Cumhuriyet Üniversitesi Fen Fakültesi
Fen Bilimleri Dergisi (CFD), Cilt:36, No: 3 Özel Sayı (2015)
ISSN: 1300-1949

Cumhuriyet University Faculty of Science
Science Journal (CSJ), Vol. 36, No: 3 Special Issue (2015)
ISSN: 1300-1949

# Operation of sprinkler irrigation systems at night using saline water at the hot and dry climate condition

Fatemeh REZVANI[1,*], Saeed DOWLATI[2]

*1-Water Structure Engineering, MSc (TarbiatModares University),SarzaminQanatConsulting Engineers Co.*

*2-Civil Engineering, MSc (Sharif University of Technology),SarzaminQanatConsulting Engineers Co.*

Received: 01.02.2015; Accepted: 05.05.2015

**Abstract.** Development of sprinkler irrigation in order to increase irrigation efficiency is in the agenda of agriculture policymakers' section. In most areas, reduced water quality by reducing the quantity of water is encountered. Consequently, in such circumstances that sprinkler irrigation by poor quality water is done on farms, due to the dissolved ions absorption by leaves results in plant toxicity and leaf-burning, which ultimately leads to reduced crop performance. On the other hand, in conditions of evaporation, high temperature and wind, sprinkler irrigation will have an adverse effect on crop performance. However, experience in Qom province has shown that even in adverse conditions, sprinkler irrigation can be done. As the study area in this research is considered in hot and dry part of country and also located in a desert area, its water consists of very high sodium and chlorine levels and the quality is poor as well. However, due to nightly sprinkler irrigation that has been done several years on this farm, optimal performance of crops is achieved. In this study, we examined the factors affecting this action in order to disseminate this method of sprinkler irrigation and use of saline water, an effective step has done to overcome the limitations of the world's water resources.

**Keywords:** sprinkler irrigation, nightly irrigation, dissolved ions absorption, stomata.

## 1. INTRODUCTION

One of the basic strategies to optimize water use in agriculture is execute of pressurized irrigation projects. Quality of water used in pressurized irrigation systems is more important than surface irrigation. In many areas with limited water resources are encountered,water quality is also very low and is not suitable for use in pressurized irrigation projects. However, the quantitative limits of the resources, execution of optimization plans is very important. Such situations lead to the formation of a paradox, so that on the one hand, in order to efficiency of water, the implementation of pressurized irrigation projects is essential; on the other hand, the project execution will fail regarding to water quality. Finding an appropriate way to solve this problem would be a great help in the efficient use of water resources for agriculture.

Salt Lake is located near the Qom province, so the plains in the neighborhood of this lake are threaten by danger of its saline water permeation. The main source of agricultural water supply in these plains is deep wells that are picked up the water from the plains aquifer. Picking up the water from these aquifers cause decrease the groundwater level and then saline water of the Salt Lake intruded into the aquifer and salinity of the water in the wells are followed. Obviously, lower water pick up from wells causes lesser saline water intrusion process of Salt Lake. In order to reduce the consumption of water aquifers, many sprinkler irrigation projects have been implemented in the region in the recent years. However, almost all the projects have failed due to water salinity, so farmers has turned to surface irrigation methods that have low efficiency.

*Corresponding author. *Email address: f.rezvani77@gmail.com*

*Special Issue:* The Second National Conference on Applied Research in Science and Technology

http://dergi.cumhuriyet.edu.tr/cumuscij 

Qom plain is one of the province plains which is located near the Salt Lake and is faced with the problem of salinity. In rural areas like Jannat Abad and Hossein Abad that are in this plain, almost all sprinkler irrigation projects that were implemented in the last years have failed and are not currently in operation. A field study result showed that almost all beneficiaries of these projects have said that leaf-burningproblem which is due to the poor quality of water is the main reason of non-operation of the mentioned plans. In the vicinity of these farms is a farm that its beneficiary is still using the sprinkler irrigation system by method of "Wheel Move" and "Permanent" and the problem of leaf-burningis largely solved. The main solution which this farmer has expressed, is that he has done the irrigation only at night and in the time of no wind. This is the basis of this research to study the condition that this farmer does sprinkler irrigation, the basic assumptions of the problem are proposed and finally with examine them, rejection or prove any attempt is done. The main assumptions that have been addressed in this study, as follows:

1) The main reason for reducing the amount of leaf-burningin the nightly irrigation is the night and day difference climatic conditions.
2) The main reason for reducing the amount of leaf-burningin the nightly irrigation is the night and day difference in the mechanism of plant leaves.
3) Integration of climatic and physiological conditions is the basic reason of leaf-burningreduction and sprinkler irrigation system success on this farm.

