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IMPROVEMENT OF THE MICROCLIMATE MONITORING DEVICE IN THE GREENHOUSE

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Abstract

Plant production in a protected area is the most intensive form of production in agriculture. Plant growth is intense throughout the year to produce high yields and good product quality. By definition, microclimate represents the climatic conditions of small spaces measured up to 2m in height from the land surface. The factors of the microclimate are soil temperature, air temperature, air humidity, soil humidity, light, and the amount of carbon dioxide (CO_2). For intensive production indoors (greenhouses) it is very important that all factors of the microclimate be within the allowed limits for a particular cultivated crop. Therefore, our project aims at indicating these factors and signaling to the manufacturer if there is any reason for any of these factors to be corrected.

Keywords

microclimate, monitoring, greenhouse, computer, analysis

1. Introduction

Through this project, a device for monitoring indoor microclimate intended for intensive agricultural production was created. This device consists of 6 sensors, controlled by the ATmega328P microcontroller and an LCD display that shows the currently read values from the sensors, as well as a memory card slot and SIM module. Power is supplied by a battery, and the plan is to have it through a solar panel, which would help to preserve the ecology and reduce the cost of electricity. The data that is collected on the memory card contained in the microcontroller gives us the ability to read the measured data in real time. This way we can analyze the data for a certain period of time from one locality. The data can be sent to the user via SMS, thanks to the integrated SIM module. The ATmega328P microcontroller, through a program written for this purpose, gives the sensors precise instructions on how long and how to make measurements. The prototype of this system is housed in a wooden box on the top side of which has an LCD display, which protects all components from external factors. For the commercial version, a 3D model of the box was made, which will be made of hard plastic.

Protected areas provide intensive production, combined off-season vegetable production, greater control of disease and pests with the application of biological control, which also ensures healthier food. It is known that production under sheltered conditions ensures early harvesting but requires additional costs for heating. Although the prices of early vegetable produce are higher than the open-market products, the uniformity of the products, the quality and the speed of fruiting allow for a good market and better placement. [5, 6, 7] For the successful use of the buildings, it is important to choose the right place (flat surface or gentle fall, deeper groundwater level), then appropriate position and wind protection. Multiple objects are placed in parallel, so that objects with one roof on the long side are in the east-west direction, and those with two roofs in the north-south direction. This ensures that the plants are illuminated evenly throughout the day. All protected area objects should be placed in a place protected from strong and cold winds. For this purpose, fences and protective arches are erected. One meter high shelter protects ten meters behind the space. [4]

Controlling the microclimate in greenhouses is a responsible and complicated process since there are several factors that affect the climate and are mutually dependent. [8] To achieve the goal, which is the highest possible yield on given surfaces, with at the same time, we need to ensure the proper quality of the product for the cultivated plants adequate microclimate conditions while respecting the minimum energy consumption requirements. [3] Work on creating algorithms and software to help protect climate in a protected environment space is part of the process by which most of these factors are controlled with minimum energy costs. [9]

