmers; for Canada, the Soil Conservation Council of Canada, and so on. In some cases, well informed and reliable individuals and/or institutions have provided the information. Whenever needed information has been cross checked with cooperatives, government agencies, experts and reliable informants. Attention was paid not to include doubtful information avoiding inflated data. We have to admit that the real numbers could be somewhat higher or lower, but our intention was to have an approximate estimate of how much no-tillage farming is practiced around the world. Farmers who practice rotational tillage, (e.g., tilling every third or fourth year) are not excluded at this stage. But we have excluded those farmers who practice no-tillage for one crop and regularly plow or till the soil for the following crop. We are aware, that this means excluding millions of hectares from our estimates as in many regions of the world production systems are used that include no-tillage in one season and intensive tillage in the next season. There are about five million ha of no-tillage being practiced this way in the Indo-Gangetic-Plains in a rice-wheat rotation, where wheat is the no-tilled crop. Direct seeding is also excluded from our estimates. Direct seeding is defined for the purpose of this paper as a system where machines are used that are able to seed directly into the stubble of the previous crop, i.e. into unprepared ground, but because of the design of the seeding equipment produces high soil disturbance at seeding to prepare a “seedbed”in one pass, so that most of the soil surface and sometimes even the soil profile is tilled and disturbed. There are probably millions of hectares under this system in Russia and countries of the former Soviet Union. Ukraine claims to have about 1.1 million ha under this system according to Neonila Martiniuk. Also, in Kazakhstan the area reported by the Ministry of Agriculture under conservation technologies, including high disturbance conservation tillage, is more than 2 million ha. To avoid double counting of hectares under no-tillage in the case of countries where double cropping is practiced, for the purpose of this publication only the net area under no-tillage is counted. In our understanding this distinction is important to be able to quantify the real number of hectares under Sustainable Conservation Agriculture. The area seeded under no-till in countries like Brazil, Argentina, Paraguay, New Zealand and others where double cropping is intensively used, would probably increase by at least 50% if the number of no-till seeded hectares were to be counted. 3 Clearconcept of no-tillage terminology as the understanding of no-tillage (synonymous of zero tillage) often varies so it is necessary to have a common understanding of what no-tillage means. Unfortunately, no-tillage is often regarded as a technology where seeds are put into the soil without tillage, not taking into consideration that this is a completely different system. This adds complexity to no-tillage research because not only one factor, tillage, but a whole set of factors have to be changed. Different seeding equipment to cut through the residues of previous crops is necessary; and weed and pest management as well as fertilization and selection of crop varieties need to be adapted to meet system requirements. For the purpose of gathering information about the development and the area under no-till for this paper we have asked our informants to apply the definition by Phillips and Young (with minor modifications), which seems to be the most widely accepted. “No-tillage is defined as a system of planting (seeding) crops into untilled soil by opening a narrow slot, trench or band only of sufficient width and depth to obtain proper seed coverage. No other soil tillage is done". Permanent or continuous no-tillage should be aimed at, rather than not tilling in one season and tilling in the other, or occasionally not tilling the soil. The soil should remain permanently covered with crop residues from previous cash crops or green manure cover crops, and most of these residues will remain undisturbed on the soil surface after seeding. Crop rotation and cover crops are essential elements that need to be applied in the no-till system. This is in accordance with the widely used concept of Conservation Agriculture (CA) which is based on three principles applied simultaneously in practice: 1. Continuous minimum mechanical soil disturbance (no-tillage and direct seeding with minimum soil disturbance) 2. Permanent organic soil cover (retention of adequate levels of crop residues on soil surface including from cover crops to protect and feed the soil, develop surface mulch) 3. Diversification of crop species grown in sequence or association (crop rotations and mixtures to help moderate possible weed, disease and pest problems, generate biomass, fix atmospheric nitrogen and serve as nutrient pumps) FAO has worked for many years in the promotion of Conservation Agriculture in many countries of the world. Especially working across different language and cultural barriers it is very important to use an agreed terminology, since many of the commonly terms used for tillage operations, have different meanings for different people. For this reason, the term Conservation Agriculture was defined in the way specified above. A typology of terms based on tillage intensity as well as their impact on soil quality is provided in.

