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Programming and Evidence of Irrigations with the Aid of a Computer

We must take all the necessary measures for the most rational upkeep and utilization of new irrigation systems.

N. Ceauşescu

1. GENERALITIES

The behaviour of an irrigation system by aspersion endowed with most up-to-date equipment was studied in the 1968—1970 period. Among other aspects linked to the upkeep and exploitation of the water supply network it was noted that the rigorous application of the irrigation method according to the classical definition (Chiriţescu 1925; Botzan 1959), namely that the controlled supply of the soil with water, in due time and in quantities necessary for ensuring constantly sustained agricultural productions — cannot be achieved to the effect of the enunciated definition, on each stationing position of the aspersion lateral and throughout the vegetation period. At the end, the irrigated soil appears as not uniformly irrigated (Leonov, [6]., 1969), this being due to various reasons and generally not studied so far, such as for example: the phenomenon of dry soils which takes place differentially according to textural characteristics and orographical and hydrogeological conditions; the heavy rains which bring a big number of lots to the field capacity, lots which then also get to the necessity of watering, but which cannot be watered simultaneously because the equipment of the systems is limited with quantities of lateral, as a rule 5 to 10 times smaller than the watering requirements at a given moment, the fluctuation of the effective of workers, defects in the supply network or stoppages in electric power or water supply (low levels of the river), etc. It was also noticed that the empirically established watering indications are too general and that in fact, it is very difficult to keep a daily evidence of the watered and non-watered lots, which has as a

consequence the accidental position of the aspersion laterals rather than according to the real necessities, that is to place them on the sides which have to be sprinkled, the situation being frequently reached in which some areas are unjustifiedly sprinkled several times during the summer and other (less accessible) lots are practically not sprinkled during the whole season, although apparently the laterals were moved in order, that is on successively adjacent positions.

If the knowing of the situation at a given moment of the sprinkled lots might be settled by an administrative measure — the situation of the humidity of soil in profoundness, on each lot and the extent to which this humidity was maintained within certain limits will be more complicated to master through the present evidence means.

In this way, the natural proposal was reached to achieve a programming and evidence system of the inflows and outflows of the quantities of water for each lot separately (position of aspersion lateral) using an electronic computer — a method which, in fact, is the object of this paper and a programming and computation system of arranging the lots in the order of the necessity of being sprinkled at a given moment.

Two aspects were followed in carrying out this programme, in the main:

— the evidence of the humidity of soil on the smallest units of irrigated area (lot), with a view to carrying out the above-mentioned principle on irrigations, and,

— the calculation of a series of lots which should be irrigated — at a given moment — in keeping with one or several criteria and which might be: the quantity of water necessary for completing the deficit, the ensurance of the increase of agricultural production through correct irrigation, the correct use of the effective of workers, etc.

The general scheme of the proposed system is given in Figure 1.

2. THE METHOD PROPOSED

An evidence was made of the balance-sheet of water on a lot by assimilating the type of a soil with a sectioned deposit which gets empty and fills up according to a programme simulating the natural process of moistening and drying of the irrigated soils. In this connection, the existent studies were used (Feodoroff [4] and Prudhomme, [8] 1969) on the existence of a characteristic curve of humidity in a drying soil among different periods A, B, C (Figure 2). In view of the proposed calculations, the type of a soil was divided into horizontal layers which in the programme worked out by the authors can be 3 ... 50, according to the precision with which we want to work. The soil layers may have equal or unequal widths between them, comprising either genetic horizons or layers with an equal mass of roots, etc.

A volume of storable water "*U*" was established for each layer of soil separately, which may correspond either to the interval of active humidity, that is the quantity of water comprised between the minimum limit and the field capacity or to another interval which we wish it to vary the water transfer in such a way as not to harm the plant and of course, to be practically most economical for exploitation.

