Water saving technique and technology of subsurface irrigation

F Juraev\textsuperscript{1} and G Karimov\textsuperscript{1}

\textsuperscript{1}Bukhara branch of the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Bukhara, Uzbekistan

fjuraev66@mail.ru

Abstract. This article is given some information about creating intensive gardens in desert areas; saving 40\%-50\% of yearly water which is used in a year thanks to effective economic technologies via irrigating through the soil. This is also useful to save energy up to 30\%-40\% by absorbing the sunshine with the help of the special modes. In this research we intended to prove that organizing irrigation system in the way of using underground waters and in this process the water enriched by mineral elements, fertilizer can be saved up to 25\%-35\% on account of moistening plant roots through the pegs straightly which are devices specially produced. Moreover, the growth of plants is meliorated and the harvested stock will be increased up to 20\%-25\%.

This method can be used in both setting half scrubby intensive gardens in such kind of areas where water is insufficient and making use of energy-saving technologies in the future.

1. Introduction

Obviously, the world is undergoing many dilemmas that we cannot look to the past for resolutions that there was no precedent for such problems like overpopulation, water, and energy scarcity, soil erosion, soil salinity, overusing pesticides, global warming, water pollution… There have been put forward a controversial issue whether the long-term effects of overpopulation, of the most essential ones, will be able to keep pace with population growth. In this article, to meet the need, some scientific projects fulfilled on using water, energy economy technologies in irrigation as well as forming intensive gardens are enlightened. To mainly supply plant roots, enhance harvest amount there exist many types of modern water-saving technologies which are practical ways of organizing irrigation system with well-balanced water and air-system of roots. We have recently built a special mechanism intended to absorb groundwater and use it to irrigate fields through the soil. The mechanism and its feature, structure, usage, technique, and technology in irrigation have been calculated thoroughly [1, 2].

There were given some direct references to economize water resources, energy supply in this process. In the field of irrigation, we viewed the positive results of many researches accomplished in highly-developed countries. For example, in the article “Mathematical modeling of moisture transfer processes during drip and subsoil irrigation” E.V. Melikova variable irrigation techniques and moisture diffusing through the soil were modeled. Other examples, in “Models and information technologies for water use management in reclamation systems providing a favorable reclamation regime” by L.V.Kireycheva, and in “Justification of the mathematical model of drip wetting the garden in the Moscow region” by I. A. Golovonov and others provided some conclusive evidence after they had learned materials from other alternative sources on the subject. After studying and analyzing researches conducted by foreign colleagues, necessary requirements were taken into
consideration that intensive gardens can be formed in high saline areas like the Bukhara region. So as to enhance the procedure [3, 4, 5, 6].

2. Methods

In intensive orchard irrigation, it is used many practical methods, including systematic analysis, theoretical mechanics, farm mechanics, mathematical planning, practices of water and energy consumption, modern methods of water and energy consumption practices of mathematical planning modern methods for determining water and energy consumption, and “Field experiments” and recommendations from … Research Institute.

In our republic, the demand for water is increasing, especially in agriculture. Clean available water is urgent to develop cotton growing, grain harvest, rice producing, fruit production, vegetables, gardening, viticulture, and these require water-saving techniques intensively. With the developments of the intensive gardens, the growth of certain fruits such as apples, apricots, peaches has been improved. Moreover, the field of agriculture began to involve raising and processing them with high tech since it became the growing demand of modern life [3, 4]

Recently, the development of intensive orchards, the cultivation, and processing of fruit and vegetable products based on high technologies have become the growing demand of modern life to grow intensive gardens in Bukhara region where water is scarce, to provide high and high yields, intensive orchards’ difficulties need to be solved. The issue requires the use of scientifically-based technology and equipment to develop improved irrigation options and apply them to agricultural production to address the water shortage. To achieve our ultimate goal, one can use water-saving technology in water economy, especially the usage of the method will be effective in water-scarce areas and our work consists of the establishments of intensive orchards for water use by utilizing underground waters with special devices and technologies and the simultaneous meeting of plant needs for water and nutrients. [2, 6]

Numerous done researches have shown that irrigation in the fields of intensive gardens through or subsurface irrigation methods has been more effective than flood irrigation.

The technique and technology recommended by us are one of the most popular water economics irrigation methods, namely watering through the soil, this technology can only be available in areas where underground waters near to the soil and the water mineralization is normal (less than 0.01-0.02 g/l) If underground water levels are normalized (less than 0.01-0.02 g/l) or excessively mineralized, the ditch water needs to be calibrated in the ducts to form a mixture of mineralized water. This will help economize water shortages and create intensive gardens in desert areas and unattended land plots it will enable us to achieve the developments of the lands and increase their efficiency from 0% to 70%- 80%. [7, 8, 9, 10, 11]

For sub-irrigation, using a combined water pipe from the central irrigation pipes, it is possible to directly moisten the root area of each seedling to a reduce of 1.55-1.75 ml and provide groundwater to a depth to be placed from 3-120° or the 4 to 90° in the circumference of the tree (Figure 1).
The pegs are installed at an angle of up to 50° – 60° above the horizon that water from the pipe is distributed evenly to the whole root system of the seeding. At the same time, normal soil moisture is provided by the water from a special peg. The peg operates in the following order. The water that comes through the hosepipes is pumped from the top to the pipe so that the soil content is absorbed by special holes.

