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Optimal Management of The Irrigation Process Based On The Dynamic Programming Method

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Introduction

In terms of effective use of irrigated lands in Azerbaijan, it is urgent to regulate soil cultivation during irrigation, providing mineral and organic fertilizers, precise regulation of irrigation norms and methods, as well as the number of irrigations, and in some cases changing them, including water and mineral-food, air and carbon dioxide. and is the basis of management and is characteristic and attracts attention with its relevance.

It is very difficult to influence the entry of light and temperature (heat) into the plant. However, it is possible to increase and decrease the temperature in the upper layer of the air and soil. Optimal water supply allows the plant to form a large leaf surface (plate), which allows it to direct light better. At the same time, it ensures the phases of its development by creating conditions for the effective use of this light energy.

As is well known, dynamic programming allows to precisely define multi-step optimization tasks.

We must note that decisions must be made step by step to manage the evolving processes determined over time. The main characteristic features of the dynamic programming method: correct expression of the principle of optimization; including the specific task of optimization among the issues that can be solved more easily; obtaining the final result in the form of recurrent-functional management related to the extreme value of the quality criterion.

The dynamic programming method does not provide a single algorithm for solving any extreme problem. At this time, the approach to solving more tasks is based on the principle of their solution and i.a. is taken as the basis. Thus, the transition from the functional equation to the algorithms providing their solution is very difficult, and in some cases it is not even possible.

Thus, the essence of the diamic programming method is that the solution of the N-step problem is replaced by the solutions of one-step, two-step, N-1, N-step problems. At this time, mathematical reporting rules are predominant, which greatly simplifies the optimization procedure at each step.

From this point of view, the use of that method clarifies the structure of the issues of optimizing the irrigation regime of agricultural plants and the results of their solution.

The problem under consideration constitutes an N-step discrete process of making decisions about the importance of irrigation and the choice of irrigation rate.

Note that in this case the problem is defined for any number of steps and belongs to the structure that does not depend on the number of steps. Note also that the selection of the irrigation rate at any step (for example, j-step) does not affect the previous (j-1) step, and after several steps (for example, K) the remaining steps (N-K) influence on the criterion size depends on the state of the system at the end of the K- decision.

The applied damage model provided in the case structure does not take into account the beginning of the process. That is, j irrigation does not depend on the costs of the previous ones.

Damage :- the agrotechnical measure designed during the full vegetation phase and the difference from the conditions that allow the maximum yield to be obtained at the current level of soil fertility, moisture supply conditions are determined.

It is determined by the price of the plant planted in the same year. These are damage measurement criteria and factors that require accurate reporting. Solving the probability equation to characterize the agreement of the effectiveness indicator of the entire process with the indicators of the effectiveness of individual steps of the process, we get this formula:

Q=∑_(k=1)^N (c_ FU(t)dt+P2k(Hk)=∑_(k=1)^N Qk

Two main approaches to the solution are known (3).

The first is a recurrent method, which consists in finding optimal solutions for approximation or stretching processes in functional space. The second approach is an approximation in the behavior space, or an interaction method based on a preview of the problem. The interest approach is prescribed for processes of practically infinite length. A recurrent method is used to find the optimal solution for finite processes.

In solving the functional equations of dynamic programming, the recurrent method is applied in order to find the optimal solution during the determination of irrigation periods and norms.

To solve the optimization problem, we call the state of the system (over the irrigation area) with the vector Y consisting of all the components of the vector X and the components of the integral constraint vector Z that do not include the components of X.

The first condition of the functional equations is the integration of the right-hand sides of X (Tn) and Z. If integral constraints do not exist, then to Y

X:Y= X is compatible.

As mentioned before, dynamic programming method

Its essence is that the solution of the N-step problem with special recurrent ratios is replaced by the sequential solution of one, two, N-step problems. At this time, a one-dimensional task of optimization is solved at each step.

The optimal solution to the given problem is found as a result of the reporting procedure, which consists of two stages. At the initial stage, the value of conditional optimal management and quality functional (conditional-optimal losses-costs for irrigation and damage during the failure of water resources) is calculated for N-issues.

The irrigation rate determined at this time:

- statistical values of average annual (for several years, at least last 5 years) evapotranspiration of agricultural plants vegetation days;
- statistical values of average annual (for several years, at least the last 5 years) precipitation of the days of vegetation of agricultural plants;
- statistical indicators of the average annual (at least the last 5 years) moisture and air temperature of the vegetation days of agricultural plants;
- The presence of groundwater is determined by its elevation

Watering rate:

Average daily deficit of water demand

- The type of plant and its phenological phase;
- The length of the root system of plants;
- Type of soil;
- Sustainability of the reporting stage of vegetation of agricultural plants;
- Wetting coefficient of the leaf surface of plants during pulse rain;
- The coefficient that takes into account the evaporation loss of water against the background of clouds during rainfall;
- The climatic coefficient of evaporation in different phases of plants is taken into account.

Let's specify the reporting algorithms

"Day" is chosen as discrete time τ. The maximum time interval of management was considered - from sowing to the end of vegetation.