GENERAL DIAGRAM ON THE ORGANIZATION OF THE COMPUTATION SYSTEM AND EVIDENCE OF WATERING

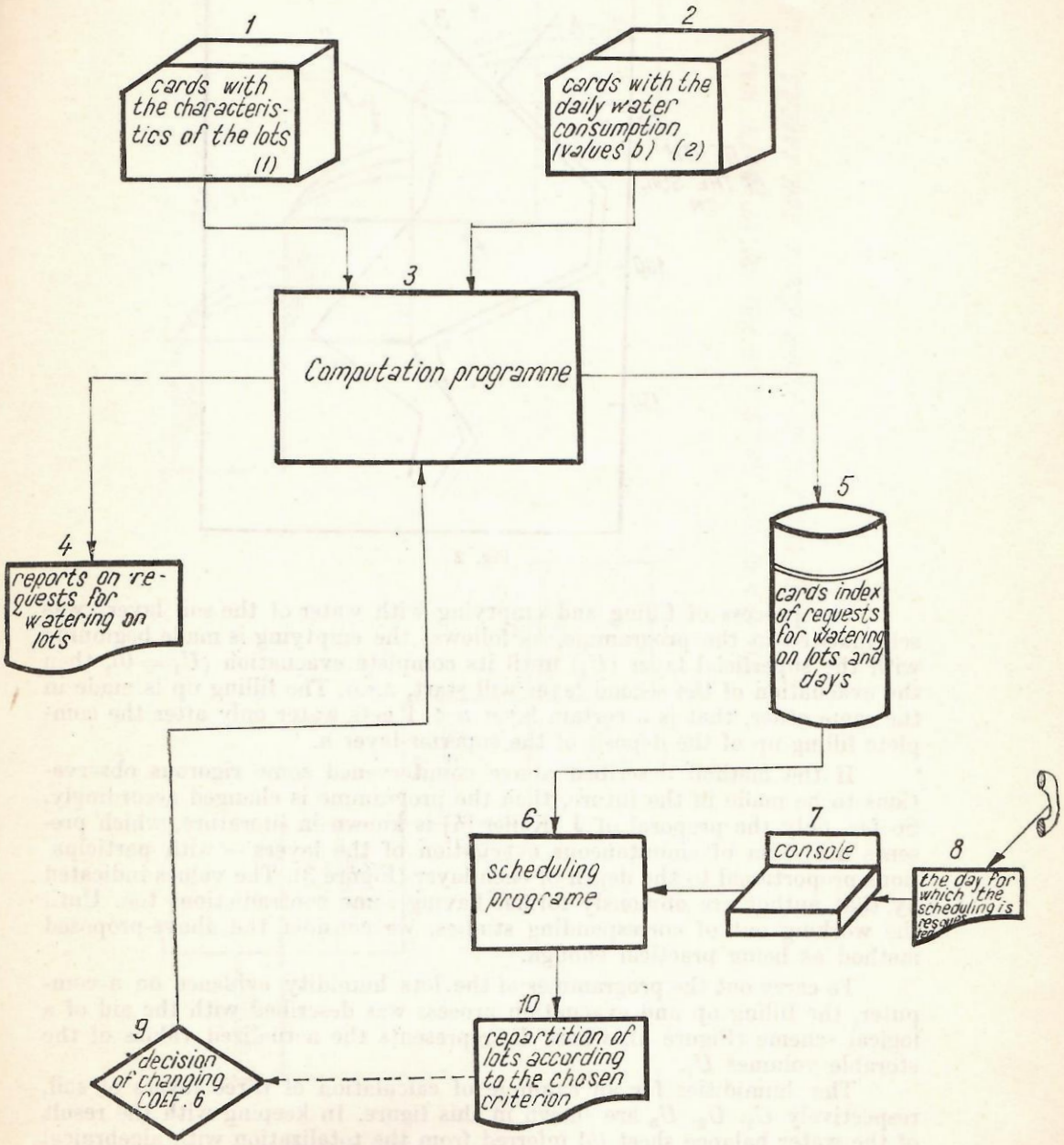

Fig. 1

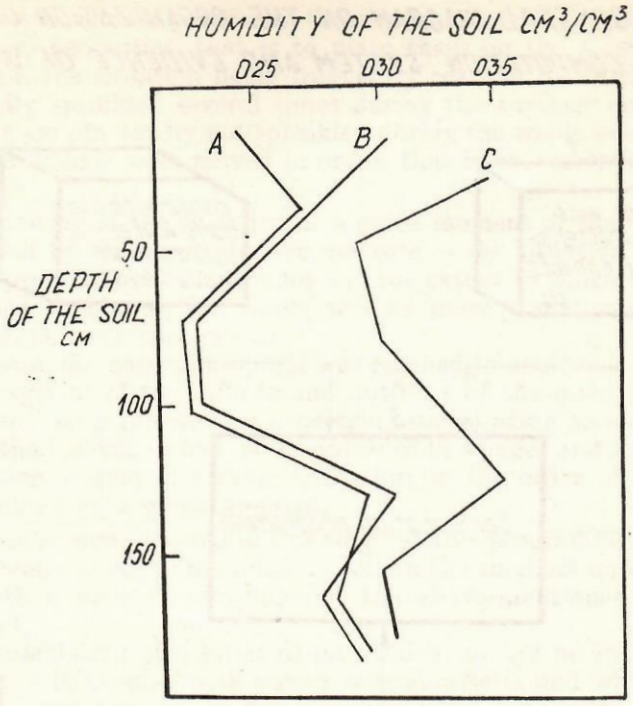

Fig. 2

The process of filling and emptying with water of the soil layers was schematized in the programme, as follows: the emptying is made beginning with the superficial layer (U_1) until its complete evacuation ($U_1 = 0$), then the evacuation of the second layer will start, a.s.o. The filling up is made in the same order, that is a certain layer $n + 1$ gets water only after the complete filling up of the deposit of the superior layer n.

If the method described above countervened some rigorous observations to be made in the future, then the programme is changed accordingly. So far, only the proposal of J. Keller [4] is known in literature, which presents a system of simultaneous evacuation of the layers — with participations proportional to the depth of each layer (Figure 3). The values indicated by that author are obviously formal having some contradictions too. Until the working out of corresponding studies, we consider the above-proposed method as being practical enough.

To carry out the programmes of the lots humidity evidence on a computer, the filling up and evacuation process was described with the aid of a logical scheme (Figure 4), where U_i represents the actualized values of the storable volumes U_i.

The humidities for an example of calculation of three layers of soil, respectively U_1, U_2, U_3 are shown in this figure. In keeping with the result of the water balance sheet (*b*) inferred from the totalization with algebraical signs of the fallen rains P, the sprinkling rates "*m*" on the one hand and of