## 2. MATERIALS AND METHODS

To investigate the fundamental assumptions which has mentioned in the introduction, first it is necessary that plants performance mechanism andalso difference of plants performance at night and day be examined.

Up to now, recognition the mechanism of existing pores in the plants organs has significant helps in forecasting weather and climate change, agriculture, examining the surface water, etc. Water vapor in the leaves is regulated by structures called stomata. On the other hand, the Food and ions dissolved in water can be quickly absorbed through the aboveground organ of plants especially leaves and their stomata. Therefore, the leaves stomata are of the most important organs of plant leaves that need to be consideredin this study.

Stoma is similar to human lips and it's surrounded by a pair of guard cells that is responsible for controlling the stomata opening size (Figure 1). The size of these stomata regulates input carbon dioxide amount which needed for photosynthesis and output water vapor amount into the atmosphere (transpiration). Leaf stomata are affected on rate of carbon dioxide absorption that is directly effective on fertility, plant growth and carbon dioxide concentration in the air.

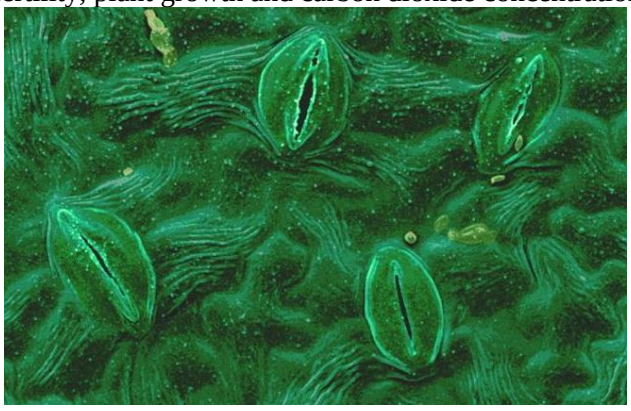

**Figure 1.** The stomata on the leaf epidermis of plant.

Carbon dioxidethat takes part in photosynthesis enters from the air to the green leaf cell through the stomata and intracellular full-branching ducts system. Leaf is the most important photosynthetic organ of the plant that may be visualize as several layers of photosynthesizing active cells (mesophilic) that is surrounded by the protective layer (epidermis) and holds the conductive elements (veins). Conductive elements transfer the materials in two directions, so that convey the raw materials into the leaf and carry photosynthesis products materials out of it. Veins are so widespread that no mesophilic cells are away more than a few cells (Galstonet al.,1980).

Stomata mean pores on the epidermis open and close in response to Turgor pressure changes of two kidney shaped cells that surround the stomata. It is clear that the stomata cells contain exceptional structural and physiological features that enable them to act this way (Galstonet al.,1980). In Figure (2), the opening and closing of stomata in the leaves is shown.

**Figure 2.** Opening and closing of leaf stomata

For 300 years, scientists have been studying these stomata, but the interesting point is that so far they are not reached realizing of the regulatory mechanisms that control the opening and closing of the stomata in response to permanent changes of the environment (Pieruschka et al., 2010). According to experimental tests, the researchers found that radiation is driving force in physical processes of leaves. They investigated the relationship between energy exchange and water vapor in the leaves with processes inside the leaves. The researchers found that the radiation energy absorbed by pigments and water inside the leaf, influence on how to control the amount of water through the stomata. In these studies, white light that was filtered from near the infrared radiation (in terms of wavelength), was reflected sunflower leaves. At this time, it was observed that the stomata reacts these radiations by more opening and was stimulated to photosynthesis. Then the lights with other colors and with the same energy reflected to the leaves and similar reaction was observed. This experiment was repeated with different levels of carbon dioxide and temperatures for five other plants. They had also designed a model based on energy balance in leave to simulate their reaction. The results of these models are fully consistent with the results of the laboratory (Pieruschka et al., 2010). Therefore,these observations ensure that heat control the opening and closing of stomata.

