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Remarks on the introduction of advanced irrigation technology in Azerbaijan

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Abstract

One of the main reasons of salinization of irrigated lands in arid areas, including vast areas in Azerbaijan, is watering by high application doses exceeding by 1.3–2.0 times the doses sufficient for crops. The principle of drop irrigation is that water reaches only the root zone of a plant, whereas the amount and periodicity of water distribution is very exact and technically simply adjusted to the needs of the plant in each phase of its growth. The obtained results indicate practicability of the implementation of drop irrigation in a large production scale.

Key words: *cotton plant, drop irrigation, micro sprinkling, dropper, water sprinkler*

INTODUCTION

One of the main reasons of salinization of irrigated lands in arid areas, including vast areas in Azerbaijan, is watering by high water doses that exceed the rate sufficient for crops by 1.3–2.0 times. This results in intensive infiltration, which, according to some scientists is excessive, to others is beneficial whereas still some other scientists think it to be quite harmful. There is an opinion that artificially created infiltration helps drawing salts off the root zones to the soil substrata and further on to drainage ditches [АЛИЕВ 2009].

IRRIGATION TECHNOLOGY

However, salts move in the ground due to currents of water. Greater amounts of salts get into active soil layer with irrigation water, than with drop irrigation and micro sprinkling. This is because irrigation water aside from bringing salts, partly permeate to ground waters raising thus their salt content.

According to literature data, the whole arable layer which is furrow watered during vegetation period is heavily packed down by autumn in spite of 5–7 fold loosening of ground particularly at depths of 10–20 and 20–30 cm giving the soil density of 1.44–1.47 $g \cdot cm^{-3}$. Domestic experiences testify that by means of drop irrigation and micro sprinkling the soil density in autumn at a depth of 0–50 cm is only 1.23–1.24 $g \cdot cm^{-3}$, i.e. closer to the original [АЛИЕВ, АЛИЕВ 1998; ЯЛИЙЕВ 2008].

Drop irrigation was for the first time designed and introduced in industrial scale as an independent type of irrigation in Israel at the beginning of the 1960s. This way of irrigation is used for growing most types of agricultural crops on soils of any type and with irrigation water even of the worst quality. What is the drop irrigation? Unlike all other types of irrigation, the principle of drop irrigation is that water reaches only root zone of a plant, whereas the amount and periodicity of water distribution is very exact and technically simply adjusted to the needs of the plant in each phase of its development. The number and location of water distribution points is specified depending on local conditions – type of soil, types of crops, climate, quality of irrigation water etc. Novelty of this method is in adjusting the mode of water and fertilizers distribution to affect directly the plant by either slowing or accelerating its growth, fruit development, development of plant biomass etc. During watering the amount of water is equally distributed among all plants in any part of the field. And only the part occupied by roots is irrigated. From 50% up to 70% of field remains non-irrigated between rows.

The actual consumption of water with 6-fold furrow watering is 6.6–7.2 thous. $m^3 \cdot ha^{-1}$. At drop irrigation and micro sprinkling even with 12-fold watering water consumption per hectare is reduced 2 times. The optimum single watering rate, both with drop irrigation and micro sprinkling does not exceed 290–300 $m^3 \cdot ha^{-1}$ or 2.9–3.0 thous. $m^3 \cdot ha^{-1}$ with 10-fold watering during vegetation. The watering rate must, however, be differentiated. So, at the beginning and at the end of vegetation, watering rates of 250–300 $m^3 \cdot ha^{-1}$ are sufficient but during the period of fruit formation they amount 500–580 $m^3 \cdot ha^{-1}$. In any case, the total water consumption per sown hectare must not exceed 3.0–3.1 thous. $m^3 \cdot ha^{-1}$. Moreover, the advantages of drop irrigation and micro sprinkling should not be restricted only to the economy of water as most experts think. Most people consider the drop irrigation simply as an irrigation system allowing water savings. That's true if one considers the drop irrigation as an irrigation system (Fig. 1).

