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Pilot Demonstration Of Scheduling Irrigation System In A Real Farm Environment

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***Abstract*—A decision support system for scheduling irrigation is developed and implemented in a real farm environment on two fields with sunflower and maize near the village of Panicheri, Hissarya region in Central Bulgaria. In this study soil properties and meteorological conditions are presented along with printer outputs of irrigation recommendations. Comparison of the real results obtained from the production experiment by our prototype system with the official statistics shows that they significantly exceed the average yields for Bulgaria.**

Keywords—Scheduling irrigation, prototype software, sunflower, maize.

I. INTRODUCTION

The problems affecting the irrigated crops farming on a global scale are no secret to anyone. Against the background of climate change leading, among other things, to a decrease in water availability in many areas of the world, every year the global agriculture – the largest user of the planet's water resources – spends huge amounts of water without getting the optimum crop results. Statistics have shown that, despite the various irrigation water management attempts available, the agricultural sector keeps on consuming about 70% of the planet's accessible fresh water; the vast majority of this resource is used precisely for irrigation. The figures unambiguously confirm the opinion shared by the world's leading eco experts, that unsustainable water use in agriculture harms the environment by changing the water table and/or depleting ground water supplies.

The scientific method exposed in a series of publications by the researchers' team (Christov et al., 1998; Sadovski, 2018; Sadovski and Christov, 2018), considers the main physical, biological and meteorological factors influencing the irrigated crops vegetation as an interconnected system, subject to monitoring and management via the irrigation regime impacting the agroecosystems water status. It helps to develop a computerized system for scheduling irrigation. Project proposal has received funding from the European Union's Horizon 2020 research and innovation programme under the title "Feasibility study for the further development and market launch of the Archimedes Universal Decision Support System for irrigated crops growers". Pilot demonstration of the TRL6 prototype software in a real farm environment started in Stoyan Pashkulov's farm as a first move towards attracting our prospective innovators' attention, to provoke their interest and to convince them that we are the ones with the problem-solving potential. Meanwhile, in terms of product development, the accomplishment of this first demonstration in a real farm would lead our technology to TRL7 (in accordance with the EC definition – System prototype demonstration in an operational environment) even before the feasibility assessment completion.

This study is an addendum to the Final report for the EU grant agreement No 826310.

II. MATERIALS AND METHODS

Implementation

Following decades of field trials, in 2018 the R&D team behind the IrriGATE technology (Archimedes-UDSS LLC) finally got the chance to apply it out of the trial field - in a real farm. First thing was re-coding the prototype software of the DSS from MS DOS 6.20 and Windows 98 to MS Windows 7/8/10.

Pilot demonstration in real conditions is carried out with the TRL6 software prototype of the future Decision Support System for Irrigation Producers on a farm in the village of Panicheri. The production experiment is conducted on two fields (0.5 ha of sunflower - Hybrid Pioneer P63LE-113 and 0.5 ha maize - Hybrid Pioneer P9415-380). The sunflower is sown on rows, with an interrows distance of 70 cm and an optimum seed density of 5500 pl/ha. The interrows distance for maize sowing is also 70 cm at a density of 8000 pl/ha. Both crops were treated with fertilizers only one time: 150 kg of NPK per ha during planting. The meteorological data are input in the system daily from a station located in the village of Panicheri, 700 m from the field (42.45 N, 24.61 E).

The experiment was done in the Hissarya region in Central Bulgaria – a location known for its mineral water springs and SPA resorts appreciated by several Roman emperors. But nevertheless the experiment definitely did not go as smoothly as we would like to.

First of all, the initial areas set to host the trials turned out to be subject of an argument between our

farmer and a neighbor, eventually resulting in total devastation of the young sowings. Thus, in early summer the alternative faced by Archimedes – UDSS was either to replant the crops in another location or to abandon the experiment. Being obstinate enough, we opted for the replanting, but then, another bunch of problems arose.

To start with, in Bulgaria the usual time to plant spring crops is April. We found ourselves forced to start again in June, precisely on 13 June. Second, the soil at the new areas that hosted the trials was not quite suitable. It was sandy and acidic. So actually we restarted the trials almost convinced that they were bound to fail.

