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SCIENTIFIC EVALUATION OF WATER-SAVING TECHNOLOGY: GERMAN POROUS HOSES IN SUBSOIL IRRIGATION

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Abstract . Given the increasing water shortage and the high share of irrigated agriculture in the Republic of Uzbekistan’s water consumption, the implementation of water-saving irrigation technologies is particularly relevant. This article presents a scientific assessment of subsurface irrigation using German-made porous polymer hoses as a promising approach to improving the efficiency of irrigation water use.

This article examines the operating principle of porous hoses, their design features, and the technological solutions used in modern subsurface irrigation systems. The potential agronomic, water management, and environmental benefits of this technology are analyzed, including reduced water loss due to evaporation and surface runoff, improved root zone moisture uniformity, increased water use efficiency (WUE), and improved soil water-air balance.

The paper summarizes data from domestic and international research, including the results of field experiments on the impact of various irrigation methods on water consumption and crop yields. It is shown that, with proper design and adherence to operational requirements, subsurface irrigation using porous hoses can reduce irrigation water consumption by approximately 30–70% compared to traditional surface methods while maintaining or increasing crop yields.

Special attention is given to the limitations of the technology related to water quality requirements, filtration, operating pressure stability, soil conditions, and the risk of micropore clogging. The need for demonstration and applied research in Uzbekistan, taking into account the soil salinity regime and regional agro-ecological characteristics, is substantiated.

The results of the study can be used by water management specialists, farmers, and students studying in relevant fields when selecting and justifying water-saving irrigation technologies.

Keywords: subsurface irrigation, porous hoses, water conservation , water use efficiency, drip irrigation, cotton, agroecology.

Abstract . Under conditions of increasing water scarcity and the dominant share of irrigated agriculture in the overall water consumption of the Republic of Uzbekistan, the implementation of water-saving irrigation technologies is of particular importance. This article presents a scientific assessment of subsurface irrigation using porous polymer hoses of German manufacture as a promising approach to improving irrigation water use efficiency.

The principle of operation of porous hoses, their design features, and technological solutions applied in modern subsurface irrigation systems are examined. The potential agronomic, water-management, and environmental advantages of the technology are analyzed, including the reduction of water losses due to evaporation and surface runoff, improved uniformity of moisture distribution within the root zone, increased water use efficiency (WUE), and improved soil water–air regime.

The study summarizes data from domestic and international research, including the results of field experiments evaluating the effects of different irrigation methods on water consumption and crop yield. The analysis shows that, when properly designed and operated, subsurface irrigation systems with porous hoses can reduce irrigation water consumption by approximately 30–70% compared to conventional surface irrigation methods, while maintaining or, in some cases, increasing crop yields.

Special attention is given to the limitations of the technology related to water quality requirements, filtration efficiency, stability of operating pressure, soil conditions, and the risk of micropore clogging. The necessity of further applied and demonstration studies under the agroecological conditions of Uzbekistan is substantiated, particularly with regard to soil salinity control and long-term system performance.

The results of this study may be useful for water management specialists, farmers, and students of agricultural and irrigation-related disciplines when selecting and substantiating water-saving irrigation technologies.

Keywords: subsurface irrigation, porous hoses, water saving, water efficiency use, drip irrigation, cotton, agroecology.

Abstract . Uzbekiston Republicsida suv resourcelari tankisligi kuchayib borayotgan va umumiy suv istemolida sugoriladigan dekonchilik ulushi yukori bulgan sharoitda suvni tezhovchi sugorish technologylarini zhoriy etish alohida ahamiyat kasb etadi. Ushbu makolada Germanyda ishlab chikarilgan govakli polymer hoselardan foydalanilgan blunt osty sugorish technologysining sugorish suvlaridan foidalanish samaradorligini oshirisdagi ilmiy bagosi keltirilgan.

Maqolada govakli hoselarning islaş principles, constructive hususiyatlari hamda zamonaviy tuprok osti sugorish tisimlarida қўllanilayotgan technologist echimlar taxḷil qilingan. Technologyning agronomik, suv hўzhaligi va ekokik afzalliklari, zhumladan buғlanish va er usti (sirt) okimi orkali suv yўqotishlarining kamayishi, ildiz zhoylashgan katlamda namlikning bir tekis taksimlanishi, suvdan foidalanish samaradorliging oshishi hamda tuproқning suv-khavo regimei yakhshilanishi kўrib chikilgan.

