WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

Journal of Food, Agriculture & Environment Vol.7 (2) : 646-650. 2009 *www.world-food.net*

Optimal application of irrigation water with drip-tape method for Pashmineh Zar croplands, Andimeshk, Southwest Iran

Abdul Amir Moezzi [1], Kazem Torfi [2], Mohammad Albaji [3]* and Arash Mahjoobi [3]

[1] Department of Soil Science, Faculty of Agriculture, Shahid Chamran University, Ahwaz, Iran. [2] KWPA, Ahwaz,Iran.
[3] Department of Irrigation and Drainage, Faculty of Water Science, Shahid Chamran University, Ahwaz, Iran.
**e-mail: m_albaji2000@yahoo.co.uk*

Received 7 January 2009, accepted 15 April 2009.

Abstract

A new generation of drip irrigation pipes was innovated a few years ago that revolutionized the pressurized irrigation technology and was known later as Drip Tape Irrigation Technique. The manufacturing of these pipes began in Iran in 1997 by Super Drip International Co. Of the successful irrigation projects executed in Khuzestan Province, southwest Iran, using drip tape method was the Pashmineh Zar project in the city of Andimeshk with an area of 50 ha. The method has numerous advantages including high efficiency (almost 90%), lower performance pressure, lacking of need for ground leveling, light weight, ease of transportation and installation and lower cost as compared with classical drip systems. Regarding the studies carried out on the pressurized irrigation systems in Khuzestan province, the drip tape irrigation scheme in Pashmineh Zar area can be considered as a successful project in encouraging farmers to use the system. The success of this scheme can be attributed to the followings: 1) selection of the suitable location in terms of slope, climate, soil texture and structure, high soil permeability, soil fertility and high quality water in the region, 2) using local labor force, especially women, 3) experienced operating company in pressurized irrigation field, 4) using standard equipment, 5) using developed storage and nursery systems, 6) applying appropriate managerial practices in operating the scheme and 7) efficient marketing in exporting of the produced crops. Totally, in the drip tape system the water use efficiency (WUE) is significantly higher in comparison to the surface irrigation method so that the WUE of 2.7 kg per cubic meter for the lettuce in surface method was raised to 7.3 kg per cubic meter by drip tape method. Also, the uniformity of the water distribution along the lateral pipes with 150 m long was almost 98%. The conclusions of this study point to the fact that the ultimate success of the Pashmineh Zar project can be related to the effective operational management which is the missing part in most of the pressurized irrigation schemes and has been neglected by solely focusing on the ending of the project and not achieving the set operational purposes. It is thus recommended that, firstly, the current potentials in the Khuzestan province for the execution of pressurized irrigation systems be identified through comprehensive research projects and, secondly, the operational management of the irrigation schemes in the area be conducted by a highly effective managerial crew in order to reduce the operational problems of the installed systems, raise the total performance efficiency and cope with the current water crisis in the region.

Key words: Khuzestan, water crisis, water use efficiency, tape drip irrigation.

Introduction

Numerous studies have been conducted about the efficiency of the current surface and traditional irrigation systems with a strong indication of low efficiency in the networks. Fatemi *et al.* [5] reported the total irrigation efficiency of the integrative and non-integrative lands of the Dez Network in Khuzestan province as of 31.7 and 21%, respectively. Shamaee *et al.* [14] studied the water application efficiency in sugarbeet and potato croplands in Chahar Mahal Bakhtiari province which was between a minimum of 25.8% and a maximum of 43.2%. Pourzand [12] reported the irrigation application efficiency in the Ghazvin Plain croplands as of 57%. Mir Abul-Ghasemi [10] suggested that the water application efficiency in traditional irrigation networks in south Ahwaz is between 45 and 60% and the total efficiency as 13.5 to 22% indicating that the most losses would occur in water transmission arrangements.

