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APPLICATION OF DRIP IRRIGATION IN MOLDAVIA

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ABSTRACT. The specification for an application and the development prospects of drip irrigation in Moldavia are presented in this article. An experimental production system of the drip irrigation of an orchard and its technical and economical indices have been described. Research results on drip- and drip-impulse irrigation of an orchard have been summarized. The irrigation regime for an apple orchard under drip irrigation has been substantiated.

Some experimental data on drip irrigation application of vegetables growing under greenhouse conditions and in open feilds , has been presented. Effects of drip irrigation on some changes in the salt status in soils of heavy mechanical composition and soil-ground in winter greenhouses have been shown.

Soil-climatic conditions in Moldavia determine the specialization of its agricultural production in the field of vinegrowing, horticulture and vegetable raising. There are a combination of factors influencing the climate, which predetermines a considerable variability of weather conditions all through the year and the significant differences over many years. However, the climate in Moldavia, being of a temperature-continental type, is milder and warmer than that of most of the European part of the USSR /Agroklimaticheskii spravochnic po Moldavskoy SSR, 1969/.

The average precipitation data for many years comprises of 427-551 mm. Almost half of it falls from May to August mainly in the form of torrential rains being of short duration. Their distribution over the whole area is very irregular and depends on the region and relief. The south-east and south receives the least rainfall. Often there are dry periods which are usually two to three years out of a decade. The north east territory of the Republic belongs to a region of insufficient rainfalls. The central, and especially the southern parts, are considered arid regions and only the far northern zone receives sufficient rainfall. Thus, under these condititions, intensive agricultural production is possible only with extensive irrigation. The relief of each region and availability of water resources have a considerable effect on the irrigation development and on the choice of irrigation methods.

The relief of Moldavia is very rugged. The land on the slopes under agricultural production comprises of 80 % of the whole area. Moldavia ranks last as to water supplies in the Soviet Union. The complete river run off comprises, on the average for a period of many years, 1.2 km^3 or 0.5 % of the All-Union resources /Alexashenco and Vdovin 1977/. Sprinkler systems covers 96 % of all the land under irrigation.

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Further increases in the areas under irrigation, the growth of water utilization in industry and daily water consumption for the population, results in a deficiency of water resources. Thus, in addition to finding measures of increasing the water supply in the Republic, it is very important to search for new methods of irrigation which contribute to a more rational use of irrigation water.

Under Moldavian conditions the drip irrigation method is of great interest for intensive agricultural crops. In 1977 experimental sites for drip irrigation systems to water spur apple orchards and vineyards were laid out. Investigations into developing technical and agronomic solutions for the drip irrigation of fruit orchards, grapes and vegetable crops have been carried out by the Complex Department of the All-Union Institute for Research in Irrigation Mechanization and Techniques, the Moldavian Institute for Research in Horticulture and by the Moldavian Research Institute of Irrigated Farming and Vegetable Growing.

Production of polyethelene parts for drip irrigation systems, on the basis of reuse and reprocessing of waste polyethelene and the manufacturing of filters for water purification, has been found. Experimental-industrial drip irrigation systems in the intercollective orchard farms covering an area of 903 ha, vineyards of 281 ha and in the winter block greenhouses of 24 ha, have been constructed and are functioning.

The further development of horticulture in Moldavia will be based on the application of the latest and most efficient irrigation methods, including drip irrigation. The areas of orchards and vineyards irrigated by this method will reach 45 000 ha in the near future. In Moldavia, drip irrigation systems for orchards and vineyards, covering an area of 250 to 650 ha are being designed and built /Danilchenco et al. 1978, Irinevich 1978/.

The drip irrigation system for the intercolletive orchard farm, „Pravda" by name, /Dubossar region/ covers an area of 532 ha /Fig. 1/.
As for its technical and economical indices this system exceeds considerably a permanent sprinkler system operating in the intercollective orchard farm, „To the memory of Ilyich" by name /Table /.

