ТЕХНИКА И ТЕХНОЛОГИИ АПК / FARM MACHINERY AND TECHNOLOGIES
ОРИГИНАЛЬНАЯ СТАТЬЯ / ORIGINAL PAPER
УДК 631.674.42: 628.1
DOI: 10.34677/1728-7936-2019-6-19-22

ПОДПОЧВЕННОЕ ОРОШЕНИЕ ВИНОГРАДНИКОВ КРЫМА ОПРЕСНЁННЫМ КОНДЕНСАТОМ МОРСКОЙ И СОЛЁНОЙ ОЗЁРНОЙ ВОДЫ

ШЕВЧЕНКО ВИКТОР АЛЕКСАНДРОВИЧ, *докт. с.-х. наук, профессор*
E-mail: Shevchenko.v.a@yandex.ru
ГУБИН ВЛАДИМИР КОНСТАНТИНОВИЧ, *канд. с.-х. наук, ведущий науч. сотрудник*
E-mail: gubin.vladimir2011@yandex.ru
КУДРЯВЦЕВА ЛИДИЯ ВЛАДИМИРОВНА, *младший науч. сотрудник*
E-mail: kudryavtzeva.lidia2016@yandex.ru
Всероссийский научно-исследовательский институт гидротехники и мелиорации имени А.Н. Костякова; 127550, Российская Федерация, г. Москва, ул. Большая Академическая, д. 44, корпус 2

В статье рассматриваются вопросы использования солёной воды для орошения многолетних насаждений на территориях, примыкающих к водоисточникам с повышенным содержанием солей, включая участки морского побережья. Даётся краткий анализ различных способов понижения содержания солей в воде. Особое внимание уделяется удалению солей методом дистилляции солёной воды с использованием энергии солнца. Рассматриваются различные конструкции солнечных опреснителей запатентованных в разных странах. Предложен способ внутрипочвенного орошения многолетних насаждений солёной водой, который заключается в испарении воды с использованием солнечной энергии, насыщении воздуха паром и последующей подачи его по перфорированным трубам в почву, где происходит конденсация пара. Для осуществления этого способа разработано специальное устройство. Эффективность применения данного способа и устройства в условиях сельскохозяйственного производства рассмотрена на примере Крыма в виноградниках. Установлено, что внутрипочвенная подача воды по сравнению с капельным поливом позволит сократить потери влаги на 20…30% за счёт предотвращения испарения с поверхности влажного пятна у капельницы. Благодаря этому, оросительную норму можно снизить до 400…500 м^3/га или до 50 литров на 1м^2. Реализация предложенного способа позволит осуществлять орошение многолетних насаждений опреснённой солёной водой и исключить при этом накопления солей в почве и потери воды на испарение.

Ключевые слова: внутрипочвенное орошение, методы опреснения солёной и морской воды, опреснение солёной воды способом дистилляции, использование солнечной энергии для опреснения воды.

Формат цитирования: Шевченко В.А., Губин В.К., Кудрявцева Л.В. Подпочвенное орошение виноградников Крыма опреснённым конденсатом морской и солёной озёрной воды // Вестник ФГОУ ВПО «МГАУ имени В.П. Горячкина». 2019; 6(94): 19-22. DOI: 10.34677/1728-7936-2019-6-19-22 (In Rus.).

SUBSOIL IRRIGATION OF CRIMEAN VINEYARDS WITH DESALINATED CONDENSATE OF SEA AND SALT LAKE WATER

VIKTOR A. SHEVCHENKO, *DSc (Agr), Professor, Director*
E-mail: Shevchenko.v.a@yandex.ru
VLADIMIR K. GUBIN, *PhD(Agr), Key Research Engineer*
E-mail: gubin.vladimir2011@yandex.ru
LIDIA V. KUDRYAVTSEVA, *Junior Research Engineer*
E-mail: kudryavtzeva.lidia2016@yandex.ru
All-Russian Scientific Research Institute of Hydraulic Engineering and Land Reclamation named after A.N. Kostyakov; 127550, Russian Federation, Moscow, Bolshaya Akademicheskaya Str., 44, bld. 2

