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Research Article

Seedbed based on IoT: A Case Study

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Abstract

Nowadays, the Wireless Sensors Network (WSN) and the Internet of Things (IOT) are widely used in providing decision support systems which solve many problems in the real-world. This paper presents IoT as the best way to solve the agricultural problems, related to seedbed resources optimization, decision making support and seed breeding monitoring. This case study provides real-time information about the seedbed that will help agriculturists make the right decisions during the seed breeding procedure. Using the basic principles of Internet and WSN technology, precision agriculture systems based on the Internet of Things (IoT) technology are explained in detail, especially in network architecture, hardware architecture and software process control of the precision seed breeding monitoring system. The implemented automation system monitors data from the sensors in a feedback loop which activates the control devices based on threshold value. The implementation of WSN in seedbed monitoring (SM) will optimize the control of air temperature and humidity, soil humidity, air capacity, luminance while it will minimize the time of seed breeding and it will also maximize the number of seeds which become plants ready for transplantation.

Keywords: Wireless Sensors Network (WSN), Internet of Things (IOT), Seedbed Monitoring (SM), Decision Support Systems, Precision Agriculture, Network Architecture

1. Introduction

The Wireless Sensor Network (WSN) is one of the best solutions in order to provide effective and economic solutions to a variety of applications ranging from agriculture and health monitoring, to military operations. Moreover, it is a modern technology that combines knowledge of sensors, automation control, digital communication, storage and information processing12.

The agriculture based in precision information and technology agricultural system, is designed to improve the agricultural processes by precisely monitoring each step to ensure maximum agricultural production with minimized environmental impact. The beginning of an agricultural process is the seeding where the seeds are becoming plants. This step involves the adjustment of sowing parameters, the modulation of air temperature, air humidity and soil humidity234.

This study has focused on transforming the traditional seedbed into an automated monitoring seed breeding system that contributes to the economic growth and sustainability of the national agriculture.

The automated monitoring seed breeding system has the benefit of providing real-time feedback on a number of different factors that affect the seed breeding process. The monitoring of different variables and data collection, allows for higher yields and lower cost. Each sensor receives only what is required for its particular space, and at the appropriate time and duration456.

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In this paper, a practical, low-cost and environmental friendly monitored seedbed is designed based on WSN and IoT technology. In this particular application, it is used to monitor key environmental parameters such as temperature, air humidity, soil humidity and luminance. In Section 2 (IoT in Agricultural & Environmental Factors - Seed Breeding), there is an overview of IoT in agricultural, as well as the features of the environmental factors and seed breeding are explained. In Section 3 the monitored seedbed construction automation and development is presented. Furthermore, in Section 4 the test analysis and results are covered and finally in Section 5 (Conclusions) the conclusions and future directions are shared.

2. Methodology

2.1 IoT in Agricultural

The IoT (Internet of Things) based agricultural convergence technology is a technology that aids in creating a high value such as improvement of production efficiency, quality increase of agricultural products in the whole process of agricultural production 127. In addition, implementing precision agriculture, which is an alternative to the future agriculture, through the convergence technology allows prediction of supply and demand, real-time management and quality maintenance during the entire life cycle of agricultural products 8910.

Methods of harvest forecasting have become increasingly elaborate. Highly refined statistical techniques in agriculture are now being used to extract information from past data and to project prediction values of economic variables456. To a large extent, these advances in the science of harvest forecasting have been made possible by the progress in IT technology. On the contrary, solitary statistical techniques do not provide perfect future situation. Therefore, it is necessary to analyze correlating monitoring crop environments with statistical information about harvesting. It is expected that from IoT-based decision support system, this information on statistical pattern of crop can be obtained. The purpose of this study is to improve the agriculture by using a seedbed monitored by an IoT system. To this end, it will be needed to manage IoT devices and gather information from them more appropriately.