Also different studies have been made regarding the pressurized irrigation practice. Keshavarz [8] critiqued the current irrigation systems in Iran and concluded that none of them are now functioning within limits set out by their original design efficiencies [1]. Salamat Manesh [13] studied 5 drip irrigation systems in Semnan province in Iran and reported the average efficiency of them as to be ranging from 57.2 to 81.7%. Keller and Merriam [7] have compiled the results of their collaborative researches for several years in the field of pressurized irrigation systems in which they recorded various problems with the pressurized irrigation schemes worldwide. For example, in Antalya, Turkey, 9 typical drip irrigation systems were evaluated showing that some of them had been maldesigned and, as a result, the filters were not performing well, the drippers were blocked and the arrangements were faulty. Mostafazadeh *et al.* [11] measured the average actual water efficiency in low quarter for evaluation of the drip irrigation systems in Isfahan province as 37% suggesting the problems as being results of failure of the treatment system, high sensitivity of the system to the obturation of the long path drippers, high manufacturing coefficient of variations and low distribution

uniformity of drippers and wide-range discharge variations with pressure in compensating emitters.

In his research on drip gravity irrigation method, Ahmadi [2] found that the performance of this technique is based upon minimization of pressure required by the drippers and suggested that with appropriate design and execution of the system, the overall efficiency of this method can be enhanced to 85%. Jahan Nama [6] drew the following conclusions: a) personal characteristics such as age, work experience, education, social awareness, financial status, social connections especially with the facilitators are influential in acceptance or refusal of the pressurized irrigation systems, b) the state and associated problems of the users were investigated. The results implied that the dissatisfaction of the users were caused by loading process, the performance of the designing companies and contractors as well as the quality of the equipment used which generally lead to strong refusal of the users against the pressurized irrigation systems.

Ataee [4] investigated several pressurized irrigation systems in Isfahan province and suggested that the potential irrigation efficiencies of the sprinkle and drip irrigation methods were 18-70% and 28-62%, respectively, while the average actual application efficiencies were 51 and 37%, respectively. Akbari *et al.* [3] reported the average performance efficiency in pressurized irrigation systems in the Isfahan province as being 50%.

The restricted water resources across Iran and the subsequent intensification because of the persistent drought events and the ever-increasing demands in various sectors including agriculture has caused the officials to opt for a maximized utilization of the available water resources and raise the performance efficiency levels and, consequently, the production per unit area. In doing so, several huge investment projects including the construction of 14 dams upon different rivers in the region have been executed in the Khuzestan province while 6 dams are under construction and 3 others are under study in this province. Also, 12 irrigation networks have been built while other 13 projects are under construction totally covering an area of 799,045 ha [15].

Thus, facilitating the improvement of the water consumption management and efficiency by modifying or optimizing the irrigation networks as well as encouraging the local farmers to participate in optimal operational management practices can play a significant role in the development of the region. It is therefore imperative that taking into consideration the increasing growth of population and steady water resources in the area the current traditional irrigation systems be replaced with high-efficiency modern techniques in order to be able to meet the ultimate food requirements in the future. One of the pressurized irrigation systems with various technical, executive and operational functionalities is the drip tape system. The present paper is aimed at giving a thorough introduction to this method through elucidating of different aspects of the Pashmineh Zar project in the city of Andimeshk, southwest Iran.

Materials and Methods

This research was carried out in two stages. During the first stage a survey covering 5 areas with 81 questions was conducted in order to identifying and evaluating the pressurized irrigation systems in the Khuzestan province. The questionnaires were completed by the operators. The main areas under question included: a) project characteristics, b) operators characteristics, c) system costs, d) cropping characteristics and e) constraints and problems of the systems. As the result of the first stage the drip-tape irrigation scheme of Pashmineh Zar was selected as the model project across the Khuzestan. During the second stage this system was evaluated and the reasons for its success were explained.

Description of Drip-Tape Irrigation System

A new generation of drip irrigation pipes was manufactured in the United States of America in 1986 which revolutionized the pressurized irrigation schemes across the world. The new pipes were known later as drip-tape irrigation. The tapes were first applied in Hawaii islands to mitigate the impacts of water scarcity on the sugarcane croplands in the region. Currently, almost 87,000 ha of sugarcane, 20,000 ha of pineapple, 6000 ha of peanuts and 3000 ha of croplands are being irrigated by this method.