The paper discusses the use of salt water for irrigation of perennial crops in areas adjacent to water sources with high salt content, including sections of the coast. The authors give a brief analysis of various ways to reduce the salt content in water. Particular attention is paid to the removal of salts by distillation of salt water using solar energy. Various designs of solar desalination plants patented in different countries are considered. The authors propose a method for subsoil irrigation of perennial crops with salt water, which consists in evaporating water using solar energy, saturating the air with steam and then supplying it through perforated pipes to the soil where steam condensation occurs. To implement this method, a special device has been developed. The effectiveness of the application of this method and device in agricultural production is considered using an example of the Crimea vineyards. It has been established that the subsoil water supply will reduce moisture loss by 20…30% as compared to drip irrigation by preventing evaporation from the surface of a wet spot near the dropper. Due to this, the irrigation rate can be reduced to 400…500 m^3/ha or up to 50 liters per 1 m^2. Implementation of the proposed method will allow irrigating perennial crops with desalinated salt water and prevent salt accumulation in the soil and the loss of water by evaporation.

Key words: subsurface irrigation, methods of salt and sea water desalination, salt water desalination by distillation, use of solar energy to desalinate water.

For citation: Shevchenko V.A., Gubin V.K., Kudryavtseva L.V. Subsoil irrigation of Crimean vineyards with desalinated condensate of sea and salt lake water. *Vestnik of Moscow Goryachkin Agroengineering University.* 2019; 6(94): 19-22. DOI: 10.34677/1728-7936-2019-6-19-22 (In Rus.).

Introduction. Only 20% of fresh water resources are located in the densely populated central and southern regions of Russia with developed industry and agriculture. At the same time, there is a significant amount of water with a salt concentration of less than 10 g/l.

For example, in the Crimea there are over 300 lakes. Most of these lakes contain salt water. Fresh lakes are mainly located in the central part of the Crimean peninsula, in the mountains or in the mountain areas. Lakes located at a short distance from the coastline, mainly of the estuary type, are almost 95% saline, even if they are formed by fresh underground sources [1].

Water containing no more than 1 g/l of dissolved solids is used for irrigation. The use of saline water in the Crimean steppe for irrigation is of significant practical interest. Quality improvement of salt water can be achieved by adding fresh water until an acceptable level of salt content is obtained. To dilute salt water, fresh water can be taken from streams and artesian wells or obtained by desalination of salt water from the same lakes.

The problem of salt water desalination, including sea water, is now becoming increasingly important. There are a significant number of ways to remove salt from salt water: several types of distillation, ion exchange, reverse osmosis and electrolysis methods, as well as freezing. It should be noted that the distillation method provides for 96% of the total amount of desalinated water in the world [2].

In our case, solar distillation of salt water is considered. Currently, due to the fact that this method is based on the use of environmentally friendly technology, considerable attention is paid to its development. For example, a patent was granted in the Russian Federation for a drip irrigation method and a device for its implementation, which includes continuous mixing of saline water with distilled water and its subsequent supply through droppers to plants. Distilled water is obtained by desalination of a portion of salt water in a solar-desalination system [3].

However, in case of drip irrigation even with diluted salt water, salts accumulate along the contour of the hydrated zone. When perennial crops are irrigated, this will lead to focal salinization of the root zone of plants. With drip irrigation, both during and after watering, a significant part of the water evaporates from the surface of the hydrated area, which leads to the irrational use of expensive desalinated water.

The Chinese company Zhongin Changjiang International Energy Investment Co., Ltd. (CN) obtained a patent in the Russian Federation for “A device for desalination of sea water and a method for using solar energy for continuous heat supply”. This device includes a system for purification and desalination of sea water, as well as the concentration and accumulation of solar heat [4]. These plants have a complex structure and are designed to produce significant volumes of fresh water for industrial and water management supply.