2.2 Environmental Factors & Seed Breeding1213

The seed development dependents on the conditions of the environment in which are grown. The environment consists of many factors mainly soil temperature, soil humidity, air humidity, light, ambient and air temperature131415. These climate factors play an important role in the quality and productivity of seed breeding, are interrelated and cannot be considered singly without regarding to the effect on others. A good knowledge of these factors and of their relationships will help an agriculturalist, or any other user of the monitored seedbed to be more aware of potential problems.

Temperature1415, influences most seed development process such as photosynthesis and flowering. Each species of seeds has a different temperature range in which they can grow. Above or below this range, enzymes become inactive and processes may be terminated unexpectedly. Therefore, temperature should be maintained at optimum level which depends on the seed that is used.

Humidity1415, controls the humidity loss from the seeds causing the water and oxygen to leave from them and absorb more CO_2. On the other hand, high humidity can cause the spreading of fungal diseases and thus decrease the process of transpiration.

Light1415, is another important factor for the seed breeding process. Seeds and plants get their energy from sun light through photosynthesis. Light also reacts on the growth of several parts of a plant.

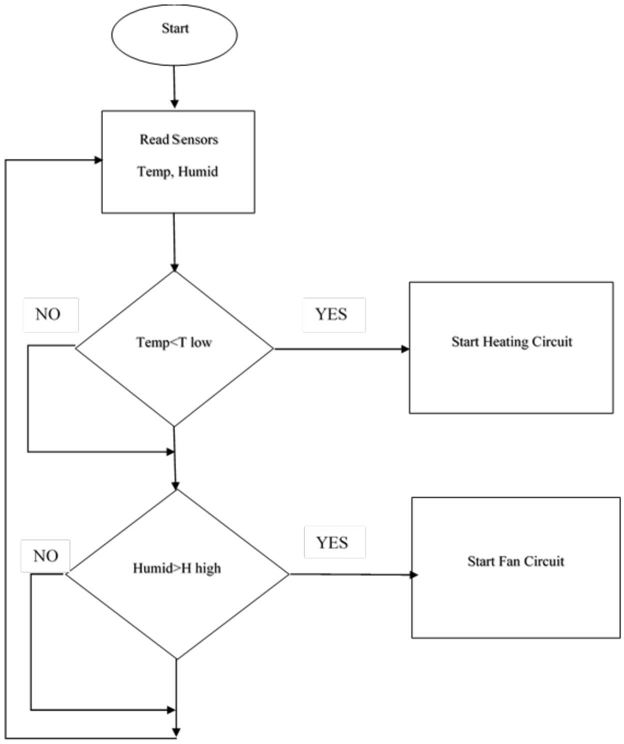
Soil humidity1415, is another essential factor that determines when to supply and in what amount of water. The percentage of water loss is determined by the soil condition, the air flow, the relative humidity in air and the temperature of the environment. In case that the soil is over humidity, the roots are never going to grow, because they cannot extract water and nutrients from soil.

3. Monitored Seedbed Construction Automation and Development

One of the most important sensors for the monitored seedbed is the soil humidity sensor. Soil humidity is the water held in the spaces between soil particles. Also, it is the main factor that defines the amount of water that is going to be supplied to the seed. Precision irrigation requires the exact and definite application of water in order to meet the specific requirements of each seed. Soil and air temperature play an important role in irrigation. Generally, the temperature near the seed is less, due to irrigation process. Currently, there are two main categories of soil humidity measurements: contact-based and contact-free methods. Contact-based methods require direct contact with the soil. This kind of method includes capacitance sensors, heat pulse sensors or fiber optic sensors141617. The second category consists of contact free measurement techniques and includes passive microwave, synthetic aperture radars, and thermal methods181920 . In our case, we are using contact-based sensors (Picture 4) that can measure, air temperature and air humidity (DHT 22) and soil temperature and soil humidity (SHT10). All these measures are being compared with an extra space temperature sensor (TMP 100) in order to get accuracy in our measurements. The whole automation and the measurements are controlled by an Arduino UNO which control the heat (Picture 2) from the heat seals. The Arduino UNO has been chosen instead the other commercial platforms (Raspberry or Netduino) due to the fact that consumes less power (Arduino consumes less than 0,5 W – Netduino consumes 1,8 W – Raspberry consumes 2,3 W) that the other two2122.