Our farmer had never grown maize or sunflower on that areas; minding the soil conditions and especially the low pH. He was sure that it would not make sense. However, being as enthusiastic as all of us, he kept on following our R&D unit's advice during the whole vegetation. It was given for the period of late planting and ended in end-October with the maize harvesting. After that, no tillage was done except for one hilling. According to the IrriGATE advice, sunflower was watered once and maize – twice during vegetation, through a simple drip irrigation system without any single sensor on it. The soil properties are given in Table 1.

Table 1: Podzolic forest soil, Profile 301 v. Staro Zhelezare, Hissarya region.

Horizon	Sample depth	Layer depth	Sand (%)	Silt (%)	Clay (%)	Gravel (%)	Humus (%)	pH in KCl
A1l	0-22	22	63.55	22.50	13.15	0.80	0.60	4.10
A1A2	32-42	10	56.95	22.55	19.50	1.00	0.55	4.50
B1t	62-72	10	45.15	17.45	35.90	1.50	0.42	4.65
B2t	91-101	10	50.85	17.90	29.75	1.50	0.30	5.15
B3t	121-131	10	55.10	16.50	27.10	1.30		5.65

The climate is transitional continental with warm and mild winters. Climate values - average summer temperature: 21.4□C; average winter temperature: 1.1□C; average annual temperature: 11.5□C; average annual precipitation: 670 l/m², expressed in June and November. Spring is early and relatively warm, summer is characterized by high temperatures (July and August), low humidity and low winds. Autumn is sunny, warm and long.

Tables 2 to 6 provide the real meteorological conditions during the production experiment. The printed output from the irrigation recommendations is shown in Figures 1 and 2. The pictures of the crops during their vegetation are shown in Figures 3 to 9.

Table 2: Measured average air temperature values (ºC)

Decade	May	June	July	August	September	October	November
1	19.86	23.60	23.74	26.39	24.18	16.27	12.77
2	18.97	23.60	24.81	25.97	21.93	17.27	7.97
3	20.45	19.77	24.61	26.07	17.17	15.47	4.57
Mean	19.78	23.05	24.39	26.14	21.56	16.31	8.31

Table 3: Measured relative humidity values (%)

Decade	May	June	July	August	September	October	November
1	54.89	51.69	54.98	45.07	43.79	55.93	67.34
2	61.35	52.59	49.03	38.83	46.85	50.78	71.14
3	55.56	62.65	58.69	42.33	39.76	51.12	64.19
Mean	57.21	55.37	54.38	42.08	44.71	52.56	67.45

Table 4: Measured wind speed values (m/s per day)

Decade	May	June	July	August	September	October	November
1	2.80	2.66	1.86	2.77	3.25	2.18	1.38
2	1.96	2.70	3.16	2.94	2.80	1.80	2.16
3	2.82	3.21	2.17	2.99	3.01	2.70	1.58
Mean	2.54	2.88	2.39	2.90	2.95	2.24	1.70

Table 5: Measured precipitation values (mm)

Decade	May	June	July	August	September	October	November
1	20.60	10.70	31.90	1.60	5.70	6.70	2.30
2	22.70	32.10	4.20	0.00	0.00	2.40	85.00
3	7.40	111.90	49.20	4.40	2.10	1.70	12.80
Mean	50.70	154.70	85.30	6.00	7.80	10.80	100.10

Table 6: Calculated net solar radiation Rn (cal/cm^2 per day) on daily base

Decade	May	June	July	August	September	October	November
1	582.01	644.44	618.63	776.19	630.67	574.53	380.81
2	530.81	518.84	716.90	760.49	661.22	511.17	260.19
3	537.74	252.25	453.19	597.39	509.01	423.83	238.54
Mean	549.78	484.30	591.63	707.68	580.94	500.62	291.42

ARCHIMEDES UDSS

SCHEDULE FOR IRRIGATION

Village - 1
Locality - 1 Initial Date: 3 / 8

FIELD No	CROP	AREA DCA	DAT TO IRRIGATE D/M	IRRIG. RATE C.M/DCA	WATER Q-TY CUB.M
1	MAIZE	5.0	5/ 8	67.1	335.7
2	SUNFLOWER	5.0	6/ 8	43.8	219.1