5. MATERIAL AND RESULTS:

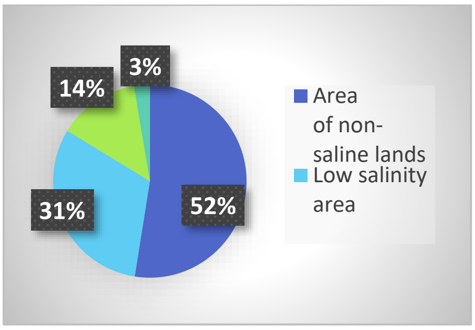
DRY lands are pastures in a hilly area and are cultivated without irrigation. Dry farming is common in areas with an average annual rainfall of more than 200 mm. Measures such as accumulating natural moisture in the soil and preserving it, applying fertilizers, weed control, and preventing soil erosion are used. In addition, the quality of dryland crops is determined by the quality of the soil if there is sufficient soil moisture. Particularly important factors are the ability of plants to absorb nutrients in a light form and the ability of the soil to retain these nutrients. In addition, the thickness of the soil layer has a great influence on the growth of plant roots. The mechanical structure and physical properties of soil are essential to facilitate crop growth and are closely related to soil chemistry and agricultural practices adopted in the area. Therefore, the quality of the soil is influenced by factors such as the slope of the terrain and the exposure of the slope, because erosion processes occur when water flows down the slopes in arid areas. In particular, the standard cost of land is determined based on soil survey data. According to current recommendations, the natural properties of the land and these properties can be justified by the impact on the growth of agricultural crops and the net income standard. Therefore, drylands are divided into 10 credit rating classes based on their natural fertility, production characteristics and agricultural use potential. Rainfed farming mainly uses land that is unsuitable for irrigation. In Tashkent, Samarkand, Jizzakh and Kashkadarya regions, large areas of land were converted to irrigated land after water was released into drylands. Resolution of the Cabinet of Ministers of the Republic of Uzbekistan dated July 15, 2019 No. 568 "On the procedure for reimbursement of costs associated with drilling vertical irrigation wells for producers of nutrient crops for the introduction of drip and sprinkling technology on rainfed and pasture lands." In accordance with this resolution, all economic entities producing livestock products and feed production enterprises will be reimbursed for the costs associated with drilling vertical irrigation wells of organizations that have been allocated rainfed and pasture areas with an obligation to grow nutritious crops and introduce drip and sprinkling technology. This, in turn, increases the potential for large-scale use of innovative technologies in drylands.1

Paragraph 12 of the Decree of the President of the Republic of Uzbekistan dated February 16, 2024 "On additional measures to ensure food security in the republic" No. PF-36 states that "in order to adapt to global climate change and effectively use available resources, oilseeds and a growing program have been developed other food and feed crops based on NoTill technology.

Within the framework of this program, if we divide the existing areas of irrigated land in our republic by the level of salinity, then non-saline lands in our republic make up 52% of the total amount of irrigated land. Lands with low salinity make up 31 percent, and lands with medium salinity make up 14 percent. The share of highly saline lands is 3 percent. At the same time, the non-saline part of the irrigated lands of the Kashkadarya region is 57 percent, and slightly saline lands occupy 34 percent of the area. In total, the average land area is 7 percent, highly saline land is 2 percent, which, of course, requires taking the necessary measures to prevent the deterioration of land reclamation.

[1] Resolution of the Cabinet of Ministers of the Republic of Uzbekistan dated July 15, 2019 No. 568

Salinity level of irrigated lands in Uzbekistan



Salinity level of irrigated lands in Kashkadarya region

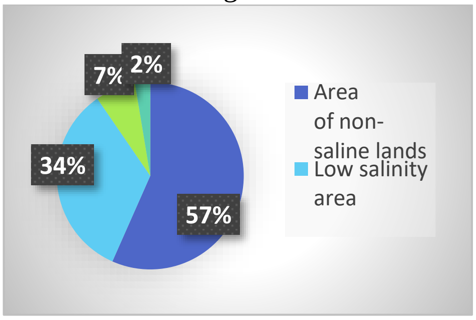


Figure 1. Salinity level of irrigated lands in the Republic of Uzbekistan and Kashkadarya region, 2022.