Ishda mahalliy va khorizhiy tadqiqotlar ma'lumotlari, zhumladan sugorishing turli usullarining suv sarfi va qishloq huzhalig ekinlari hosildorliga ta'sirini bagolovchi dala tazhribalari natizhalari umumlashtirilgan. Taglil natizhalariga kura, tugri loyigalash va exploitation talablari bazharilganda, govakli hosellar asosidagi duprok osti sugorish tizimlari ananaviy er ustidan sugorish usullariga nisbatan sugorish suv sarfini takhminan 30-70% ha kamaitirish bilan birga khosildorlikni saklab kolish yoki ayrim holatlarda oshirish imkonini beradi.

Technologyning cheklovlari sifatida sugorish suvining sifati va filterlash darazhasig қўyiladigan talablar, ishchi bosimning barqarorligi, tuprok sharoitlari hamda govak tuzilmalarning tiqilib kolish havfi kўrsatib ўtilgan. Shuningdek, Uzbekistanning agroecology sharoitlarida, ainiksa tuprok shўrlanishi nazorati va tisimning uzoq muddatli samaradorligini

hisobga olgan holda, qўimcha amaliy va namoyish tazhribalarini ўtkazish zarurligi asoslab berylgan.

Mazkur tadqiqot natizhalari suv khuzhaligi mutahassislari, farmer khuzhaliklari hamda qishlok khuzhaligi va land reclamation yўnalishlarida taẋsil olayotgan talabalar uchun suvni tezhovchi sugorish technologylarini tanlash va asoslashda Amaliy ahamiyatga ego.

Kalit suzlar: tuprok ichidan sugorish, govakli hoselar, suvni tezhash, suvdan foidalanish samaradorligi, tomchilatib sugorish, pakhtachilik, agroecology.

Introduction . Water scarcity in the arid and semi-arid regions of Central Asia, including the Republic of Uzbekistan, is considered a key factor limiting the sustainable development of the agricultural sector. According to industry and international estimates, more than 90% of the country's total freshwater withdrawal is used for irrigated agriculture, making water use efficiency a critical indicator of food and environmental security [1].

A significant proportion of water resources is lost at the stages of transportation, distribution and directly in the field due to the use of traditional surface irrigation methods – Furrow and flood irrigation. These methods are characterized by high water losses due to evaporation, infiltration beyond the root zone and surface runoff, as well as uneven soil moisture [6; 8].

Drip irrigation, when properly designed and managed, demonstrates higher water yields and allows for significantly increased efficiency in the use of irrigation water.

of water-saving technologies in Uzbekistan remained limited in the late 2010s : the share of land equipped with drip irrigation systems was estimated at around 2%. However, by 2025, the situation has changed dramatically – Water-saving technologies are already being used on half of all irrigated land in the country. This was made possible by large-scale investments: from 2020 to 2024, 60 trillion soums from the budget and $622 million in foreign investment were allocated to develop the irrigation sector.

Additionally, as part of the sustainable development of the agricultural sector, projects to use solar energy for drip irrigation began in 2024, increasing the autonomy of the systems and reducing energy costs. For example, in the Tashkent region, a pumping station powered by solar panels is already operational , serving over 3 hectares of farmland.

Under these conditions, subsurface irrigation—a type of localized irrigation system in which water is delivered directly to the root zone—is of particular scientific and practical interest. This approach minimizes unproductive moisture loss and creates a more stable water- - air regime for the soil [6; 7].

The purpose of this article is to scientifically evaluate porous polymer hoses of German production as an element of water-saving technology of subsurface irrigation, analyze their operating principle, potential advantages and limitations, and substantiate the prospects for use in the agro-ecological conditions of Uzbekistan.

The operating principle of porous hoses in subsurface irrigation . Subsurface irrigation is based on the delivery of water directly to the root zone of the soil using distributed humidifiers. Porous hoses (German: Perlschlauch , English: Soaker) Hose , Drip Hose or Porous Hose) are flexible polymer tubes, the walls of which are permeated with a system of micropores, evenly distributed along the entire length of the product.

