Development of Scheduling Irrigation in Bulgaria

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Abstract

The paper traces the emergence and development of the problem of scheduling irrigation as a scientific and practical issue at the Institute of Soil Science "N. Poushkarov" for half a century. The main participants in this process and the leading scientific publications are noted.

Key words: scheduling irrigation, computer software, evapotranspiration, FAO project.

Introduction

The reason for writing this paper is the fact that some Bulgarian researchers due to lack of knowledge or deliberately do not cite the initiators of the scientific and practical achievements in the scheduling irrigation problem in Bulgaria. Here are the facts about this problem.

Beginning

My involvement with the problem was caused by Dr. Howard Haise during his visit in May 1972 and October 1973, as a consultant on soil physics and irrigation to the FAO project AGl:DP/BUL/69/506 at the N. Poushkarov Institute of Soil Science (H. Haise, 1973; H. Haise, 1973a). Before leaving, he left written recommendations for work on these issues at the Institute, both scientifically and practically. One of his main recommendations was to start research, development and implementation of a system for programming irrigation recommendations. He provided literature on the issue (H. Penman, 1948; M. Jensen, H. Haise, 1963; M. Jensen, D. Heermann, 1970; R. Follett et al, 1973; D. Kincaid, D. Heermann, 1974) and give recommendations to test Dr. Jensen's Kansas Programming System in an experimental field using the Wang 700B Programmable Calculator.

Such a system was developed in the United States in 1969 and has since been successfully exploited in the states of Arizona, Idaho and Nebraska in drought and semi-dry areas for different crops. Between 1969 and 1971, the Nebraska system used a large electronic computing machine the CDC-6400, located in Colorado University, Fort Collins. Data from daily meteorological observations and irrigation data at the Mitchell experimental station were telephoned twice a week to the computing center, where they were returned by post to the station after processing. Irrigation recommendations arrived in two days, indicating the need to perform the calculations at the station itself.

In the year 1972, small programmable calculators Wang 600 and Wang 700 were delivered to the station. Irrigation programs were processed for these small machines. By using the calculators, it has become possible to daily adjust the irrigation data and recommendations to be available to irrigation specialists immediately without the need for data transmission at a distance.

In essence, this system uses readily available data on climate, soil and crops to predict when to irrigate and how much water to consume. The calculations have two stages - the first is for the determination of water consumption and the second one is by balance to find the necessary quantities of water for irrigation.

Since the Poushkarov Institute has a small Wang 700 calculator, Dr Haise left the computational programs and their description for use. The materials are stored with me. Not once have I asked different specialists if they will be interested in them, but so far they have not been used by anyone.

On 29.X.1973, by the initiative of Dr. Devan (then the FAO project leader), a meeting was held with the participation of Dr. A. Behar, Dr. Dinchev from Soil Irrigation System department, Dr. L. Glogov, Prof. Krafti, Dr. Varlev, at the end of which I was also presented. The issue of experimenting the system according Dr. H. Haise's recommendations was discussed. In conclusion, it was recommended to set up a working group for testing the method in one experimental station in parallel with a production experiment in the Agroindustrial Complex (AIC). However, after leaving Dr. Devan at the beginning of 1974, no one took the initiative and the working group was not set up.

According to colleagues from the Department of Soil Physics, in 1974, there was another meeting at the Poushkarov Institute with representatives from the Institute of Hydrotechnics and Meliorations, for which I have not been told. I do not know if there is something about development of this problem in the Institute of Hydrotechnics and Meliorations.

In a conversation with Professor G. Krafti I realized that he was interested in the scientific side of the matter - he developed his own method and wanted to use separate elements of the finished work but did not deal with the practical implementation of the system in AIC. Separate collaborators from the Institute have expressed the view that the ready implementation of Dr. Haise would have a significant agronomic and economic effect, but nobody has put it as a task. It stimulates me on 1.II.1975 to present to the Institute's Director a memorandum (A. Sadovski, 1975) to challenge actions by his side.