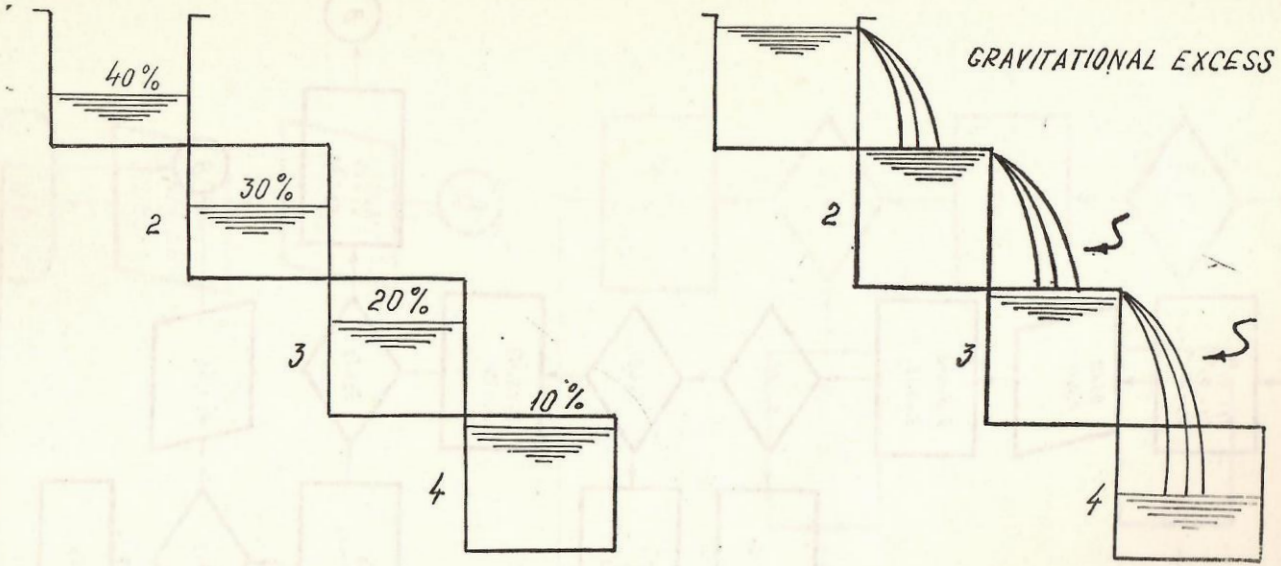

Fig. 3

DRYING OF THE SOILS AND FILLING UP WITH WATER (by KELLER) ON FOUR EQUAL SOIL LAYERS

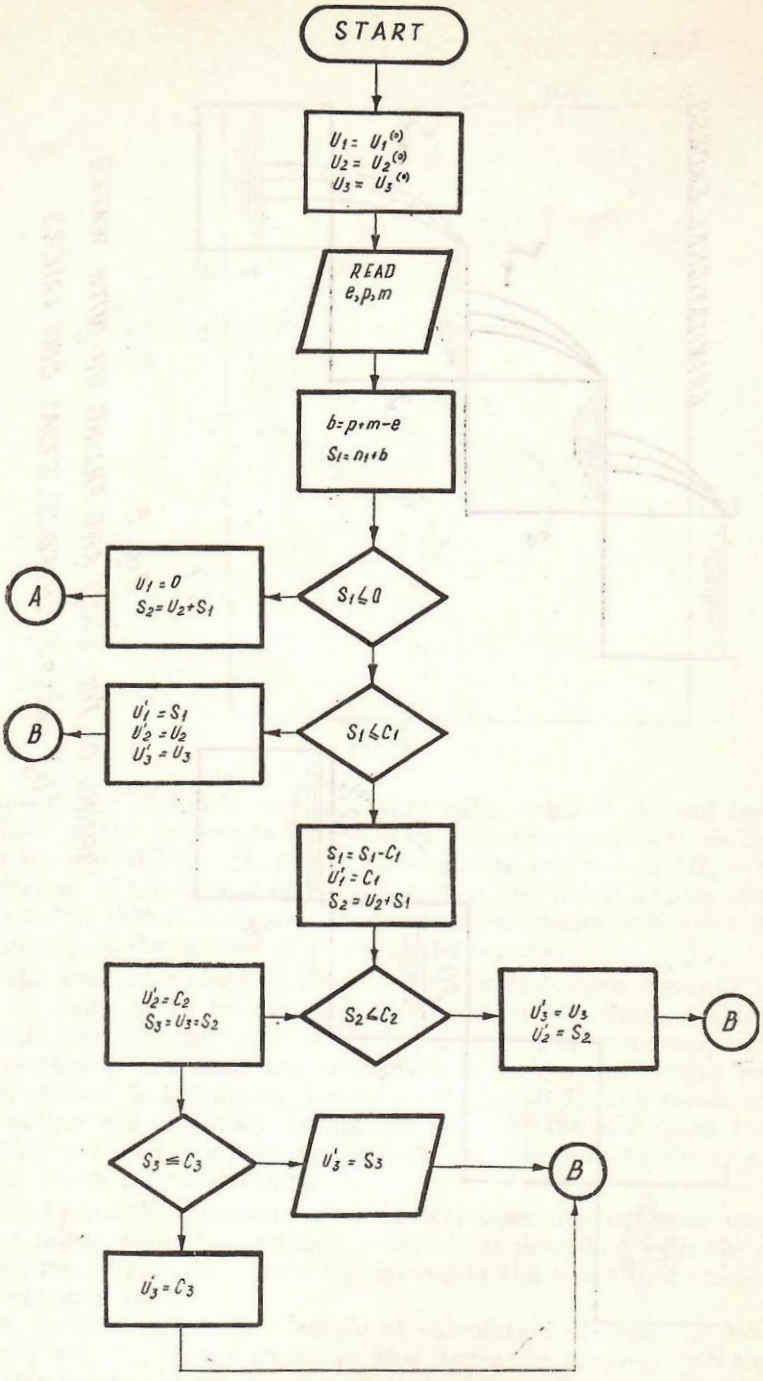
START
$U_1 = U_1^{(0)}$
$U_2 = U_2^{(0)}$
$U_3 = U_3^{(0)}$
READ
e, p, m
b = p + m − e
$S_1 = n_1 + b$
$S_1 \leq 0$
$U_1 = 0$
$S_2 = U_2 + S_1$
A
$S_1 \leq C_1$
$U'_1 = S_1$
$U'_2 = U_2$
$U'_3 = U_3$
B
$S_1 = S_1 - C_1$
$U'_1 = C_1$
$S_2 = U_2 + S_1$
$S_2 < C_2$
$U'_2 = C_2$
$S_3 = U_3 = S_2$
$U'_3 = U_3$
$U'_2 = S_2$
B
$S_3 \leq C_3$
$U'_3 = S_3$
B
$U'_3 = C_3$