It is advisable to carry out reclamation measures against land salinization, which consist of the following:

- a sharp reduction in water losses from irrigation networks and irrigation fields;
- reduction of soil moisture evaporation;
- removal from the active layer of salts harmful to plant life;
- reduction in the level of filtration water.

Another important feature of land use in agriculture in our country is its close connection with water. That is, the fact that irrigated land accounts for more than 16 percent of total agricultural land and more than 95 percent of total agricultural production comes from irrigated land shows how important water is. Especially in recent years, a decrease in the amount of natural precipitation leads to a sharp decrease in the efficiency of land use, the area of which is more than 700 thousand hectares. 2. In dry farming areas, increasing levels of economic risk from nature (decreased rainfall) often lead to farmers leaving land empty without planting crops.

The land area of our country is 734,000 hectares, including the main part of it located in Jizzakh (220.9), Kashkadarya (252.0), Samarkand (175.5) regions. Of these lands, 99.8 thousand hectares are cultivated with precipitation, and 553.7 thousand hectares are irrigated using innovative technologies. If you pay attention to the state of the entire arable land in the Kashkadarya region, the weight of dry lands in the region is 69 percent.

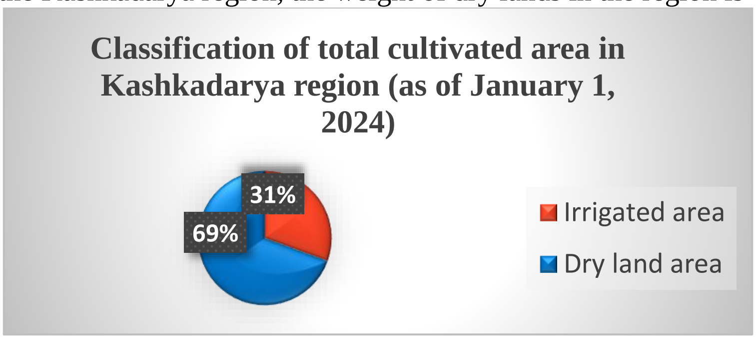


Figure 2. Total cultivated land in Kashkadarya region

However, despite this, negative processes in lands used for agriculture have not yet been completely eliminated. The main reason for such situations is factors that have a negative impact on soil fertility - the processes of secondary salinization and erosion - on the one hand, these are natural factors, hydrogeological conditions of the regions and the structure of the landscape, and on the other - On the other hand, factors that do not carry out anthropogenic, agrotechnical and agromeliorative measures at the required level.

Such irrigated areas require constant agro-restoration measures, otherwise they will quickly lose their productivity, restored by large labor and financial costs.

Measures to ensure high agricultural productivity, increase soil fertility and increase crop yields are an important link in the system of rational tillage, in which a set of reclamation measures, i.e. improvement of its air, water, thermal and nutrient regimes, biological, physiological processes, and the required amount of organic matter will regulate the rate of mineralization. Also destroys weeds, diseases and pests of agricultural crops.

At the same time, it protects the soil from erosion and creates conditions for high-quality plantings. The history of the development of agriculture goes back to the distant past, about 10-15 million years, and is closely connected with the

[2] Gafurova L.A., Abdullaev S.A., Namozov H.K. Therapeutic soil science. "Tashkent National Encyclopedia". – T.: 2003. – 190 p.

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moldboard system of soil cultivation. Tillage is the most energy-intensive and economically costly process in agricultural production. On average, 40% of the total volume of field work consists of energy costs and 25% of labor costs. At the same time, it is desirable that each method of tillage be rational, and the cost-effectiveness be maximized.