When water is delivered under relatively low and stable pressure (typically 0.5–1.5 bar), water percolates through the micropores of the hose walls and enters the surrounding soil as a distributed filtration flow. Unlike point emitters in drip irrigation, water is delivered along the entire length of the line, creating a more uniform irrigation pattern.

Typically, porous hoses are laid at a depth of 10-40 cm , depending on the crop, soil texture, root depth, and planting pattern. This placement ensures moisture delivery directly to the active root absorption zone and helps maintain the topsoil relatively dry [6; 7].

Design features and innovations of German solutions

German porous hose manufacturers position their products as components of highly efficient water-saving irrigation systems. Specifically, *CS Bewässerungssysteme GmbH* produces porous polymer hoses designed for surface and underground installation.

Figure 1. Porous polymer hose

The technical documentation emphasizes the possibility of a significant reduction in water consumption, provided that the requirements for pressure, filtration and operating modes are met [9].

Key design features of German porous hoses include:

- use of polymeric materials with controlled porosity;
- uniform distribution of micropores along the length of the hose;
- UV resistance (for surface installation);
- Compatibility with filtration and pressure regulation systems.

The scientific literature also describes experimental and commercially available solutions with partial self-regulation of water flow, based on the use of membrane or composite porous materials. Such systems are capable of varying the intensity of water release depending on the moisture content of the surrounding soil, allowing for a more adaptive irrigation regime and reducing the risk of overwatering [5].

Potential benefits of subsurface irrigation technology with porous hoses

An analysis of literary sources allows us to identify a number of potential advantages of the technology under consideration:

- Reducing water losses due to evaporation and surface runoff. Underground water supply eliminates direct evaporation from the soil surface and reduces unproductive losses [6; 7].

- Improving water use efficiency (WUE). With proper irrigation management, it is possible to increase the yield per unit of water used [6; 7].
- Reducing weed infestation in crops. A drier topsoil limits weed germination [7].
- Reduction in soil crust formation. The absence of surface moisture helps maintain the favorable structure of the upper horizon [7].
- Improving the efficiency of fertigation . Localized delivery of water and dissolved fertilizers directly to the root zone reduces losses and increases the efficiency of nutrient utilization [3; 4].

It should be emphasized that the severity of these effects depends significantly on soil conditions, the quality of irrigation water, the depth of hose installation, the distance between lines, and the level of technological discipline in operating the system.

Methodology of scientific evaluation of effectiveness

To objectively evaluate the effectiveness of porous hoses, a combined approach was used, including field experiments and analytical comparison of alternative irrigation methods.

Field research scheme

The following options were compared:

1. Traditional surface irrigation (furrow or overflow);
2. Surface drip irrigation ;
3. In subsurface irrigation using porous hoses.

Data were analyzed on the same crops (e.g. cotton, grain or vegetable crops) and in similar soil and - climatic conditions.

Evaluation indicators

Key criteria include:

Indicator	Unit of measurement	Characteristic
Water consumption for irrigation	m^3/ha	**Total volume of water supplied per season**
Productivity	c/ha	**Mass of products per unit area**
WUE	kg/m^3	**Yield to water ratio**
Soil moisture	% or mm	**Moisture distribution across the profile**
Agroecological indicators	—	**Salinization, aeration, contamination**

Experimental data were processed using mathematical statistics methods (e.g., analysis of variance) to assess the reliability of differences between variants.

Additionally, economic indicators were analyzed: capital costs for the system, energy costs (working pressures of about 0.5–1.5 bar), operating costs and payback period [6; 7; 9].

Summary of published research results

The results of a comparative analysis of various irrigation methods confirm significant differences in both water consumption and agronomic efficiency. A comparison of the key technical and agroecological characteristics of traditional surface irrigation, surface drip irrigation, and subsurface irrigation using porous hoses is presented in Table 1.