Figure 1: Irrigation recommendation on date 03.08.2018

PRRECOME

ARCHIMEDES UDSS

SCHEDULE FOR IRRIGATION

Village - 1
Locality - 1 Initial Date: 4 / 9

FIELD No	CROP	AREA DCA	DAT TO IRRIGATE D/M	IRRIG. RATE C.M/DCA	WATER Q-TY CUB.M
1	MAIZE	5.0	8/ 9	8.5	42.7
2	SUNFLOWER	5.0	NO IRRIGATION		

Figure 2: Irrigation recommendation on date 04.09.2018.

III.RESULTS AND DISCUSSION

The outcomes: **2900** kg of **sunflower** per ha, harvested in early October, and **8100** kg of **maize** grain per ha, harvested in late October. As the title says, the farmer got stunned, and no wonders. To sum up here: late planting, poor soil, one fertilization, one hilling, and the watering recommended by the scheduling irrigation system (IrriGATE). Our grower expected little, but eventually got real yields, moreover at a cost of two-thirds of his usual expenses for sunflower and almost half of those for maize.

It is appropriate to make a comparison of the real results obtained from the production experiment by our prototype system with the official statistics:

Sunflower Average yield for Bulgaria (2000 - 2017) YSfl = **1735.8** kg/ha */

Standard deviation Sd = 470.2 kg/ha

Minimal yield (p = 95%) YSfl - 2*Sd = 795.4

Maximal yield (p = 95%) YSfl + 2*Sd = 2676.1

Maize - Average yield for Bulgaria (2000 - 2017) YMz = **4664.8** kg/ha */

Standard deviationSd = 1689.5 kg/ha

Minimal yield (p = 95%) YMz - 2*Sd = 1285.8

Maximal yield (p = 95%) YMz + 2*Sd = 8043.9

/ Source: Bulgarian Ministry of Agriculture, Food and Forestry, Agrostatistics Department, Survey yields of crops.

The numbers speak eloquently on its own about the success of our efforts !

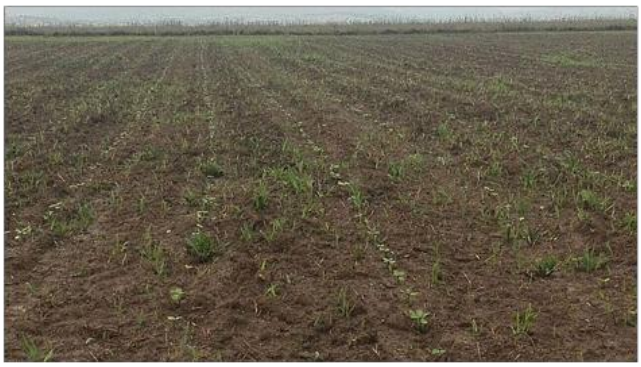

Figure 3: Sunflower 29.06.2018.

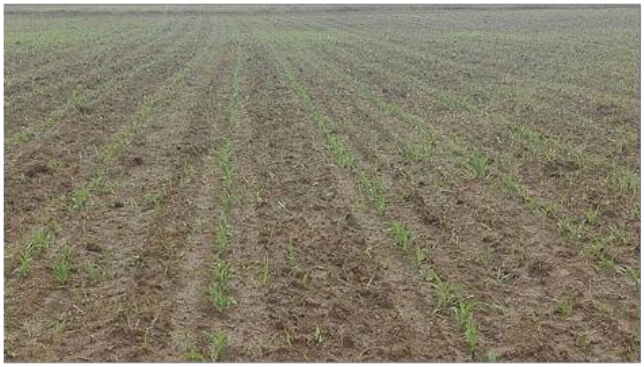

Figure 4: Maize 29.06.2018.

Figure 5: Sunflower 23.07.2018.