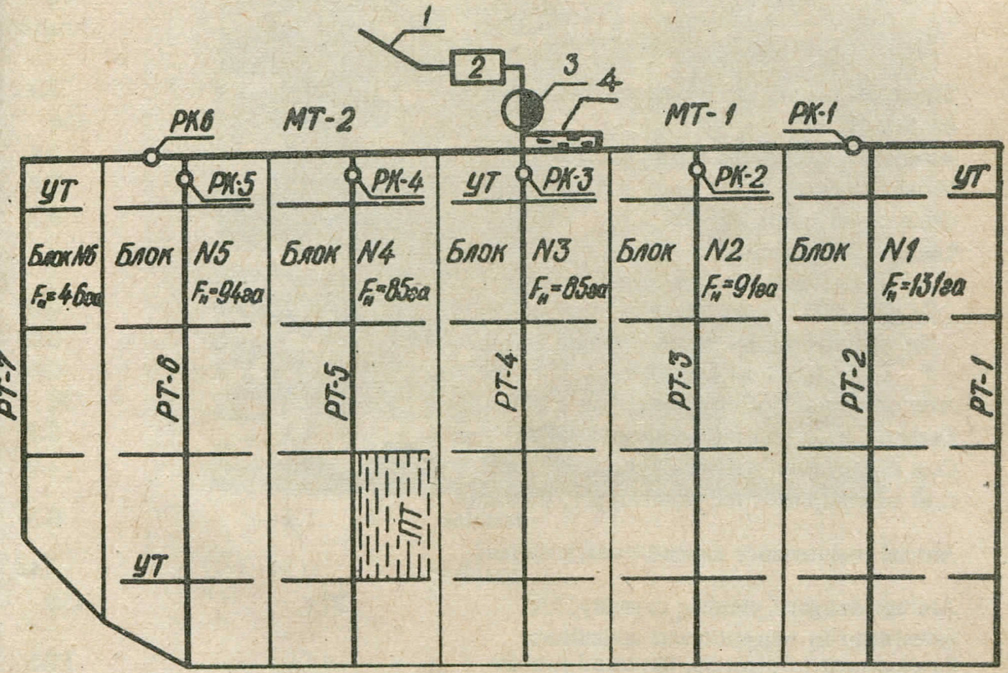

Figure 1. The scheme of the drip irrigation system for an orchard 1 — gravity flowing pipe-line; 2 — regulating basin; 3 — pumping station; 4 — gang of filters; MT — main pipe-line; PT — distribution pipe-line; YT — site pipe-line; T — irrigation pipe-line; PK — regulating well on a pipe-line.

Table

Technical and economic indices on drip and permanent sprinkler irrigation /on the basis of 1 ha /

Item	Permanent sprinkling	Drip irrigation
Supply of material to a construction site, t	38	1.3
Earthwork, m^3	530	156
Assembled monolithic ferro-concrete, m^3	2.2	0.4
Metal-framework, t	0.51	0.01
Quantity of filters FPZ-4N	–	3*
Length of pipe-lines, km		
a/ of steel and asbestos-cement tubes 150-400 mm in diameter	0.22	0.02
b/ of polyethelene tubes 110 mm and	–	0.03
17.6-20 mm in diameter	–	0.63
Average amount of drippers	–	730
Designed irrigation rate, thousand m^3	4.5	2.2
Cost of irrigation network, thousand roubles	3.7	2.0
Cost of equipment for watersupply, thousand roubles	1.3	0.5
Annual maintenance expenditures, thousand roubles	0.29	0.14
Average designed yielding capacity, hwt	374	450
Investment in irrigation and agricultural development of projects, thousand roubles	15.0	12.5
The investment after specified number of years will begin to pay off	1.7	1.2

* On the basis of the whole orchard area.

The water from a regulation basin, after passing the filters, goes into the main closed pipe-lines /MT - 1 and MT - 2/. The whole area under irrigation is divided into 6 blocks. The water runs into each block through separate distribution pipe-lines /PT-1 PT-7/, where regulating wells /PK/ are established. They are equipped with slide-valves and electric drives.