Fig. 4

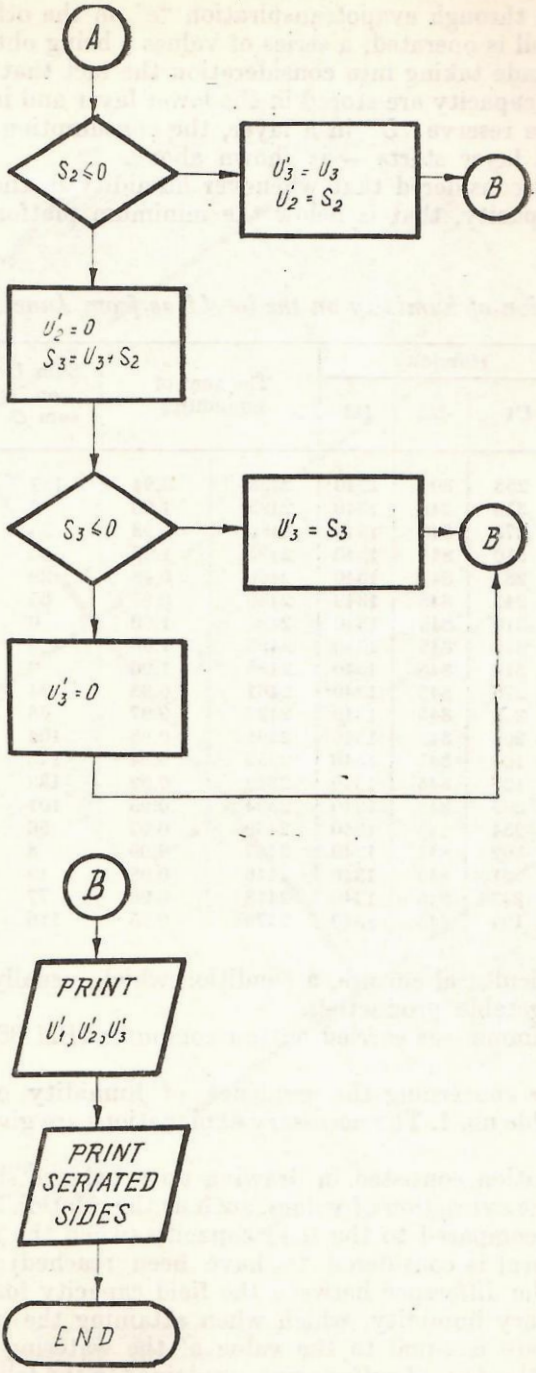
A
$S_2 \leq 0$
$U'_3 = U_3$
$U'_2 = S_2$
B
$U'_2 = 0$
$S_3 = U_3 + S_2$
$S_3 \leq 0$
$U'_3 = S_3$
B
$U'_3 = 0$
B
PRINT
U'_1, U'_2, U'_3
PRINT
SERIATED
SIDES
END

Fig. 4 *b*

the consumption through evapotranspiration "*e*" on the other, the humidity existing in the soil is operated, a series of values *s* being obtained. The above operations are made taking into consideration the fact that the volumes surpassing the field capacity are stored in the lower layer and in the event of the exhaustion of the reserve "*U*" in a layer, the consumption from the reserve of the subjacent layer starts — as shown above.

It was also considered that whenever humidity in the soil is less than half the field capacity, that is below the minimum platform, it is a day of

Table 1

Situation of humidity on the lot 44 as from June 1, 1969

Date	Humidity			The sum of humidities		Sum *U* on sum *C*	No. suffering days	Cumulated suffering days
	*U*1	*U*2	*U*3					
01.06.69	258	800	1340	2358	0.94	137	0	0
02.06.69	310	845	1340	2495	1.00	0	0	0
03.06.69	275	845	1340	2460	0.98	35	0	0
04.06.69	310	845	1340	2495	1.00	0	0	0
05.06.69	281	845	1340	2466	0.98	29	0	0
06.06.69	245	845	1340	2430	0.97	65	0	0
07.06.69	310	845	1340	2495	1.00	0	0	0
08.06.69	310	845	1340	2495	1.00	0	0	0
09.06.69	310	845	1340	2495	1.00	0	0	0
10.06.69	276	845	1340	2461	0.98	34	0	0
11.06.69	242	845	1340	2427	0.97	68	0	0
12.06.69	206	845	1340	2391	0.95	104	0	0
13.06.69	167	845	1340	2352	0.94	143	0	0
14.06.69	127	845	1340	2312	0.92	183	0	0
15.06.69	209	845	1340	2394	0.95	101	0	0
16.06.69	254	845	1340	2439	0.97	56	0	0
17.06.69	302	845	1340	2487	0.99	8	0	0
18.06.69	261	845	1340	2446	0.98	49	0	0
19.06.69	233	845	1340	2418	0.96	77	0	0
20.06.69	194	845	1340	2379	0.95	116	0	0

suffering for agricultural culture, a condition which, usually, is reflected in a reduction of vegetable production.

The programme was carried out on computer IBM 360, in the COBOL language.

The results concerning the evidence of humidity on lots and days appear as in Table no. 1. The necessary explanations are given in paragraph 5 and Figure 5.

The calculation consisted in drawing up a balance sheet of the water in the soil and the extraction of values, such as the relation between the humidity in the soil compared to the field capacity (when the relation is 0,5 the minimum platform is considered to have been reached); the water deficit resulting from the difference between the field capacity for water of the soil and its momentary humidity, which when attaining the value of 600 cubic meters per hectare is equal to the value of the watering norm and finally the valuation of the days of suffering are explained in the following paragraphs.