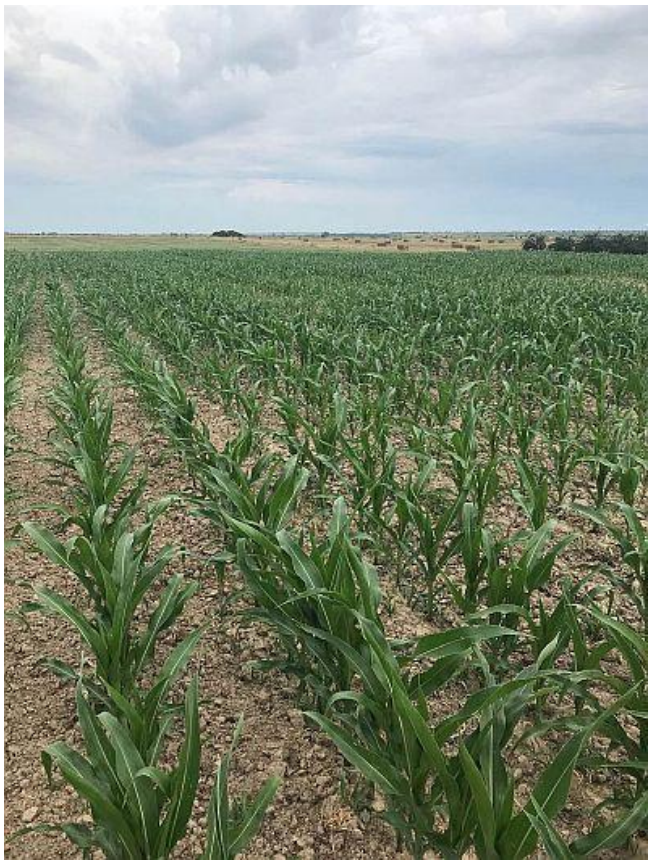

Figure 6: Maize 23.07.2018

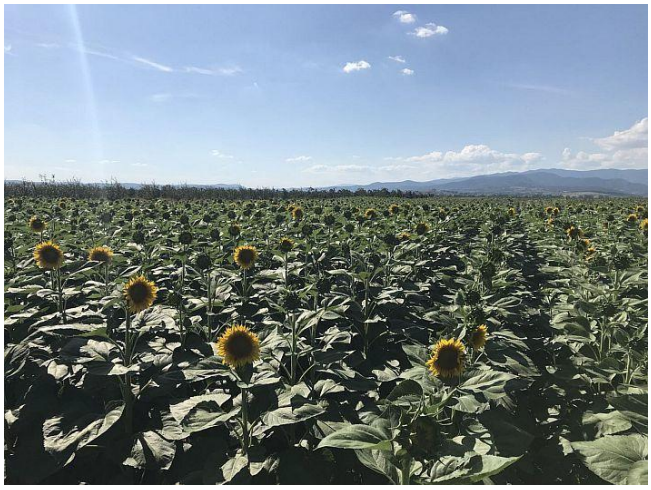

Figure 7: Sunflower 12.08.2018.

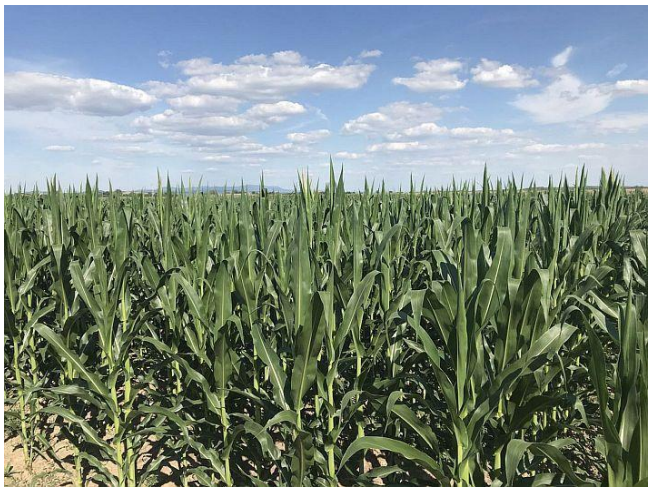

Figure 8: Maize 12.08.2018.

Figure 9: Sunflower 01.09.2018.

Figure 10: Maize 09.09.2018

IV.ACKNOWLEDGMENT

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