Determination of rational areas of irrigated plots in saline and subjected lands to irrigation erosion

S Avezbayev¹, K Khuzhakeldiev², F Umarova¹ and S Sharipov¹

¹Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan
²Karshi Engineering and Economics Institute, Karshi, Uzbekistan

s.avezbaev@mail.ru

Abstract. The article considers the issues of determining the rational plots of irrigated plots on lands inhabited and subjected to irrigation erosion. Rational areas of irrigated plots are determined based on the optimal aspect ratio of the irrigated plots, the degree of salinity of soils, the slope of the irrigated surface, and the flow rate of water in irrigated furrows. The optimal combination of irrigators and drains, which are the boundaries of irrigated plots and optimal distances between drains, were also taken into account. Recommended rational areas are defined for slightly, medium, and highly saline, as well as lands subject to irrigation erosion.

1. Introduction

In the irrigated area, the workplace for performing field work is the irrigated plots. The effective development of agricultural production, especially in connection with complex mechanization, requires the design of irrigation plots that are optimal in size and convenient in configuration, since the productivity of working tractor units, the magnitude of some losses, as well as the rational use of irrigation water and land reclamation, depend on it.

Researchers dealing with the size of irrigated plots determine the optimal ratio of their sides, taking into account the creation of the most favorable conditions, for the mechanization of agricultural work [1]; road transport work [2], as well as by optimizing losses for mechanized work, the yield on headlands and with the area occupied by linear elements that are the boundaries of irrigated plots [3].

The Uzgiprozem Design Institute recommends that the rational sizes of irrigated plots, be established based on the economically feasible planning area and the designed equipment, irrigation in conjunction with the efficient use of rectangular agricultural machines with aspect ratios of 1: 2 - 1: 3 [4].

2. Methods

The results of our researches on optimizing the aspect ratio of irrigated plots, taking into account the rational combination of a permanent collector-drainage network with an irrigation network, which are the boundaries of irrigated plots, showed that the optimal ratio is 1: 2.1 for medium and highly saline lands, or slightly saline lands or plots secured by closed drains - 1: 2.6 [5].

However, when designing and placing irrigated plots, it is almost impossible to establish the optimal aspect ratio, as this is impeded by soil differences, topography, existing elements of the territory, etc.
Therefore, when designing, some deviations from the optimal aspect ratio are allowed. According to our research, the best results are obtained when designing irrigated plots with aspect ratios in the range: on medium- and highly saline lands 1: 1.6 - 1: 2.6, on lightly saline and non-saline lands, as well as with closed drains 1: 2.2 - 1: 3.3 [6] In these intervals, the total annual losses are closest to the optimum and do not have significant differences.

3. Results and Discussion

The determination of the rational size of the irrigated plots by area is affected by the mechanical composition and degree of soil salinity, the location of the collector - drainage and irrigation network, as well as the costs of planning the surfaces of the irrigated plots. In the conditions of the region, the surface planning of irrigated plots is mainly carried out without bias to zero. Naturally, at the same time, with the increase in the area of the irrigated plots, the costs of surface planning increase.

On saline lands, when using open drains, the scientifically based distance between drains is one of the most important elements which determine the area of the irrigated plot [11–15].

On salinized and potentially prone to salinization, lands drains must be located in the middle between two adjacent irrigators of permanent or temporary action [7]. This scheme of combining a permanent collector of a drainage network with an irrigation network is widely used in the development of on-farm land management projects.

In the table 1 shows approximate distances between drains on the recommendation of V.M. Legostaev for cotton farms.

| Degree of soil salinity | Ground water depth, m | The distance between the drains, "L", m |
|-------------------------|-----------------------|----------------------------------------|
|                         | Before irrigation and | After flushing | Heavy soils | Medium soils | Light soils |
| Weak                    | 2-3                   | 1-2          | The device of individual collectors in low places |
| Medium and strong       | 2-3                   | 1-2          | 250-300     | 300-400     | 400-600     |
| Weak                    | 1-2                   | 1-2          | 300-400     | 400-500     | 500-600     |
| Medium and strong       | 1-2                   | 1-2          | 200-250     | 250-300     | 300-400     |
| Weak                    | 0-1                   | 1-2          | 150-200     | 200-250     | 250-350     |
| Medium and strong       | 0-1                   | 1-2          | 100-150     | 150-200     | 200-300     |

Determining the distance between drains using table 1, one can calculate the width of the irrigated area \((B = L/2)\), and then its area in hectares - by the formula:
\[ P = \frac{B^2 K}{10000} \]  

(1)

where \( K \) is the ratio of length to width of the irrigated plots  
\( (K = \frac{A}{B}) \)

Using this formula, using the data in Table 1, it is possible to determine the rational size of irrigated areas with soils that differ in salinity, depth of groundwater, and mechanical composition (Table 2).

