AZERBAIJAN REPUBLIC

On the rights of the manuscript

IMPROVEMENT OF FERTIRRIGATION TECHNOLOGY APPLIED IN THE CULTIVATION OF GRAPE PLANTATIONS

Speciality: **3103.02-Development, recultivation, conservation**

Field of research: **Agrarian sciences**

Applicant: **Lamiya Mirnaib Mirsalahova**

ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

BAKU – 2024

Dissertation work was carried out at the Department of Melioration and Water Development Works and Soil Science and Agrochemistry, the Azerbaijan State Agrarian University

Head of research: Doctor od agrarian sciences, professor **Seyidaliyev Nizami Yagub**

Official opponents: Correspondent member of ANAS, d. Agrş sci, prof. **Ibrahim Hasan oglu Jafarov**
d.agrşsci., dosent **Mehman Agariza oglu Rzayev**
Ph.d., in agr. sci., docent
Zakir Huseyn oglu Aliyev

FD 1.32 Dissertation Council operating under the Higher Attestation Commission near the President of the Republic of Azerbaijan, the Azerbaijan Republic Ministry of Science Education, within the Institute of Soil Science and Agrochemistry

Dissertation Committee Chairman: Corresponding Member of MEA, Doctor of Agrarian Sciences, professor ANAS **Alovsat Gulush oglu Guliyev**

Dissertation Committee Secretary: Doctor of Philosophy in Biological Sciences, Associate Professor ______ **Shalala Jafar gizi Salimova**

Workshop Panel Chairman: doctor of agricultural sciences, associate professor **Mustafa Gylman oglu Mustafayev**

INTRODUCTION

Relevance of the topic and level of research. Starting from the 60s of the last century, the negative course of natural processes has been observed in the world. According to the information provided by the world hydrometeorology service centres, global climate changes on Earth have become more intensive. As per experts' calculations and natural observations, the average annual air temperature in the world has increased by 0.6-1.30C and the amount of atmospheric precipitation has decreased by 10-20%[1]. Analyses show that there is a serious tension in the country's water balance. According to experts' calculations, if climate changes develop at this rate, then by 2050, the available water resources of Azerbaijan may decrease by more than 40%[2,3]. According to the World Bank's report on drought in the countries of Central Asia and the Caucasus, the available water resources in Azerbaijan are expected to decrease by 9.5-11.5 billion m^3 by 2100 [4].

According to the collected data, water resources in our country are very limited[5], and yet progressive irrigation and fertilization technologies are applied in very few areas, more precisely, in only 74 thousand hectares of 1.42 million/ha irrigated lands.

Ganja-Dashkasan economic region has favourable climatic conditions and fertile soils for the development of viticulture. However, it is very difficult to achieve the expected results without

---

[1] Hasanov, S.T. Global climate changes: chronicle, global warming, causes, opposite views / S.T. Hasanov, F.F. Allahverdiyeva. - Baku: 2011, -244 p.

[2] Hasanov, S.T. The method of predicting the impact of climate changes on water resources // Collection of scientific works of AzHRSPU.-Baku: Elm, 2019, c. XXXIX, - p. 34-39.

[3] Hasanov, S.T. Forecasting the impact of global climate changes on water management / S.T. Hasanov, F.F. Allahverdiyeva. // Science of AzHRSPU collection of works. - Baku: Elm, 2018, c. XXXVII, - p. 65-74.

[4] . L.Zasuha. Assessment of management and mitigation effects for the countries of Central Asia and the Caucasus / World Bank Report No. 31998-ECA, 2005, 126pp.

[5] Hasanov, S.T. Water resources and reserves of Azerbaijan / S.T. Hasanov, C.C. Gulmammadov, V.N. Abbasov // Collection of scientific works of AzHRSPU. - Baku: Elm, 2018, c. XXXVII, - pp. 6-18.

irrigation in order to obtain high productivity from these lands. Using the available water resources more efficiently, preventing water losses, increasing soil productivity and adapting to global climate changes are the most important issues facing science and practice today. One of the main and important measures to achieve the solution of these issues is the development of more efficient and advanced irrigation and fertilization equipment and technologies, and the improvement of known techniques.

Goals and objectives of the research. The main goal of the work is to develop a more advanced irrigation and fertilization system and methods and prepare their scientific-practical bases to use water and mineral fertilizers more efficiently and economically, to increase the productivity of vineyards and orchards, and to protect the ecological balance of the environment. To achieve the set goal, the following issues were resolved:

1. Preparation of an overview of existing irrigation methods and techniques, determination of their advantages and disadvantages, preparation of a detailed classification of irrigation equipment and technologies, clarification of existing conflicting understanding of irrigation methods;

2. Improvement of the well-known, but not studied in detail, in-soil injection irrigation system, creation of a new and adjustable injector, development of a method for hydraulic analysis of the injection irrigation system and its design;

3. Analysis of fertilization equipment and techniques as well as preparation of management principles of the fertigation system and development of equipment and technology for delivering fertilizers to the root system of plants with an injection irrigation system;

4. Determining the effect of injection (in-soil fertigation), irrigation and fertilization (in-soil fertigation) technologies on the development and productivity of the grape plant;

5. Determining the economic efficiency of injection irrigation and fertilization system and technology.

Research methodology. In order to solve the issues presented, the tested methodology according to the essence of each issue was used and explained in the text of the dissertation. In general, a systematic approach method was applied. The studied issues were solved by conducting laboratory and field experiments. The hydraulic report and design methods of the proposed injection irrigation system, as well as injection irrigation and fertilization equipment and technologies were prepared based on scientific judgment and the study and analysis of calculation methods described in literature sources. The economic efficiency of operations was determined according to the costs invested in the production of the product and the income obtained from the sale of the product.