In 1989, patent CH 672227 A5 was issued in Switzerland for a method of using condensed moisture for subsoil irrigation. The essence of this invention is that air is pumped through a system of tunnels made of translucent material containing salt water. The air is heated up, saturated with water vapor and pumped into the subsoil perforated humidifiers, where condensation occurs, and the condensate flows to the roots of plants [5].

In 2016, US patent No. 9301442 B1 was issued in the United States for an “Irrigation System”, in which desalination of salt water is carried out by heating it in an evaporator using solar energy, and vacuum is used to reduce the boiling point of water. To do this, the air is sucked out of the evaporator, this reducing pressure in it, then water vapor is piped to the spherical heads of the water outlets, in which, due to expansion, it is condensed to form drip moisture, which hydrates the root system of plants [6].

The study purpose is to develop a method and device for irrigation of perennial crops with salt water.

Materials and methods. Researchers of VNIIGiM named after A.N. Kostyakov developed a method for irrigating perennial crops with salt water, which includes saltwater evaporation with solar energy, saturation of the air with steam, and its supply through perforated pipes to the soil where steam is condensed. To implement this method, a special device was developed. A patent was issued for the method and the device for its implementation [7]. According to this invention, the air, preheated to 60…70°C, is saturated with water vapor in a solar evaporator and taken to the irrigated area, where it is cooled in the plant root zone at a depth of 0.4…0.6 m with precipitation of condensed desalinated moisture.

A device for irrigating perennial crops with salt water o is shown in Fig. The proposed device has a pump for supplying salt water from a water source, a solar heater, an evaporation chamber connected with a pipeline for supplying desalinated water to the plant root system. Wicks made of hydrophilic material are placed in the evaporation chamber, and an air solar collector equipped with an air intake valve and connected to the evaporation chamber is mounted outside. The evaporation chamber is connected by an air duct made in the form of a pipe placed in a heat-insulating casing with an underground perforated pipe. The surface of this pipeline is covered with a layer of hydrophilic material. The end part of the perforated pipe is equipped with an air exhaust device. In addition, the air intake valve of the solar collector has an air intake regulator in the form of a bimetallic plate. The air exhaust device at the end of the perforated pipe is equipped with a chamber, divided by membrane screen and an exhaust fan.

During the device operation, air is pre-heated in the solar collector to 60…70°C, which increases its moisture capacity. Then the heated air enters the evaporator body. Passing between wicks dipped in salt water, it is saturated with moisture.

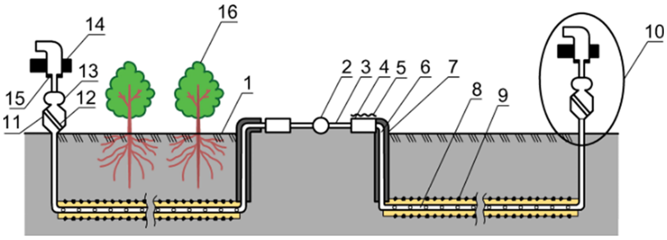

Fig. Device for irrigating perennial crops with salt water:
1 – soil surface, 2 – a supply pipe, 3 – a discharge pipe,
4 – an evaporator, 5 – a solar air collector, 6 – a connecting pipe,
7 – a heat-shielding casing, 8 – a perforated irrigation pipe,
9 – a cover made of hydrophilic material,
10 – an air exhaust device, 11 – a condensation chamber,
12 – a condensing screen, 13 – an exhaust fan, 14 – a vane,
15 – an elbow, 16 – an irrigated plant

Рис. Устройство для орошения многолетних насаждений солёной водой:
1 – поверхность участка, 2 – подводящий трубопровод,
3 – отводящий трубопровод, 4 – испаритель,
5 – солнечный воздушный коллектор, 6 – соединительный трубопровод, 7 – теплозащитный кожух,
8 – оросительный перфорированный трубопровод,
9 – чехол из гидрофильного материала,
10 – воздуховытяжное устройство,
11 – конденсационная камера, 12 – конденсирующий экран,
13 – вытяжной вентилятор, 14 – флюгер,
15 – коленчатый патрубок, 16 – орошаемое растение