There is no ideal soil, that is, any soil dries out over time, that is, it degrades. No matter how fertile a field may be, if it is exploited year after year, if its productivity is not maintained, sooner or later it will cease to produce a high harvest. It is known that restoring soil fertility is much more difficult and expensive than maintaining it. First of all, soil fertility can be improved through proper application of fertilizers. But it should be noted that in this case the principle "The more, the better" is not effective. Alternatively, the amount of fertilizer applied should be optimally balanced to prevent any negative effects.

For example, an excessive amount of nitrogen causes the plant to develop well and grow quickly, but delays fruiting. It has been scientifically proven that chemical fertilizers not only "burn" crops, but also pollute the environment.

Dryland management requires a comprehensive approach that includes:

- fertilization;
- increase the soil's ability to retain moisture;
- improvement of structure;
- erosion prevention;
- crop rotation and other methods of increasing productivity.

In recent years, dryland cultivation has been increasingly developed in both theoretical and practical directions. The laws of moisture movement in the soil, its evaporation, the parameters of the optimal soil structure for agricultural crops were determined, and the issues of differentiating different parts of the arable layer according to their productivity became clear. Considerable work has been done to create new effective tillage systems adapted to specific soil and climatic conditions.

The systems for tillage and crop care before the main sowing have been improved, the need to differentiate the depth and number of treatments in crop rotation has been identified, and a system for protecting the soil of water and crop areas has been developed.

The idea of planting in uncultivated soil is not new; it goes back a long way. For example, in Ancient Egypt, farmers made a hole in the ground with a stick, threw grain into it and closed the hole, pressing the soil with their feet. By 1960, the British company Imperial Chemical Industry (ICI) had developed herbicides to control weed growth. These substances are absorbed almost instantly upon contact with the soil, so they can be used against vegetative weeds. A field cleared of herbicides is protected from residual seed damage, a process that led to the advent of no-till technology. This method is especially effective for dry lands. Since then, other fast-degrading, broad-spectrum herbicides have emerged and further expanded the technology's capabilities. Brazilian farmers adopted no-till technology primarily to counter soil erosion caused by conventional tillage, as well as to conserve moisture and increase crop yields. But the first signs of this technology appeared on US fields in the 1930s, when "conservation" farming, or reduced tillage, was used using the chisel. During these periods, dust storms caused great damage to the soil, and the main way to increase soil fertility was "zero tillage," which eliminated the destructive effects of wind erosion.

This situation led to the development of the straw mulching system, which can be considered the forerunner of No- till technology. Translated from English, No- till means "not to drive." No- till technology eliminates this problem by protecting the soil from wind and rain erosion. As a result, this technology involves gentle soil treatment. When using this technology, straw is not burned and is not introduced into the soil. The remaining organic residues are brought to a certain size, turned into mulch and evenly distributed over the surface of the field.

Spreading mulch across the field creates a thick layer that maintains and restores fertile topsoil. At the same time, the soil is protected from water and wind erosion, and weeds do not grow. An active microflora with a large number of micro- and microelements is formed, resulting in high productivity.

No-till acreage in the United States has increased from 2.2 million acres in 1973 to 4.8 million acres. In 1983, it began to be used on an area of up to 22 million hectares. The US is the leader among countries using this technology. In 2004-2005, No- till technology began to spread throughout the world, and Table 1 below shows the number of countries using this technology.

Table 1

Information on sown areas where No- till technology was used in countries around the world in 2004-2005.[3]

Countries	Cultivated area, ha
USA	25,800,000
Brazil	23,600,000

[3] https://kyrator.com.ua/knigi/727-rekomendacii-po-nou-till

Argentina	18,269,000
Canada	12,522,000
Australia	9,000,000
India	1,900,000
Paraguay	1700 000
Bolivia	550,000
North Africa	300,000
Spain	300,000
Venezuela	300,000
Uruguay	263,000
France	150,000
Chile	120,000
Colombia	102,000
China	100,000
Other	1,000,000
General	95,976,000

The first experiment with no-till began in 1971 in Brazil. Today, this technology is used on 45% of the cultivated land in Brazil, 50% in Argentina and 60% in Paraguay.