The main provisions defended:

- Generalization of existing irrigation methods and irrigation techniques, their advantages and disadvantages, detailed classification of irrigation techniques and technologies;

- improved construction of the injection irrigation system, its design and calculation methods;

- fertilizing techniques, fertigation and fertilizing system management principles, injection irrigation system and equipment and technology of giving fertilizers to plants;

- effect of injection irrigation and fertilization (fertigation) technologies on the development and productivity of the grape plant.

Scientific innovations of research.

1. Generalization of existing irrigation methods and irrigation techniques was carried out, their detailed classification was prepared.

2. The injection irrigation and fertilization system has been improved and new design of its elements have been developed.

3. An advanced methodology has been developed to conduct a hydraulic report of the injection irrigation system and to design it.

4. Fertigation and fertilizing technologies have been improved as an injection irrigation system, and the management principles of the fertigation system have been developed.

5. The effectiveness of the injection irrigation and fertilization fertigation system was tested in laboratory and production (field) conditions and its economic efficiency was determined.

Theoretical and practical significance of research. The hydraulic calculation and design procedure developed for the injection irrigation and fertilization (fertigation) system can be used in the calculation and design of similar systems. The results of the research show that the specially designed injection irrigation and fertilization system allows to save irrigation water and fertilizers by 2-4 times, prevent water and fertilizer losses, significantly increase the productivity of vineyards and orchards, and finally eliminate water shortages. Generalization and information about irrigation methods and irrigation techniques can be used as methodological tools in higher education institutions, research institutes and other educational schools.

Approval and application of work. Scientific results and provisions of the dissertation at national and international workshops, including the III international scientific conference of Young Scientists. Ganja State University (Ganja, 2018), Actual scientific-technical and ecological problems of land reclamation. Agricultural Academy of the Belarusian State Order of the October Revolution and the Labour Red Banner. IV International Scientific and Practical Conference dedicated to the memory of V.I. Yakovlev, (Gorki City, Belarus Republic, 2022), Heydar Aliyev and Azerbaijan's Agriculture. Azerbaijan State Agrarian University (Ganja, 2022), Yesterday, Today and Tomorrow of Soil Science, Ministry of Science and Education of Azerbaijan Institute of Soil Science and Agrochemistry International Workshop (Baku, 2022), Design, technology and innovation in textile and consumer goods industry, Azerbaijan University of Technology (Ganja, 2022). Azerbaijan Hydrotechnics and Reclamation Science-Production Union "AzHRSPU " (Baku, 2022), Ryazan State Agrotechnological University named after P.A. Kostycheva, (Ryazan, 2022), Non-oil sector global food security problems at the International scientific-practical conference (Ganja, 2023), Recommendation. Azerbaijan State Agrarian University, (Ganja, 2023), LLC "Research Center for Ecology and Construction" (2023, No. 4), Bulletin of Science and Practice, Nizhnevartovsk, st. Khanty-Mansiyskaya, 17, 81 (February 2024, No. 2, T.10) It was reported and discussed at the international workshop. The results of the carried out research work were discussed annually 2017-2021) at the Scientific Council of the Engineering Department at the Azerbaijan State Agrarian University.

Based on the results of the dissertation, guidelines on irrigation was prepared and used as a teaching aid at ADAU. "Proposals on irrigation of grapes with injection irrigation and fertilization (fertigation) technology" was prepared and submitted to AMIN Production Union.

Dissertation work area. The dissertation was completed at the Melioration and Hydrotechnical Plants Department of the Azerbaijan State Agrarian University.

The total volume of the dissertation with a character indicating the separate volume of the structural sections of it. The dissertation consists of an introduction, 5 chapters, a conclusion, a proposal, a list of 181 references and appendices. There are 27 figures, 1 diagram, 21 tables and appendices. In the content of the dissertation, the introduction is 6 pages, 9854 marks, the first chapter is 38 pages, 53200 marks, the second chapter is 28 pages, 38334 marks, the third chapter is 21 pages, 33816 marks, the fourth chapter is 45 pages, 60065 and the fifth chapter is 8 pages. Out of 12101 characters, results are 2 pages, 2666 characters, production recommendations are 1 page, 1302 characters, and 181 references are 18 pages, 26771 characters. The volume of the dissertation consists of 166 pages of computer writing, the total volume of which is 290073 characters (259354 characters excluding the list of used literature and appendices).

MAIN CONTENTS OF THE WORK
CHAPTER I. IRRIGATION METHODS AND TECHNIQUE

In this chapter, irrigation methods, the essence of each of them, advantages and disadvantages, irrigation techniques, their design and working principles are described in detail[6,7,8,9].

Up to now, detailed systematization has not been carried out in this field, and there is no precise classification of irrigation methods

---

6 Aslanov, H.Q. Reclamation soil science / H.Q. Aslanov. - Baku: "Education" NPM, 2004, -309 p.

7 Bagirov, Sh.N. Irrigation melioration / Sh.N. Bagirov-Baku: Maarif, 1985,-300p.

8 Bashirov, N.B. Advanced irrigation technique /N.B. Bashirov. -Baku: Elm, 1999,-139 p.

9 Zubairov, O.Z. Irrigation reclamation / O.Z.Zubairov, Kh.N.Gabdeev, A.G. Rau [et al.] -Almaty: Nur-Print, 2014, -273 p.

and technique. Unlike existing explanations and comments, it was determined that there are 4 types and 12 methods of irrigation and the corresponding irrigation techniques that implement these methods. Irrigation types, irrigation methods and techniques are classified as follows. Types of irrigation:

I. Type and technique of surface (surface) irrigation;

II. Type and technique of underground irrigation;

III. Type and technique of in-ground irrigation;

IV. Combined irrigation type and technique.

It refers to the type and techniques of surface irrigation:

1. Self-flow irrigation method and appropriate irrigation techniques;

2. Sprinkler irrigation method and relevant irrigation techniques;

3. Rainfall irrigation method and relevant irrigation techniques;

4. Disperse (aerosol) irrigation method and relevant irrigation techniques;

5. Impulse or pulsation irrigation method and corresponding irrigation techniques;

6. Drip irrigation method and relevant irrigation techniques;

7. Continuous (greenhouse) irrigation method and appropriate irrigation techniques;

8. Burial or port irrigation method and related irrigation techniques. It refers to the type and techniques of underground irrigation:

1. Underground (capillary) irrigation method and relevant irrigation techniques;

2. Subirrigation irrigation method and corresponding irrigation techniques. Types and techniques of in-ground irrigation include:

1. Injection irrigation method and relevant irrigation techniques;

2. Xylem (where the root fringes of the plant separate) needle irrigation method and appropriate irrigation techniques. It refers to the type and techniques of combined irrigation:

1. Joint application of self-flow irrigation and aerosol irrigation method and technique;

2. Combined use of sprinkler and aerosol irrigation methods and techniques;

3. Joint application of subirrigation and sprinkler irrigation methods and techniques;

4. Combined use of self-flow and impulse irrigation methods and techniques;

5. Combined use of aerosol or sprinkler irrigation methods and techniques with underground irrigation (capillary irrigation) method.

CHAPTER II. INJECTION (IN-SOIL) IRRIGATION SYSTEM, ITS IMPROVEMENT AND HYDRAULIC REPORT

In this chapter of the work, the essence, construction, working principle and application conditions of the injection irrigation method and system related to the type of in-soil irrigation were explained, the injection system was improved, and the hydraulic calculation method was developed to design it.

Taking into account the above-mentioned, a more perfect and multifunctional injection irrigation and fertilization system was developed by us in terms of construction and working principle[10].

The proposed injection irrigation system is located on the bank of the river (in case water is taken from the river, which is rich in irrigation water supply) from intake chamber, pump, pressure tower, fertilizer preparation tank, main, distribution and irrigation pipelines, remotely controlled drawers, moisture and water consumption information (alarm) consists of transmitters (sensors), control panel (station), specially designed injectors and other control and measuring devices (Fig. 1).

An advanced design of the injector, which is the most basic and functional element of the injection irrigation system, has been developed. The injector consists of a connecting element-plug, a regulating throttle, an injection pipe and a pointed end (plug) (Fig.2).

[10] Mirsalahova, L.M. Injection irrigation system // Bulletin of the Ryazan State Agrotechnological University named after P.A. Kostycheva. -Ryazan: 2022, t 14, no. 1. C 43-50

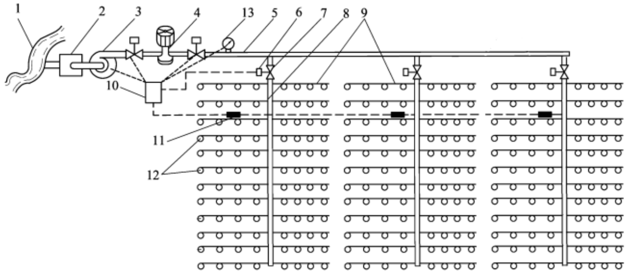

Fig. 1. Injection irrigation system:
1-water source (river); 2-intake chamber; 3-pump; 4-water tower with fertilizer mixer; 5-main pipeline; 6-signal transmitter for remote control of the drawer; 7-drawer; 8- distribution pipeline; 9- irrigation pipeline; 10-control panel (station); 11- moisture transmitter; 12-injector; 13-pressure gauge and water meter.

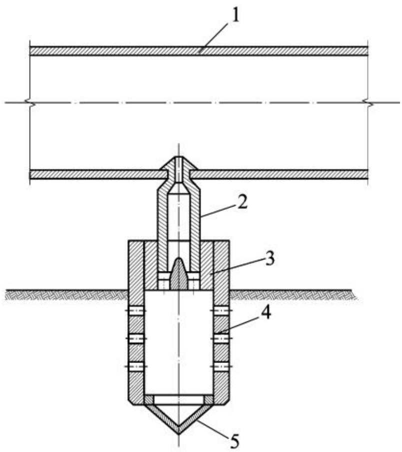

Fig.2. Connecting the injector to the irrigation pipeline:
1-irrigation pipeline; 2-nozzle; 3-throttle;
4-injection tube; 5-detachable tip.

In order to ensure a reliable connection of the injector to the irrigation pipeline, the head of the connecting element-plug is made flexible and truncated conical, and the output part is equipped with a flow control throttle (Fig. 3).

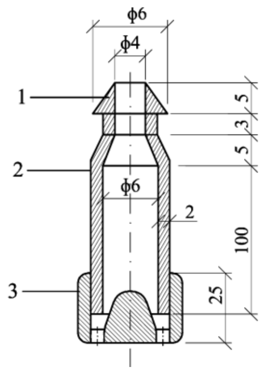

Fig.3. Nozzle with throttle:
1-flexible cone head; 2-nozzle; 3-throttle.

The flow control valve consists of a throttle body and a truncated conical leg. 4 holes with a diametre of 2mm are opened in the seat of the body. The throttle is connected to the nozzle by means of a groove, and by opening and closing it, the water flow is regulated (Fig. 4).