Air saturated with moisture is sucked into the perforated pipe. Upon contact with the walls of the perforated pipeline laid in the soil in the plant roots zone at a depth of 0.4…0.6 m, it is condensed to form desalinated water. This is due to the fact that the pipeline walls have a temperature corresponding to the surrounding soil temperature (no more than 20°C). Due to the temperature difference between the steam and the pipeline walls, the condensation process occurs. The moisture formed is absorbed by the hydrophilic material and is retained in a form accessible to plant roots.

Results and discussion. The effectiveness of the application of this method and device in agricultural production is exemplified by the conditions of the Crimea, where there is an acute need for fresh irrigation water with a sufficient amount of salt water and favorable climatic conditions. For grapes, the drip irrigation rate, depending on the availability of rainfall, is 600…700 m^3/ha. The subsurface water supply, as compared with drip irrigation, will reduce moisture loss by 20…30% by preventing evaporation from the wet spot surface next to the dropper. Due to this, the irrigation rate can be reduced to 400…500 m^3/ha or up to 50 liters per 1 m^2.

The period of time during which the vineyard may need additional irrigation is about 180 days in the Crimea – from April to September, of which 170 days are sunny. The vineyard needs to be watered from June to September, when an average daily air temperature ranges from +23°C in June to +27°C in July – August. The night air temperature in these months is within +10…17°C. The average soil temperature at a depth of 0.5 m does not exceed +20°C.

When one pipeline is laid under a row of vines and the distance between rows is 4 m, a 100 m-long pipeline irrigates a strip of 400 m^2 and must supply 20,000 liters of water per season, or about 1.0…1.5 liters per 1 m^2 a day. At a temperature of +25°C and a relative humidity of 40%, a cubic meter of air will contain about 90 grams of moisture. After heating the air in the solar collector to +60…70°C, the air moisture capacity will increase to 200 g/m^3. Having entered the evaporator, this air will be saturated with moisture to a relative humidity of 90…95% and will contain about 180 g/m^3 of moisture. In a perforated pipeline, its temperature will drop to +20°C. At this temperature, the moisture capacity of the air is 17 g/m^3. Thus, with a decrease in air temperature during movement through the pipeline from each of its cubic meters, about 160 g of condensate can accumulate on the pipeline walls. To get 125 liters of water per day, about 800 m^3 air must be moved through the pipeline. The heated air with a high moisture content can be supplied within about ten hours from 10 a.m. to 8 p.m. Thus, the air supply should be 80 m^3/hour. It should be kept in mind, that during the rest of the day at air temperature above +20°C, moisture will be also condensed in the pipeline, although in smaller quantities. At night, when the air temperature drops to +10…17°C it will cool pipeline walls by moving through the pipeline. After passing through the pipeline, the air enters the chamber mounted at its end. While passing through the membrane material of the screen in the chamber, the air will leave condensed moisture on it, which will flow into the perforated pipeline and will be used for soil irrigation.

Conclusions

Thus, the implementation of the proposed method using the considered device will allow irrigating perennial crops with desalinated water and prevent salt accumulation in the soil and the loss of water by evaporation.

References

1. Kayukova V.P., Barabashkina T.A., Kosinova I.I. Resursniy potentsial presnykh vod Kryma [Resource capacity of fresh water in the Crimea]. *Vestnik VGU. Seriya: Geologiya*. 2014; 4: 108. (In Russian)

2. Obzor metodov opresneniya morskoy i solonoy vody [Overview of sea and salt water desalination methods]. [Electronic resource]. URL: /ecoalfa.ru>files/5/0/506/ opresneniye pdf (Access date 12.11.2019) (In Russian)