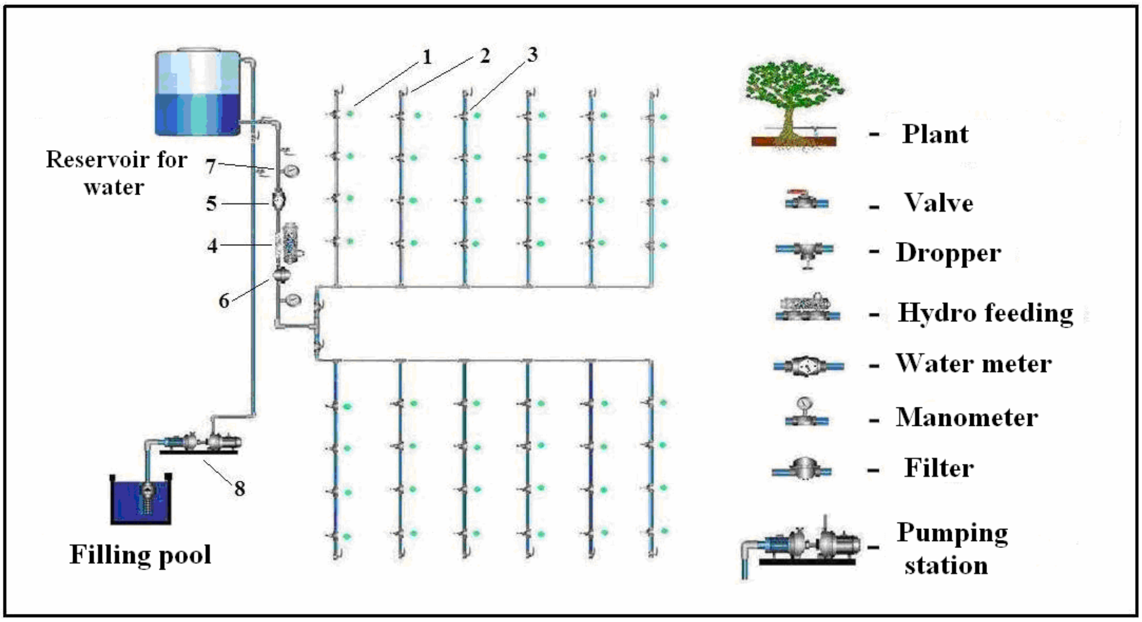

Fig. 1. A scheme of the drop irrigation system

The system consists of a pumping station (usually composed of water pumps with water output from 20 to 350 $m^3 \cdot h^{-1}$ and pressure 2.5 atm.), the device for obligatory purification of water, hydro feeding, sand filters, grid and hydro cyclone, the plastic pipe lines delivering water to irrigated agricultural area, the watering tubes – hoses – placed along the rows of plants, and droppers. The droppers discharge water and dissolved fertilizers or herbicides to each plant in exact and small rates from 2 to 8 $l \cdot h^{-1}$ – such irrigation system really saves 50% water and allows to raise the productivity by 20–40% (Fig. 2) [Алиев, Алиев 2001; Алиев *et al.*, 2002].

The combination of filters allows to clean irrigation water from any, even the polluted sources to reach the required quality. The filters are provided with automatic washing system and are assembled into filter stations with the output of 500–600 $m^3 \cdot h^{-1}$. Hydro feeder is a device assembled in block with filter station, by means of which strictly dosed and timely supplied mineral fertilizers are carried through the system of drop irrigation directly to the root of each plant. The system of main and distributing plastic pipe

