Hydraulic calculation lateral in drip irrigation

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Hydraulic calculation lateral in drip irrigation

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Abstract. Drip irrigation systems are widely used worldwide to satisfy the water demand of agricultural crops. It is known that drip irrigation technology has a number of other advantages, such as intensive irrigation, automation, and water economical benefits. The methods which is available in hydraulics are widely used in the calculation of drip irrigation design. One of the most important issues in the drip irrigation system is the correct estimation of the discharge coming out of the drippers. As known from hydraulic calculations, it is necessary to take into account the pressure when determining the discharge coming out of the emitters. It should also be noted that discharge from emitters has a special effect on pressure losses in drip irrigation systems. The article presents the results of the research conducted in natural field conditions on the assessment of hydraulic processes in drip irrigation systems. As an object of research, the cultivated field of the "Sharifjan oglu Akhmadjon" farm in Rishton district, Fergana region was selected. The results of measurement work at 36 points of the research object are highlighted. As a result of the conducted research, recommendations for determining discharge in irrigation pipes were developed.

1. Introduction

Drip irrigation system is one of the resource-efficient technologies [1,2]. Globally, special attention has been paid to this area. Drip irrigation systems are distinguished by their water efficiency, uniform wetting of the soil, convenience in distributing mineral fertilizers to cultivated fields [3,4]. When designing drip irrigation systems, it is necessary to take into account the water demand of the plant. It will be necessary to provide the necessary moisture to the soil in a certain period of time. Provide enough moisture belong to the different factors, as a soil moisture before irrigation, mechanical composition, air temperature [5,6]. During the summer months, the amount of evapotranspiration from the soil and plants increases dramatically as a result of a sharp increase in air temperature. Increased evapotranspiration causes a decrease in soil moisture. As a result, it will be necessary to launch irrigation works at short intervals. Intensive irrigation should be carried out especially in June and July of the summer season [7,8]. In the design process, the irrigation time is calculated in order to ensure soil moisture. The duration of watering should not exceed 8 hours. If the duration of irrigation exceeds 8 hours, a certain part of the amount of water falling from drip irrigation systems is spent on evaporation. Consolidation of soil moisture contours takes a long time. As a result, the amount of electricity consumed by the pump increases and the economic efficiency decreases. Discharge in drip irrigation systems depends on the pressure in the pipes. It is necessary to ensure the necessary effort in ensuring discharge [9,10]. The

pressure in irrigation pipes of irrigation systems is designed at a value of 100 kPa. The value of water consumption under the influence of pressure of 1 Bar in any irrigation pipes has been developed. During irrigation, it is necessary to maintain the pressure in the irrigation pipes at a value not less than 1 Bar. If the pressure value in the irrigation pipes is less than 1 Bar, it leads to a decrease in the discharge coming out of the emitters. Discharge of drippers was determined by manufacturers in laboratory conditions and recommendations were developed [11,12]. Water consumption data of drippers are determined only at a certain pressure, mostly 1 Bar value. But it is not detected at values smaller than 1 Bar.

2. Methods

When justifying the design parameters of drip irrigation systems, first of all, it is necessary to perform hydraulic calculations and take into account the results of calculations. According to the results of hydraulic calculation, issues such as pipe sizes of drip irrigation systems, selection of pumps taking into account pressure losses, and uniform distribution of discharge are solved [13,14,15]. Until now, a number of scientific studies have been conducted by researchers on the application of drip irrigation systems in irrigated fields [16,17,18]. As a result of the conducted scientific research, taking into account the type of crop, planting scheme, different climatic conditions of regions, and water-physical properties, certain positive results were achieved and scientifically based recommendations were developed in solving issues such as irrigation rate, number of irrigations, irrigation periods in drip irrigation systems [19 ,20]. But today, regardless of the scientific research conducted in these areas and the achieved results, the hydraulic processes in dripline is not enough information, because of differences the length of the pipe, the local resistances that appear in the drippers, and the method of calculating the pressure losses, taking into account the variability of discharge, have not been sufficiently studied.

In order to study hydraulic processes in drip irrigation systems on July 15-22, Rishton district of Fergana region was visited. Researches were conducted in the cultivated fields of "Sharifjon oglu Akhmadjon" farm, where drip irrigation systems were used. The total area of "Sharifjon oglu Akhmadjon" farm is 50 hectares, of which 34 hectares are planted with cotton and 16 hectares with wheat. Drip irrigation systems were applied to 24 ha. An area of 3 ha. was selected as a research object (Fig. 1). The size of the cultivated area is 180x170 m.