### Table 2. Rational sizes of irrigated plots

| Degree of soil salinity | Ground water depth, m | Rational sizes of irrigation plots, ha | | | |
|------------------------|-----------------------|-----------------------------------------| | | |
|                        | After flushing        | Heavy soil                              | Medium soil                 | Light soil                |
| Weak                   | 2-3                   | 1-2                                     | 16-36                       | 7.2-10.4                  | 16.2-23.4                  |
| Medium and strong      | 2-3                   | 1-2                                     | 4.1-5.9                     | 7.2-10.4                  | 16.2-23.4                  |
| Weak                   | 1-2                   | 1-2                                     | 7.2-10.4                    | 11.3-16.3                 | 16.2-23.4                  |
| Medium and strong      | 1-2                   | 1-2                                     | 2.8-3.4                     | 4.1-5.9                   | 7.2-10.4                  |
| Weak                   | 0-1                   | 1-2                                     | 1.8-2.6                     | 2.8-4.1                   | 5.5-8.0                   |
| Medium and strong      | 0-1                   | 1-2                                     | 1.0-1.5                     | 1.8-2.6                   | 4.1-5.9                   |

The size of irrigated plots in erosion-hazardous areas is affected by the conditions of erosion protection of the territory. In the case of wind erosion, the inter-lane distances of field-protecting forest strips have a limiting effect, and in case of irrigation erosion, the permissible lengths and water flow rate of irrigation furrows [8].

Currently, the main method of cotton irrigation is irrigation with furrows, therefore, an important task is to reduce flushing in furrows to the lowest possible value and to prevent soil loss in general from the irrigated plots. The condition of the non-erosion of the soil in the irrigation furrow determines the upper limit of the possible value of water flow into the furrow [9]. One of the methods to control irrigation erosion is irrigation with permissible water consumption. For some soils, allowable costs for different slopes had established experimentally by scientists (Table 3).

### Table 3. Recommended elements of irrigation technology for Kashkadarya region (according to M.D. Chelyukanov, G.A. Bezborodov, H.T. Tashev).

| Soil, Water permeability | Indicators* | Slope of irrigation furrows |
|--------------------------|-------------|-----------------------------|
|                          |             | 0.01 | 0.007 | 0.002 | 0.0005 |
| Sandy loam and light loam, highly permeable | R  | 0.50 | 0.75 | 1.50 | 1.00 |
|                          | L  | 100  | 150  | 200  | 150   |
|                          | T  | 4.7  | 4.7  | 3.1  | 3.3   |
| Light powerful loam of increased permeability | R  | 0.40 | 0.75 | 1.00 | 0.75 |
|                          | L  | 150  | 200  | 300  | 250   |
|                          | T  | 9.2  | 6.3  | 6.7  | 6.7   |
| Medium loamy, medium permeable | R  | 0.25 | 0.50 | 0.75 | 0.50 |
|                          | L  | 175  | 250  | 300  | 300   |
|                          | T  | 15.0 | 11.7 | 8.35 | 10.0  |
| Heavy loam of low permeability | R  | 0.20 | 0.25 | 0.30 | 0.50 |
The calculations are carried out in this order: set the width of the irrigated plots. The width of the irrigated plots depends on the degree of salinity of the soil mechanical composition and the location of the forest shelter belts [10]. The recommended width of irrigated areas is 300-400 m.

The number of irrigation furrows in the irrigation plot is determined by the formula:

$$N_f = \frac{B}{a}$$

(2)

Where: B is the width of irrigation plot, m; a is the row spacing (0.6-0.9 m).

The number of simultaneously irrigated irrigation furrows is determined by the formula:

$$N_{fi} = \frac{Q_{cd}}{R}$$

(3)

Where: $Q_{cd}$ is the consumption of the district distributor, l/s; R is the water flow rate in the furrow, l/s.