I made advise and recommended the following:

1. To set up a working team who, with the assistance of AIC specialists, will plan and conduct a production experiment in 1-2 experimental stations and 5-10 fields in the AIC to determine the efficiency and the accuracy of the proposed method.
2. In case of positive results, continue the research work of Dr. Hayes and simultaneously extend the production experiment of larger irrigated areas.
3. As the main flow of information arises from decentralized - climatic data from stations throughout the country, it will be correct that the processing by computers will also be decentralized - in the AIC or the territorial computing centers.
4. In the future work on the Automated soil and agrochemical servicing system for agriculture and current prediction of the yields, provision should be made and the connection with the

irrigation system as the irrigation programming algorithms shall be developed centrally at the Institute and then transmitted for use by centers on the country.

In conclusion, I believed that the question raised is of great importance for the country, as water resources are limited and available quantities have to be used optimally.

Development

In May 1976 was held in Sofia an Experts Panel (FAO, 1976) on computerized soil management with participation of FAO consultants: Prof. Dr. M. Elgabaly, Dr. S. Bie, Dr. J. Gower, Mr. J. Riquier, Mr. N. Stalbrand, Mr. J. Rjks and several member of the N. Poushkarov Institute staff. As a conclusion several recommendations have been made. One of them was concerned with irrigation: Experiments are required to verity the irrigation recommendations and to include measurements on infiltration, permeability, moisture storage capacity and crop coefficients. When estimating water use for optimal yield, fertilizer recommendations cannot be ignored. Climatic data used for irrigation recommendations should be kept in the original (raw data) form. They can then be used to derive frequency estimates for irrigation and land productivity evaluation. The agrometeorological network should be strengthened. The Panel will supply further information on suitable stations equipment. Close cooperation with the National Hydrometeorological Service is urged.

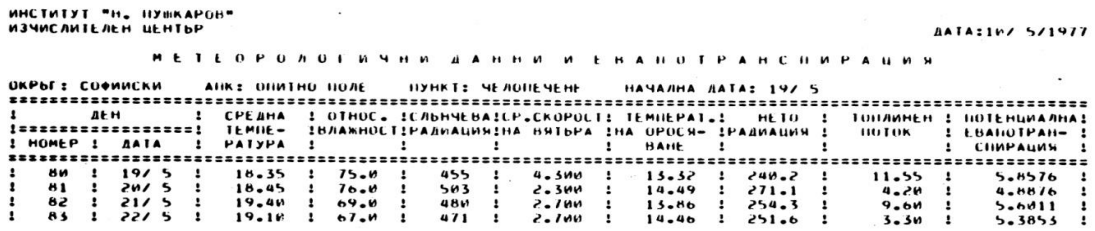
It stimulates me to start work and in the period 1976 - 1978 to develop an analogous system of computer software with several modifications and additions in BASIC program language at the N. Poushkarov Institute Computing Center for NOVA-ECLIPSE minicomputer (Data General, 1975) with some help of Dr. I. Christov. After computer experiments and field experiments conducted in 1977 - 1978, it has become possible to apply this new system of forecasting and management of scheduling irrigation. The results are presented in a number of publications (A. Sadovski, 1976; G. Krafti et al. 1980; G. Krafti et al., 1980a; G. Krafti et. al., 1981; I. Christov, A. Sadovski, 1984). Computer outputs (Fig. 1 and Fig. 2) from the new irrigation forecasting and management system for experimental field in Chelopechene (1977) are provided as an illustration.

Table 1. *Measured (M1) and calculated (M2) water stock for the layer 0 - 80 cm.*

Date	M1 (mm)	M2 (mm)	Difference (%)
5.VI	262.0	272.1	3.9
13.VI	251.9	256.0	1.6
30.VI	264.0	263.4	-0.3
11.VII	223.0	217.2	-2.6
25.VII	231.6	236.9	2.2
8.VIII	241.2	246.4	2.2
25.VIII	271.4	278.5	2.6

With the help of the described complex computer model was performed operational management of the irrigation regime on maize located in the experimental field of the N. Poushkarov Institute near G. Lozen, Sofia District (G. Krafti et al., 1980), as well as through a production experiment with maize held in eight modular units located in different Bulgarian

ecological regions, which confirmed the universality of the model. The meteorological indicators for the vegetation period were taken from the Botunets hydro-meteorological station situated near the fields, and the daily solar radiation data – from the National Institute of Meteorology and Hydrology in Sofia. Potential evapotranspiration was determined by compensatory type lysimeters. Water storage in soil was followed by soil samples with the TLC method. The detected initial water stock is used to determine water deficit. The comparison of the average experimental values of the water stock in the soil with the calculated values based on the computer model is presented in Table 1. As can be seen, the values obtained using the computer model show an impressive degree of coincidence with the measurements of soil samples.