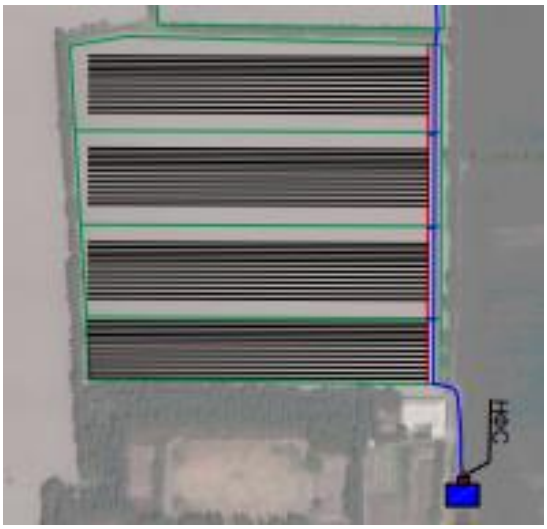

Figure 1. Space image of the research object

During the research, hydraulic processes in irrigation systems were analyzed. Pressure loss along the length of the pipe and discharge falling from the drippers were studied. During the research, measurements were made at 36 points in the drip irrigation emitters. Discharge was determined by the

volumetric method (formula 1), and the pressure in the pipes was determined using a manometer (Fig. 2). Determined results were analytically analyzed by the method of mathematical statistics.

$$q = \frac{W}{t}; (1)$$

where: q-discharge coming out from dripper, W - water volume in the tank, t - time which spent to fill tank.

Figure 2. Measuring works and devices

3. Results and discussion

In order to study the hydraulic processes in drip irrigation systems, according to the researches carried out in natural field conditions, it was found that the consumption of water falling from the drippers of the irrigation pipes depends on the pressure. Research work was carried out in the values of pressure in irrigation pipes from 0.3 Bar to 1.53 Bar. The research object was divided into 4 fields. Data were analyzed separately in each field. In the first field of the research facility, discharge was determined at pressure values from 1.53 Bar to 1 Bar. According to the results of the research, it was determined that discharge in the first field varies from 1.58 l/h at 1 Bar to 1.75 l/h at 1.53 Bar (Table 1).

Table 1. Results of hydraulic studies

No	p, Bar	W, cm^3/s	t, minute	q, l/h
1	1.53	250	8.55	1.75
2	1.45	220	7.67	1.72
3	1.3	240	8.45	1.70
4	1.27	270	9.81	1.65
5	1.25	290	10.69	1.63
6	1.24	235	8.7	1.62
7	1.2	285	10.61	1.61
8	1.1	255	9.56	1.60
9	1	240	9.1	1.58

A number of measurements were also carried out in the second field of the research object. During the measurements, discharge was determined at pressure values from 0.86 Bar to 0.3 Bar. According to the results of the research, it was determined that discharge in the first field varies from 1.10 l/h at 0.86 Bar to 0.59 l/h at 0.3 Bar (Table 2).

Table 2. Results of hydraulic studies

No	p, Bar	W, cm^3/s	t, minute	q, l/h
1	0.86	220	12.05	1.10
2	0.78	180	10.8	1.00

3	0.75	140	8.84	0.95
4	0.71	125	8.33	0.90
5	0.6 7	185	12.61	0.88
6	0.6 6	210	14.82	0.85
7	0.52	205	14.81	0, 72
8	0.4 0	83	6.07	0.65 _
9	0.3 0	258	20.64	0.59 _

A number of measurement works were also carried out in the third field of the research object. During the measurements, discharge was determined at pressure values from 0.65 Bar to 0.3 Bar. According to the results of the research, it was determined that discharge in the first field varies from 0.85 l/h at 0.65 Bar to 0.56 l/h at 0.3 Bar (Table 3).

Table 3. Results of hydraulic studies

No	p, Bar	W, cm^3/s	t, minute	q, l/h
1	0.65	200	14,12	0.85
2	0.61	195	14.44	0.81
3	0.57	178	13.69	0.78
4	0.48	150	12.68	0.71
5	0.45	195	17.46	0.67
6	0.44	185	17.9	0.62
7	0.41	136	14.46	0.56
8	0.35	118	12.44	0.57
9	0.30	182	19.46	0.56

A number of measurement works were also carried out in the fourth field of the research object. During the measurements, discharge was determined at pressure values from 0.98 Bar to 0.66 Bar. According to the results of the research, it was determined that the discharge in the first field changed from 1.23 l/h at 0.98 Bar to 0.96 l/h at 0.66 Bar (Table 4).