The diameter if the irrigation pipes make up the irrigation process on the condition that $d \leq 0.1H$. To check its work order we observe the water flow from leaking liquid under unchangeable pressure from the sharp circle hole of a tank that has a large capacity. During leaking the water from the hole shape of transversal changes and the face shrinks. The compressed surface is located 0.5$d$ from the hole.

$$\varepsilon = \frac{\omega_c}{\omega}$$

So, the compressed face of the $\omega_c$ equals m$^2$; $\omega$ is from the experiences, the diameter of the compressed flow cross-section equals $d_c = 0.8d$, that’s why the compression coefficient is given by the following:

$$\varepsilon = \frac{\omega_c}{\omega} \approx \left( \frac{d_c}{d} \right)^2 = \left( \frac{0.8d}{d} \right)^2 = 0.64$$

Except for the flow compression, the flow inversion is also observed. Inversion is a term that determines the change of the cross-sectional flow rate. For example, If the cross-sectional surface of a stream is square in shape, the figure may take a cross shape or others. It is parametrically determined the leakage of liquids from the irrigation peg (figure 2).
The rate of flow of fluid from the reservoir is the same as that of the compressed section, we write the Bernoulli equation or the two cross-sections: the free surface of the reservoir and the cross-section.

\[ Z_0 + \frac{p_0}{\rho g} + \frac{\alpha \nu_0^2}{2g} = Z + \frac{p_0}{\rho g} + \frac{\alpha \nu_0^2}{2g} + h_0 \]

The pressure in the compressed section is greater than the underground pressure \( p_c > p_y \) because the flow does not move freely under the ground. Coriolis coefficient \( \alpha = 1.5 \), because velocities at each point of the compressed section are parallel and mutually exclusive.

There is a formula for lost pressure: \( h_0 = \zeta \frac{g^2}{2g} \) and \( \frac{\alpha \nu_0^2}{2g} \)

\[ z_0 = z + \frac{g^2}{2g} + \zeta \frac{g^2}{2g}; \quad z_0 - z = H = (1 + \zeta) \frac{g^2}{2g}; \]

If the pressure on the center of weight of the hole-H is assumed to be pressure, the following formula for outflow rate of water is:

\[
\begin{align*}
\vartheta &= \frac{1}{\sqrt{1 + \zeta}} \sqrt{2gH}; \\
\varphi &= \frac{1}{\sqrt{1 + \zeta}}; \\
\vartheta &= \varphi \sqrt{2gH};
\end{align*}
\]

\( \varphi \) is called the velocity coefficient, for small circular holes, a large number of \( Re - Reynolds \) have the value \( \varphi = 0.95 \) if the velocity coefficient \( \varphi \) is given, the coefficient of resistance can be found as:

\[ \zeta = \frac{1}{\varphi^2} - 1 \]

Flow spending is found by the formula \( q = \omega \vartheta \). The compressed cross-section consumption for the given case \( q = \omega_c \nu_c \).

The compressed surface is found in the following formula: \( \omega_c = \varepsilon \omega \).
$\omega$ is the surface of the hole, and average velocity \( \nu_{op} = \varphi \sqrt{2gH} \). Then, we choose
\[
 q = \omega_c \cdot \nu_c = \varepsilon \omega \varphi \sqrt{2gH} = \varepsilon \omega \alpha \sqrt{2gH}
\]
\( \varepsilon \varphi = \mu \) for water consumption, the result is \( q = \mu \omega \sqrt{2gH} \)

\( \mu \) is called consumption coefficient and \( \varepsilon = 0.64 \), and in turn \( \varphi = 0.97 \)

\( \mu = \varepsilon \varphi = 0.64 \times 0.97 = 0.62 \)

\( \varepsilon, \varphi, \mu \) values are given in the reference. The number of holes is multiplied by the flow consumption.

\[
 Q = q_1 + q_2 + \ldots + q_n = m^* q;
\]

\[
 Q = m \int_{q=1}^{m} \mu \omega \sqrt{2gH} d\omega;
\]

\[
 dQ = \mu \omega \sqrt{2gH} = \mu b \sqrt{2gH} \cdot dH
\]

Integrating this mathematical expression between the bottom and the top dimensions of the hole, we find the water consumption through the hole, so
\[
 Q = \int_{H_1}^{H_2} \mu b \sqrt{2gH} \cdot dH = \frac{2}{3} \mu b \sqrt{2g} \left( H_2^{\frac{3}{2}} - H_1^{\frac{3}{2}} \right)
\]

When applying this solution in practice, \( \mu = 0.62 \) which is suitable for small circle holes and as a result \( m' = 0.41 \). In general, integrating this integral is assumed to be \( m = const \), but \( m \) is a consumption coefficient, and is a variable number.