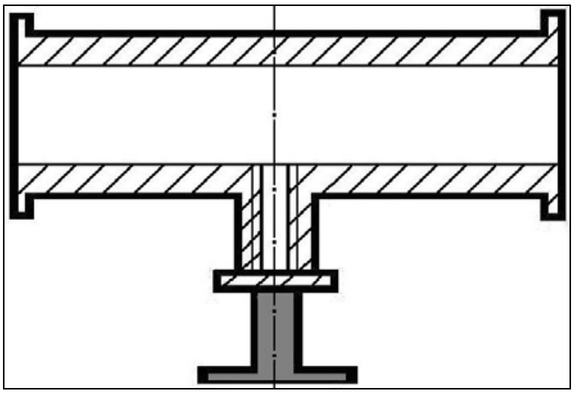

Fig. 2. Cross-section of the dropper – discharge outlet

lines is made of pipes of different diameter from 40 to 300 mm carrying water from pumps to watering pipe line. Watering pipe lines are polyethylene tubes up to 12 mm which are put along the rows of plants parallel to each other. The droppers are a device for point distribution of water from watering pipe lines to which they are fixed. The most often used droppers are those with water output of 2, 4, 6, and 8 $l \cdot h^{-1}$. Water distributing and adjusting equipment consists of valves, bolts, valves with manual or automatic drive, water meters, manometers – for the regulation of sequence and duration of water supply on irrigated area. Drop irrigation is indeed a new technology of farming. How does it work? First, it needs changes in soil cultivation both before sowing and during plant growth. In autumn, fertilisers are used in smaller amount, but deep loosening and maximum destruction of weeds is a must. No cutting of furrows is required on ploughed crops but after the first, second and third cultivation farm machinery is practically not used in the field. Using the seeders of exact sowing excludes the need of weeding and herbicides applied with water and only partial moistening of soil strongly limit the growth of weeds. Removing of top foliage in cotton plants, for instance, substituted by chemical substances and the application of nitrogen, phosphorus and potassium fertilisers according to this method and watering mode will allow to adjust the growth of plants and fruit formation and to prepare the plants for harvest. Secondly, the constant moistening will allow to use sandy soil and slopes – lands "uncomfortable" for agriculture by using mineralized irrigation water for watering.

Here are some data from research works on usual productivity of agricultural crops with drop irrigation: cotton 5.0–5.5 $t \cdot ha^{-1}$ at water consumption of 3.5–4.5 thous. $m^3 \cdot ha^{-1}$. The record harvest on an experimental area (10 ha) was 7.0–8.0 $t \cdot ha^{-1}$. Maize (sweet) – green mass 120–130 $t \cdot ha^{-1}$, kernels 25–32 $t \cdot ha^{-1}$. Tomatoes (for industrial processing) – 130–140 $t \cdot ha^{-1}$ on fields and up to 500 $t \cdot ha^{-1}$ in greenhouses. Vineyards – 45 $t \cdot ha^{-1}$. Of no less importance is the ability of the advanced machinery and irrigation technology to provide the uniformity of water distribution among all plants on the area of the irrigated section and thus even distribution of fertilizers and other nutrients with water [Алиев 1999; Алиев, Алиев 1999]. Besides, labour costs of cultivating cotton plants on 1 hectare with furrow watering with the use of present technology is 8.8 man-hours, whereas the new technology allows to reduce that cost to 4 men-hours which is 2.2 times less. Three to four operators can control the watering during the season in an area of 150–200 ha due to automatic control of drop irrigation. The requirement for agricultural machines is considerably reduces due to a less frequent soil cultivation and to the application of chemicals and fertilisers with irrigation water.

The reduction of water consumption in the field leads to the reduction of the total water supply, reduces the workload of the main irrigation networks, contributes to a better work of hydro-constructions and to the reduction of maintenance costs. It decreases the total volume of filtered and evaporated water in irrigation networks. Equally important is the fact that drop irrigation and micro sprinkling exclude the loss of soil, mineral fertilizers and other nutrients.

Long-term studies showed that 10–30% of nitrogen introduced with standard methods remain unused by plants, 15% goes to the atmosphere, 30–35% is absorbed by plants, 5–10% remains on the soil surface and 5–15% permeates down to lower soil horizons and to ground water. Applied phosphorus fertilizers are absorbed by plants in 7–15%, 55–75% is accumulated in soil, 10–15% concentrates on the soil surface, 5–10% runs off to surface waters and less than 1% is drained to lower soil horizons and ground waters.