Figure 1. Grenhouses

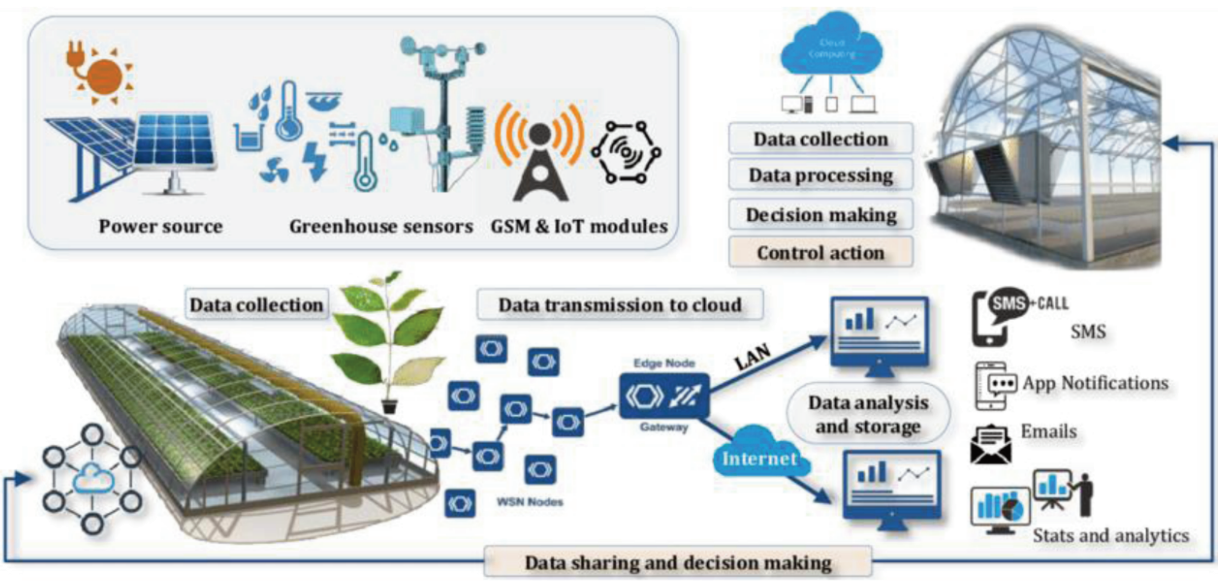

Figure 2. Smart microclimate monitoring systems

Modern microclimate control is today based on the basics of artificial technology intelligence. The programs that were developed included the expertise of experts and empirical knowledge of crop growers. [2] Device prototypes were tested in experimental greenhouses under controlled conditions and designed appropriately software. A model-specific algorithm (control program) was created for predictable climate environment, to be used to simulate energy efficiency and control scheme optimization. The algorithm is designed to be used for appropriate software that provides pre-processing of meteorological data as code model. [1] Using this approach, it is possible to simulate any enclosed structure, at an example of a greenhouse or greenhouse, where appropriate information must be provided. Controllers are devices that adjust various parameters to achieve the best possible microclimate while cultivating crops and at the same time fulfills the goal in terms of high yields and quality of fruits, with the primary goal - the least energy consumption. [10]

2. Material and Method

To create the project, an Arduino platform was used that contained a microcontroller to which the sensors were connected. After the sensors were connected, a program was written using which the microcontroller stores the data on the SD card, and in addition it was enabled to send data via SMS to the end user. In addition to the sd card and sms module, the project also contains an lcd that alternately displays data from the sensor.