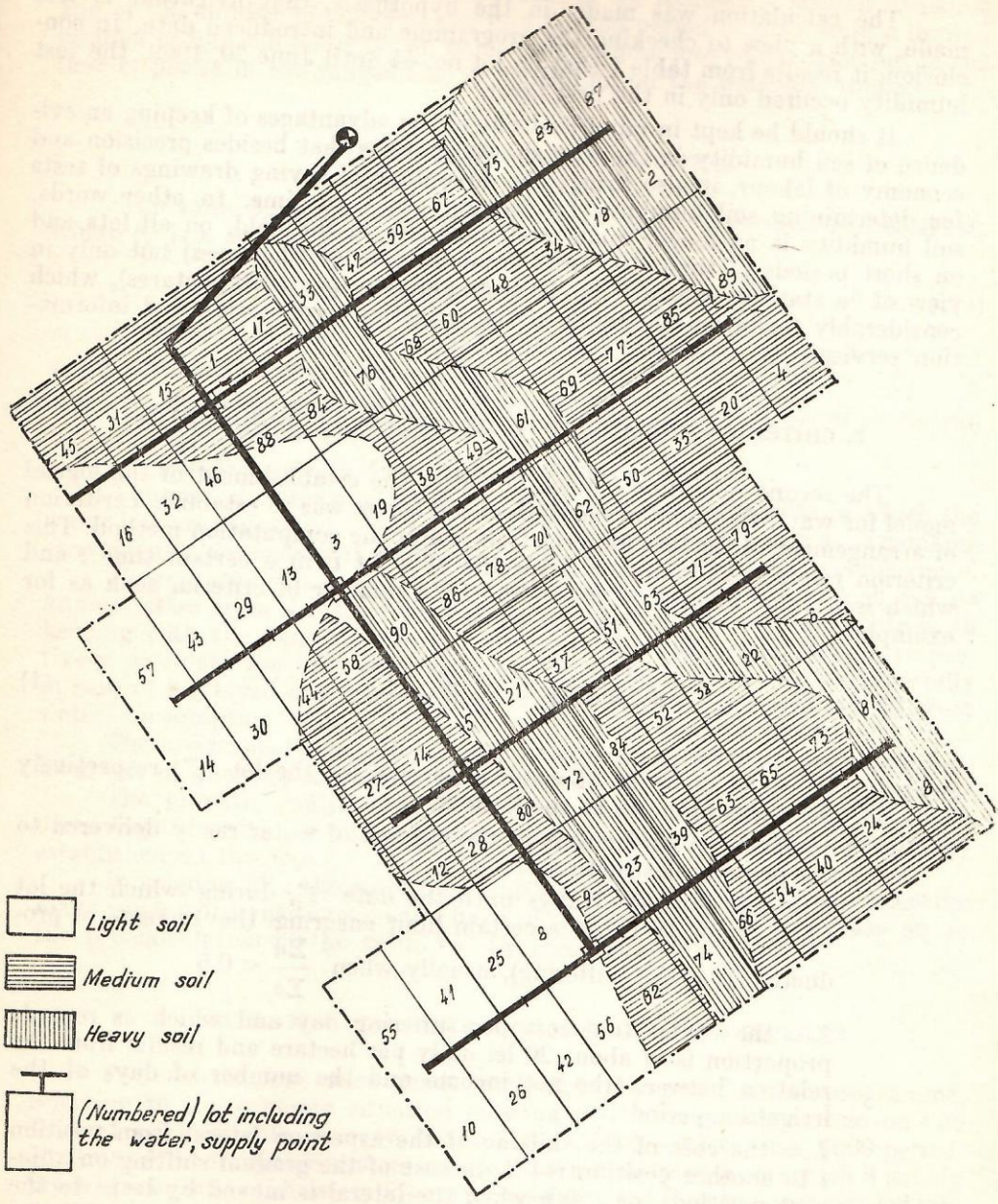

Fig. 5 - Sketch of the irrigated farm and the lots taken in the example of calculation

The calculation was made, in the hypothesis, that irrigation is not made, with a view to checking the programme and introduced data. In conclusion, it results from table 1 that on lot no. 44 until June 20, 1969, the lost humidity occured only in the first layer.

It should be kept in mind that one of the advantages of keeping an evidence of soil humidity in the way shown above is that besides precision and economy of labour, it also brings the advantage of saving drawings of tests for determining soil humidity for longer periods of time. In other words, soil humidity is no longer made systematically in the field, on all lots and on short periods of time (100 tests annually per 1000 hectares) but only in view of "a statistic control" (5—10 tests annually per 1000 hectares), which considerably facilitates the work of the irrigation exploitation and information services.

3. CRITERION OF RANGEMENT OF THE LOTS FOR IRRIGATION

The second operation carried out after the establishment of the logical model for water filling up-evacuation of soil layers was to establish a criterion of arrangement of the lots for irrigation and of the computation method. This criterion refers to an indicator J specific of a lot i, in a certain time t and which is a value expression depending on a number of criteria, such as for example:

$$J_{it} = W/c + N \cdot Z + \frac{1}{L} + \ldots \qquad (1)$$

where: W = the quantity of water necessary for the lot "i", respectively the watering norm at the time "t"

c = the cost of the unit of the volume of water ready delivered to the point of destination "i"

N = the number of days until the date "t", during which the lot i had humidity below a certain limit ensuring the increase of production (days of suffering), usually when $\frac{\Sigma n}{\Sigma c} < 0.5$

Z = the contractual cost per suffering day and which as regards proportion is of about 20 lei daily per hectare and results from the relation between the net income and the number of days of the irrigation period

L = the cost of the shifting of the aspersion lateral from position i to another position $i + 1$, in case of the gradual shifting on adjacent positions, or $i + n$ when the lateral is moved by leaps to the lots which have to be irrigated, not observing the adjacent shifting.

At the end when we want to know the situation of the watering needs, the calculation of the afore-mentioned sum (1) on each lot based on the $U1$, $U2$, $U3$ humidity data will be made and the answer will be the rangement of the lots in the system in the order of the values J_{it}. Because of the limited

volume of water to be pumped every day, of the number of laterals available and of the number of workers, etc. in a limited period of time, only a limited number of lots can be irrigated, namely only those lots which came out in the first m places in the rangement, m depending on the indicated limits.