This is mostly explained by the fact that under the existing technologies mineral fertilizers are applied alongside with cutting furrows for watering i.e. they are placed in dry ground. Plants can assimilate nutrients only in dissolved form. But as 2–3 days pass between the input of fertilizers and the supply of irrigation water the nutrition period of plants extends from 5 to10 days. This is one of the factors why only 30–35% of nitrogen and 7–15% of phosphorus is absorbed by plants.

DISCUSSION

As a result of laboratory and field tests with droppers and micro sprinklers of the new type, the following main characteristics were revealed in the trial area:

- droppers and micro sprinklers of the new type are 10–12 times cheaper due to a smaller consumption of materials compared to products of the same type produced abroad, and in terms of reliability and working capacity equal their foreign analogues;
- droppers, when used for watering cotton plants, reduce watering rate 1.5–2.0 times compared with furrow watering. Herewith, a band of moistening 0.95–1.0 m deep and 0.90 m wide is created which wholly corresponds with the requirements of the developing root system of the cotton plant;
- droppers of the new type do not require fine purification of irrigation water on condition that the concentration of solid particles does not exceed 50 $mg \cdot l^{-1}$ and the size of particles is not less than 30–50 microns;
- the use of droppers on any soil type in terms of its mechanical composition is allowed under the general mineralization of irrigation water up to 2 $g \cdot l^{-1}$. Water pH must be within 6–9;
- the system of drop irrigation can be used on surface slopes of i = 0.03, the pressure at the end of the watering hose must not exceed 3 m;
- in comparison with furrow irrigation an improvement was observed in the growth of cotton plants and other crops and an increase in productivity by 5–10 $s \cdot ha^{-1}$ in those areas where droppers were used [Алиев, Алиев 2001; 2005].

A question arises as to where it is better to use drop irrigation? Taking into account that drop irrigation is more expensive than usual ways of irrigation the former is recommended to be used with its maximum output and when it is really essential. This means first of all slope lands, where natural pressure can be used; sandy soils; lands with already existing machine irrigation and lands with a deficit of irrigation water. Flat and developed lands should be switched to drop irrigation as the last ones

The cost of growing agricultural crops should also be considered. Our scientific-research institute performed zoning of the advanced machinery and irrigation technology in the republic. The root system develops better with drop irrigation than with any other method, roots near the moistening are much thicker i.e. plant does not spend energy and mass, but growing roots in depth, to water, and develops in conditions of its constant presence in the upper fertile layer, at the optimum depth for each plant. When switched from other types of irrigation to drop irrigation, the process of adaptation of plants occurs quickly and painlessly. Feeding the plant with drop irrigation is most effective. Quick and intensive absorption of nutrients occurs due to large development of root system in moistened area of soil. Besides, the absence of excessive moistening, alternation of humid and dry areas of ground and water circulation through capillary rising allows the macro porosity to remain almost dry, the air there is not completely displaced by water. If surface irrigation first overfills ground with moisture, subjecting plants to stress, then overdrying of ground before the next irrigation causes additional stress whereas drop irrigation due to small, but long acting doses forces the plant to develop constantly in time. Agricultural operations at drop irrigation can be conducted as rows remain always dry and farm machinery can freely move on the whole field. This has particularly good effect on the quality of soil, which does not undergo compaction. The control of weeds and diseases is simplified, since chemicals are mostly introduced with irrigation water. The temperature of soil at drop irrigation is higher than at surface irrigation which has a positive impact on earlier ripening of plants. Introduction of fertilisers, micro elements, herbicides and other chemical substances is an integral part of drop irrigations. Direct application of fertilisers in strictly calculated doses and in due time to that part of soil where the root system develops increases the productivity and ensures more economical (less than 50%) and efficient fertilisers use. The rates of fertiliser application and its inflow to each plant should be adjusted to changing needs of agricultural crops throughout their growth. Thereby, drop irrigation is not only the way of moistening and introducing fertilisers. It is particularly efficient when applying fast migrating fertilisers, for instance nitrogen. Multiple feeding in small doses contributes to a significant increase in productivity. The ecological advantages are that at drop irrigation there is no need to perform planning of the field for irrigation system and to remove the fertile layer fixed by vegetation partly leaving infertile dust soils. In mountain and foothill conditions soil erosion is prevented due to large natural slopes. Small irrigation rates allow not only to save water reserves, but also to prevent discharge of harmful substances with drainage water back into surface or underground sources.