The site pipe-lines /YT/ are connected to distribution pipe-lines and provide the supply of water to irrigation pipe-lines /Л T/ with drippers. Dislocation of the main, distributive, and site pipe-lines are tied up to the road system of the orchard.

Irrigation pipe-lines equipped with spiral passage drippers „Moldavia 1" are suspended from the lower row of trellis wires by a special device /Fig. 2/.

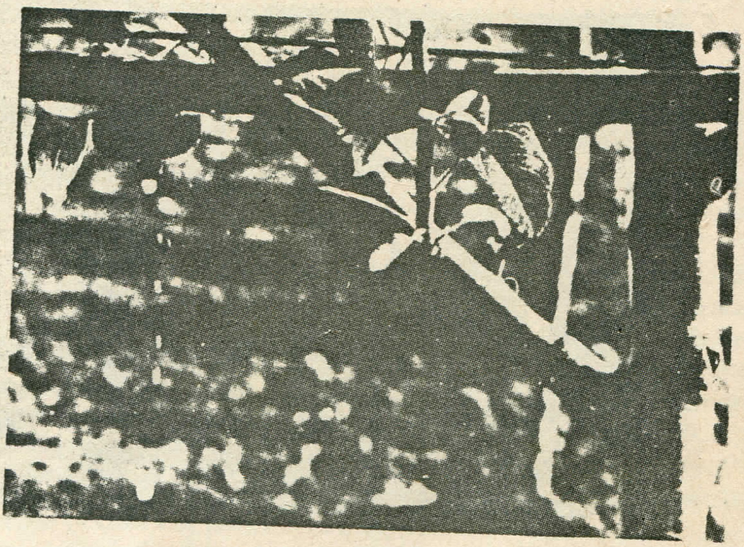

Figure 2. The arrangement of an irrigation pipe-line and the method of its fixing.

The drippers are maintained on an irrigation pipe near every tree at a distance of 30 cm from the trunk. Dripper discharge data /Qk/ which ranges from 3 to 9 l/h for the spiral passage drippers and from 3.5 to 4 l/h for the „Moldavia 1" drippers. For successive switching in of the watering system a program control is provided by the design on each block.

The average water turbidity in the rivers of Moldavia comprises 150-1000 mg/l but in some periods it may reach 1750-2100 mg/l.

During spring floods there is mainly silt and dust in the water and 60-80 % of the total turbidity is due to this.

The system of drip irrigation in Moldavia is provided with pressure filters possessing a floating foampolysterol charge /FPZ-4/ for purifying the suspended particles from water /Fig. 3/.

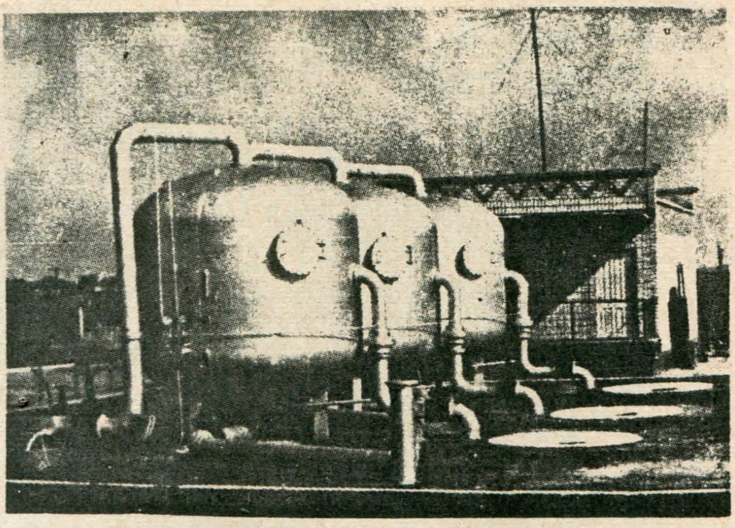

Figure 3. Gang of filters FPZ–4N

The filters work on a nonreagent scheme like an independent installation. They provide for sufficient water clarification /5-30 mg/l/ at a high filtration speed /15-30 m/h/ under high productivity /250 m^3/h/.

