Study on drip irrigation system as the best solution for irrigated agriculture

S B Gulomov1 and A G Sherov1

1Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, 100000 Tashkent, Uzbekistan

*Email: g.sardor1980@mail.ru

Abstract. This article analyzes the current research on drip irrigation for the efficient use of water resources caused by increasing global warming, examines their various designs, advantages, disadvantages, and low-pressure drops created at the Tashkent Institute of Irrigation and Mechanization Engineers. Irrigation method was applied on apple sort of “golden” in the meadow gray soils of the Tashkent region according to the mechanical composition of sandy loam soils. With the use of an apple orchard, water savings and high productivity have been achieved.

1. Introduction

Today the water resources deficit in our region is increasing year by year. The use of water-saving technologies in crop cultivation on irrigated lands and improving methods of their calculation remains an important issue [1-6]. In this regard, it is important to ensure efficient water use and high crop yields. [7-10]. Therefore, special attention is paid to the research work on the development and simplification of the design and technology of drip irrigation systems in Israel, USA, France, China, Turkey, Russia, India and other countries. The emergence of modern plastics in the middle of the 20th century for the efficient use of water resources was a significant step in the development of drip irrigation systems. The application of plastic microwaves for irrigation systems was arranged. Drip irrigation technology was invented in Israel by Simcha Blass and her son Eshayahu. Instead of watering through small holes where small sand particles are blocked water flow, plastic pressure injectors start to exert pressure. Similar drip irrigation system was created by S. Blass and H. Kibbutz (USA), together with the irrigation company Netafim, which together created the first drip irrigation system for the drop irrigation system. Drip irrigation systems were common in Australia, North and South America in the late 1960s [11-13]. At the same time, the first drip tape in the US, known as the "dew hose", was created by P.Richard, an engineer at ChapinWatermatics (USA) (1964). Since 1989, Jain irrigation has assisted Indians in the development of irrigation drip systems in water management. Further improvements are associated with lowering the value of the system, as well as combating dosage and supply pipelines [14-18]. According to V.N. Scorchous [19], in 11 years of research in the Crimea’s drip irrigation system, the average annual rainfall in the experimental area varied from 290 to 540 mm. Each tree had humidifiers with a water consumption of 5 l/s, and a significant increase in water consumption was observed when the soil moisture was reduced by up to 80% during the riparian years. In drip irrigation, the average annual net income increased by 2-3 times compared to control, and the costs decreased by
14 times when cultivated at 80% humidity. The payback period for this method is 1 year. In the optimal (80%) drip irrigation, the highest yield was 287 c/ha, while the control was 89.6 c/ha.

2. Materials and Methods
Field experiments were conducted in 2015-2017 to develop a procedure for irrigation of gardens using local low pressure drip irrigation technology. Typical (similar) experimental site were chosen according to the method of V.V. Shabanov and E.P. Rudachenko [20]. The soil of the experimental area is moderately loamy, meadow gray, saline soils with granulometric composition. The groundwater is 2.7-3m, with a mineralization of less than 1-3 g / l. Area of experimental site 1.02 ha. It has a rectangular 34x300m and has a PT-3 pipe, S-1.3 water outlet and field tracks. The distance between the rows in each variant and range is 5 meters, and the apple sapling range is 4 meters. Field research is based on the techniques of “Golden” sort of apple tree drip irrigation based on the methods of the Tashkent Institute of Irrigation and Engineers of Agricultural Mechanization (TIIAME), the Scientific Research Institute of Irrigation and Water Problems (RIIWP), the Scientific Research Institute of Agrotechnology and Crop Breeding (RIACB). Conducted field studies were on the order of irrigation of apple varieties [20, 21].

3. Results and Discussion
Optimal irrigation of apple orchards in low-pressure drip irrigation technology in 2015-2017, the educational and practical base of the TIIAME in the Upper Chirchik district of Tashkent region was carried out in the following system (Table 1).

| № of exp. | Irrigation technologies | The elements of irrigation technologies | Soil humidity before irrigation, relatively to the LFMC, % |
|-----------|-------------------------|----------------------------------------|--------------------------------------------------------|
| 1         | Furrow irrigation, control | The length of furrow 200 m | observations |
| 2         | Local low pressure drip irrigation method | The length of the pipe 200 m | 70-70-60 |
| 3         | Local low pressure drip irrigation method | The length of the pipe 250 m | 70-70-60 |
| 4         | Local low pressure drip irrigation method | The length of the pipe 300 m | 70-70-60 |
| 5         | Local low pressure drip irrigation method | The length of the pipe 350 m | 70-70-60 |
| 6         | Local low pressure drip irrigation method | The length of the pipe 400 m | 70-70-60 |
| 7         | Local low pressure drip irrigation method | The length of the pipe 450 m | 70-70-60 |