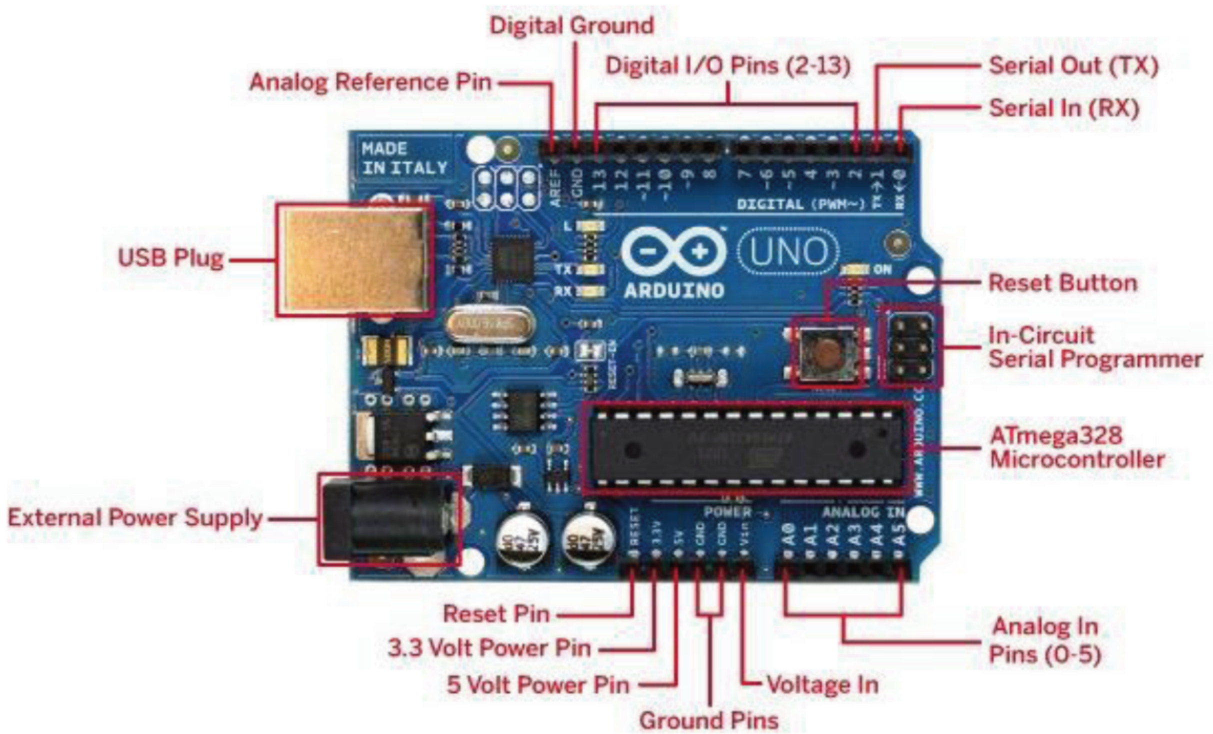

Figure 3. Arduino Uno

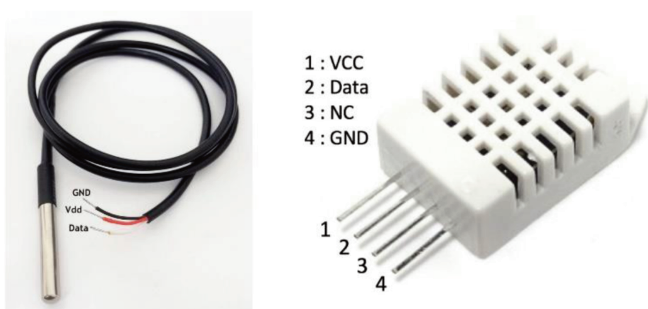

Figure 4. Soil temperature sensor and air temperature and humidity sensor

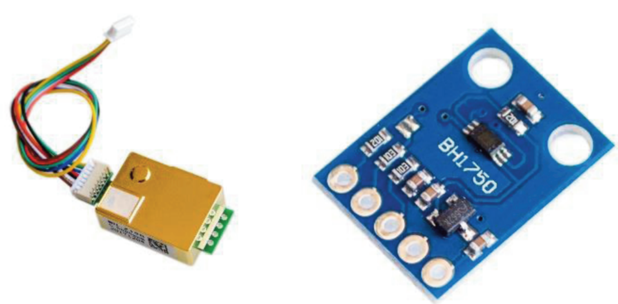

Figure 5. CO_2 content sensor and lighting sensor

Figure 6. Soil moisture sensor, sim module and sd module

Sensors were also used for the project, such as soil temperature sensor, air temperature and humidity sensor, CO_2 content sensor, lighting sensor, soil moisture sensor, sim module and sd module.

3. Results

By interconnecting all the components shown above, we obtained a prototype of a commercial device for monitoring microclimate in a greenhouse (Fig. 7). After connecting and putting the device into operation, an analysis of the device's performance was performed. Testing of the project was carried out in a facility of semi-tall greenhouse type during the month of January 2019. The unit was installed in one part of the greenhouse for 24 hours.

The data obtained are presented in an excel table by date, time, parameter they measure and size, as well as a diagrammatic representation.

The components of the system are interconnected by standard conductors, all of which are housed together in a wooden box because it is a prototype of the device. For the commercial version of the device, a 3D model of the box was made, which will be made of plasticized polymer (Fig. 8).

As mentioned earlier, this model of microclimate monitoring device is mounted in a high tunnel greenhouse. Measurements were made over a period of 24 hours and during this time the device recorded all the data from the sensors at specified intervals and stored them on the sd card. This set up (Fig. 9) allowed us to collect and use the data for further analysis of the device operation, and in addition to observe the microclimatic conditions that prevail inside the greenhouse.