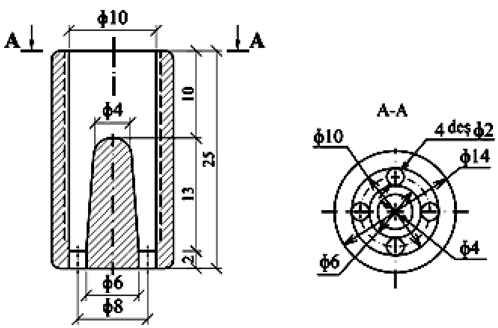

Fig.4. Throttle

The injection tube, which ensures uniform hydration of the root system of the plants, is perforated chequerwise and its tip is equipped with a pointed part for easy burying in the soil (Fig. 5)

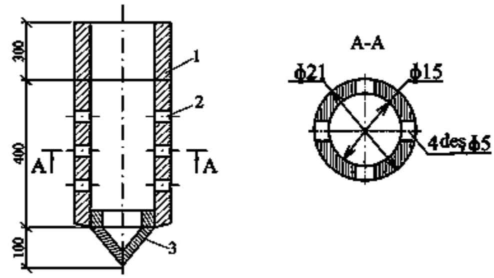

Fig.5. Injection tube:
1-tube; 2-hole; 3-head.

The length of the injection pipe is 70-80cm, the part buried in the soil is 40-50cm. 10 water passing holes of a diametre of 5mm were opened in the part buried in the ground. The injector is pressed into the ground at a distance of 5-10cm from the trunk of each vine or tree planted in the field and connected to the irrigation pipeline (Fig. 6).

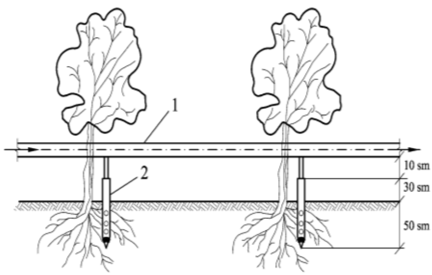

Fig.6. Layout for the injector in the root system of the plant:
1-irrigation pipeline; 2-injector.

This is how the injection irrigation and fertilization system works. A net is placed in front of the drainage channel from the river to prevent floating foreign objects and large debris from entering the intake chamber. Water freed from large particles enters the advance chamber, where some particles (sludge) settle. Clean water free of large impurities (this water may be partially silty) is pumped into the water tower. From there, the water flows to main, distribution and irrigation pipelines. Water from the irrigation pipeline enters the injector, and the water coming out of the holes of the injector moistens the soil zone where the root system of plants develops.

Sensors that measure humidity and transmit signals placed in the humidification zone send the data to the control panel. As soon as the soil moisture reaches a predetermined upper limit, the system stops watering, and when the soil moisture reaches a lower limit, the system starts automatically.

A procedure was developed to conduct a hydraulic report of the injection irrigation and fertilization system[11]. The summary of the method is as follows. During the injection irrigation method, the required irrigation rate is determined by the following expression:

$$M_i = KM \; ; m^3/ha, \tag{1}$$

where M is the irrigation rate, m^3/ha, determined on the basis of multi-year experiences for a specific plant; K-is the coefficient of reduction of the wetting area and is found by the following expression:

$$K = \frac{FN}{10000}, \tag{2}$$

where F- is the area of the moisture contour of a plant ($F=\pi d^2/4$), m^2; d - the diametre of the moisture contour, m; N - the number of plants per hectare; 10000 is the expression of one hectare in m^2. The total amount of water required in one growing season (V) is determined:

$$V=M_i\,\Omega, \tag{3}$$

where Ω is the total area where the irrigated crop is planted, hektare. The water consumption (Q) required to provide irrigative water to the cultivated area and to carry out the hydraulic report of the main pipeline is determined by the following formula:

$$Q = \frac{V}{86400\,t}, \text{ m}^3/\text{sec}, \tag{4}$$

where t is the duration of irrigation during the vegetation period, days; 86400 seconds a day. The remaining symbols are the previous quantities. Then the diametres (d) of the main, distribution and field pipelines are determined:

---

[11] Mirsalahova, L.M. Injection irrigation system // Bulletin of the Ryazan State Agrotechnological University named after P.A. Kostycheva. -Ryazan: 2022, t 14, no. 1. C 43-50

$$d = 1000\ (\frac{nQ}{0.312\sqrt{i}})^{\frac{3}{8}}, \tag{5}$$

where n is the internal roughness coefficient of the pipe; i is the hydraulic gradient and is found by the ratio of the difference in levels or initial pressure (H) to the length (l) of the pipeline (i=H/l). The pressure loss in the main pipeline (hfm) is calculated by the following formula:

$$H_{fm} = \sum_{i=1}^{n} \frac{l_i Q_i^2}{K^2}, \text{ i=1,2...n}, \tag{6}$$

where li is the length of individual sections of the main pipeline, m; Water consumption in separate areas of the Qi-belt, m^3/sec; K-is the consumption characteristic or consumption module (m^3/sec), the value of which is taken from a special table or determined by the following formula:

$$K = \omega C \sqrt{R}, \tag{7}$$

where ω-pipeline live cross-sectional area ($\omega = \pi d^2/4$), m^2; R-hydraulic radius (R=d/4), m; C – Chezy coefficient ($m^{0.5}$/sec) or its value is found by W. Kutter's formula:

$$C = \frac{100}{1 + (0.25/\sqrt{R}}. \tag{8}$$

The pressure loss in the distribution pipeline (hfp) is calculated by the following formula:

$$h_{fp} = \frac{l_p Q_3^2}{3K^2}, \tag{9}$$

where lp is the length of the distribution pipeline, m; $Q_s = Q_p/N_s$ – consumption of water released into an irrigation pipeline, m^3/sec; $Q_p = Q/n$ – consumption of the distribution pipeline, m^3/sec; $N_s = l_p/b$ number of irrigation pipelines; Q – consumption of the main pipeline, m^3/sec; n-number of distribution pipelines; b-is the distance between rows, m. The pressure loss (hfs) occurring in the irrigation pipeline is determined by the following formula:

$$h_{fs} = \frac{l_s q_i}{3K^2}, \tag{10}$$

where ls is the length of the irrigation pipeline, m; $q_i = Q_s/N_i$ – consumption of one injector, m^3/sec; Q_s–consumption of an irrigation pipeline, m^3/sec; $N_i=l_s/a$ – the number of injectors on one irrigation pipeline; a – is the distance between plants in a row, m. The total pressure loss (hfc) for the system is determined by the following expression:

$$h_{fc} = N_m h_{fm} + N_p h_{fp} + N_s h_{fs} . \tag{11}$$

where N_m is the number of sections of the trunk pipeline. The remaining symbols are the quantities in formulas (6), (9) and (10). The subflow capacity of the valve (Q_s) is determined by the following formula, taking into account pressure losses (hfc):

$$Q_ş = \mu\omega\sqrt{2g(H - h_{fc})} , \tag{12}$$

where μ=0.82 – consumption coefficient; ω=0.785 d_2 – cross-sectional area of the inlet part of the connector, m^2; H-work pressure in the irrigation pipeline, m; g=9.81 m/sec^2 free fall is instantaneous. The subflow capacity (Q_i) of the injection tube is determined by V.M. Nasberg’s formula:

$$Q_i = \frac{kh^2}{0.423kg(4h/d)} , \tag{13}$$

where h is the height of the water column in the injector, m; k - soil seepage coefficient, m/day; d is the diametre of the injection tube, m.

The described calculation method allows designing an injection irrigation system and other similar irrigation systems, for example, a drip irrigation system. In the dissertation, the method was explained as a specific example. At the same time, based on the proposed method, it was determined that pressure losses almost do not occur due to equal distribution of consumption in distribution and irrigation pipelines.

CHAPTER III. FERTIRRIGATION AND FERTILIZER TECHNIQUE

In this chapter, an overview of fertigation, types of fertilizers and the procedure of applying them to the soil is given, a procedure for turning solid fertilizers into liquid and giving them to plants with an injection irrigation system and design of the installation it implements, determining the fertilizer rate, and the principles of managing fertigation and fertilization processes are explained.

In fertigation and fertilization techniques, after dissolving solid fertilizers in water, they are mixed with irrigation water and given to the plant. This technology has so far been implemented through a drip irrigation system. Its efficiency and implementation principles have not been studied when using this technology in the injection irrigation system. The history of the use of fertilizers is closely related to the development of knowledge about plant nutrition.

Studies show that the issues of using mineral fertilizers have not been brought to an end. For example, application of solid mineral fertilizers to the soil, determination of their optimal rates, degree of assimilation by plants, cycle of nutrients, effect of fertilizers on crop quality and environment, etc.

The study and analysis of the sources show that one of the most optimal technologies to reduce the costs of the fertilization process and to use fertilizers efficiently is to apply solid fertilizers (including mineral, organic and mixed fertilizers) to plants by turning them into liquid or solution. Various fertilizer preparation units are used to implement this technology. A device that has a simpler design and can be applied in an injection irrigation system, which prepares liquid fertilizer and delivers it to the system have been developed iin this work. The unit consists of a tank located next to the pressure tower, an electric motor, a paddle mixer, a working platform, pipes receiving and supplying water to the system, an elevator, a ladder, supports and drawers (Fig. 7).

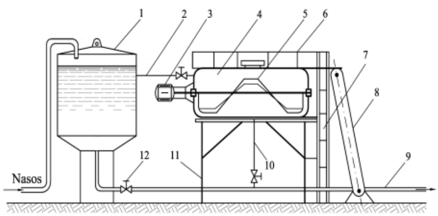

Fig. 7. Liquid fertilizer preparation and system supply unit:
1-pressure water tower (tank); 2-pipe connecting the tower with the fertilizer tank; 3-electric motor; 4-fertilizer tank; 5-paddle mixer; 6-working space; 7-ladder; 8-conveyor; 9-main pipeline; 10-pipe connecting the fertilizer tank with the main pipeline; 11- support; 12-valve (lock).

The working principle of the unit is quite simple. Solid granular mineral fertilizers are poured into the mixing tank in the required dose, and after mixing with water, they are discharged into the system. Liquid fertilizer enters the injector, and from there it enters the root system of the plant together with irrigation water.

At this time, the actual fertilizer rate (m_{fak}) is determined by the following expression due to the reduction of the fertilized area:

$$m_{fak}=km_b, \tag{14}$$

where $m_b=\varepsilon M$-the amount (norm) of fertilizer given to the soil by the traditional fertilization method, kg/ha; ε-fertilizer consumption coefficient, kg/sec; M-required or planned productivity, cen/ha; k - is the reduction coefficient of the fertilized area and is determined by the expression k=fN; f - is the fertilization or moistening area of a plant ($f=0.785\ d^2$), m^2; N is the number of plants per hectare.

Control of fertigation and fertilizing process. Both processes are carried out through an injection irrigation system. Therefore, both watering and fertilizing processes are automatically controlled in the same way. Thus, it includes the management of the irrigation process, as well as the management of the fertilization process[12,13,14].

Unlike traditional approaches upper limits of full moisture capacity of soil moisture was determined as 70-80%. Based on these parameters, fertigation and fertilizing processes are managed in an automated manner with the help of the injection irrigation system. Moisture recording sensors (transmitters) send a signal to the control panel at the lower limit of moisture (β_{low}=(0.5-0.6) β_{TNT}, where β_{TNT} is the full moisture content, in % by weight) and the system starts automatically. As soon as the humidity reaches the upper limit (β_{up}=(0.70-0.80) β_{TNT}), the system is automatically stopped.

---

[12] Application of fertigation for the effective use of fertilizers (Israel experience) / author V.Yu. Kirillov, N.B. Kazangapov. https:articlekz. com/article/8880, 2022.