The new tapes were first generated in Iran by Kish Super Drip International Co. [9] and applied on small-scale projects in suburbs of Tehran and greenhouse crops. This method has been extensively in use recently, as the benefits of the method were more experienced by the consumers across the country.

Design and performance of the drip tapes: The tape is consisted of a tape-like pipe with self-mounted drippers, is easy to install and of high total efficacy. The design of the tape includes a main water pipe (1) and water outlets (orifices) (2) spaced at specific intervals. The water is directed in the zigzag lateral pipe (3) provided to lower the outflow pressure. After flowing through the pipe, water drips in form of free drops (4). As seen from Fig. 1, the pipe outlets act wholly as a screen that prevents the possible suspended particle in the inflow to the zigzag lateral pipe. Thus, in practice, each dripper has a separate filter and a pressure lowering pipe that acts independently, and its discharge is set within a defined range of pressure values. In developing tapes, a mix of plastic materials is used that is adequately resistant against ultraviolet radiations, temperature variations, deterioration and pesticides.

Figure 1. A portion of the drip-tape irrigation systems.

Advantages of drip-tape irrigation: 1) It is light weighted and easy to transport. 2) Tapes can be installed without a need for ground leveling and extensively across croplands even at the same time of sowing (by tractor). 3) The tapes are still efficient with a low pressure and can transmit water to the plant gravitationally. 4). The installation of tape pipe is easier and quicker in comparison to that of the classical drip systems as it does not need any specialized staff to do the job. 5) The tape pipe can be buried underground and since the surrounding soil is usually unsaturated the aeration of the roots takes place smoothly, also, the wind effect on the efficiency of the system is negligible and thus less amount of water is evaporated. 6) Irrigation efficiency can be improved to 95%. 7) Due to the water saving in the tape system, the area of the cultivated land in unit area is increased

and thus the investment in the crop production is more profitable. 8) Since in tape system as compared to other classical systems lower moisture rate occurs over the cropland the generation of fungus and bacteria is extensively prevented. 9) By using tape system chemical fertilizers soluble nutrients and even systematic toxins can reach directly to the plant roots and thus a great amount of them can be saved. 10) In the tape system only a part of the ground is irrigated and thus fewer weeds grow in the field and are easier to control. 11) Since the irrigation frequency is short in this system, using saline water does not make any major problems. 12) This system is compatible to various types of crops including industrial plants, summer crops, melon grounds, vegetables, grains, citrus, vines, tea, forestry, greenhouse crops and landscapes. 13) Reduction of water evaporation from soil surface. 14) Reduction of pests and diseases. 15) Reduction of drainage problems. 16) Tapes can be collected at the end of sowing season by a special collecting tool and preserved for the next season and thus they do not interrupt the plowing and sowing activities.

Technical specifications of the tapes: The water pressure drop is low in tapes and the inflow of the drippers can be regulated by modifying the pressure applied. Tapes can be installed on leveled grounds with a 2% slope up to 150 m of length, and thus the pressure loss is negligible and the discharge difference of the first and the last drippers is less than 10%. On the slopes more than 4%, the tape should be installed vertical to the ground slope. If the slope is less than 2%, the water distribution uniformity in the tape will amount to 98%. The radius of the moisture bulb by each dripper of the tape pipe in the medium soil is 35 cm and the lighter the soil texture, the narrower the radius and vice versa.

Over a length of 150 m and in the medium soil a wet tape of 70 cm width along with the tape pipe is laid. This system, alike other pressurized systems, is operated within a defined range of working pressure, however, since the tape pipes require a low pressure rate (between 0.3 and 1.3 bar), there is no need for using high-pressure pumps which reduces the initial investment costs to large extent. Since the water required in the agricultural section is supplied by different water resources, the consumed water is of varying qualities and thus utilization of a suitable filterization system is integral in this system. Considering the quantity and quality of the irrigation water, appropriate filters including silicone, media filters, screen filters or disc filters, fertilizer tank and dissolved toxins should be used in the system (Table 1).