Table 1

Comparison of the main agrotechnical and water management indicators of various irrigation methods

Indicator	Superficial (grooved)	Surface drip	Subsurface (porous hoses)
Working pressure, bar	0.1–0.3	0.8–2.0	0.5–1.5

Water loss due to evaporation, %	25–40	10–20	3–8
Uniformity of moisture distribution	Low	Medium-high	High
Moistening the soil surface	Complete	Partial	Minimum
Risk of crust formation	High	Average	Short
Weed infestation of crops	High	Average	Low
Fertigation capability	Limited	High	High
Water Use Efficiency (WUE)	Low	Medium-high	High

As Table 1 shows, traditional furrow irrigation is characterized by the highest water losses due to evaporation and surface runoff (25-40 %), poor moisture uniformity, and an increased risk of soil crust formation. In contrast, surface drip irrigation provides more controlled water delivery and reduces unproductive losses. However, it maintains partial wetting of the soil surface, limiting the potential for water conservation and weed suppression.

Subsurface irrigation using porous hoses demonstrates the best results in uniform root zone moisture distribution and minimal water loss due to evaporation (3–8%), due to the water being delivered directly to the active root absorption zone . This confirms the conceptual advantage of subsurface irrigation systems in terms of targeted water delivery .

A quantitative assessment of water consumption for various irrigation technologies is given in Table 2.

Table 2

Reduced water consumption compared to traditional surface irrigation

Irrigation method	Reduction in water consumption, %
Surface drip	25 - 40
Subsurface drip irrigation	35 - 55
Subsurface irrigation with porous hoses	30 - 70

Analysis shows that switching from traditional surface irrigation to surface drip irrigation reduces irrigation water consumption by an average of 25-40 % . When using subsurface systems, this figure increases to 35-55 % , and for systems with porous hoses, under optimal operating conditions, it can reach 70%. Actual water savings depend on the crop, soil, installation depth, and the quality of irrigation management.

The data in Table 2 are consistent with the results presented in Figure 2, which shows the relative water consumption for different irrigation methods.

Subsurface irrigation with porous hoses is characterized by the smallest volume of water applied compared to furrow and surface drip irrigation, demonstrating the technology's high potential efficiency in water-scarce conditions. Furrow irrigation results in significant losses due to evaporation, infiltration, and uneven moisture distribution. With surface drip irrigation, water is delivered to the root zone, but some still evaporates from the surface. Subsurface irrigation results in minimal losses because there is no surface evaporation; water immediately reaches the root zone, creating a uniform oval-shaped moisture zone.

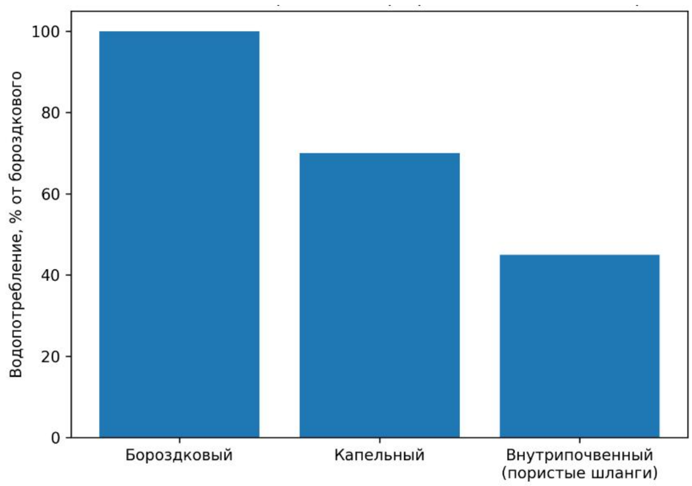

Figure 2. Relative water consumption for different irrigation methods (as a percentage of furrow irrigation)

The influence of irrigation method on crop yields is illustrated using cotton as an example (Table 3).

Table 3

Cotton yield under different irrigation methods

Watering method	Yield, c/ha
Furrowed	33.8
Sprinkling	36.3
Surface drip	43.8
Subsurface (porous hoses)	48 - 52

According to the data presented, the transition from furrow irrigation to surface drip irrigation is accompanied by an increase in yield from 33.8 Up to 43.8 c/ha. The use of subsurface irrigation with porous hoses provides an additional yield increase of up to 48-52 c /ha, which may be due to a more stable water-air regime in the root zone and a reduction in stress factors associated with fluctuations in soil moisture.

The increase in crop yield while reducing the volume of water supplied is reflected in an increase in water use efficiency, which is clearly shown in Figure 3.