[13] Bar-Yosef, B. Fertilization under drip irrigation // In: Fluid Fertilizer, Science and Techology. Ed. by D.A. Palgrave. Marcel Dekker, New York. - 1992.-pp. 285-329.

[14] Kafkafi, U. and J. Tarchitzky. Fertigation: A Tool for Efficient Fertilizer and Water Management //First edition, IFA, IPI, Paris, France, May. - 2011. - P.138.

CHAPTER IV. EFFECT OF INJECTION IRRIGATION AND FERTILIZER (FERRTIRRIGATION) TECHNOLOGIES ON GRAPE DEVELOPMENT AND PRODUCTIVITY

This chapter is devoted to laboratory and field experiments conducted to determine the effects of injection irrigation and fertilization technologies on the growth and yield of grape vines.

In the physical model developed in **laboratory experiments**, the performance of the injection irrigation system, the dependence between injector consumption and pressure, pressure losses occurring in the system and their causes, evaporation occurring during soil and surface moistening, the process of dissolving mineral fertilizers and the technology of supplying liquid fertilizer to the system, as well as in vegetation containers grape plant development has been studied. The physical model of the irrigation system is made in a special unit. In order to conduct comparative analysis, both injection and drip irrigation systems are placed in the physical model (Fig. 8).

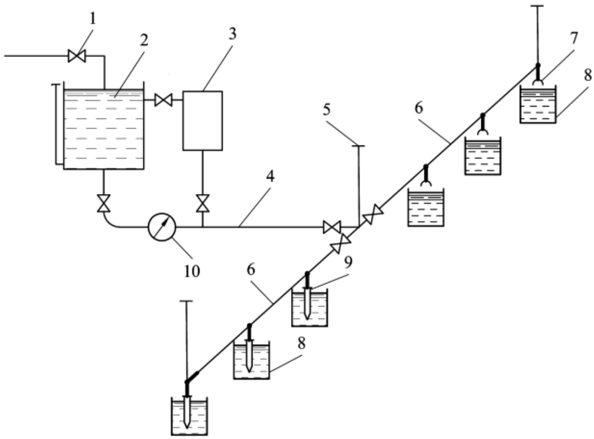

Fig. 8. Injection and drip irrigation system design:
1-water faucet; 2-pressure tank; 3-fertilizer preparation tank; 4- distribution pipeline (main pipeline); 5-piezometer; 6- irrigation pipeline; 7-dripper; 8-vegetation container (container when measurement); 9-injector; 10-water meter.

Initial injections at 1; 0.5; 0.2 and 0.1 m/s studied in various cases. It was determined that a sharp decrease in pressure leads to a gradual decrease in the subflow capacity of the system. Thus, a 10-

fold reduction of the injection causes a 3.2-fold reduction of the consumption, a 5-fold reduction of the injection causes 2.2 reduction of the consumption, and a 2-fold reduction in the injection causes a 1.47-fold reduction of the consumption. During the distribution of water from the main distribution and irrigation pipelines, the consumption is divided equally between the pipelines belonging to the same consumption module. This consistency ensures equal flow from one pipeline to another and improves system performance.

Based on laboratory experiments, it was determined that the injector's ability to pass at the smallest pressure is sufficient. Thus, the consumption of the injector at a pressure of 0.1m is 12l/h, and if the pressure is 1m, it is 39l/h. Such a regularity allows the injection irrigation system to be applied even in conditions with low pressure.

On the basis of watering (drip and injection method) in vegetation containers, it was determined that when using the injection irrigation method, the amount of water used for irrigation is reduced by 27% compared to drip irrigation, and the number of irrigations is reduced by 3 times. Thus, during the growing season, irrigation was carried out 11 times in the injection method, and 14 times in the drip irrigation method. In the injection irrigation method, 132 litres of water was given to one vegetation trough, and 168 litres in drip irrigation. The actual water consumption was 97 litres more than the calculated consumption.

The process of dissolving solid granular mineral fertilizers in water is 1:1 in 4 options in cases of free and forced dissolution; 1:2; 1:3 and 1:4 ratios were studied. It was determined that the period of free solubility of granular fertilizers in water is 14 hours in the ratio of 1:1, 12 hours in the ratio of 1:2; a ratio of 1:3 is 8 hours, and a ratio of 1:4 is 0.5 hours. The period of dissolution of mineral fertilizers in water during forced dissolution was 3, 1, 0.5 and 0.3 hours, respectively.

It was determined that during irrigation and fertilization with the injection irrigation method, the height growth of grapes is 35-41cm per month, and during drip irrigation and fertilization, it is 33-38cm per month.

Results of field (production) experiments. The experiments were carried out in two options. In option 1, irrigation and fertilization (fertigation) was carried out by means of an injection irrigation system (experimental option); in option 2 - irrigation was carried out by furrows and fertilizer was applied to the soil as solid (control option).

In both options, the length of the experimental areas was 21m, the width was 9m, and the area was 190m^2.

Grapes were planted with a scheme of 1.5x3.0m (Fig. 9). The general irrigation rate is found by the formula (1). In the injection irrigation method (experimental version), the cycle irrigation norm (the amount of water given to irrigation each time during the vegetation period) is determined by the following formula:

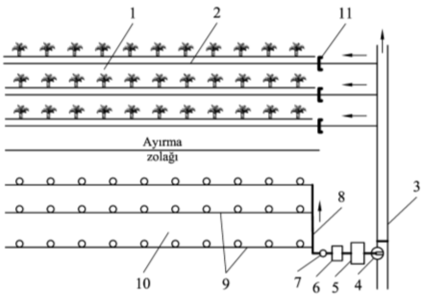

Fig. 9. Experimental area layout:

1-field irrigated with furrows (control option); 2-furrow; 3-irrigation channel; 4-pump; 5-pressure tank; 6-fertilizer mixing tank; 7-water meter; 8- distribution pipeline; 9- irrigation pipeline; 10-area irrigated by injection system (experimental option); 11-water valve.