These filters also provide for the reduction of phytoplankton in the irrigation water by 60-85 %. One such filter can clarify the water for the irrigation of 100-150 ha /Kalenikov and Sitov 1978/.

Research on drip irrigation in Moldavia has mainly been aimed at developing the main elements of irrigation regimes while taking into account the specification of water division and discharge by different crops and the determination of the influence this method of irrigation exerts on the growth, development, and productivity of plants, as well as studies on salt accumulation in the soil moistening zone. Some technical problems connected with designing and constructing drip irrigation systems have been elaborated.

I.S. Flyurze et al. /1977, 1979/ established that the diameter of the moistening zone in the typical heavy loam chernozem at the depth of 40 cm by 9-10 l/h discharge and that a volume of 48 l for a single supply of water may reach 1.6-2 m. An increase in the water volume supplied by a single irrigation results in a slight extention of the moistening region, and also in a larger amount of infiltrating water. The character of capillary pressure distribution, typical for soil moisture before irrigation, at the end of the irrigation and one or two days after irrigation, has shown that the water mainly flows under the influence of gravitational forces and, under small free moisture accumulation capacity, is moving mainly into the depths. A sufficient sharp change from a moist to a dry zone takes place in a horizontal direction.

The results of the present experiment are in agreement with the observations by A.A. Alexashenco and N.I. Vdovin /1977/ over moisture dynamics under drip irrigation as well as the suggested mathematical model which permits to carry out infiltration calculations when the soil is moistened by this method of irrigation, on soils similar in their mechanical composition.

Investigations have shown that the irrigation rate per tree in a fruiting apple orchard by a single irrigation treatment changed from 44 to 80 l when dripper discharge was, 7-8 l/h and an interval between water application of 1-6 days /Kalenikov and Komerzan 1979, Poiyag 1974/. The irrigation regime depends on the developmental stage of a fruiting tree and the tension of meteorological factors. The irrigation rate under drip irrigation was 539 m^3/ha and under overcrown sprinkling /control/ it reached 910 m^3/ha. When the sprinkling system was substituted by drip irrigation, the yields of apple varieties, Calville snezhny and Jonathan, increased by 16 and 22 hwt/ha, respectively. An earlier maturation of fruit was observed /6-8 days/.

The experiments by N.B. Danilchenco et al. /1978/ on the drip-impulse irrigation of an orchard, conducted on 4-year old plantings, with an apple variety called Golden Delicious, demonstrated properties of soil moistening in the rooting zone and evaluated optimum shemes of impulse action in dropper distribution. The system of drip-impulse irrigation was established permanently with the distribution and irrigation pipe-lines laid at a depth of 50-70 cm. The dripper arrangement was defined by the orchard scheme of 2.5 x 4.0 m.

Each tree was provided with a dripper at a distance of 20 cm from the tree. Two types of dripper arrangements were tested namely, with subcrown above ground and with a subsoil placement in the plowing layer. The water rate supply in both cases was similar. The value of the daily supply of water was supposed to be equal to the daily water consumption by an apple tree, which was determined according to a bioclimatic method. A period of continuous work of the system was evaluated dependent on the daily water consumptions. In 1975 the duration of these periods was 10-15 days and in 1976 – 1-7 days. A tree received 0.1 l water with each impulse. The interval between impulses was estimated dependent on the daily irrigation rate.

In the treatment of the subcrown above ground, the dripper distribution moistening the contour radius, at the depth of 80-100 cm, was 60-80 cm; in the treatment of the subsoil, dripper distribution was 125 cm and more, i.e. an overlapping of the moisture contours in the row was provided. When maintaining the soil moisture at the level of 70-75 % of minimum water field capacity and water supply rate of 18 l/day per tree by one dripper located in the arable layer, 75-85 % of the apple tree root zone is moistened and only 50-60 % when drippers are located above ground.