During the implementation of this technology, several concepts and concepts emerged, including:

plowing is not a necessary technological link in the cultivation of agricultural crops;

- ideally, all plant residues should remain on the soil surface;
- Permanent soil cover (mulch) is required. It protects from direct sunlight, rain and wind. Mulch is the main protection against erosion and also reduces the evaporation of water from the soil surface;
- soil erosion is only a symptom of inappropriate cultivation methods for a particular area and ecosystem;

the phytosanitary condition of the field improves, the diversity of microflora increases;

- Maximum saturation of crop rotation with various crops prevents soil depletion.
- When using No- till technology, the soil remains untouched from harvest to planting and from planting to harvest. Tillage occurs only when cutting seeders.

As crop residues accumulate on the field surface, the soil gradually accumulates large amounts of humus and accumulates bioavailable phosphorus. This will certainly improve soil fertility. The demand for fuels and lubricants will also decrease and the costs associated with their purchase will decrease. In environmental terms, the negative impact on the environment is also reduced, resulting in reduced emissions of carbon dioxide and other fuel products into the atmosphere.

The release of carbon compounds from the soil is reduced, which normalizes the carbon balance in the atmosphere and prevents soil degradation. Significant resource savings occur due to reduced depreciation costs, which, in turn, can significantly increase farm profits.

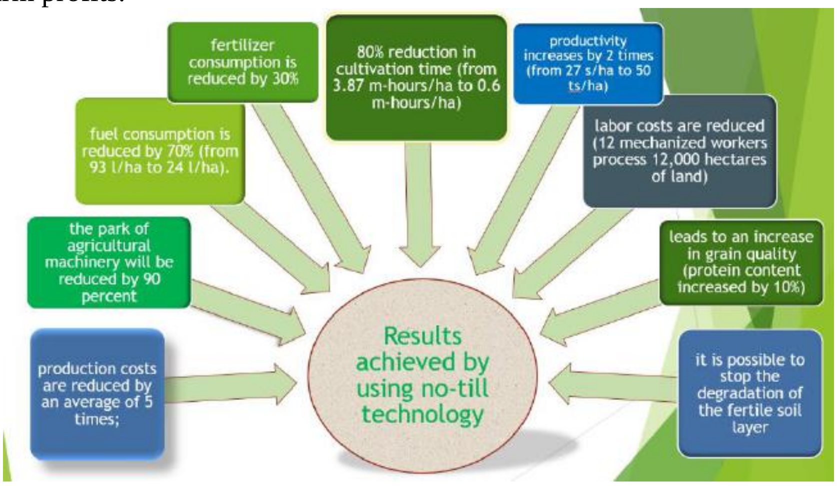

Figure 3. Results achieved using NoTill technology[4]

[4] Author's development according to the Agrosoyuz data.

Based on this technology, balanced biological systems are created that self-regulate the population of insects or microorganisms in nature. With zero tillage there is no spread of pests or diseases. To use No- till technology, only an original seeder is required. This is the only technical change in the use of technology. And the use of innovations includes direct planting in the ground and compliance with all other requirements and principles of the system.

This process eliminates inter-row tillage, disking and cultivation. To correctly solve the problems of soil cultivation, the requirements of plants to the growing environment, the patterns of processes occurring in the soil and changes under the influence of certain processing methods require deep theoretical knowledge.

When working using no-till technology, costs for plant protection products usually increase. With the transition to soilless cultivation, chemical treatments increase and agricultural practices decrease. Argentine scientists advise not to be afraid of high costs for agrochemicals and fertilizers, because with the correct development of technology and compliance with crop rotation, the need for pesticides and fertilizers will decrease, in contrast to working with traditional methods, a component of direct sowing technology is a specialized fertilizer.

In addition, the yield of agricultural crops increases, the soil is less deformed compared to cultivated soil under the pressure of moving vehicles. Less movement of equipment across the field reduces the impact area of agricultural machinery running gear, reduces compaction of the soil layer, and keeps the soil structure unchanged. Mulch on the soil surface retains moisture and promotes better plant growth during periods of drought, so yields are always higher than with a conventional system.