$$m_v = \frac{F\gamma\,(\beta_{yux} - \beta_{aş})\,N}{100}, \qquad (15)$$

where F=0.785d^2 - the area of the moisture contour, m^2; d-diametre of the wetting contour, m; γ-volumetric mass of soil, g/cm^3; β_{up} and β_{low}-- the upper and lower limits of moisture in the active soil layer, respectively, % by weight; h - power of the active layer, m; N is the number of plants (vines) or inectors per hectare, plant/ha. During irrigation with furrows, the cycle irrigation rate m_v was calculated by the following formula:

$$m_v = 100\gamma h\,(\beta_{yux} - \beta_{aş}), \tag{16}$$

where all characters are quantities in formula (15). The number of irrigations during the vegetation period n_s is found by the following expression:

$$n_s = M/m_v, \tag{17}$$

where M is the total irrigation rate, m^3/ha.

In the injection irrigation method, the duration of one cycle of irrigation t is determined by the following formula:

$$t = \frac{m_v}{0.024 q_i N}, \tag{18}$$

where q_i – injector consumption, l/h; Conversion factor from 0.024- l/h to m^3/day; the remaining characters are the previous quantities.

In the method of irrigation with furrows, the duration of one cycle of irrigation t is determined by the following formula:

$$t = \frac{m_v \omega}{86.4 q_s}, \tag{19}$$

where q_s - consumption of furrow or channel, l/sec; ω - irrigated area, ha; 86.4 is the conversion factor from l/sec to m^3/day.

During the field experiments conducted, the actual irrigation norms, duration of irrigation, actual fertilizer norms and the yield of the grape plant were studied according to the options.

In both variants, the experiments were carried out according to the preprepared procedure. In the experimental version, irrigation was carried out 4 times a year, the value of the actual irrigation norm varied between 355-410 m^3/ha, and the value of the total irrigation norm was 1442-1624m/ha. In the control option, irrigation was carried out 4 times a year, the price of irrigation norms was 790-1050 m^3/ha, and the total irrigation norm was 3810-3890 m^3/ha.

In the experimental version, the amount of water used for irrigation was 2.43-2.64 times less compared to the control version, and 2266-2368m^3/ha of irrigation water was saved in one vegetation period. In the experimental version, 10kg/ha of nitrogen, 30kg/ha of phosphorus and 10kg/ha of potassium were applied to the root system of the vine 3 times a year in the bud formation phase and 8, 20 and 8kg/ha in the flowering phase, respectively, but the fertilizers of 6, 20 and 6kg/ha in the bud formation phase, were liquidized and given with irrigation water to the zone where the root system of grapes is developing.

In the experimental version, the fertilizer rate was 2.5-2.6 times less than in the control version.

The actual productivity of the Tabriz grape variety was determined by the method of harvesting and weighing. The yield of grapes in the experimental variant was 183-195cen/ha, and in the control option it was 162-167cen/ha.Comparing with the traditional method the productivity was more than 21-28 cen\ha.

Table

Harvesting and yield of grapes

Irrigation method (practical technique)	Harvested from actual and managed lands within an area of 0.019ha (m), kg				Productivity ($M=m/100\omega$), *cen/ha*
	Row 1	Row 2	Row 3	Total	
2018					
Injection irrigation (practical technique)	116	114	118	348	183
Strip irrigation (check method)	105	103	101	309	162
2019					
Injection irrigation (practical technique)	120	119	122	371	195
Strip irrigation (check method)	107	110	100	317	167

CHAPTER V. ECONOMIC EFFICIENCY OF INJECTION IRRIGATION AND FERTILIZER (FERRTIRRIGATION) TECHNOLOGIES

The economic efficiency obtained as a result of the application of the developed techniques and technologies was determined by the reduction of the direct costs of the farm for product production and the income obtained from processing raw materials and selling them as final products[15,16,17]. According to the calculations based on the

[15] The price of wine. BRABO /https // sezam.az>vino, 2022.

actual prices, it was determined that 94man/ha due to saving irrigation water, 163man/ha due to saving fertilizers and improving the technology of applying it to the soil, 3076man/ha due to the increase in productivity and selling the product as raw materials, and finally, raw materials A net income of 245.7 thousand man/ha is obtained due to the processing of (grape) and its sale as a final product.

RESULTS

1. On the basis of literature sources analysis, it was determined that there are sharp contradictions, shortcomings and fragmentation in the ideas about irrigation methods and techniques. A detailed systematization of irrigation methods and techniques was carried out and they were classified in order to eliminate the mentioned shortcomings and contradictions and clarify a number of issues.
2. It has been established that during drip irrigation, which is considered the most advanced irrigation method and techniques, water losses are allowed due to evaporation from the soil surface. In order to prevent water losses, save irrigation water and use it efficiently, the injection irrigation system has been improved and a new design of its elements has been developed.
3. Investigations shows that,when applying the injection irrigation system, irrigation water is saved 1.3 times compared to drip irrigation, and more than 2-3 times compared to other irrigation techniques.
4. For the first time, based on the results the procedure for calculating and designing the injection irrigation system and similar systems has been developed.
5. It was determined that the pressure loss in the injection irrigation system occurs only in the main pipeline. Due to the equal distribution of water along their length, pressure losses

[16] The price of wine. BRABO /https //www.az/online, 2022.
[17] The price of wine. Bazarstore / office@bazarstore.az, 2022

practically do not occur in distribution and irrigation pipelines. This allows the system to work and apply at a smaller pressure.