In addition to heat, other factors also influence the opening and closing of stomata. When the photosynthesis is done in the plant, it consumes carbon dioxide and produces oxygen (Figure 3). Sincethere is sun light in the day, ATP production is high and photosynthesis occurs 10 to 20 times more than respiration. In this condition, the plant carbon dioxide amount is reduced and the carbon dioxide balance inside the plant and its surroundings is disturbed. Because of the carbon dioxide imbalance inside and outside the plant, stomata open and as a result of respiration, oxygen is received by the leaves and CO2 produced. In this way, the amount of plant carbon dioxideis balanced. So the leaves stomata are open in a day. But when there is no sunlight, the plant can’t produce ATP and reduced amount of photosynthesis to respiration.

Thus, the production and consumption of carbon dioxide in plant are balanced and leaves stomata are approximately closed. So light is another factor in opening and closing of stomata.

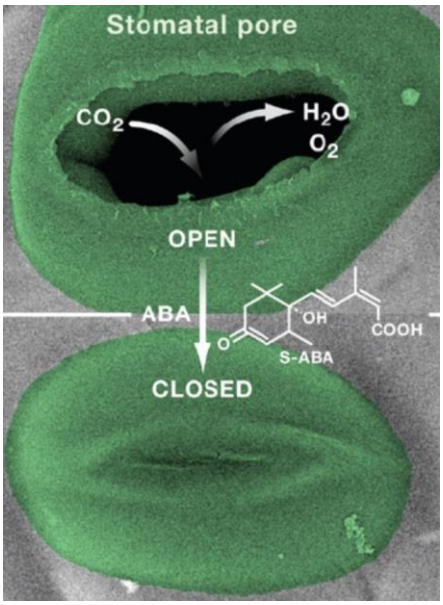


**Figure 3.** Photosynthesis and respiration of leafç

## 3. DISCUSSION AND CONCLUSION

Any substance that is dissolved in water and increased salinity, Depending on the properties of ions can cause damage to plants and the risk of leaf-burningis followed. Therefore, it is necessary to control the amount of ions added to the water and ions concentration amount in the water be measured before irrigation operation and irrigation water quality be specified.

In the condition that saline water with high concentration of chlorine and sodium sheds on the leaves through the stomata of the leaves can be absorbed and cause burning. Most fruit trees such as grape and pistachio and ornamental plants are sensitive to chlorine and when leaf chlorine concentration reached0/5 percent of dry matter, leaves blight symptoms develop (Tisdale & Nelson,1993).

It is obvious that more intensifier factors of the dissolved ions absorption through the leaves, more extreme leaf-burningand ultimately it will lead to the reduction in crop performance. In general, factors that extreme the absorption of sodium and chlorine through the leaves can be stated as follows:

1) Leaf stomata opening
2) High concentration of thedissolved ions in the water
3) High temperature of the ambient
4) Low relative humidity of the ambient
5) Wind at the time of irrigation

It is quite clear that to reduce burning the plant leaves, remove one or more of the above is very effective. But some of them cannot be removed in any way. For example, in areas with hot and dry climate, control temperature and relative humidity are not possible or in a situation where water resource has poor quality, control of water dissolved ions concentration is out of power. However, these terms are improvable through applying the management practices. Since the main purpose of this paper is to examine the management practices of sprinkle irrigation

systems in hot and dry climate and saline water, Managerial procedures to cover this issue are as follows:

1) Irrigation provided that water temperature rate is low.
2) Irrigation provided that the relative air humidity is high.
3) Irrigation in no wind condition (to prevent evaporation)
4) Irrigation when the leaf stomata are closed (to reduce the dissolved ions absorption).
5) Increasing the irrigation shift and reduce irrigation count.
6) Use small garden sprinklers that only the lower part of plants are wet.
7) Increasing the discharge of sprinklers to wash leaves area and create large droplets of water to reduce the amount of the dissolved ions absorption.

As mentioned, the absorption of sodium and chlorine through leaf stomata in sprinkler irrigation is one of the main causes of leaf-burning. In other words, if the sprinkler irrigation be done in a condition that the stomata in plant are closed, leaf-burningwill be under control remarkably. Research also has shown that the light and heat are the main causes of stomata opening and at night when there is almost no light and the heat is less rather than the day, the stomata are almost closed. So if irrigation is done at night, due to stomata closure and lack of chlorine and sodium absorption, leaf-burningwill be under control significantly. On the other hand, wind causes to increase the evaporation and concentration of the dissolved ions in sprinkler irrigation and is also one of stomata opening factors. Therefore, if nightly irrigation be done in no wind condition, it still has a positive effect in controlling the leaf.

As mentioned in the introduction, one of Qom province farms despite the poor quality of water, use sprinkler irrigation system for several years with optimum crops performance are in operation. The reason is that the above-mentioned measures has been done on this farm and achieved amazing results.