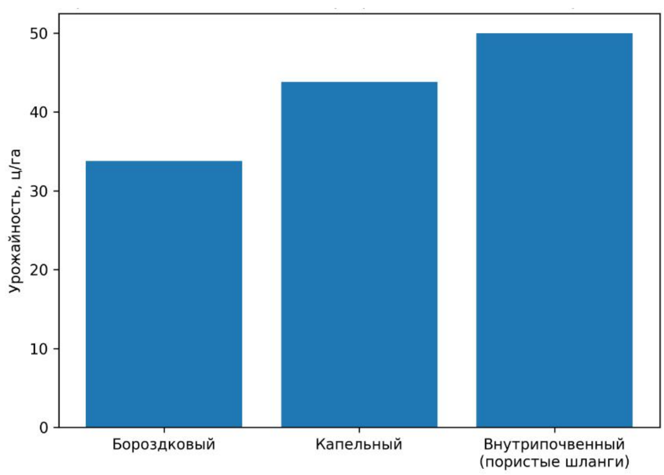

Figure 3. Cotton yield depending on the irrigation method.

For example, when growing cotton in Turkey, placing humidifiers at a depth of approximately 40 cm resulted in a yield increase of approximately 18% compared to surface drip irrigation. Under comparable conditions, yields were: 43.8 c/ha with drip irrigation , 36.3 c/ha with sprinkling irrigation , and 33.8 c/ha with furrow irrigation [2].

In the conditions of Uzbekistan, the introduction of drip irrigation in cotton growing was accompanied by an increase in yield by 8 - 10 c/ha and a decrease in the need for nitrogen fertilizers by 35 - 40% [3; 4].

The WUE values for subsurface irrigation exceed similar values for surface methods, which confirms the more rational use of water resources with this technology (Figure 4).

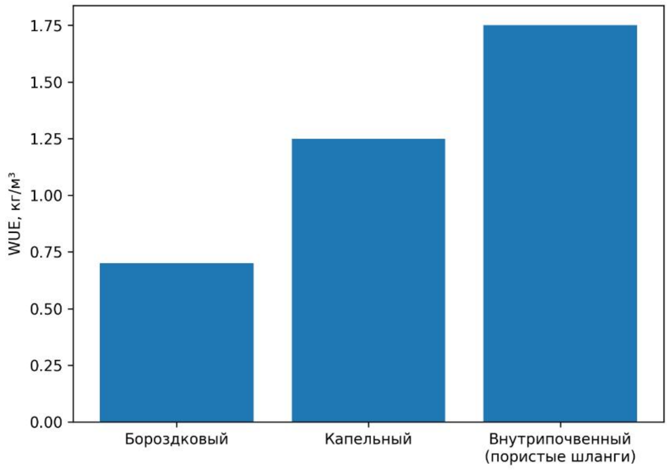

Figure 4. Water use efficiency (WUE) for different irrigation methods

An additional factor identified during the analysis is a change in the agroecological state of the topsoil. A drier surface with subsurface water application reduces crust formation and weed infestation, which is consistent with the data presented in Table 1 and previously published studies. The moisture distribution pattern in the soil profile (Figure 5) demonstrates the formation of a stable moistening zone around the porous hose line with minimal surface wetting.

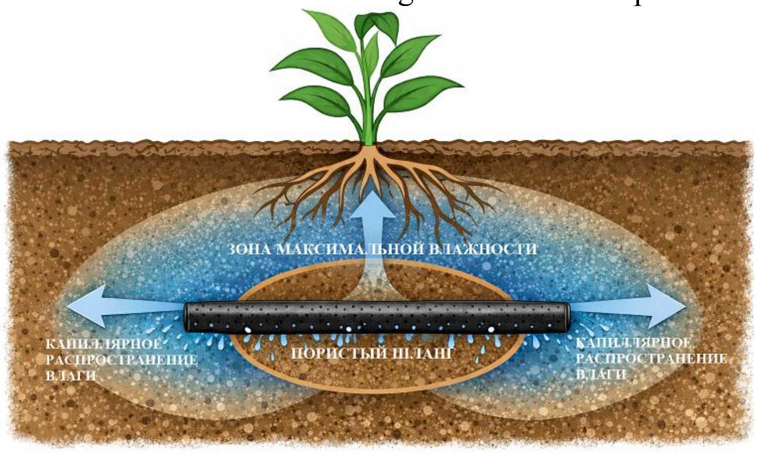

Figure 5. Moisture distribution diagram in the soil profile during subsurface irrigation using a porous hose