Drop irrigation decreases the probability of diseases and spreading of weeds which are transferred at conventional irrigation and prevents soil diseases which may occur in anaerobic conditions. The results obtained while testing the droppers of the new type in irrigating agricultural crops justify their introduction in large production scale not only for irrigation of cotton plants, but also of other crops such as vineyards, apple trees, pear trees, tomatoes, cucumbers and, particularly, greenhouse crops.

To increase the efficiency of the drop irrigation system instead of traditional sources of energy it is proposed to use solar energy in the future which is quite abundant in Azerbaijan. Initially it is foreseen to use the new system for local irrigation from bore holes.

The cost of the system on flow irrigation can vary between 700 and 2000 US dollars per hectare of cotton plants, greenhouse and garden crops. The main material for the systems of drop irrigations is polyethylene. Its use amounts up to 0.3–0.4 $t \cdot ha^{-1}$ for gardens and vineyards and 0.5–0.6 $t \cdot ha^{-1}$ for cultivated crops. The share of this material makes up 70–80% of the total cost of the drop irrigation construction. Thence, the cost of the equipment for drop irrigation is estimated at 0.1–1.0 thous. dollars per 1 ha of gardens, 1.2–1.5 thous. dollars for vineyards and 2.0–2.4 thous. dollars for cultivated crops. The ability of drop systems to operate for a long time without repair depends on the reliability of each node. All details and elements must be manufactured at high technical and technological level and be tested in factory conditions. Besides drop irrigation, there are also the systems of micro sprinkling, whose principles of use and design do not significantly differ from drop irrigation and whose costs are by 20–40% smaller. These systems allow to irrigate pastures, grass, wheat, vegetables and other crops. The use of solar energy increases the cost by 40% [Алиев 2006].

SUMMARY

Despite all advantages of the presented system, it does not cover the need of agricultural crops for moisture in accordance with their physiological phases of growth. For example, the plant as a living organism is awake during certain part of the day or rests during the other part. So, it follows that it consumes water at its desire. In order to solve this problem our scientific – research institute conducts studies on the development of irrigation system where the plant itself will have a defining role.

To sum up, modern farming technology is beginning to occupy a worthy place. In conclusion we would like to point out that Azerbaijan enters new market relations with water acquiring the real price. Under such conditions there is no alternative was to water saving technology than drop irrigation and micro sprinkling.

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Zaawansowane technologie nawadniania w Azerbejdżanie

STRESZCZENIE

Słowa kluczowe: *bawełna, kroplownik, mikrozraszanie, nawadnianie kroplowe,*

Jedną z głównych przyczyn zasolenia nawadnianych gleb na obszarach o suchym klimacie (takich jak rozległe tereny Azerbejdżanu) jest nadmierne nawadnianie, które przekracza 1,3–3,0 razy dawki, pokrywające zapotrzebowanie upraw. W nawadnianiu kroplowym woda dociera tylko do strefy korzeniowej roślin. Ilość i okresowość zasilania w wodę można dokładnie zaplanować i w prosty technicznie sposób dostosować do potrzeb roślin w każdej fazie ich wzrostu.

Uzyskane wyniki wskazują na celowość wprowadzania na dużą skalę nawadniania kroplowego nie tylko w uprawie bawełny, ale także winogron, jabłek, gruszek, pomidorów, ogórków, szczególnie w szklarniach.

Biorąc od uwagę przyrodniczo-klimatyczne warunki Azerbejdżanu oraz rynkowe relacje cen, zwłaszcza cen wody, wydaje się, że przyszłościowe są tylko technologie oszczędzające wodę.