Table 1. The technical specifications of the tapes.

Max operating pressure : 4 bar	Outlets spacing :20 or 30 cm
Pipe length: 150 (m)	Internal Diameter : 16.5 (mm)
Reel Length : 1000 (m)	Wall thickness : 0.25 (mm)
Reel weight : 14.5-15 kg	1 (m) pipe weight : 14.5-15 g/m
Pipe type : PVC	Working pressure : 0.3-1.3 bar

Requirements for optimal use of the drip-tape system during its operation: 1) The system pressure should be within an allowed range of 0.3 to 1.3 bars. 2) The end of the laterals should be opened and cleaned before operation. This should be repeated once in two weeks. 3) During the irrigation period, the filtration system should be checked once in two days to ensure the physical status of silicone, media, screen and disc filters. 4) In case of any need to use fertilizers, the fertilizer tank should be cleaned by water by its end valve before the fertilization starts. 5) In case of using different kinds of fertilizers, each should be resolved individually and separately and then added to the fertilizers tank. 6) No phosphorus fertilizer or phosphorus-carrying toxin should be used into the fertilizer tank. 7) The tank should be discharged and cleaned after fertilization and then irrigation should be carried out. 8) After the irrigation is over and at the same time with crop harvest, the tapes should be collected by the collector (Fig. 2) and then cleaned and stored in an appropriate place accordingly.

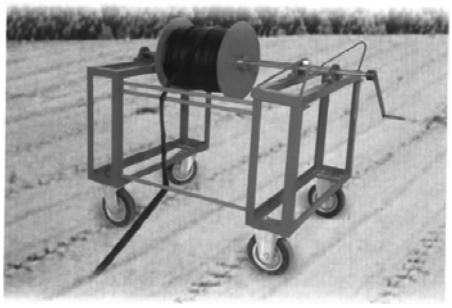

Figure 2. Drip-tape collector device.

Drip-Tape Irrigation System of the Pashmineh Zar, Andimeshk

This scheme which was initiated over an area of 50 ha of Pashmineh Zar region, Andimeshk, Khuzestan province, and finally operated in August 2003, has been considered as one of the pioneering projects in initiation and development of pressurized irrigation systems, especially drip irrigation, in the region. Fig. 3 shows photos of the drip-tape irrigation system in the Pashmineh Zar field.

The operator of this project was Tehran Vahdat Company, one of the leading, experienced companies in the field of pressurized irrigation systems in the country. In order to execute the tape-drip irrigation system in the region, this company rented a fertile area of 50 ha of Pashmineh Zar region for 5 years. The soil texture of this area is medium (loamy), which is capable of growing various plant species. This project is in its first year, however, considering the high yields to date it can be concluded that the soil of the region is of a high quality.

In order to pump water into the system, a diesel motor pump was used that pumps water directly from a water well into the system with a discharge of 45 litres/s. Then the water flows into the silicone filter and the sand and gravel particles are taken away. The water then passes through the injection system of fertilizers and resolved toxins and the disk filter. It flows into the main pipe and then branched at the beginning of each sub unit by a 2-inch diameter pipe from which the tapes stem from and go along plant rows.

In this project, in order to pre-maturing the crop to start early marketing of the yields, 5 nursery places with plastic covers of 8 m x 100 m were prepared in such that the seeds of different crops (alternate cropping) were planted in special boxes or small furrows in the greenhouse and after one or two months, depending on the crop species, were moved into an open place and placed near to the tape drippers at the intervals of 20 or 30 cm. The advantages of this method are as the following: 1) Since the required spacing is met in sowing the related costs are reduced substantially. 2) Savings can be made in the use of crop seeds. 3) Since the plants are past the germination stage they are more resistant and the plant losses are less and few repeats are required. 4) In this method

Figure 3. Photos of the drip-tape irrigation system in the Pashmineh Zar field.

the crop outgrows the weeds and thus the crop yields increase as the weeds are less than in other methods. 5) In this method the crop yields are marketed earlier and thus they are sold at a higher price.