We have used 49 tomatoes seeds inside the monitored seedbed and 49 tomatoes seeds using a seedbed in indoor conditions in order to compare the breeding process. The tomato seeds need an environment with air temperature between 24 ^oC and 27 ^oC and air humidity between 60% to 70%. We have found that the breeding of the tomato seeds that were in the monitored seedbed was faster by 7 days than the tomato seeds that were in the indoor conditions seedbed. The flow chart below (Picture 1) explains the procedure of controlling the air temperature soil humidity and air humidity. The program at the beginning reads the values from temperature and humidity and if those values are the desired it waits until there is a change. In case that the temperature is low it turns on the heat seal and if the humidity is high it starts the fan circuit.

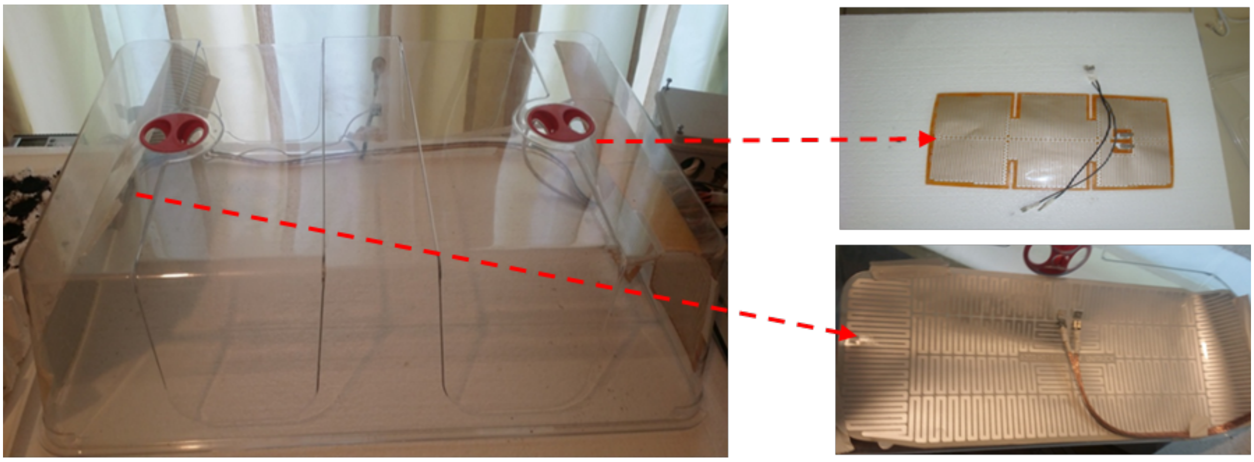
The breeding procedure of the tomato seeds in the monitored seedbed and of those in the indoor conditions seedbed is showed at Pictures 6 to 8.