In spite of many positive factors, according to A.D. Irinevich, /1978/, drip irrigation increases the salt content in the soils of heavy mechanical composition when using highly mineralized water for irrigation from local run off. After preliminary data, salt content increased by 1.5-10 times in the 10-30 cm layer of the moistening soil zone at the end of irrigation season, when on heavy loam soils under the drip irrigation of an apple orchard the water applied for irrigation was mineralized to 1.0 g/l. However, by spring of the next year, there was no difference in the salt content of the one meter-soil-layer on a nonirrigated site or that under drip irrigation.

Since 1976 research in the drip irrigation of vegetable crops has been under way. At the Moldavian Institute for Research in irrigated farming and vegetable growing, experiments were conducted in the winter block greenhouses using cucumber and tomato. Experiments conducted in the open ground were done with tomatoes.

The drip irrigation system in sheltered ground includes a control-distributive assembly, main and distribution pipe-lines, as well as irrigation pipes with water-outlet-drippers. The control-distributive assembly consists of valves, a water meter, a pressure gauge and a filter. When applying mineral fertilizers through the system with water, a hydrofertilizer distributor was arranged in front of the filter. The main distribution and irrigation pipes were made of a dark polyethelene of an average density. The cross-section diameter of the main and distribution pipe-lines was 32-28 mm and that of the irrigation was – 14-16 mm. Irrigation pipe-lines, with drippers of 36-42 m long, were placed along each plant row. Every 40 cm there were drippers-microtubes, with a diameter of 1.3 mm and an average discharge of 2.4 l/h or selfregulating drippers „Moldavia 1" with an average discharge of 2.8 l/h.

A middlefruited hybrid cucumber „Teplichny ranny 65", bee-pollinated, and the hybrid tomato, „Curato" were used in the experiments. The planting design for cucumbers was 120 x 30 cm and for tomatoes – 90 + 60 x 40 cm / 2.8 and 3.3 plants per 1 m^2, respectively/. Cucumbers were grown from January to June and tomatoes from February to July.

Irrigation before the plant fruiting, was conducted in 1-2 days, depended on the solar radiation intensity; during the fruiting period irrigation was applied daily. For cucumbers the air was periodically wetted to maintain the air humidity at the required level. The irrigation rate value corresponded to that of the evapotranspiration of the previous day and was calculated after D.A. Shtoyko's formulae

$$E_{day\ /period/} = \sum t(0.1\ t_c - a/100) \qquad 1$$

$$E_{day\ /period/} = \sum t(0.1\ t_c + 1\text{-}a/100) \qquad 2$$

where $E_{day\ /period/}$ = summed evapotranspiration, m^3/ha;

t = sum of average daily air temperature for day and night /period/, ^oC;

t_c= average daily air temperature for day and night /period/, ^oC;

a = average relative humidity of air for day and night /period/, %

Formula /1/ was used before plants finally closed in rows, and formula /2/ – after it.

The adjustment of productive soil moisture storage was carried out, every 5 days, on the basis of the balance calculations. The studies showed that it was possible to use water outlets /drippers/ of 2.4-2.8 l/h in a discharge on the soil-ground with 1.04-1.07 g/cm^3 in a bulk mass and a layer depth of 30 cm. The arrangement of such drippers on an irrigation pipe-line, at a distance of one every 40 cm, helps to create a moistening strip at a 10 cm depth along a plant row 40-50 cm in width. Thus, the highest soil-ground moisture is reached in the row where the main mass of the root system is concentrated. Moisture redistribution occurs 2 hours after irrigation. The soil ground gets wet through to its depth and the moisture degree reaches the minimum water field capacity. This irrigation technique, raises the efficiency of labour and allows all the operations of plant management to be carried out. All the necessary work can be done during the irrigation process.

When growing vegetables in winter greenhouses during the winter-spring period the temperature regime of the soil-ground is of importants. It depends on soil and air heating, primarily. But irrigation methods have some influence on the ground temperature. Drip irrigation, compared with sprinkling, stimulates some rise in the soil-ground temperature, especially in winter months and on cold spring days. This explains, partly, the fact that the plants using the drip irrigation treatment develop better than those under sprinkler irrigation, and this results in the setting of more fruit and an increase in the early yield.