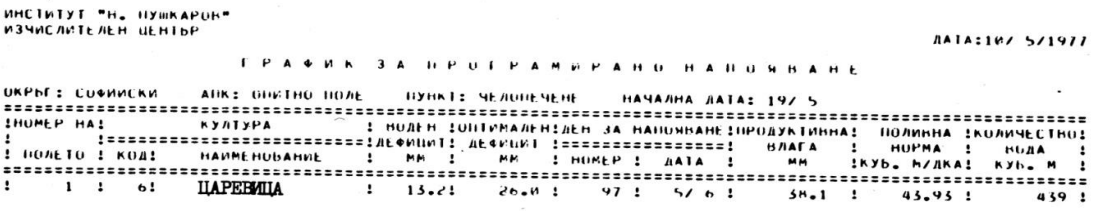
ИНСТИТУТ "Н. ПУШКАРОВ"
ИЗЧИСЛИТЕЛЕН ЦЕНТЪР
ДАТА:10/ 5/1977

М Е Т Е О Р О Л О Г И Ч Н И Д А Н Н И И Е В А П О Т Р А Н С П И Р А Ц И Я

ОКРЪГ: СОФИЙСКИ АПК: ОПИТНО ПОЛЕ ПУНКТ: ЧЕЛОПЕЧЕНЕ НАЧАЛНА ДАТА: 19/ 5

НОМЕР	ДЕН ДАТА	СРЕДНА ТЕМПЕ-РАТУРА	ОТНОС. ВЛАЖНОСТ	СЛЪНЧЕВА РАДИАЦИЯ	СР.СКОРОСТ НА ВЯТЪРА	ТЕМПЕРАТ. НА ОРОСЯ-ВАНЕ	НЕТО РАДИАЦИЯ	ТОПЛИНЕН ПОТОК	ПОТЕНЦИАЛНА ЕВАПОТРАН-СПИРАЦИЯ
80	19/ 5	18.35	75.0	455	4.3М	13.32	240.2	11.55	5.8576
81	20/ 5	18.45	76.0	503	2.3М	14.49	271.1	4.2М	4.8876
82	21/ 5	19.4М	69.0	48М	2.7М	13.86	254.3	9.6М	5.6011
83	22/ 5	19.1М	67.0	471	2.7М	14.46	251.6	3.5М	5.3853

Figure. 1. *Output from Penman program (original in Bulgarian)*



ИНСТИТУТ "Н. ПУШКАРОВ"
ИЗЧИСЛИТЕЛЕН ЦЕНТЪР
ДАТА:10/ 5/1977

Г Р А Ф И К З А П Р О Г Р А М И Р А Н О Н А П О Я В А Н Е

ОКРЪГ: СОФИЙСКИ АПК: ОПИТНО ПОЛЕ ПУНКТ: ЧЕЛОПЕЧЕНЕ НАЧАЛНА ДАТА: 19/ 5

НОМЕР НА ПОЛЕТО	КОД	КУЛТУРА НАИМЕНОВАНИЕ	МОДЕН ДЕФИЦИТ мм	ОПТИМАЛЕН ДЕФИЦИТ мм	ДЕН ЗА НАПОЯВАНЕ НОМЕР	ДАТА	ПРОДУКТИВНА ВЛАГА мм	ПОЛИВНА НОРМА КУБ. М/ДКА	КОЛИЧЕСТВО ВОДА КУБ. М
1	61	ЦАРЕВИЦА	13.2	26.И	97	5/ 6	5М.1	43.95	439

Figure 2. *Output from Scheduling program (original in Bulgarian)*

Institute "N. Poushkarov"