After sowing, the irrigation is conducted in such way that the irrigation frequency varies from 1 to 3 days each time of 1.5 hours in each sub unit. Due to the fact that the plant root zone is always in the state of retention capacity, the plant is not affected by the water stress and thus the plant growth conditions are optimal which result in a considerably higher yield. Also, since the plant foot never is submerged and the cropping occurs in a moderate temperature season, the produced plants are attractive in form and are economically exportable. It should be noted that the economic profits obtained from exporting produced crops is satisfying to the operator of the irrigation system in such that he only cultivates the fields for half of the year.

The length of the tapes in each plot does not exceed 150 m and after the tests it was observed that the length of tapes had a distribution uniformity of 98%. In this research the WUE as to the lettuce crop was studied and compared by the adjacent surface irrigation system in such that the WUE for lettuce in surface irrigation scheme was 2.7 kg per cubic meter while it was 7.3 kg per cubic meter in tape drip irrigation method for the same crop.

The ground water quality in this project was excellent in such that it poses no limitation to the plants, drippers and filters (EC <0.5 dS/m). The labor force in this project was mainly consisted of local women and considering the fact it is usually cheap (2$ a day) thus the labor cost was considerably reduced.

Conclusions

Considering the results of evaluation of the project, it can be set as a successful model project in using pressurized irrigation systems in Khuzestan. The success of the project can be attributed to the followings: 1) Suitable location rented by the operator since the area has a mild topography; and since the area has been under surface irrigation in the past, it has been leveled and thus distribution uniformity is achieved. The area has mild fall and winter seasons, therefore the need for evaporation requirement and also plant water requirements are low and savings are made to the daily water consumption. The soil texture of the area is medium (loamy) and is suitable for growing most of the crop productions, and also since the infiltration rate of soil is high, no run-off is formed and the moisture bulb is symmetrical and thus root ventilation and development are acceptable. Due to the traditional cropping has been dominant in the region, the field soil is almost deep and fertile. The quality of the sub-surface water is exceptional and can be used even as drinking water, so that the clogging of the drippers or salinity does not occur and this enhances the crop production ultimately. It also eliminates the need for filtration system, which results in cost reduction in this respect. The selection of the project location based on the initial technical studies has been appropriate, and this in its turn created a better understanding of the purposes of this project during design, execution and operation stages. 2) Enhancement of the water distribution uniformity efficiency and water consumption efficiency as compared to the surface irrigation systems. 3) Using local labor force with low cost and economic cost-effectiveness. 4) The experienced operator: since the Vahdat Company had implemented both successful and unsuccessful similar projects in other parts of Iran, it had the necessary knowledge of the strengths and weaknesses of the system, which resulted in an optimal operation of the system. 5) Using standard equipment in the system, which resulted in the enhanced operational efficacy. 6) Appropriate management of the system during operation: the supervision of the operation of this project has been conducted by an experienced agricultural expert who along with his regular site inspections taught the laborer to implement the cropping and irrigation operation in the study area carefully and to ultimately increase the efficiency of the project. 7) Using the greenhouse as the nursery: this caused pre-maturing of the crop yields and thus

an early marketing of it, reduction in seed use, avoidance of thinly scattering and repetition, and the growth of weeds and increase of crop quality that enhances the profits in short term. 8) Marketing to export yields: considering the high quality of the crop produced, packaging and marketing in the Middle East countries much production by this system are exported which increases economic profits. 9) Due to the fact that this system requires a low energy between 0.3 and 1.0 bars, there is no need for a separate pumping system and the required pressure is supplied by the well pump and savings are made in terms of energy consumption. 10) Since all the stages of the project implementation including design, execution and operation were carried out by the private sector; the purpose has been to generate the maximum revenues through high efficiency of the system. 11) No use of the bank loans i) facilitated the implementation and operation of this project and ii) the contractor was aware of the value of the investments made and attempted to obtain the highest efficiency in this respect. 12) Since this system is a low-cost system compared to other irrigation drip systems and is easy to install and operate, the typical financial and technical problems faced in other projects are minimized. 13) Since the security of the facilities was provided by some locals in the area, the system was not damaged by robberies or criminal acts.