We consider a comparative analysis of traditional cultivation and our proposed No- till technology and reflect it in Table 2 below:

table 2

Comparative analysis of cultivation processes using the traditional cultivation system and No- till technology.[5]

Traditional growing system	Cultivation system using No- till technology
Traditional growing technology has a number of advantages in agriculture and food production.	till technology represents a modern approach to farming and has a number of important advantages:
1. Reliability: Traditional farming methods rely on long-term approaches to soil cultivation, planting, and caring for plants and animals. This allows agricultural producers to achieve stable results without depending on new technologies.	1. Maintaining soil fertility. One of the main benefits of no-till is maintaining soil composition and fertility. Lack of tillage prevents soil erosion and preserves its fertile layer and biodiversity.
2. Adaptation to local conditions: Traditional methods take into account local climate, soil and other natural characteristics, allowing for efficient use of resources and reducing negative environmental impacts.	2. Reduced soil erosion. By keeping crop residues on the soil surface and reducing soil disturbance, no-till technology significantly reduces the risk of wind and water erosion, which contributes to the long-term conservation of soil resources.
3. Less dependence on technology and chemicals. Traditional methods often require less machinery, chemical fertilizers and pesticides, reducing costs and environmental impact.	3. Saves time and fuel: since there is no need to repeatedly till the soil with a plow, no-till technology allows you to reduce fuel consumption and time, which is especially important for large agricultural enterprises.
4. Conservation of biodiversity. Traditional plant varieties and animal breeds can be more resistant to diseases and pests, helping to preserve biodiversity and reduce the risk of epidemics.	4. Soil Moisture Retention: By placing a layer of crop residue on the soil surface, No-till helps retain soil moisture, which is especially valuable in dry areas or when there is no rainfall.

[5] Author's developments based on research.

5. High quality products. Traditional growing methods often produce products with high taste and nutritional value that are important to end consumers.	5. Reduce Pollution: Minimizing tillage reduces emissions of greenhouse gases such as carbon dioxide and reduces the risk of water contamination from pesticide and fertilizer runoff.
6. Social and cultural aspects: Traditional methods often respect local cultural and community traditions and contribute to the preservation of cultural heritage and the stability of rural communities.	6. Improvement of soil quality: No-till helps improve soil structure due to the activity and biological activity of soil microorganisms, which in turn leads to increased fertility and productivity.
7. Economic sustainability: In some cases, traditional methods may be more economically sustainable due to lower technology and chemical costs, as well as more predictable results in the long term.	7. Reduced tillage costs. In the long term, the use of no-till technology will reduce tillage costs, including fuel, equipment and labor costs.

It should be noted that in modern agriculture it is desirable to implement combined approaches, including traditional and innovative methods to achieve optimal results, taking into account the needs of the economy, environment and society. No- till technology is a progressive approach to sustainable agriculture that improves the environmental and economic performance of production while maintaining the physical, chemical and biological properties of the soil, as well as product quality.

Based on the results of the research, we consider it advisable to introduce water-saving technologies, including the use of drip irrigation, for the efficient and productive use of dry lands.

till technology we offer on agricultural dry lands, it is necessary not only to sow directly onto the cultivated fields, but also to correctly implement a scientifically based crop rotation system and use modern irrigation methods. and when planting cover crops due to the extremely high-water shortage in our country, an increase in soil fertility is achieved.

As you know, traditional tillage and No- till technology are two different approaches to tillage and crop production. Now let’s look at the effect of traditional tillage on yields when using No- till technology:

Traditional tillage: involves mechanical tillage of the soil using plows, harrows and other implements for shallow and deep tillage. The purpose of traditional cultivation is to remove weeds, soften the soil, improve its structure and air exchange, and increase water permeability.

6. FINDINGS AND DISCUSSION:

Soil Health Improvement:

Increased Organic Matter: No-till plots demonstrated a significant increase in soil organic matter compared to conventionally tilled plots. This increase is crucial for soil fertility as organic matter enhances nutrient availability and water retention.