The following signs are accepted:

K=1.2....N-step forward number. The increase of k in the backward movement corresponds to the movement to the beginning of vegetation: on the other hand, k is the number of the day, calculated from the end of vegetation and the beginning of the management interval considered in the recurrent procedure.

The beginning of the control interval is T = (N-K)

Ts- the end of management coincides with the end of vegetation;

t-the continuity of the specified interval during the day;

Vector:

Hl- irrigation norm per day from the beginning of vegetation;

Conditional optimal state of Fn-system.

Following recommendations (4,5), the sequence of functions fk (yl) is determined with the help of the following recurrence relation:

f1 (yN) = min QN (yN, HN)

fk=(YN-K+1)= min QN-K+1(Y N-K+1HN-K+1)+fK-1(Y N-K+Π (Y N-K+1HN-K+1) €Ω̃ N-K+1

In the formula (7), the first phrase is to find out the state of the system and the amount of irrigation volume norm on the last day, the required minimum

F2=(YN-1)=min QN-1(YN-1 HN-1)+fK-1(Y N-1+Π (Y N-1HN-1) HN-1€Ω̃N-1

In (6), Yl +Π (Yl Hl) is the state vector at the beginning of the first day, that is, at the moment when the control Hl in the state Yl of the system is added;

Π(Yl Hl) component growth vector during l-day:

Ω̃l –(l-1)t is the area of management to be at the moment

fk(yr) is the minimum value of total losses at the beginning of Yr of this interval. In other words,

fk(Yl)-(l-l) are expected minimal losses at time t until the end of vegetation.

The state of the system before making the next decision is Yl, and optimal decisions are made at this time and at a future time.

It is clear from expressions[1-7] that the solution of the k-step problem consists in adding one step to the (k-l)-step problem and using the results obtained for steps (k-l) to solve it.

L and K are functionally connected l=N-K+l, fk, which is considered a common member of the equation (7), can be written as follows:

fk=(Yl)= min Q1(Y1 H1)+fK-1(Y N-1+Π (Y1 H1) H1 €Ω̃1

The accepted approach to the solution of the functional control of dynamic programming uses the principle of changing the image in the state phase according to which, according to this principle, each coordinate of the Y state in (7) is level quantized: including the irrigation rates at the nodes of the process and the grid where the losses corresponding to them are located. structure is formed.

fk (Y) is calculated at the marked nodes of the grid structure of the function. The size of the grid structure corresponds to the size of the vector Y. The step quantity H and the maximum number of gradations of the norms t are selected taking into account the demand for the irrigation regime.

The adopted step of the grid determines the number of different points. It determines the number of points. It is possible to determine the values of fk (Y) at those points.

Thus, if the state of the YN system at the last step is known, then the HN-control (7) can be found according to the first expression of the ratio. The difficulty is that when starting the management report for the next stage, the entire vegetation planning time-T (planting) Ts

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(harvest end) and not at the last step, i.e. at time t (N-l) from the management within the system.

T, t(N-l) depends on hydrometeorological conditions during the entire vegetation phase. Therefore, the state of the system at the moment t(N-l), that is, all possible YN we are forced to look at situations and make different assumptions about determining the appropriate optimal management for each.

As a result of the solution of the expression in relation[7], for the possible states of (YN), in the last step fN (YN) as well as conditional-optimal indicators of management effectiveness and conditional-optimal management HN are obtained.

Both quantities are recorded in the memory of the EHM, and the next step takes place. (7) from the last equation of the ratio, it can be concluded that the value of the efficiency indicator in this step is found as the sum of two sets:

Q= QN+QN-1

It should be noted that the optimal control will be when it minimizes Q.

that is, losses within the last two days

Since QN-1 €QN-1 (Y N-1) depends on the state of the system in the considered time section, the conditional-optimal losses fK-1(Y N-1) are found from the following expression:

fK-1(Y N-1)= min QN-1(YN-1)+QNYN)

where YN =Y N-1+Π (Y N-1HN-1)

the state at the end of the penultimate interval, Y N-1

Y from the end of the state to the beginning of the interval

Since (9) does not depend on the first collected HN:

fN-l = Y N-1 = min QN-1(YN-1)+min Q(YN)=min QN-1(YN-1)+ fN (Y N)

Obtained massifs (fN-l(YN-1) and (HN-1 (YN-1) are stored in memory and transition to the next step occurs.

When solving the problem in N-2 interval, the results obtained in N-1 interval are used.

Continuing this procedure , we get the optimal losses and the optimal controls for the possible multiplicity of the system in the controlled phase corresponding to them. ≅

In this case, the optimal solution is determined using the solution of the previous step. Such recurrence is the basis of the dynamic programming method.

After the “reverse trip”, a “straight trip” is performed. This time

Y (TH)=Y0

A management strategy that matches the initial condition is used.

During “straight travel” conditionally-optimal controls are selected that correspond to the real state of the system. The optimal controls obtained at each step of the “Straight Walk” are printed.

At the end of the procedure, the summarized results of the optimization are included.

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