Computing Center

Date: 10/05/1977

METEOROLOGICAL DATA AND EVAPOTRANSPIRATION

DISTRICT: SOFIA AIC: EXPERIMENTAL FIELD LOCATION: CHELOPECHENE BEGINING DATE: 19/05

DAY		MEAN TEMPERATURE	RELATIVE HUMIDITY	SOLAR RADIATION	MEAN WIND SPEED	DEW POINT TEMPER.	NET RADIATION	HEAT FLUX	POTENTIAL ET
NUMBER	DATE								
80	19-May	18.35	75.0	455	4.30	13.32	240.2	11.55	5.8576
81	20-May	18.45	76.0	503	2.30	14.49	271.1	4.20	4.8876
82	21-May	19.40	69.0	480	2.70	13.86	254.3	9.60	5.6011
83	22-May	19.10	67.0	471	2.70	14.45	251.6	3.30	5.3853

Figure 3. *Output from Penman program (English translation)*

Institute "N. Poushkarov"

Computing Center

Date: 10/05/1977

SCHEDULE FOR PROGRAMMING IRRIGATION

DISTRICT: SOFIA AIC: EXPERIMENTAL FIELD LOCATION: CHELOPECHENE BEGINING DATE: 19/05

FIELD NUMBER	CROP		MOISTURE DEFICIT	OPTIMAL DEFICIT	DAY TO IRRIGATE		PRODUCTIVE MOISTURE	IRRIATION RATE	WATER QUANTITY
	CODE	NAME			NUMBER	DATE			
1	6	MAIZE	13.2	26.0	97	05-Jun	38.1	43.93	439

Figure 4. *Output from Scheduling program (English translation)*

The model for managing the irrigation regime considers two important related functions. The first is periodic forecasting the irrigation schedule, taking in account the specific soil, biophysical and meteorological conditions. The second function is periodically updating this irrigation schedule based on a 24-hour balance of income and expenditure quantities energy and water in the system "soil - plant sowing - atmosphere". Periodicity in both cases is three days.

Verification of the biophysical model was also done with respect to the dynamics of the water stock in the soil. Comparison of the average experimental values of the water stock in the soil with the calculated values on the base of the model is presented. As can be seen, the data obtained by both methods show a good coincidence. Therefore, it can be argued that

the model correctly reflects the basic laws of the evapotranspiration process under the conditions considered.

In conclusion, it can be emphasized that the model under consideration is extremely useful, economical and effective. It cancels the periodic taking soil moisture samples and labor-intensive and expensive application of the thermostatic weighing method. Additionally, it gives the possibility of preliminary quantitative assessment of the irrigation schedule. Another particularly important advantage is the fact that the model gives integral values of evapotranspiration, water stock in the soil and other quantities for large-scale areas, while periodic soil moisture sampling is limited by place process. The possibilities of this approach for operational management of the irrigation regime on the scale of individual districts and aggregating country-wide information will provide a unified leadership on a scientific basis in this important branch of our agricultural practice and production.

Applications

We determined the irrigation schedules for maize (ARIS variety) and cotton (SINDOS-80) grown in the Experimental Field of the Institute at Sindos, Greece, in 1994, using the improved scientific basis and the corresponding software package, and carrying out periodical up-dating calculations (I. Christov et al., 1998). The application of the computer technology for irrigation scheduling in different geographical (soil, relief and climatic) conditions, is feasible. We can establish the dependencies of the crop yield amount and quality on the soil water status estimated by the index of soil-moisture energy levels for different regions. For this purpose, field experiments should be conducted in the future.

It is worth mentioning that on the issue of irrigation management there are a number of publications by Bulgarian authors (I. Varlev et al., 1995; I. Varlev, Z. Popova, 1999; I. Christov, 2004; A. Sadovski, 2018).

Conclusion

This brief paper summarizes over forty five years of progress in the development of modern methodology for scheduling irrigation in Bulgaria. The experience that I gained working with my college Prof. I. Christov over almost half century has been very rewarding personally. If I have emphasized my involvement too much it’s because I have been associated with the development of a Decision Support System, based on the sound scientific ground using mathematical models and algorithms, which deserve to be implemented in practice not only in my country, but also worldwide for more food, with less loss of non-renewable water resources and protection of our environment.

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