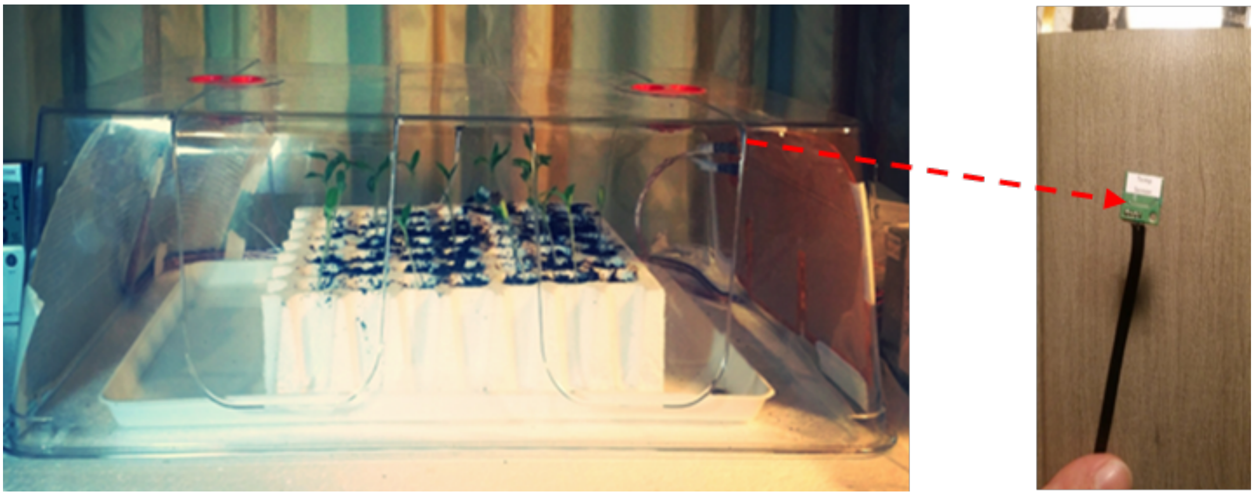
Pic. 1:.Flow Chart of the automation software

4. Materials and Methods

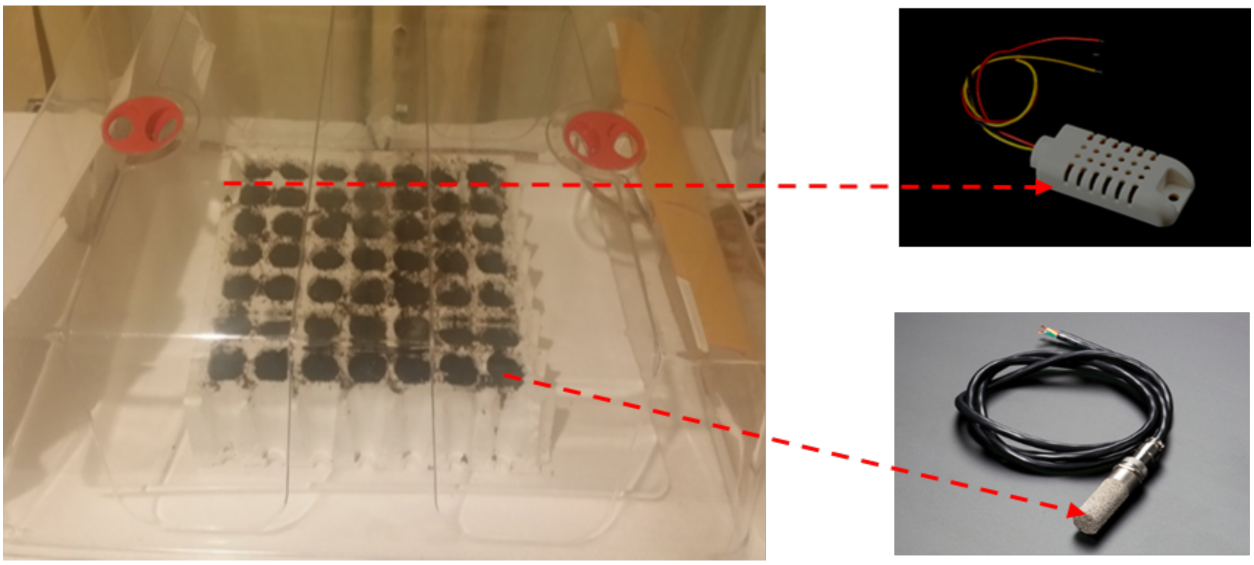
Photo 2 shows the places that the heat seal is installed inside the monitored seedbed. They have been installed at the distance of 10 cm far from the seeds, in order not to cause overheating and eventually stop the procedure. At the following photos (3-4) there is a depiction of humidity, temperature and soil humidity sensors inside the monitored seedbed. The arrows show the exact position of all sensors.