4. THE PROPOSED WORKING METHOD

The value b_{it} is introduced every day on the evidence card of each lot, where b_{it} is a sum of the form:

$$b_{it} = m + p - (e - a) \tag{2}$$

m = the water rate effectively applied to the lot i on the day t

e = precipitations received on the day t

e = evapotranspiration (calculated after the indications given by Botzan 1959, Melissenda, 1966)

a = phreatic contribution (when it exists)

The rate of water applied results from the working reports in which the water lots are registered. The report can be made in such a way as to combine conveniently precision with the facility of keeping evidence and its conveyance.

Precipitations as well as evapotranspiration are elements which can be known either from a meteorological station or from the warning centres. In keeping with the exigence wished, one may take into consideration, respectively calculate the territorial variations of these two parameters especially in case of big layed out areas or in case of cultures with a sensibly different water consumption, etc.

The precision of registrations and the correctness of the report are a problem out of question and a matter of course.

The phreatic contribution — there where it is noted — will be considered together with the values indicated by the designers or those practically established on the spot.

In keeping with the ampleness which we want to render to the scientific management of irrigations on the basis of a programme one may pass on to the pre-calculation of the value "b" by theoretical relations.

5. CALCULATION VARIANTS AND THE OBTAINED RESULTS

Two calculations were made with the above-mentioned programme, referring to the concrete situation existing in the irrigation system on "30 Decembrie" farm, Ilfov county, in the June 1, 1969 — October 1, 1969 period. An area of the irrigation system supplied by a main pipe from which 8 supply pipes branch out, as shown in Figure 5, was delimited. The area was divided into 90 lots which for the facility of the present calculation which has a demonstrative character, was considered to be the area which is irrigated at the same time.

The same figure indicates the texture of the soils which varies from sandy to clayey. For simplification, three categories of soil: medium, heavy

and light with different hydro-physical characteristics, as has resulted from the planning data, were taken into consideration.

The numbering of the lots in Figure 5 was made according to the successive positions which should be occupied by the laterals on an supply pipe in the present conception.

It was also considered that the cost of the water brought to the various lots varies according to the length of transport, respectively the cost of energy lost for breaking the hydraulic friction. The cost was considered in conventional values as shown in table no. 2.

Table 2

The conventional price of the water for the supply of various lots (example)

Conventional Price of Water	Number of lots
1	1, 18, 46, 88
2	31, 32, 29, 13, 3, 19, 84, 17
3	45, 16, 43, 30, 44, 58, 90, 78, 36, 76, 33
4	57, 14, 27, 11, 5, 21, 37, 51, 70, 49, 68, 47
5	12, 28, 20, 72, 64, 52, 38, 63, 62, 61, 60, 59
6	55, 41, 25, 9, 7, 23, 39, 53, 65, 73, 22, 71, 50, 69, 48. 67
a. s. o.	

The Studied Variants. For studying the model shown in Figure no. 5 two variants of calculations were scheduled:

Variant 1. "non-irrigated" in which values of reference for variant 2 are obtained

Variant 2. the situation in which irrigation decisions are requested and part of these indications are applied.

This calculation made in variant 2 referred to the following working hypothesis:

— reports on recommendation of the lots which have to be irrigated are requested every six days

— the scheduling of the lots to be irrigated is made according to the maximum values of the report.

$$J_{tt} = \frac{W}{c}$$

with the notations in the formula (2) and which expresses the necessity of the priority irrigation of the lots which have both big deficits of water and low costs of water adduction. For reasons meant to simplify the calculation, scheduling was no longer requested according to the value of the days of suffering, the unitary cost, etc., this being resumed in a subsequent stage of study.

— it was recommended that not more than 5 lots (the first 5 lots recommended in the scheduling) can be satisfied, in this period.

— irrigation is made with standard norms of 500 cubic meters per hectare and not according to the real deficit, and the possibility exists of trying other variants too.

— the calculation period was chosen between August 11 th, 1969 and August 29 th, 1969, when an obvious deficit of water takes place in the soils of the analysed lots.

THE OBTAINED RESULTS

The calculation variant 1 which aimed at verifying the programme was made for the lots 1, 2 and 3 belonging to the three types of soil — in non-irrigated system and for the whole irrigation period between June 1st, 1969 and September 14th, 1969.

The results shown in table no. 3 are an except from the reported data and refer only to the situation existing at three important calendar dates in the calculation of the balance sheet of water in the soil, namely at the beginning of the calculation, June lst, 1969, when it was considered that the whole soil was saturated with water to the field capacity C(that is $U = C$), on August 24th, 1969 when humidity in the soil reaches the minimum limit that is the total sum of humidity in the soil compared to the field capacity is smaller than 50% and on the last day of the calculation, September 14th, 1969. Between August 18th, 1969 and the last day, days of suffering appear for all lots and total at the end 22 days for light and medium soils and 28 days for heavy soils.

It is noticed that the sandy soils are better supplied with water and they maintain their humidity above the minimum limit by six days more than the heavy soils.

The water deficit is equal for all categories of soil following the equal quantity consumed by evapo-transpiration — the possibility existing of acting in another way, for example, of differentiating this consumption according to the type of soil, the degree of actual humidity, the agricultural culture, the degree of plants covering, etc. To this purpose, the necessary data will be introduced in the programme.

The *results* obtained in the calculation variant 2 are shown in table no. 4, where the situation of the first 20 lots is given, scheduled after the values of J, out of the total 90, at four different dates: 11, 17, 23 and 29 August, 1969, indicating the degree of soil humidity, the water deficit, the value J_{tt} and the number of days of suffering. The irrigated lots, that is which received the watering rate of 500 m^3/ha, their demand having been satisfied within a certain limit, were indicated in the frame.