Table 4. Results of hydraulic studies

No	P	W	t	Q
1	0.98	172	8.42	1.23
2	0.91	180	9.18	1.18
3	0.89	140	7.26	1.16
4	0.85	125	6.69	1.12
5	0.84	185	10.28	1.08
6	0.83	210	11.77	1.07
7	0.82	205	11.71	1.05
8	0.75	150	8.73	1.03
9	0.66	240	15.06	0.96

The results of the research conducted in order to study the hydraulic processes in drip irrigation systems were summarized. Based on the generalized results, the pressure graph of the discharge falling from the droppers is drawn. The relationship between the discharge and the pressure falling from the drippers in the irrigation pipes was obtained (Fig. 3).

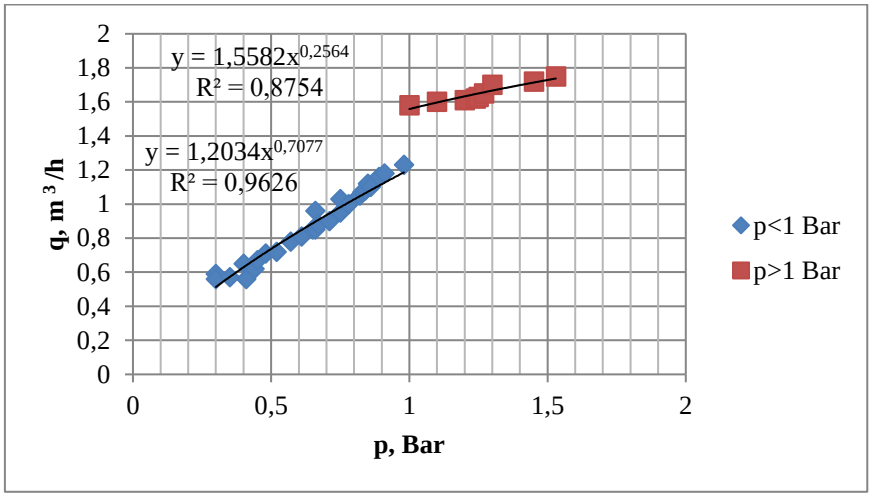

Figure 3. Dependence of discharge and pressure

According to the results of the analysis, it was found that the discharge of the drippers installed in the dripline is up to 1.2 l/h at pressure values up to 1 Bar, and from 1.60 l/h to 1.75 l/h at pressure values above 1 Bar.

It is important to apply the results from reseaarch to the design process drip irrigation. It is known that during the irrigation season, in some cases, it is not possible to create a pressure higher than 1 Bar. In such cases, it is necessary to specify the time required for irrigation. If the discharge of falling from the drippers during irrigation is not taken into account, the possibility of moistening the soil to the required level will decrease. This situation complicates the issue of facing water demand of plants. As a result, the plant does not develop well and productivity will decrease.

1 Bar pressure and a corresponding discharge 1.60 l/h were selected as benchmarks to determine the discharge flowing from the irrigation pipe drippers. Derived from the following link using the benchmark value.

$$\frac{q_i}{q_e} = f\left(\frac{p_i}{p_e}\right) \tag{2}$$

where: q_i - discharge at the dripline emitters, q_e - etalon discharge, r_i -pressure , r_e -etalon pressure.

The results obtained under natural field conditions were calculated using the above equation

$$\frac{q_i}{q_e} = f\left(\frac{p_i}{p_e}\right).$$

The obtained results were analyzed mathematically and statistically, and the following formula was obtained for determining the consumption of water coming out of the droppers.

When the pressure in the irrigation pipe is less than 1 Bar:

$$q_i = 1{,}4304 q_e \left(\frac{p_i}{p_e}\right)^{1{,}3425} \tag{3}$$

When the pressure in the irrigation pipe is higher than 1 Bar:

$$q_i = 0{,}9738 q_e \left(\frac{p_i}{p_e}\right)^{0{,}2564} \tag{4}$$

4. Conclusion

According to the results of the research carried out in natural field conditions, when the pressure value in the irrigation pipes is up to 1 Bar, discharge in the drippers is up to 1.6 l/h, and when it exceeds 1 Bar, it is higher than 1.6 l/h.