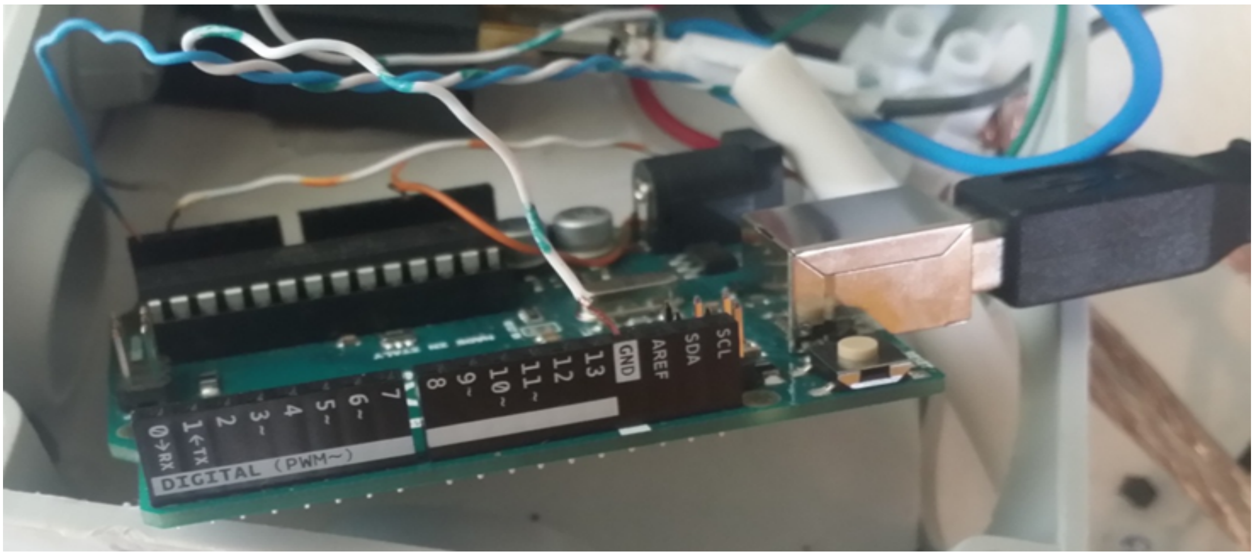
Pic. 2. Construction with heating seals (12V-35 Watt)



Pic. 3. Temperature Sensor (Tmp 100)



Pic. 4. On this picture presents the locations of Humidity-Temperature Air Sensor (DHT 22) & SHT10 Temperature/Humidity Sensor (Soil) inside the seedbed. The data from those two sensors are evaluated from the Arduino UNO in order to act provide stable humid and temperature.



Pic. 5. The automation control system (Arduino UNO**)** together with the wiring connections