However, the results discussed should be interpreted taking into account the limitations of the technology. The effectiveness of subsurface irrigation with porous hoses depends significantly on the soil texture, the depth of the lines, the quality of the irrigation water, and the stability of the operating pressure. In heavy clay soils or with high water mineralization, deviations from optimal irrigation regimes are possible, requiring adjustments to design solutions and enhanced monitoring.

In general, a comparison of experimental and generalized data (Tables 1–3 , Figures 2–4) confirms that subsurface irrigation using porous hoses has significant potential as a water-saving and agro-ecologically oriented technology, especially in arid climates and limited water resources.

Limitations and risks of use . Despite its significant potential, the technology has a number of limitations:

1. Relatively high initial capital costs;
2. Strict requirements for water quality and filtration efficiency due to the risk -of micropore clogging [9];
3. The need for stable and limited working pressure;
4. High soil dependence of efficiency, especially on heavy clay soils [8];
5. Lack of long-term local data on the durability of porous lines.

Particular attention should be paid to salt management. In conditions of risk of secondary salinization, the introduction of subsurface systems should be accompanied by regular monitoring of the soil solution's electrical conductivity and adjustments to irrigation regimes [8].

Practical aspects of implementation in Uzbekistan

The most promising application of porous hoses appears to be for intensive farms and crops with high economic returns. State programs to support water-saving technologies can create favorable conditions for expanding the use of this system [1].

It is recommended to organize demonstration and experimental plots in various soil and -climate zones with mandatory comparison of alternative irrigation methods and a comprehensive assessment of agro-ecological and economic indicators.

Conclusion . Porous hoses for subsurface irrigation are a promising water-saving technology aimed at increasing the efficiency of using irrigation water by delivering it directly to the root zone [6; 7]. A summary of published data indicates the possibility of reducing water consumption by approximately 30–70 % while maintaining or increasing crop yields with correct design and operation [6; 7; 9].

For Uzbekistan, this technology requires further applied research, demonstration projects, and adaptation to local soil, -climate, and hydrogeochemical conditions. With an integrated approach, porous hoses could become an important element in a system of measures to improve water efficiency in the agricultural sector.

List of references

1. Khamidov A. , Kasymov U. , Dzhumaboev K. , Paul WITH . *Rebound Effects in Irrigated Agriculture in Uzbekistan: A Stakeholder-Based Assessment.* Sustainability , 2022, 14(14), 8375.

2. Bobokandov Sh., Ziyatov M. Effect of different irrigation methods on cotton yield. Proceedings of the international conf . "Modern problems of agricultural science", Moscow - Tashkent, 2024, pp. 49 - 55.

3. Avliyakulova M., Matyakubov B. Efficiency of drip irrigation and its impact on fertilizer application in cotton growing. Irrigation and Land Reclamation Journal, 2022, no. 4, pp. 27–32 .

4. Ravshanov A.E., Shamsiev A.S., Makhmudov I.E. The Impact of Drip Irrigation on the Quality and Quantity of Raw Cotton Yield. Bulletin of Agricultural Sciences of Uzbekistan, 2022, No. 3, pp. 15-20 .

5. Stein R., Dührkoop J., Liederer P. *Innovative Porous Pipes for Sustainable Subsurface Irrigation.* Journal of Agricultural Engineering , 2014, Vol . 37(2), pp . 112 - 118.
6. Colorado State University Extension. *Subsurface Drip Irrigation (SDI) – Fact Sheet 4.716.* 2014.
7. University of Nebraska - Lincoln Extension. *Advantages and Disadvantages of Subsurface Drip Irrigation (EC776).* 2005.
8. Isaev H.M., Petrov V.V. Methods of subsurface irrigation. Study guide. Tashkent, IIMN, 2021, 180 p.
9. CS Bewässerungssysteme GmbH. Product Information: *CS Soaker Hose Premium 10 m.* 2024.