A formula was developed for determining discharge in drippers when the pressure in the irrigation pipes is up to 1 Bar and for the process above 1 Bar. With the help of the developed formula, it is possible to determine the water consumption at the desired pressure. This, in turn, makes it possible to organize irrigation correctly, to calculate irrigation time give the amount of moiste of soil, taking into account the amount of pressure, to fully satisfy the plant's demand for water.

References

[1] Arifzhanov AM, Fatkhullaev AM, Samiev LN 2017 *Processes in Uzan and river sediments.* (Tashkent)
[2] Fathulloyev A, et al. 2020 Method designing of open drainages *IOP Conference Series: Materials Science and Engineering* pp 120-9
[3] Abduraimova D, et al. 2021 Methods for determining water flow from rice field to open drainage system *CONMECHYDRO-2021* pp 187-194.
[4] Kurbanov S A, Magomedova D S 2015 Kapelnoe oroshenie-osnova rationalnogo ispolzovaniya vodnyx resursov *Strategicheskoe Razvitie Apk I Selskikh Territoriy Rf V Sovremennyx Mejdunarodnyx Usloviyax* pp 243-248
[5] Kurbanov S A, Mayer A V 2012 Issledovanie sistemy kapelnogo aroshenia s melkodispersnym dodevaniem *Problemy razvitiya APK regiona* **11(3)** 15-19.
[6] Akhmedov A D, Galiullina E Yu 2012 Kontury uvlajneniya pochvy pri kapelnom oroshenii *Izvestia Nizhnevoljskogo agrouniversitetskogo kompleksa: nauka i vysshee professionalnoe obrazovanie* **3** 183-188.
[7] Agrawal N, Singhal S 2015 Smart drip irrigation system using raspberry pi and arduino *International Conference on Computing, Communication & Automation. - IEEE, 2015* pp 928-932.
[8] Kavianand G et al. 2016 Smart drip irrigation system for sustainable agriculture *2016 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR). - IEEE, 2016* pp 19-22.
[9] Jamrey PK, Nigam GK 2018 Performance evaluation of drip irrigation systems *The Pharma Innovation Journal* **7(1)** 346-8
[10] Parthasarathi T et al. 2018 Evaluation of drip irrigation system for water productivity and yield of rice *Agronomy Journal* **110(6)** 2378-89
[11] Divyapriya S et al. 2020 IoT Enabled Drip Irrigation System with Weather Forecasting *2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC). - IEEE , 2020* pp 86-89
[12] Mistry P et al. 2017 Evaluation of drip irrigation system for different operating pressures *International Journal Of Advance Engineering And Research Development* **72(4)** 2348-4470.
[13] Bhamoriya V, Mathew S 2014 An analysis of resource conservation technology: a case of micro-irrigation system (drip irrigation) Final report of Center for Management in Agriculture, Indian Institute of Management, Ahmedabad. - 2014.
[14] Amiri Z et al. 2022 An attempt to find a suitable place for soil moisture sensor in a drip irrigation system *Information Processing in Agriculture* **9(2)** 254-65
[15] Ghosh S et al. 2016 Smart irrigation: A smart drip irrigation system using cloud, android and data mining *2016 IEEE international conference on advances in electronics, communication and computer technology (ICAECCT). - IEEE, 2016* pp 236-239
[16] Anand K et al. 2015 Automatic drip irrigation system using fuzzy logic and mobile technology *2015 IEEE technological innovation in ict for agriculture and rural development (TIAR). - IEEE, 2015* pp 54-58.

[17] Lamm FR, Rogers DH 2017 Longevity and performance of a subsurface drip irrigation system *Transactions of the ASABE* **60(3)** 931-939.
[18] Feng J et al. 2018 Effect of optimization forms of flow path on emitter hydraulic and anti-clogging performance in drip irrigation system *Irrigation science* **36(1)** 37-47.
[19] Muhammad T et al. 2021 Effects of phosphorus-fertigation on emitter clogging in drip irrigation system with saline water *Agricultural Water Management* **243** 106392.
[20] Barman A, Neogi B, Pal S 2020 Solar-powered automated IoT-based drip irrigation system *IoT and Analytics for Agriculture* pp 27-49.