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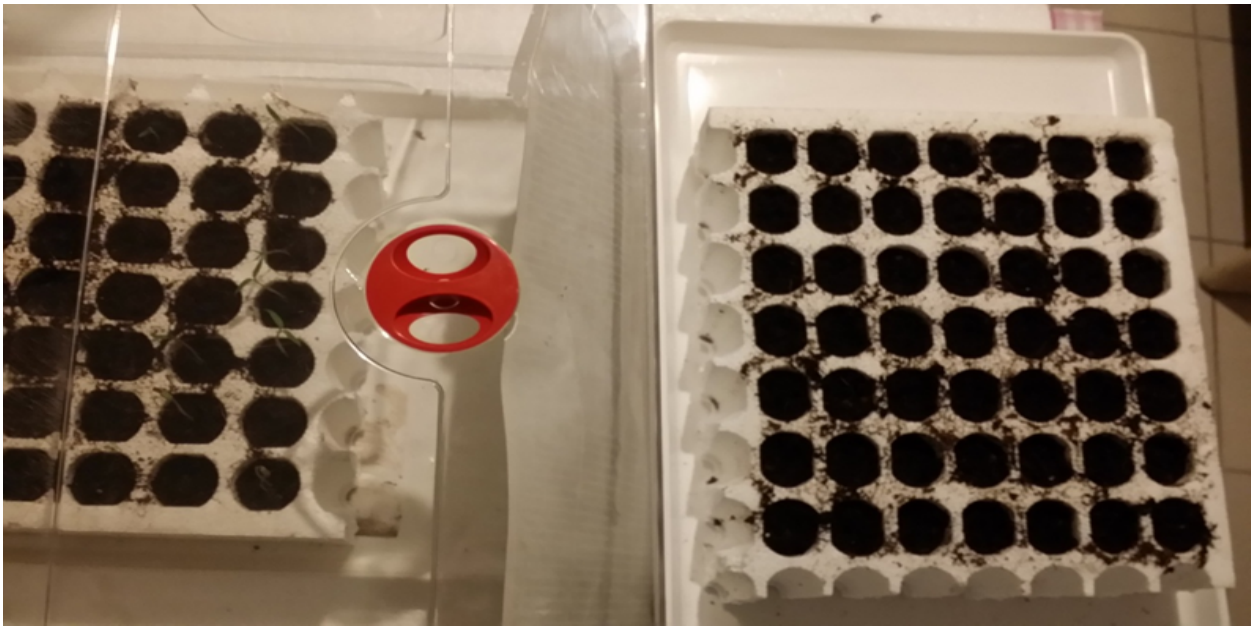