The above-mentioned farm with an area of 80 acres is located in the southwestern of Qom province in 51/04 degrees longitude and 34/47 degrees latitude. The main cultivation of this farm is alfalfa and barley and water source is a well. Based on a qualitative analysis of well water (test results, 2012), the amount of water chlorine is 36 meq/lit and sodium 27 meq/lit that the results are presented in Table (1).

**Table 1.** Results of water quality test of mentionedwell.

| The limitation degree According to FAO | Unit | amount | Parameter |
|---|---|---|---|
| appropriate | - | 6/6 | pH |
| High limitation | ds/m | 4/3 | EC |
| High limitation | meq/lit | 36 | Chlorine |
| appropriate | meq/lit | 0/5 | Bicarbonate |
| - | meq/lit | 7/5 | Sulfate |
| High limitation | meq/lit | 18 | Calcium and magnesium |
| High limitation | meq/lit | 27 | Sodium |
| - | - | 9 | SAR |

42 acres of above land is covered by sprinkler irrigation system While 25acres of that farm is irrigated by Wheel Move irrigation systems and the other 17acres by Permanent irrigation systems. In almost all near farms, sprinkler irrigation failed due to water salinity, and only in this farm, this system has been in operation successfully more than 10years. The main reason of this success is due to nightly irrigation and in no wind condition. The farmer has found it

through experience and put it in action. In Figure (4), satellite image of the farm (by Google Earth) and in figure (5) images of farm cultivation can be seen.

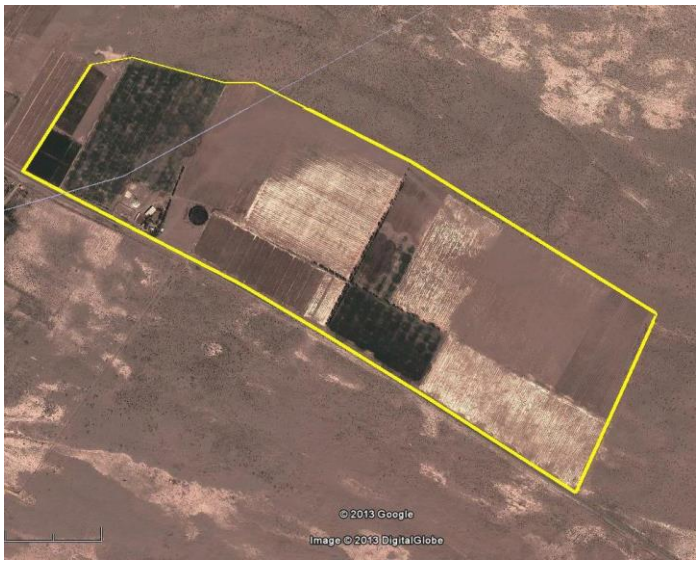


**Figure 4.** Satellite image of mentioned farm (by Google Earth).

**Figure 5.** Alfalfa and barley cultivation of mentioned farm.

## 4. CONCLUSION

1) One of the best parts of the leaf are stomata that play a major role in the leaf photosynthesis rate, absorption of thedissolved ions and food through leaf.
2) Light, heat and humidity levels are key causes of the opening and closing of stomata.
3) At night, because of almost no light and less heat rather than the day, most of stomata are closed.
4) In condition of using sprinkler irrigation with saline water, due to the physiological requirements of plants, nightly irrigation can be very effective in reducing the impact of plants leaf-burning.

5) Wind causes water evaporation and increased concentration ofthe dissolved ions and on the other hand, due to air movement and reduced humidity around the leaves has a direct effect on stomata opening. Therefore, nightly irrigation in no wind condition will help to the success of the operation of sprinkler irrigation remarkably.

## REFERENCES

[1] GalstonA. W., Davies P. J., Satter R. L. (1980),"The life of the green plant",Edition 3, ISBN-13: 978-0135363188, PublisherBenjamin Cummings.
[2] Pieruschka, R., Huber, G., Berry, J. A.(2010),"Control of transpiration by radiation", Proceedings of the National Academy of Sciences, 107 (30), pp 372-377.
[3] Tisdale S. L., Nelson W. L.(1993),"Soil fertility and fertilizers", Edition 5, ISBN 0024208353. 9780024208354, Publisher Macmillan, Michigan.
[4] Quality test results of well water sample (2012), Fadak specialized laboratory, Iran, Qom.