We note that:

— the water deficits — as is normal — are growing from one period to another on the non-irrigated lots, no variations existing among the types of soil to which the respective lots belong;

— the watering order which takes into account the price of water makes that the lots which, as regards humidity, are nearer the minimum limit should not be included in the irrigation urgency because of the discharge cost of the water which is higher in comparison with the cost of the water brought to the lots from the vecinity of the pumping station;

— most advanced to the irrigation necessities are the lots with heavy soils followed by the medium and light ones;

Table 3

Results of the calculation in variant 1 (calculation of the balance-sheet of water in soil in non-irrigated simulated regime)

No. soil Type of soil	Date	Results of calculation of balance-sheet in non-irrigated regime							Obs.
		Humidity of soil m³/ha*			Total per type H = 1.8 m	$\frac{\Sigma U}{\Sigma C}$	Deficit m³/ha $(c-u)$	Number of days of suffering $\Sigma U/\Sigma C<0.5$	
		Layer 1 H = 0.15 m	Layer 2 H = 0.45 m	Layer 3 H = 1.2 m					
Lot no. 3 Light soil	01.06.69	258	800	1300	2358	0.94	137	0	
	24.08.69	0	0	1200	1200	0.48	1251	1	
	14.09.69	0	0	551	551	0.22	1944	22	
Lot no. 1 Medium soil	01.06.69	208	600	1500	2308	0,94	135	0	
	24.08.69	0	0	1192	1192	0.48	1251	1	
	14.09.69	0	0	499	499	0,20	1944	22	
Lot. no. 2 Heavy soil	01.06.69	198	600	1200	1998	0,97	45	0	
	18.08.69	0	0	1014	1014	0,49	1029	1	
	14.09.69	0	0	99	99	0,04	1944	28	

* The pedophysical data were taken after M. Botzan: Irrigated Cultures, page 39

— the lots were watered with norms smaller than the dificit; for this reason, the lots no. 88, 46, 15, 1 and 84 irrigated on August 11, will be irrigated again on August 23 rd, taking the place of other lots. Contributing to this situation was also the very low price of the discharge of water on these lots; after receiving the second watering, they yield the place to other lots with big water deficits of the order of 1400 m^3/ha and even more.

— watering the lots in the indicated urgency, differentiations are taking place as regards the degree of humidity and the watering order changes fundamentally from one report to the other. This proves the idea underlined at the beginning of the paper, namely that a variety of humidities of the lots is obtained in the irrigation systems, at the end (called by Leonov "a diversity of irrigations"). Proceeding to the irrigation of lots on adjacent positions, after the classical method used at present in practice and designing or after other criteria which do not take into account the effective humidity in the soil, the above-mentioned differentiation becomes more profound and the principle of observing the minimum limit is less taken into consideration.

It may be noted from tables 4 and 5 that the lots proposed to be irrigated have a better humidity than others which are not included among the first 5 to 10 lots. This is due to the influence of the economic factor (in this

Table 4

Results obtained in the calculation variant 2

Number lot	Report on 11.08.1969					Report on 17.08.1969				
	No. lot	U %	Deficit m^3/ha	J	Number of days suffering	No. lot	U %	Deficit m^3/ha	J	Number of days suffering
1	88	0.69	736	736	0	32	0,60	998	499	0
2	46	0,70	736	736	0	31	0,59	998	499	0
3	15	0,69	736	736	0	29	0,60	998	499	0
4	1	0,69	736	736	0	19	0,60	998	499	0
5	84	0,69	736	368	0	17	0,59	998	499	0
6	32	0,70	736	368	0	13	0,60	998	499	0
7	31	0,69	736	368	0	3	0,60	998	499	0
8	29	0,70	736	368	0	88	0,79	498	498	0
9	19	0,70	736	368	0	15	0,79	498	498	0
10	17	0,69	736	368	0	1	0,79	498	498	0
11	13	0,70	736	368	0	46	0,86	338	338	0
12	3	0,70	736	368	0	90	0,51	998	332	0
13	90	0,63	736	245	0	86	0,59	998	332	0
14	86	0,69	736	245	0	78	0,59	998	332	0
15	78	0,69	736	245	0	76	0,51	998	332	0
16	76	0,63	736	245	0	58	0,59	998	332	0
17	58	0,69	736	245	0	45	0,60	998	332	0
18	45	0,70	736	245	0	44	0,60	998	332	0
19	44	0,70	736	245	0	43	0,60	998	332	0
20	43	0,70	736	245	0	36	0,59	998	332	0
21	36	0,69	736	245	0	33	0,51	998	332	0
22	33	0,63	736	245	0	30	0,60	998	332	0

Note: the lots 88, 46, 15, 1 and 84 will be watered for which available water of 3680 m^3 = = (736 × 5) exists.

case the conventionally taken price of water) which disturbs the purely technical recommendation of irrigating any lot which has $\frac{\Sigma u}{\Sigma c} < 0.5$.

The results may be discussed from the point of view of the proportion of the days of suffering which appear in connection with the opportuneness of the chosen rangement criterion, etc.

The only method indicated in this situation is to follow the evolution of the soil humidity on each lot separately, using the proposed or a similar system.

A daily telephone report on the number of irrigated lots and the norm received, on daily evapo-transpiration and eventually on precipitations can be practically organized. After being introduced in the computer, the result on the distribution of the lots to be irrigated on the following day is obtained in a few minutes (10—40 minutes), which is transmitted by telephone. The carrying out of the operation is confirmed the following evening and so on.