6. Application of fertilizer to the soil by traditional methods and techniques leads to a decrease in the coefficient of use of fertilizers, an increase in the consumption of labor and resources, and pollution of the environment. Therefore, the most convenient fertilizing technology is to turn fertilizers into liquid and give them to the root system of plants. In this case, the injection irrigation system can be used. When using the system, the cost of fertilizer is reduced by 60%, and the cost of applying it to the soil or plants is reduced by 100%.
7. Fertigation and fertilization system and technology have been improved in the example of injection irrigation system and its management principles have been developed.
8. It was determined that the development of the grape plant accelerates and its productivity increases significantly during the application of injection irrigation and fertilization (fertigation) technologies. The productivity of the "Tabriz" grape variety was 163cen/ha during irrigation with furrows, and 195cen/ha when irrigation was carried out using the injection method.
9. On the basis of experiments carried out in production conditions, it was determined that in order to achieve high productivity, it is more appropriate to keep the lower limit of moisture in the soil between 50-60% of the full moisture capacity, and the upper limit between 70-80%.
10. As a result of the application of injection irrigation and fertilizing (fertigation) technology in the irrigation and fertilization of grape plants, it is possible to obtain a net income of 245.7 thousand manats from one hectare of land every year due to the saving of irrigation water and fertilizer, the increase of productivity, the processing and sale of raw materials.

SUGGESTIONS AND RECOMMENDATIONS ON THE APPLICATION OF SCIENTIFIC RESULTS

1. When choosing certain methods and techniques of irrigation and fertilization, the soil and climate conditions of the area, the type of agricultural plants and the relief of the earth's surface should be taken into account.
2. In the cultivation of vineyards and orchards, trees and ornamental shrubs, the use of injection (in-soil) irrigation and fertilization system allows to save 2-3 times irrigation water and 60% fertilizer.
3. The design and calculation methods developed for the injection irrigation and fertilization system can be used in the design of similar irrigation and fertilization systems.
4. In order to obtain a high yield from the grape plant, it is recommended to keep the lower limit of moisture in the soil between 50-60% of the full water capacity, and the upper limit between 70-80%, and make liquid mineral fertilizers and give them directly to the root system of the grape plant.
5. In the conditions of the Ganja-Dashkasan economic region, it is recommended to give fertilizers with N_{24} P_{70} K_{24} norms and in the phases of bud formation, flowering and black formation in the technology of irrigation and fertilization of grape plants by injection method.
6. The information given in the dissertation about irrigation and fertilization methods and techniques, as well as the injection irrigation and fertilization system, obtained scientific and practical results, can be used as methodological tools in higher and secondary specialized institutions, and as methodological instructions and guidelines in production and project organizations.

SCIENTIFIC WORKS PUBLISHED ON THE DISSERTATION

1. Mirsalahova L.M. New irrigation and fertilization technology in viticulture // III international scientific conference of young scientists. - Ganja: October 17-18, 2018, - p. 167-169.
2. Mirsalahova L.M. Injection irrigation technology is a high-yield provider and regulator of economic and soil ecological environmental factors / Yesterday, today and tomorrow of soil science. International Scientific-Practical Conference.- Baku: December 5-6, 2022, p.112-114.
3. Mirsalahova L.M. Injection irrigation system // Bulletin of the Ryazan State Agrotechnological University named after P.A. Kostycheva. -Ryazan: 2022, t 14, no. 1, p. 43-50.
4. Mirsalahova L.M. Hydraulic calculation of an injection irrigation system // Bulletin of the Belarusian State Agricultural Academy Gorki: 2022, No. 2. p.204-211.
5. Mirsalahova L.M. Efficiency of injection irrigation // Materials of the IV International Research and Production Committee on the topic “Current scientific, technical and environmental problems of land reclamation”. Gorki: April 21-22, 2022, p.178-184.
6. Mirsalahova L.M. Some results of fertigation irrigation and fertilization technologies //Azerbaijan State Agrarian University, Ganja city. Ozan k. 102. May 5, 2022, p. 17-19.
7. Mirsalahova L.M. Irrigation methods and techniques, their level of application // Collection of scientific works of "AzHRSPU ". - Baku: Elm, 2022, c. XLIII, - p. 143-149 (co-author C.C. Gulmammadov).
8. Mirsalahova L.M. Hydrostructural design of an injector for in-soil vertical fertigation technology// Azerbaijan University of Technology, Ganja city, 103 Shah Ismayil Khatai Prospekt, 2022, p:214-216.
9. Mirsalahova L.M. Recommendation on the application of the new injection fertigation irrigation method in the cultivation of grape plantations// Azerbaijan State Agrarian University, Ganja city, Ozan street, 102. 2023, 36 pages.

10. Mirsalahova L.M. Comparative analysis of indicators of injection and furrow irrigation in grape plantation // Azerbaijan State Agrarian University, Ganja city, Ozan street, 102. 2023, p.16-20.
11. Mirsalakhova L.M. The importance of the fertigation-injection irrigation system in saving irrigation water // LLC Scientific Research Center for Ecology and Construction. 2023, p.4-9.
12. Mirsalakhova L.M. Comparative study of the influence of fertigation and drip irrigation technologies on the development of grape plants (in laboratory conditions) // Bulletin of Science and Practice Nizhnevartovsk, st. Khanty-Mansiyskaya, 17, 81. 2024, p. 131-138.

Dissertation defence on « 04 » October 2024 at 11⁰⁰ -will be held at the meeting of the FD1.32 Dissertation Council operating under the Azerbaijan Republic Ministry of Science Education, Institute of Soil Science and Agrochemistry

Address: Az1073,Baku,M.Rahim Street 5 e-mail: tai.aretn@mail.ru

The dissertation can be found in the library of the AR MSE Institute of Soil Science and Agrochemistry

Abstract are posted on the official website defterxana@tai.sciense.az

The abstract "25" was sent to the necessary adresses on august 2024

Passed for printing:
Paper size: 210x297 1\4
Volume: 36428
Edition size:100