Finally, with the aim of identifying potentials for implementation of pressurized irrigation systems in Khuzestan province, it is recommended that similar schemes only will be performed in areas with suitable conditions to secure the profitability of the projects. Also, appropriate and efficient management of the project, as in the Pashmineh Zar project, plays a significant role in the enhancement of the system efficiency and savings in the water consumption.

Acknowledgements

The authors should gratefully acknowledge the Research and Standards Office for Irrigation and Drainage Networks of Khuzestan Water and Power Authority (KWPA) for their financial support and assistance during the study and field visits.

References

[1]AB Varzan Consulting Engineering Co (AVCE) 2000. The Report of Investigation of Irrigation Methods in Khuzestan Province. KWPA, Ahwaz, Iran.

[2]Ahmadi, R. 1998. Gravity drip irrigation. Proceeding of the Ninth Iranian National Conference on Irrigation and Drainage Networks, Iran.

[3]Akbari, M. and Kochak Zadeh, M. 2000. Investigation of pressurized irrigation systems in Isfahan Province. Proceeding of the Tenth Iranian National Conference on Irrigation and Drainage Networks, Iran.

[4]Attaee, M. 1997. Evaluation and Investigation Pressurized Irrigation Systems in Isfahan Province. MSc. thesis, Isfahan Industrial University, Isfahan, Iran.

[5]Fatemi, M., Shokrolahi, A. and Shiravi, M.G. 1994. The effectiveness of integrative and non-integrative lands of the Dez Irrigation Networks. Proceeding of the Seventh Seminar of Iranian National Committee on Irrigation and Drainage, Iran.

[6]Jahan Nama, F. 2001. Investigation in Effective Economical and Social Problems for Accepting or Refusing Pressurized Irrigation in Tehran. The Economical Investigation Office for Agricultural Researches Projects, Ministry of Agriculture, Tehran, Iran.

[7]Keller, J. 1979. National Engineering Handbook. Section 15, Chap. 7. Soil Conservation Service (SCS), USA.

[8]Keshavarz, A. 2000. Evaluation of the Pressurized Irrigation Systems in Iran. MSc. thesis, College of Agriculture, Tehran University, Tehran, Iran.

[9]Kish Super Drip International Co (SDI) 1997. Technical Manual of Drip Irrigation Systems. Tehran, Iran.

[10]Mir Abul-Ghasemi, H. 1994. Evaluation of irrigation application efficiency in traditional irrigation networks in Iran. Proceeding of the Seventh Seminar of Iranian National Committee on Irrigation and Drainage, Iran.

[11]Mostafazadeh, B.1998. Evaluation of the drip irrigation systems in Isfahan Province. Proceeding of the Ninth Iranian National Conference on Irrigation and Drainage Networks, Iran.

[12]Pourzand, A.1994. A case study of Ghazvin Irrigation and Drainage Networks designing. Proceeding of the Seventh Seminar of Iranian National Committee on Irrigation and Drainage, Iran.

[13]Salamat Manesh, G. 2001. Study and Evaluation of Drip Irrigation Systems in Semnan Province. MSc. thesis, College of Agriculture, Tehran University, Tehran, Iran.

[14]Shamaee, G., Mossavi, B. and Mostafa Zadeh, F. 1996. Evaluation of water application efficiencies in Chahar Mahal Bakhtiari Province. Proceeding of the Eighths Seminar of Iranian National Committee on Irrigation and Drainage, Iran.

[15]The Water Planning Office 2003. Khuzestan Water and Power Authority (KWPA). Ahwaz, Iran.