It can be inferred from above that intensive gardens require modeling of the root system of the seedlings using a water-efficient technology, using specialized pegs, learning, and enhancing this process clearly. This involves the improvement of this process for the whole system and the development of a mathematical model of the amount of water consumed in the process and the limit of its distribution in the plant root system.

3. Results and discussion

The developed equipment was used and checked on the land plots of many farms semi-intensive gardens in Bukhara regional territory and taken positive results. For instance, it was carried out a garden with six hectares in the “Zodabek” farm in Kogon, Bukhara (figure 1).

The process of developing the scrubby orchard seeding root system is given below.
The fulfilled some investigations basically on three years of data, namely the development of root systems of seedling of farms, the growth of seedlings, and water consumption of simple, and recommended methods.

The experimental research on "Golden delicious" (a type of apple) pond intensive garden irrigation has been conducted for three years. The results of the long term studies have shown that irrigation under the soil allows to save water and fertilizer as much as possible compared to other irrigation methods [12, 13, 14, 15].

Table 1. Experimental research data irrigation system on aa intensive garden farm - “Zodabek” in Kogon, Bukhara

| Variations              | The amount of consumed yearly water, m³/ha | The amount of yearly fertilizer, kr/ha | Watering numbers | Total average water consumption m³/ha |
|-------------------------|------------------------------------------|--------------------------------------|------------------|-------------------------------------|
|                         | 2 ha (1 year)                            | 2 ha (2 year)                        | 2 ha (3 year)    |                                     |
|                         | 18000                                    | 1825                                 | 18550            | 25-30                               | 150-160                             | 45-55                               | 210-250                             | 12                                   | 18123                               |
| Control version(suface irrigation) | 9750                                    | 1012                                 | 10350            | 23-27                               | 125-135                             | 40-45                               | 185-195                             | 19                                   | 9925                                |
| Drip irrigation         | 7650                                    | 8100                                 | 8250             | 28-35                               | 110-125                             | 30-35                               | 170-180                             | 14                                   | 7923                                |
| Sub-surface irrigation  | 7650                                    | 8100                                 | 8250             | 28-35                               | 110-125                             | 30-35                               | 170-180                             | 14                                   | 7923                                |

Picture 1. Learning “Golden delicious” scrubby apple seedlings root system.
As you can see from the first table, three methods of irrigation: flood irrigation, drip irrigation, and subsurface irrigation have been learned comparatively. In the means of the experimental fields, the average annual water consumption has been 18123 m³/hectare, 9925 m³/hectare, 7923 m³/hectare. In this process, it is determined the water saved by 46% on drip irrigation and 57% on recommended subsurface irrigation than the flush irrigation (1-table).

The specificity of the sub-surface irrigation system is determined by its specificity from the continuous water distribution network. This water network supplies a regular layer of the seedlings directly and regularly with a mixture of fertilizer. In almost all methods of traditional irrigation which watering over the soil, we can observe soaking during irrigation and drying after it.

The roots are usually in a depth of 25-50 cm beneath the ground, while the roots grown in rocky fields are several meters deep. The depth in which the root is formed depends on the oxygen and moisture content in the soil. In the condition of high soil density and poor oxygen exchange, roots developed close to the soil surface with higher oxygen content whereas in low density soils the roots are deeper. It was done researches on growing “Golden delicious” apple, a scrubby tree of the intensive garden, in different conditions.

The movement of water in irrigation from the soil was found using the following Golova formula. As a result of research extensive is being carried out to establish the scientific basis for addressing the problems like plant disease, pest control, overgrowing weeds, mistakes in linking seedlings to the sticks, organization of drip irrigation from the soil, the organization of the supply of dried water with mineral fertilizer mixtures through the water softener and the likes which were found in the intensive gardens and the solutions they had discovered [16, 17, 18, 19, 20].

4. Conclusions.
The advantages of intensive garden irrigation from the soil are that the aqueous root system is normally damped together with fertilizer, the moisture is evenly distributed in the soil, with very little water evaporation (3-4%) is happened, so this avoids wasting much water. At the same time, it prevents excess water from being wasted, it can also be avoided water waste, plants can be stopped the land from overwatering and leaving draughts, and all of the implementations create the basis for normal growth, development, and high-yield.

Having existed advantages and drawbacks in irrigation technologies, there have been some technical problems to be tackled such as converting current technologies into water and energy-saving technologies, preventing water shortage.

However, this is in contrast to what is recommended, although it is the best water-saving technology, it is not designed in-soil irrigation to be applied to intensive gardens that we intend to apply. Right clear directions have not been provided in this field yet.

For this reason, contemporary fast-growing irrigation technology requires the development of optimal irrigation options for the cultivation of various agricultural products.

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