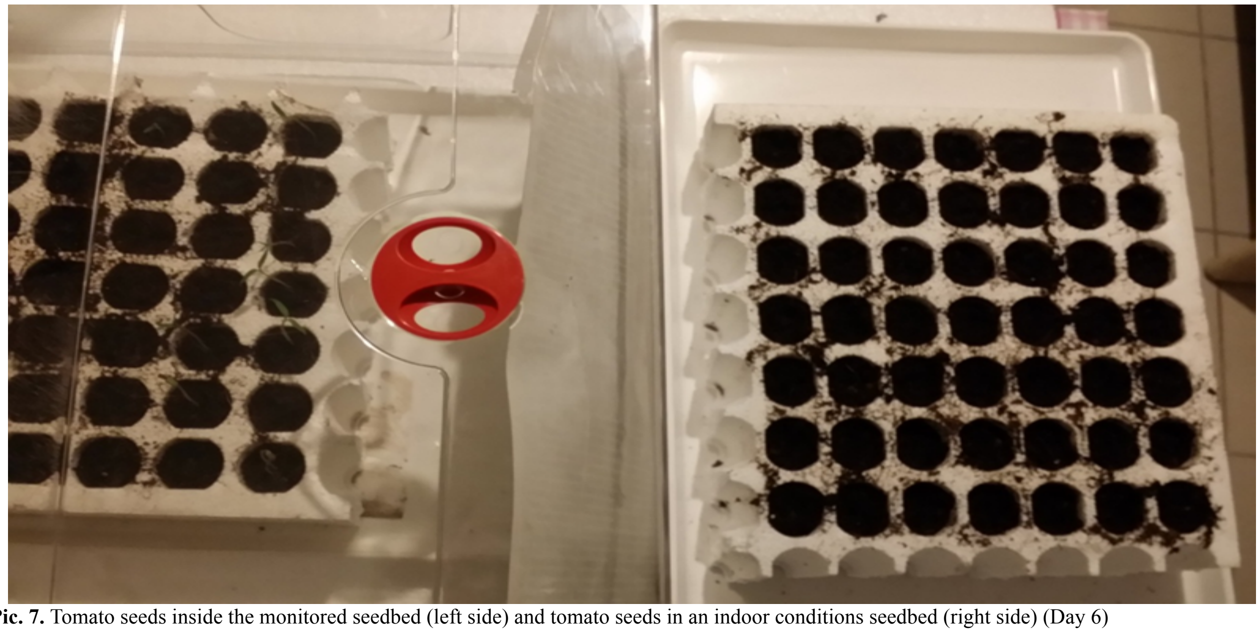
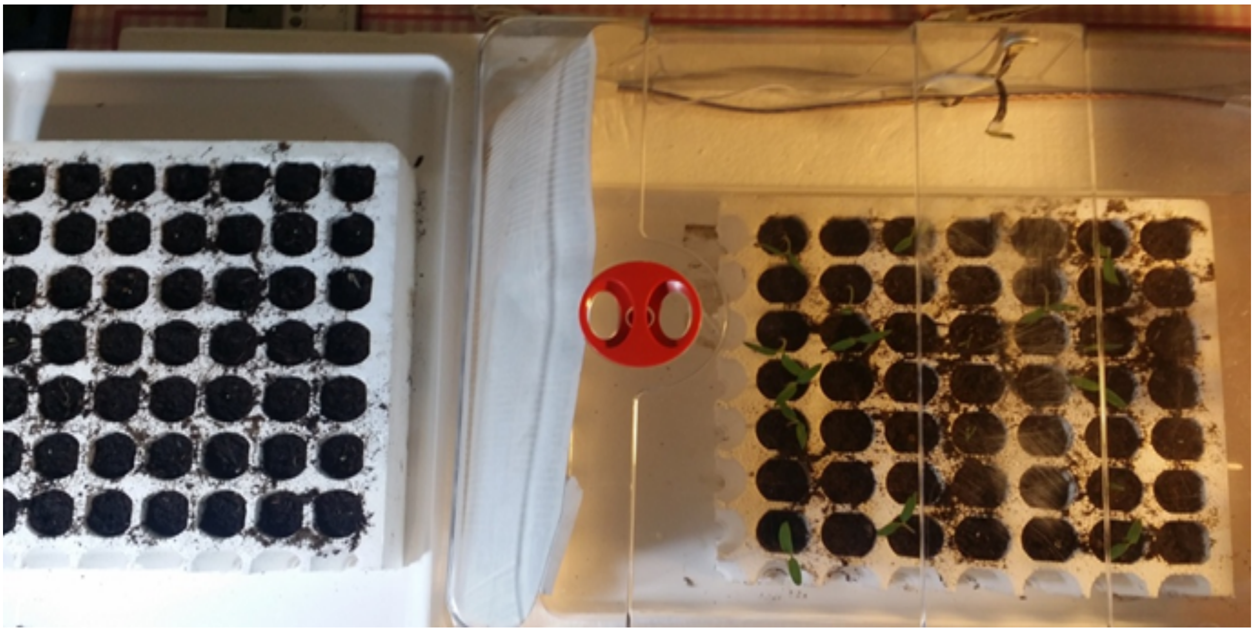