Figure 1. ET0 dynamics at the experiment site
Irrigation of apple orchards is a set of methods and measures used to distribute irrigation water to irrigated areas and to convert water flow into soil and atmospheric moisture. In the experiment, drip irrigation is applied. As the standard, and the efficiency of drip irrigation was determined by comparing the two modes, 70-70-60 and 70-80-70% with respect to the LFMC (limited field moisture capacity), respectively. In the high-pressure drip irrigation system, the rate of blockage for drip-tubes was determined by weighing the sludge drops along the length of the tubes [4-6]. For this purpose, the tensile strength of the tube was investigated before and after irrigation. The water-holding capacity of the pipes at different pressures was determined.

In determining the water permeability of the soil in the experimental area, it is known that water permeability is one of the most important physical properties of the soil, which is mainly dependent on the mechanical composition of the soil, humus content, field slope and other factors [8, 12].

Complete mathematical description of infiltration is provided by A.N. Kostyakov. Indicators are recommended for the characteristics of this complex process:

\[ K_1 = K_\phi \cdot t^\alpha \text{ m/c} \]  

(1)

here: \( K_1 \) - the absorption rate at the end of the first unit of time;
\( K_\phi \) - the set absorption rate, (K-Darcy), m/s;
\( t \) - the time when the infiltration ends and the absorption has fixed character, s;
\( \alpha \) - curve infiltration rate indicator;

\[ \alpha = \frac{\log K_1 - \log K_\phi}{\log t - \log t_\phi} \]  

(2)

here: \( K_\phi \) - absorption’s \( t \) rate at a given time,
\( K_\phi = \frac{K_1}{1 - \alpha} \text{ m/hour} \)  

(3)

here: \( K_\phi \) - the average absorption rate at the end of the first unit of time (during first minute),
\( K_{cp} = \frac{K_\phi}{t_\phi} \text{ m/hour} \)  

(4)

here: \( K_{cp} \) - average velocity at a given \( t \) time.

In the logarithmic coordinates, the absorption curve during the infiltration represents a straight line

\[ K_1 = \frac{K_\phi}{t_\phi^\alpha} \]

(5)

I.G. Aliev and N.F. Bonchkovskiy proposed the following formula:

\[ K_\phi = K_{cp} (10 \Pi)^\alpha \]  

(6)

here: \( \Pi = 0,5^{0,1694} \)

\[ K_{cp} = \frac{K_1 t_1 + K_\phi t_2}{t} \]  

(7)

here: \( K_{cp} \) - the average absorption rate during the infiltration period;
\( t_1 \) - infiltration absorption time, m/s;
\( t_2 \) - infiltration absorption time, m/s;

According to abovementioned methods, the soil permeability of the experimental area was determined.
In the sandy soil of the experimental site, the rate of water absorption initially during vegetation period at the beginning of the first hour was 0.089 m/h at the end of the fourth hour, with a filtration rate of 0.017 and 0.014 m/hr.

Figure 2 shows the variation in water absorption rate, layer, and filtration rates over the first hour of the vegetation period.

![Soil permeability, m/s](image)

**Figure 2.** Soil permeability rate, m/hr

Irrigation regimes of apple trees and calculation of irrigation norms of apple orchard. The limited area of soil, soils and hydrogeological conditions, which define homogeneous irrigation, are called the hydro module region. The groundwater level of the project conditions is 3 meters below the surface, and the soil is assumed to be the 3rd hydro module region due to its mechanical composition.

| Type of tree | Depth of root mass distribution, m | Interval between furrows, m | Wetting zone parameters depth h, m | Wetting of center diameter or strip width |
|--------------|-----------------------------------|-----------------------------|-----------------------------------|----------------------------------------|
| “Golden” sort of apple | 1.0-1.5 | 4.0-5.0 | 0.7-1.0 | 2.0-3.0 |

We set up the parameters of the wet zone: \( h = 1.0 \text{ m}, \ d = 2.0 \text{ m}. \)

In all the variants irrigated by local low-pressure drip irrigation technology, pre-irrigation soil moisture content relatively to the LFMC was 70-70-60% and 70-80-70%, respectively. In the batch irrigation option, this was determined by factual observations.

In the control version of the apple orchard, the irrigation carried out four times in scheme 1-2-1, with irrigation rates of 900-994 m³/ha and seasonal irrigation rates of 3964 m³/ha.

In the case of local low-pressure drip irrigation technology with a 200 m long irrigation pipeline, pre-irrigated soil moisture variation was 70-70-60% versus LFMC, with irrigation rates 11 to 11 times per scheme 1-7-3, with irrigation rates 179-204 m³/ha and seasonal irrigation rates are 2060 m³/ha.