3. Voyevodina L.A., Chernova D.A. Sposob regulirovaniya mineralizatsii orositel'noy vody pri kapel'nom oroshenii i ustroystvo dlya yego osushchestvleniya: patent RF № 2483528. MKI A01G 25/02 [Method of regulating the mineralization of irrigation water for drip irrigation and a device for its implementation: Patent RF, No. 2483528. MKI A01G 25/02, 2013], 2013. (In Russian)

4. Chen' Ilun', Yan Tsinpin, Chzhan Yan'fyn. Ustroystvo dlya opresneniya morskoy vody i sposob primeneniya solnechnoy energii dlya nepreryvnoy podachi tepla: patent RF No.2603799. MKI C02 F1/14 [Device for desalination of sea water and a method of using solar energy for continuous heat supply: Patent RF, No. 2603799. MKI C02 F1/14, 2016], 2016. (In Russian)

5. Ruess Kurt. Meerwasserentsalzungs-und Bewässerungsverfahren mit einem Luft-Wasserdampf-Gemisch. Patent CH No.672227 A5. Int/Cl A01G 25/6, 15.11.1989. (In German)

6. Adel Abdulmuhsen Al-Wasis. Irrigation system. Patent United States 9301442. Int/Cl A01G25/02, April 5, 2016. (In English)

7. Gubin V.K., Shevchenko V.A., Kudryavtseva L.V. Sposob orosheniya mnogoletnikh nasazhdeniy solonoy vodoy i ustroystvo dlya yego osushchestvleniya: patent RF No. 27003185. MKI A 01G 25/06 [Method of irrigating perennial crops with salt water and a device for its implementation: Patent RF, No. 27003185. MKI A 01G 25/06], 2019. (In Russian)

Библиографический список

1. Каюкова В.П., Барабашкина Т.А., Косинова И.И. Ресурсный потенциал пресных вод Крыма // Вестник ВГУ. Серия: Геология. 2014. № 4. 108 с.

2. Обзор методов опреснения морской и солёной воды. Электронный ресурс. URL: /ecoalfa.ru>files/5/0/506/ опреснение pdf (дата обращения 12.11.2019 г.)

3. Способ регулирования минерализации оросительной воды при капельном орошении и устройство для его осуществления: патент РФ № 2483528. МКИ А01G 25/02 / Л.А. Воеводина, Д.А. Чернова; опубл.10.06.2013 г. Бюлл. № 16.

4. Устройство для опреснения морской воды и способ применения солнечной энергии для непрерывной подачи тепла: патент РФ № 2603799.МКИ С02 F1/14 / Чень Илунь, Ян Цинпин, Чжан Яньфын; опубл. 27.11.2016. Бюлл. № 33.

5. Ruess Kurt. Meerwasserentsalzungs-und Bewässerungsverfahren mit einem Luft-Wasserdampf-Gemisch. Patent CH № 672227 A5. Int/Cl A01G 25/6, 15.11.1989.

6. Adel Abdulmuhsen Al-Wasis. Irrigation system. Patent United States 9301442. Int/Cl A01G25/02, April 5, 2016.

7. Способ орошения многолетних насаждений солёной водой и устройство для его осуществления: патент РФ № 27003185. МКИ А 01G 25/06 / В.К. Губин, В.А. Шевченко, Л.В. Кудрявцева; опубл.15.10.2019.

Критерии авторства

Шевченко В.А., Губин В.К., Кудрявцева Л.В. выполнили теоретические исследования, на основании полученных результатов провели обобщение и написали рукопись. Шевченко В.А., Губин В.К., Кудрявцева Л.В. имеют на статью авторские права и несут ответственность за плагиат.

Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Статья поступила 12.11.2019

Опубликована 20.12.2019

Contribution

Shevchenko V.A., Gubin V.K., Kudryavtseva L.V. performed theoretical studies, and based on the results obtained, generalized the results and wrote a manuscript. Shevchenko V.A., Gubin V.K., Kudryavtseva L.V. have copyrights for the paper and are responsible for plagiarism.

Conflict of interests

The authors declare no conflict of interests regarding the publication of this paper.

The paper was received on November 12, 2019

Published 20.12.2019