In greenhouse conditions, under irrigation, when using water from the Dniestr river, with 0.2-0.7 g/l of salt content, the salt status is of a quite different character than that of the drip irrigation of an orchard. In the soil-ground of the first year's use, under a dripper and at a distance of 10 cm from it, the amount of salt in a 0-20 cm layer decreased by 30-31 % compared with their original content; at a distance of 20 cm from a dripper it remained practically the same.

Drip irrigation of vegetable crops in the sheltered ground induces an increase in yield and a decrease in irrigation water expenditure even in the case when the soil-ground moisture is maintained at the same level for both comparable treatments.

In 1979 the yielding capacity of cucumbers grown in the winter-spring period /planting on January 16, the end of harvesting on June 20 / was by 2.4 kg/m^2 higher and the water expenditure for a unit of produce was 30 % less than under sprinkling. Much less water /approximately two times less/ was applied for receiving a unit of produce on a production site when compared with sprinkling.

In 1979 an experimental tomato yield, in winter block greenhouses under drip irrigation, was 10 % higher and 25 % less water was applied for receiving the unit of produce when comparing it with that under furrow irrigation.

During the first month of fruiting under drip irrigation in 1979-1980 the tomato yield was on the average 22 % higher than that under furrow irrigation. Drip irrigation also gave much earlier yield and due to that, the returns were higher and, on the other hand, it would be possible to speed up the compensation of the investments.

Preliminary results on drip irrigation for a tomato variety, „Ranny 83", in the open ground, when grown in early culture, have been obtained. The yield by July 20 1979 under drip irrigation was 266 hwt/ha and under furrow irrigation – 177 hwt/ha. On the site under drip irrigation the fruit were of better marketable appearance and the plants were not damaged by diseases.

Thus, the experience of drip irrigation application in Moldavia shows it to be of great promise. Further investigations are needed on improving drip irrigation techniques and on clarifying its effects on plant and soil.

REFERENCES

1. Agroklimaticheskii spravochnic po Moldavskoy SSR, 1969
2. Alexashenco, A.A., N.I. Vdovin, 1977. Teoreticheskiye voprosy kopielnovo orosheniya. Viestnic sielskokhozyaistviennoy nauki, no 8
3. Danilchenco, N.V., V.G. Bykov, T.U. Bykova. 1978. Kopielno-impulsnoye orosheniye yablonevovo sada. Sadovodstvo, Vinogradarstvo i Vinodelie Moldavii, no. 2
4. Fyedorets, A.A., S.M. Moroz, W.A. Konukhov. 1978. Opredeleniye soprotivlyeniya polyetylenovykh truboprovodov s kopielnitsami. Gidrotechnika i Mielyoratsia, no. 2
5. Flyurze, I.S., et al. 1977. Kopielnoye orosheniye plodovykh kultur. Sadovodstvo, Vinogradarstvo i Vinodelie Moldavii, no. 6
6. Flyurze. I.S., I.N. Boltsatu. 1979. Kopielnoye orosheniye plodovykh kultur v Moldavii. Gidrotechnika i Mielyoratsia, no. 6
7. Irinevich, A.D. 1978. O vozmodznykh izmienyenyakh solievovo sostava pochv i gruntov na mosivakh kopielnovo orosheniya. Tezisy dokladov riespublicanskoy nauchnoi konferentsiy „Optimalizatsiya prirodnoy sredi v usloviakh kontsentratsiy i spietsyalizatsiy proizvodstva". Kishinev.
8. Kalenikov, A.T., V.S. Komerzan. 1979. Sistema kopielnovo orosheniya v miedzkolkhoznom sadu. Sadovodstvo, Vinogradarstvo i Vinodelie Moldavii, no. 11
9. Kalenikov, A.T., I.P. Sitov. 1978. Kopielnoye orosheniye sadov. Expriess informatsiya. Moldninti. Kishinev
10. Poiyag, M.A.. 1974. Kompliexnoye ispolzovaniye i okhrana vodnykh resursov Moldavii, no. 11.