Table 5

Number lot	Report on 23.08.1969					Report on 29.08.1969				
	No. lot	U %	Deficit m³/ha	J	No. days of suffering	No. lot	U %	Deficit m³/ha	J	Number days of suffering
1	88	0,70	710	710	0	46	0,69	753	753	0
2	15	0,70	710	710	0	90	0,30	1413	471	12
3	1	0,70	710	710	0	86	0,42	1413	471	6
4	13	0,51	1210	605	0	78	0,42	1413	471	6
5	3	0,51	1210	605	0	76	0,30	1413	471	6
6	46	0,77	550	550	0	58	0,42	1413	471	6
7	90	0,40	1210	403	6	45	0,43	1413	471	6
8	86	0,50	1210	403	0	44	0,43	1413	471	6
9	78	0,50	1210	403	0	43	0,43	1413	471	6
10	76	0,40	1210	403	0	36	0,42	1413	471	6
11	58	0,50	1210	403	0	33	0,30	1413	471	12
12	45	0,51	1210	403	0	30	0,43	1413	471	6
13	44	0,51	1210	403	0	16	0,43	1413	471	6
14	43	0,51	1210	403	0	84	0,62	913	456	0
15	36	0,50	1210	403	0	32	0,63	913	456	0
16	33	0,40	1210	403	6	31	0,62	913	456	0
17	30	0,51	1210	403	0	29	0,63	913	456	0
18	16	0,51	1210	403	0	19	0,63	913	456	0
19	84	0,70	710	355	0	17	0,62	913	456	0
20	32	0,71	710	355	0	13	0,63	913	456	0
21	31	0,70	710	355	0	88	0,83	413	413	0
22	29	0,71	710	355	0	15	0,83	413	413	0

6. DISCUSSIONS AND CONCLUSIONS ON THE MADE CALCULATIONS

The calculation programme of the water balance sheet for each irrigable lot and the repartition of the necessary lots for irrigaion at a given moment according to established economic and technical criteria enables the organs exploiting the irrigation systems to guide work with minimum efforts and with important savings of water, electricity and man power.

The keeping of the evidence of soil humidity on each lot and every day is necessary from the point of view of the scientific application of waterings nad it is possible through the well known method of perforated cards, constituting the most adequate warning method.

It has clearly appeared from the results obtained on the basis of concrete data on the spot and presented in the paper that the shifting of the laterals cannot always be made regularly from the watering position to the adjacent watering position and that the best moving decision can be taken only by taking into consideration all local technical and economic factors and the situation of all lots in the analysed irrigation system.

For the further development of the expounded method, studies and researches are necessary for establishing the phenomenon of soil drying, for determining the value of the day of suffering of the cultures which were not irrigated in due time, for establishing the cost of the moving of laterals through the mechanized method, etc.

An analysis and checking of the expounded programme are necessary in the concrete conditions of several irrigation systems.

7. UTILITY OF THE PROGRAMME

For exploitation. A report on the distribution of the requests for watering of the lots can be asked for every 2—5 days, after which the farmer's decision is established which should take into consideration the proposed repartition entirely, partially or fragmentarily. The decision taken for the following or coming days is entirely applied on the ground or partly when frequent objective and subjective causes occure in practice. Nevertheless, it is absolutely necessary for the effectively applied irrigations to be reported correctly.

With the report on repartition, other useful indications may be requested through the computer programme, such as humidity on layers and in percentages on the total layers, or the total number of days of suffering on lots or totally on system, the cost of the water consumed by the respective lot and which related to production may contribute to settling the cost of the agricultural product, etc.

For designing. The climatic data p (precipitations) and e (consumption through evapotranspiration) for the last 10—20 years may be introduced in the computer and various irrigation regimes should be simulated at equal periods, with a fixed or variable number of norms annually, etc., in the end asking for the periodical, total or cumulated water consumption, days of suffering, the value of mutations, etc. These data may lead to useful specifications, such as: the proportion of water catching (frontal installation), of the frequency of the use of adduction routes taken into consideration in various planned variants, the economic limit of the irrigation system, the determination of the optimum number of wings, equipment, etc. for each variant of irrigation regime (water consumption) introduced in computation.

For research. Big volumes of experiments on the irrigation system can be checked. In this connection, the climatic data of the respective years and the norms applied in the optimum variant of production (or for the turning

of water to good account) will be introduced, repeating the calculations for various widths and number of soil layers and for various U water capacities of the layers. Finally, the effective water consumption, the proportion of the days of suffering out of the total days of the watering period, etc. would result — upon request. Generally, a type of soil is obtained "attuned" to the best experience and which may be recommended for utility in exploitation.

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LA PROGRAMMATION ET L'EVIDENCE DE L'ARROSAGE A L'AIDE D'UN ORDINATEUR

Pour avoir une évidence quotidienne de la situation des lots arrosés et non arrosés et des nécessités en eau pour chaque lot selon un critérium donné, on a réalisé un système de programmation et d'évidence des entrées et des sorties des quantités d'eau sur chaque lot séparemment, utilisant un ordinateur électronique.

Dans la réalisation de ce programme on a poursuivi deux aspects:

— l'évidence de l'humidité du sol sur les moindres surfaces irriguées (le lot) en vue de réaliser pratiquement le principe de l'irrigation selon les nécessités réelles;

— obtenir une ordination des lots à irriguer — à un moment donné — par rapport à un ou à plusieurs critères.

Les auteurs présentent aussi un exemple pratique en interprétant les résultats obtenus

ПРОГРАММИРОВАНИЕ И УЧЕТ ПОЛИВОК ПРИ ПОМОЩИ КАЛЬКУЛЯТОРА

Для точного учета положения орошаемых и неорошаемых участков и потребности в поливке каждого участка по определенному критерию в настоящей статье была разработана система программирования и учета поступления и отлива количества воды по каждому отдельному участку с ислпользованием в этих целях электронного калькулятора.

При разработке указанной программы был сделан упор на два аспекта:

— учет влажности почвы на наименьших единицах орошаемой площади (участка) в целях практического осуществления принципа орошения в зависимости от реальных потребностей;

— получение очередности подлежащих орошению участков — в определенный момент — в зависимости от одного или нескольких критериев.

В статье приводится и конкретный пример с толкованием полученных результатов.