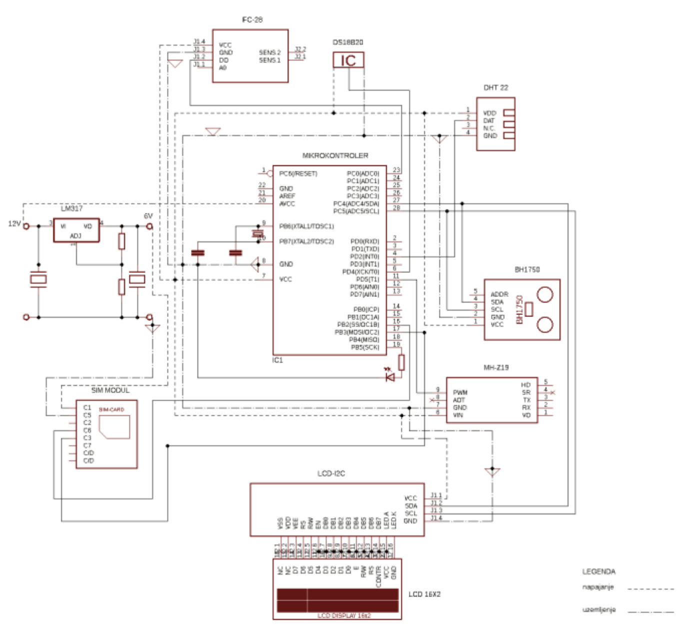

Figure 7. Electrical scheme of the device

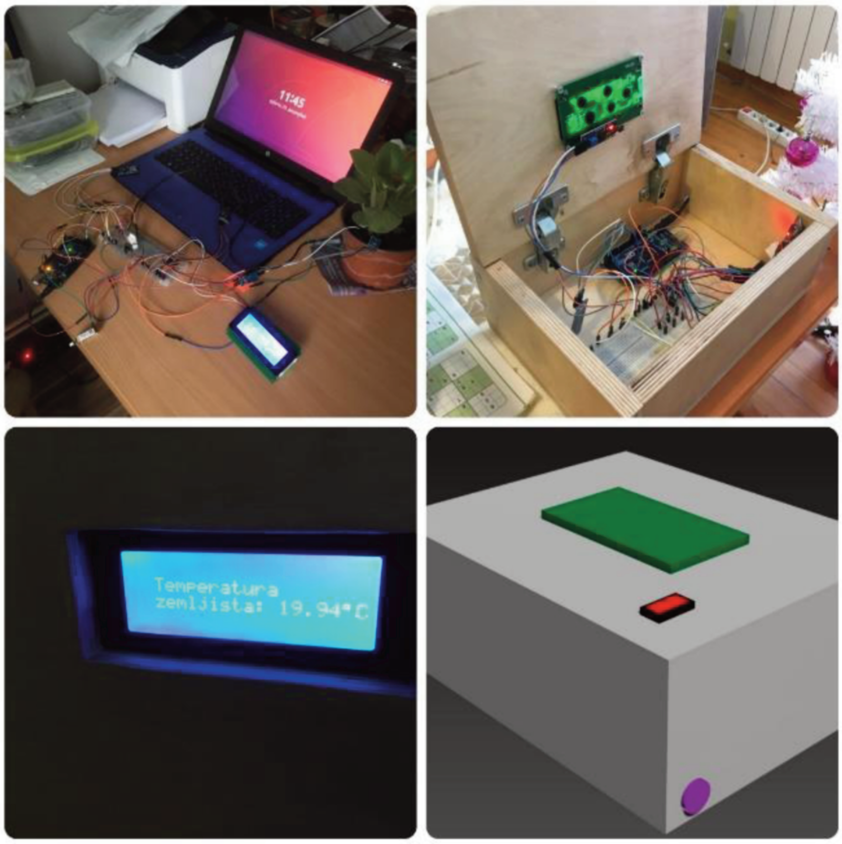

Figure 8. Layout of prototype microclimate monitoring device

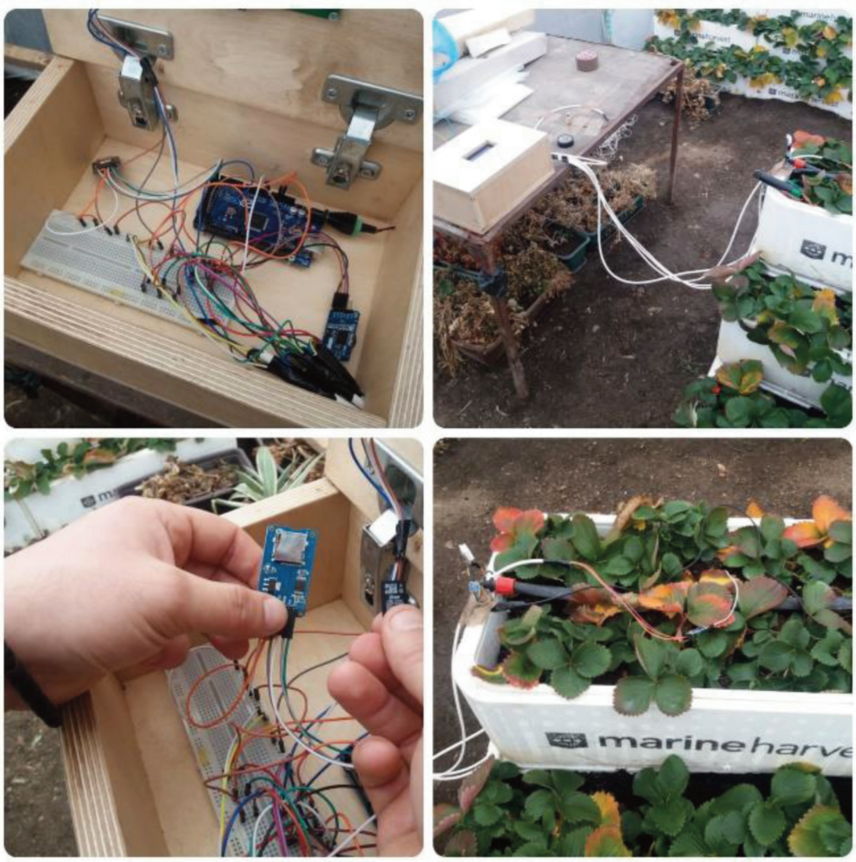

Figure 9. Setting up measurements

After 24 hours of measurement the sd card was removed and data was collected from it, what we received is shown in the following table (Table 1).

The table shows only part of the data because the total number of data exceeds the number of 2500 of consecutive measurements. In addition to the classic table, graphs of the measured magnitude were made (Fig. 10).

Table 1. Values from the sensors

Time	Air humidity	Air temperature	Soil moisture	Soil temperature	Lighting	Solar radiation	CO_2
2019/1/4 (Friday) 14:24:38	55.6	1.9	68	15.19	29	0.04	14
2019/1/4 (Friday) 14:25:10	55.2	1.9	66	15.13	1	0.00	162
2019/1/4 (Friday) 14:25:42	55.3	1.9	67	15.00	3	0.00	162
2019/1/4 (Friday) 14:26:14	55.8	1.9	67	14.94	31	0.05	298
2019/1/4 (Friday) 14:26:46	55.8	1.9	66	14.88	32	0.05	292
2019/1/4 (Friday) 14:27:18	55.9	1.9	66	14.81	32	0.05	288