The number of irrigation furrows watered for two days is determined by the formula:

$$N_{fs} = \frac{T_c N_f}{R}$$

(4)

Where: $T_c$ is the duration of watering for two days, h / 32-36 h /; T is the duration of irrigation simultaneous irrigated sprinklers furrows, h. (Table 3)

The length of the irrigated plot can be determined by the formula:

$$A = \frac{N_f}{N_{fs}} : L$$

(5)

Where: L is the length of the furrow, m (Table 3).

The area of irrigated plots in hectares is determined by the formula:

$$P = \frac{A \cdot B}{10000}$$

(6)

The results of our studies to determine the rational size of irrigated plots on lands subject to irrigation erosion are given in Table 4.

| Soil, water permeability | Water consumption plots, distribution, l/s | Slope of irrigation furrows |
|--------------------------|------------------------------------------|----------------------------|
|                          |                                          | 0.01          | 0.007         | 0.002         | 0.005         |
| Sandy loam and light loam, highly permeable | 200 | 18.0 | 18.0 | 18.0 | 18.0 |
| Light powerful loam of increased permeability | 200 | 18.0 | 18.0 | 18.0 | 18.0 |
| Medium loam of Medium permeability | 250 | 26.2 | 22.5 | 27.0 | 27.0 |
| Heavy loam of low permeability | 300 | 31.5 | 30.0 | 27.0 | 36.0 |
permeability  
|    |   |
|----|---|
| 250| 24.0 |
| 240| 27.0 |
| 240| 24.0 |
| 210| 21.0 |
| 300| 30.0 |
| 300| 27.0 |
| 240| 31.5 |

4. Discussion

However, it must be remembered that the rational size of irrigated plots also depends on the territorial features of the area: the dissection of the area by large canals and other constant lines. Therefore, the determination of the rational size of irrigated plots should be made for each specific case, taking into account all the features: territorial, irrigation, and organizational and economic.

5. Conclusions

1. The rational sizes of irrigated plots determined by us, taking into account the degree of soil salinity, are in the intervals: for slightly saline lands 2-36 ha; for medium and highly saline 1-23 ha, depending on the depth of mineralized groundwater.

2. The rational size of irrigated plots on lands subject to irrigation erosion, depending on the slope of irrigation furrows, is in the range from 15 to 36 ha.

References

[1] Lutsenko M S 1962 Size and shape of processing maps in the complex of cotton-growing mechanization of cotton growing. In: *Proc. TIIAME* Tashkent pp 59–68
[2] Kuznetsov G A Romanenko I A Slavutsky A K Frank L N 1976 Improvement of territorial ties of collective farms and state farms Moscow *Publishing Hause Stroyizdat* pp45–48
[3] Chertovitsky A S 1975 Analysis of factors affecting the aspect ratio of fields in irrigated areas In: *Proc. TIIAME* Tashkent pp 33–36
[4] Abdurazakova A T Safagariev R A 1977 Land management in irrigated areas of the Central Asia Tashkent *Publishing Hause Uzgiprozem* pp 91–97
[5] Avezbayev S 1978 Design of irrigation plots In: *Sci Work MIIZ* pp 105–114
[6] Chelyukanov M D Bezborodov G A Toshev HT 1972 The study of water losses and cotton irrigation techniques in Karshi steppe In: *Proc SANIIRI* Tashkent pp 135–138
[7] Artomonov V S 1974 Soil protection from wind and water erosion In: Collec. Of TIIAME Tashkent pp 87–89
[8] Raximboev F M 1980 Land reclamation state Tashkent: Uzbekistan
[9] Rachinsky A A Vavilov A P 1981 Designing a reclamation event In: *Irrig. Uzb. Vol. IV* Tashkent *Publishing Hause Fan* pp 267–284
[10] Baturin G E 1985 Horizontal drainage In: *UzSE Vol. 1* Tashkent pp 347–349
[11] Xamidov M X Shukurlaev X I Mamataliev AB 2019 Hydrotechnical melioration of agriculture Tashkent *Publishing Hause Sharq* pp 230–235
[12] Legostaev VM 1959 Reclamation of saline lands In: Tashkent State Publ. House Uzb. SSR
[13] Khuzhakeldiev K N 1987 Irrigation erosion and the rational size of irrigated areas In: *Moscow Sci Work MIIZ* pp 125–128
[14] Avezbaev S 2007 Designing of land management Tashkent *Publishing Hause Cholpon*
[15] Laktaev N T 1978 Watering of the cotton Moscow *Publishing Hause Kolos*