In local low-pressure drip irrigation technology, the irrigation pipeline has a length of 200 m, the pre-irrigation soil moisture is 70-80-70% versus LFMC and seasonal irrigation rates were 2170 m³/ha. This is 1794 m³/ha or 45% less than control.

In Local Low Pressure Drip Irrigation, the irrigation water is 250 m long and the pre-irrigation soil moisture is 70-70-60% versus LFMC and seasonal irrigation rates were 2350 m³/ha.
In the local low-pressure drip irrigation technology with a 250 m long irrigation tube, irrigation 5- to 70-80-70% of pre-irrigated soil moisture content is 11 times in Scheme 1-8-2 with irrigation rates of 210-245 m³/ha and seasonal irrigation rates are 2460 m³/ha. This is 1504 m³/ha or 38% less than control.

In the local low-pressure drip irrigation technology, the variation of option 6 is 11 times in scheme 1-7-3 with irrigation length 300 m, 70-70-60% of pre-irrigation soil moisture content of LFMC with irrigation rates of 232-260 m³/ha. and seasonal irrigation rates were 2,640 m³/ha.

In the case of local low pressure drip irrigation technology with 300 m of irrigation experience, the 5- to 5-fold irrigation with 70-80-70% of pre-irrigated soil moisture content is 11 times in Scheme 1-8-2 with irrigation rates 250-280 m³/ha and seasonal irrigation rates are 2840 m³/ha. This is 1124 m³/ha or 28% less than control.

| Experiments | Irrigation technologies | Elements of irrigation | Soil humidity before irrigation, relative to LFMC, % | Seasonal irrigation norm, m³/ha | Economized water, m³/ha | Productivity, t/ha | Difference |
|-------------|------------------------|-----------------------|---------------------------------------------|----------------------------------|--------------------------|-----------------|------------|
| 1           | Furrow irrigation, control | Furrow length, 200 m  | Traditional irrigation                       | 3964                            | -                        | 12.3            | -          |
| 2           | Local low pressure irrigation technologies | Length of irrigation pipe 200 m | 70-70-60%                                  | 2060                            | 1904                     | 18.9            | +6.6       |
| 3           | Local low pressure irrigation technologies | Length of irrigation pipe 200 m | 70-80-70%                                  | 2170                            | 1794                     | 19.8            | +7.5       |
| 4           | Local low pressure irrigation technologies | Length of irrigation pipe 250 m | 70-70-60%                                  | 2350                            | 1614                     | 15.6            | +3.3       |
| 5           | Local low pressure irrigation technologies | Length of irrigation pipe 250 m | 70-80-70%                                  | 2460                            | 1504                     | 16.6            | +4.3       |
| 6           | Local low pressure irrigation technologies | Length of irrigation pipe 300 m | 70-70-60%                                  | 2640                            | 1324                     | 13.1            | +0.8       |
| 7           | Local low pressure irrigation technologies | Length of irrigation pipe 300 m | 70-80-70%                                  | 2840                            | 1124                     | 16.2            | +3.9       |

In this site, the number of irrigation options, that is in the irrigated field, was four times, the seasonal water consumption was 3964 m³/ha, and the average annual yield was 12.3 t/ha. The maximum productivity in the experimental field (19.8 t/ha) was obtained at a rate of 2170 m³/ha in the order of 200 m length of pipes of the local low pressure drip irrigation system 70-80-70% of LFMC. It was found to be 7.5 t higher than the control option. In this scenario, the seasonal water level was 2170 m³/ha, saving 1794 m³ or 45% of water compared to control.

Sufficient irrigation (70-80-70% of the LFMC), with the irrigation capacity of 250 and 300 meters of the 3rd and 4th variants of apple yield was 16.6 and 16.2 t/ha, respectively and 2460 and 2840 m³/ha, respectively.

4. Conclusions
1. 1.28-1.72% of the experimental area, 50.9-51.8% soil capacity, 1.36-1.45 t/m³, water permeability: water permeability at the beginning of 1 hour at the beginning of vegetation 0.089 m/h at the end of 4 hours 0.05 m/h, filtration rate was 0.014 m/h.
2. At local low-pressure drip irrigation technology, irrigation water length is 200 m, pre-irrigation soil moisture content is 70-80-70% compared to LFMC, irrigation is 11 times in figure 1-8-2, irrigation rates 179-210 m³/ha and seasonal irrigation. Norms are 2170 m³/ha, saving water by 1794 m³/ha or 45% less than control and achieving the highest apple tree yield of 19.8 t/ha.

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