2019/1/4 (Friday) 14:27:50	55.8	1.9	67	14.69	33	0.05	282
2019/1/4 (Friday) 14:28:22	55.8	1.9	67	14.63	33	0.05	272
2019/1/4 (Friday) 14:28:54	56.0	1.9	66	14.50	33	0.05	268
2019/1/4 (Friday) 14:29:26	56.1	1.9	67	14.44	33	0.05	262
2019/1/4 (Friday) 14:29:58	56.1	1.9	66	14.38	33	0.05	258
2019/1/4 (Friday) 14:30:30	56.2	1.9	66	14.25	33	0.05	252
2019/1/4 (Friday) 14:31:2	56.3	1.9	67	14.19	33	0.05	248
2019/1/4 (Friday) 14:31:34	56.3	1.9	66	14.13	33	0.05	242
2019/1/4 (Friday) 14:32:6	56.4	1.9	66	14.06	33	0.05	234
2019/1/4 (Friday) 14:32:38	56.4	1.9	66	13.94	32	0.05	236
2019/1/4 (Friday) 14:33:10	56.5	1.9	65	13.88	32	0.05	238
2019/1/4 (Friday) 14:33:42	56.6	1.9	66	13.75	32	0.05	236
2019/1/4 (Friday) 14:34:14	56.8	1.9	66	13.69	32	0.05	234
2019/1/4 (Friday) 14:34:46	56.9	1.9	66	13.63	31	0.05	230
2019/1/4 (Friday) 14:35:17	57.1	1.9	66	13.50	31	0.05	234
2019/1/4 (Friday) 14:35:49	57.2	1.9	66	13.44	31	0.05	232
2019/1/4 (Friday) 14:36:21	57.4	1.9	66	13.38	31	0.05	236
2019/1/4 (Friday) 14:36:53	57.5	1.9	65	13.31	31	0.05	236
2019/1/4 (Friday) 14:37:25	57.6	1.9	66	13.19	32	0.05	234
2019/1/4 (Friday) 14:37:57	57.6	1.9	65	13.13	32	0.05	232