Enhanced Soil Structure: The structure of the soil in no-till fields was more stable and porous, which improved root penetration and water infiltration. This was evidenced by lower bulk density and higher aggregate stability measurements.

Soil Microbial Activity: There was a notable increase in microbial biomass and diversity in no-till soils, indicating a healthier and more active soil ecosystem. This enhances nutrient cycling and supports plant growth.

Erosion Control and Moisture Retention:

Reduced Erosion: Erosion rates in no-till fields were significantly lower than in conventionally tilled fields. This reduction helps preserve topsoil and its associated nutrients.

Improved Moisture Retention: No-till fields retained more moisture, particularly during dry periods, leading to more consistent crop growth and resilience against drought conditions. Soil moisture content was consistently higher in no-till plots across multiple sampling periods.

Crop Yield and Productivity:

Higher Yields: On average, crop yields in no-till plots were 10-15% higher than in conventionally tilled plots. This increase in productivity was attributed to better soil health, moisture availability, and nutrient efficiency.

Cost Efficiency: Farmers practicing no-till reported reduced costs associated with labor, fuel, and machinery maintenance. These savings contributed to higher net profits despite the initial investment in no-till equipment and training.

Adoption Challenges and Benefits:
Farmer Perceptions: Interviews revealed that farmers recognized the long-term benefits of no-till practices, including improved soil health and cost savings. However, challenges such as the need for initial investments, learning new techniques, and managing crop residues were also noted.
Policy and Support: The survey indicated that farmers who received training and financial support from agricultural extension services were more likely to adopt and sustain no-till practices. Policy incentives and access to no-till equipment were critical in facilitating adoption.

7. DISCUSSION:

Impact on Soil Fertility:
The significant increase in soil organic matter and microbial activity in no-till fields underscores the importance of these practices in enhancing soil fertility. Organic matter not only improves nutrient availability but also supports a diverse soil biota, which is essential for sustainable nutrient cycling. The findings align with soil conservation theory, emphasizing the preservation of soil health as a foundation for long-term productivity.
Environmental Benefits:
The reduction in soil erosion and improvement in moisture retention highlight the environmental benefits of no-till technology. These findings are consistent with the principles of sustainable agriculture and agroecology, which advocate for practices that maintain ecological balance and resource efficiency. By reducing erosion, no-till practices help maintain soil fertility and prevent the loss of valuable topsoil.
Economic Viability:
Higher crop yields and cost savings associated with no-till farming contribute to its economic viability. The improved productivity and reduced input costs enhance farmers' profitability, making no-till a financially attractive option. This supports the theory of sustainable agriculture, which integrates economic, environmental, and social dimensions to ensure long-term viability.
Adoption and Policy Implications:
The challenges identified in adopting no-till practices, such as the need for initial investments and technical knowledge, suggest the need for targeted support and education. Policies that provide financial incentives, training programs, and access to no-till equipment can facilitate wider adoption. The role of agricultural extension services in promoting no-till practices is critical, as evidenced by the higher adoption rates among supported farmers.
Long-Term Sustainability:
The long-term benefits of no-till farming, including improved soil health, increased resilience to climate variability, and enhanced productivity, underscore its importance for sustainable agriculture. The integration of no-till practices can contribute to achieving food security and environmental sustainability goals. Future research should focus on long-term studies to further validate these findings and explore the scalability of no-till practices in different agro-climatic regions.

8. CONCLUSION / SUMMARY:

The findings of this study demonstrate that no-till technology significantly enhances soil fertility and productivity, offering a sustainable solution to the challenges of soil degradation and declining agricultural productivity. By improving soil health, reducing erosion, and increasing crop yields, no-till practices contribute to the long-term viability of arable lands. To maximize the benefits of no-till technology, it is essential to address adoption challenges through supportive policies, education, and access to resources. The integration of no-till farming into broader agricultural strategies can play a vital role in promoting sustainable agriculture and ensuring food security.

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