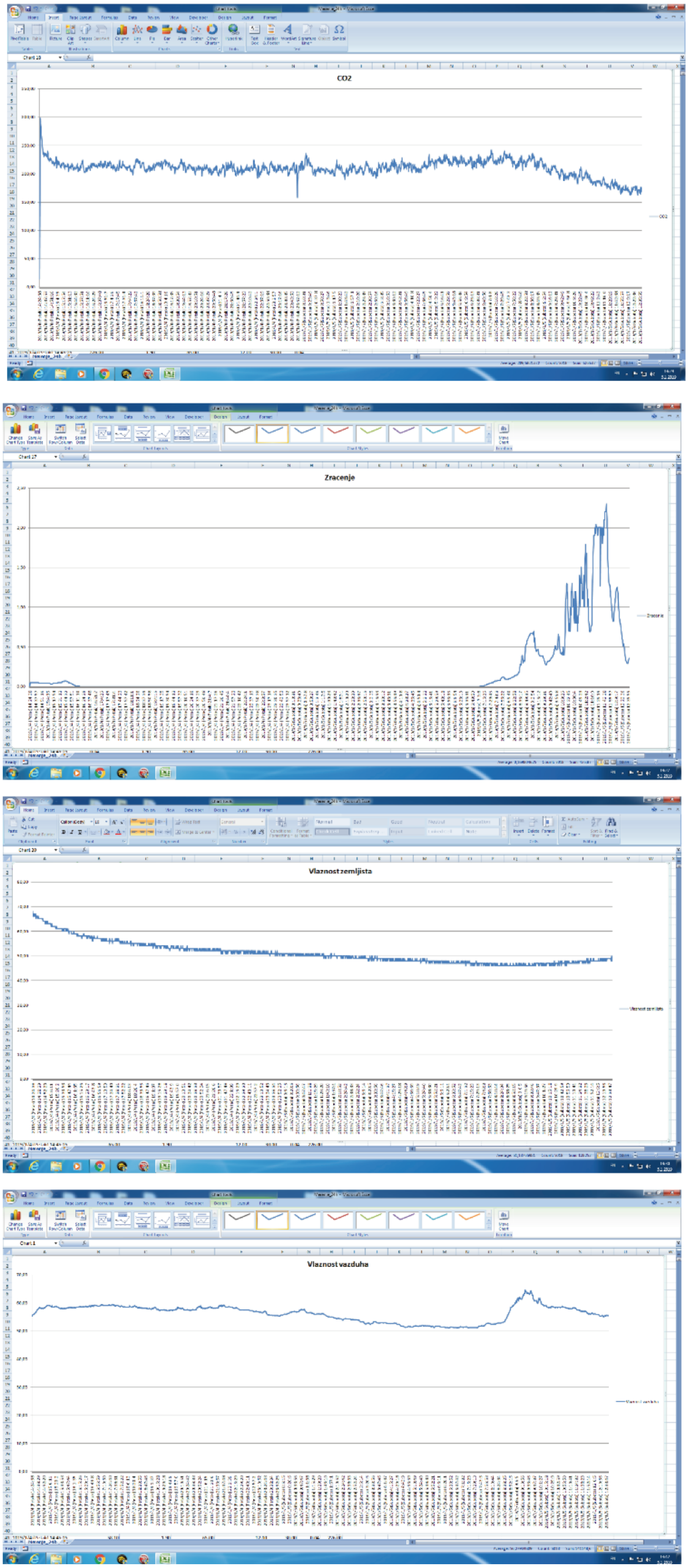

Figure 10. Graphical display of values from the sensor

Conclusion

The country of Serbia has great potential in agricultural production. However, our manufacturers do not have material resources in quantities as is the case in Western European countries. Therefore, the device we made may be available to Serbian manufacturers because his cost price is much lower compared to a similar product in e.g. Germany. This device is intended to help manufacturers to understand all the important microclimatic factors that affect the growth and development of their products and so respond in a timely manner to maintain all parameters within the limits allowed for the culture they grow. This device can also analyze data measured over a period of time and determine why a particular breeding problem occurs.

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