Pic. 6. Tomato seeds inside the monitored seedbed (left side) and tomato seeds in an indoor climate conditions seedbed (right side) (Day 1)



Pic. 7. Tomato seeds inside the monitored seedbed (left side) and tomato seeds in an indoor conditions seedbed (right side) (Day 6)



Pic. 8. Tomato seeds inside the monitored seedbed (right side) and tomato seeds in an indoor conditions seedbed (left side) (Day 9)

5. Results

Diagram A shows the tomato seeds that are brought up inside a monitored seedbed in contrast to the tomato seeds that are brought up in an indoor conditions seedbed. After the ninth day the plants are ready for transplantation. On the other hand, it was noticed that the majority of the tomato seeds that were left in an indoor conditions seedbed (Picture 8) didn't grow at all and the rest of them were 7 days behind in height, in contrast with those that were raised in the monitored seedbed with controlled temperature, air humidity and soil humidity.

Diagrams B and C show that the stability of the temperature and humidity conditions along with the appropriate soil humidity that were provided by the monitored seedbed to the tomato seeds proved to be a convenient climate for a faster breeding. Diagrams B and C also show that indoor climate conditions were less suitable for the tomato seeds to grow up when compared with the monitored seedbed conditions.

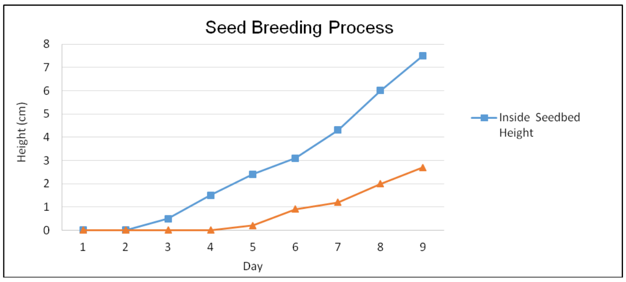


Diagram A. It shows how the seeds are breeding inside the monitored seedbed and in an indoor conditions seedbed

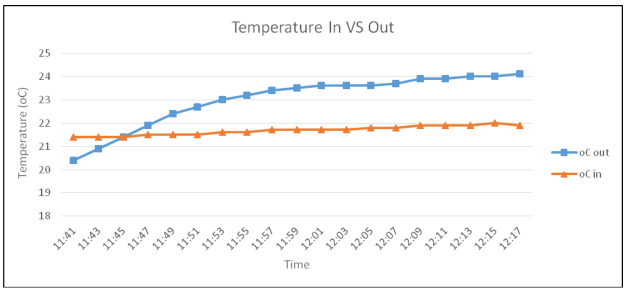


Diagram B: It shows the stability of the temperature inside the monitored seedbed and the temperature in an indoor conditions seedbed

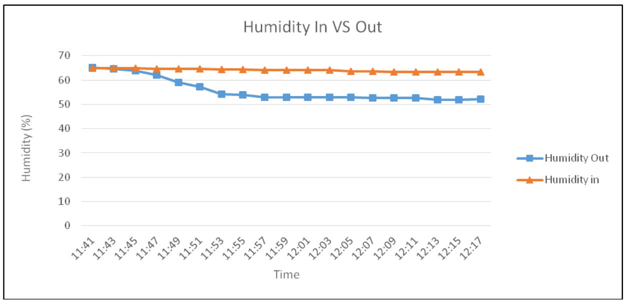


Diagram C: It shows the humidity that is sustained inside the monitored seedbed and the humidity that exists in an indoor conditions seedbed

6. Conclusions

In the presented case study, real-time information is provided about the inner conditions of the monitored seedbed, that are going to help the agriculturalists to make the proper decisions during the seed breeding procedure. The implemented automation system monitors data from the sensors in a feedback loop which activates the control devices based on threshold value. The implementation of WSN in seedbed monitoring (SM) is going to optimize the control of air temperature and humidity, soil humidity, and also it is going to maximize the number of seeds that become plats ready for transplantation. The measurements showed how the humidity and the temperature in a monitored conditions environment affect the seeds breeding faster than seeds that have been left in an indoor conditions environment.

Future work in this case study can include a fan system with filtered system, that will create turbulent air flow and provide by this way better air humidity among plants. Another improvement that can be implemented, is a controlled luminance system that will work in appropriate frequency and emulate the photosynthesis procedure. An automated photosynthesis procedure can enhance the breeding procedure. Adding flexible solar panel that will cover the whole monitored seedbed is another amelioration to the system and will provide the extra power to the electronic systems. Finally adding a camera inside the seedbed, together with an alert system via email, can insure that the seed breeding procedure will be constantly monitored by the owner avoiding any fail such as a plant disease that may occur or any other unfortunate event.

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References

1. Rodriguez de la Concepcion, A.; Stefanelli, R.; Trinchero, D., "*A wireless sensor network platform optimized for assisted sustainable agriculture*," in Global Humanitarian Technology Conference (GHTC), 2014 IEEE, vol., no., pp.159-165, 10-13 Oct., 2014
2. Meonghun Lee; Jeonghwan Hwang; Hyun Yoe, "*Agricultural Production System Based on IoT*," in Computational Science and Engineering (CSE), 2013 IEEE 16th International Conference on, vol., no., pp.833-837, 3-5 Dec. 2013
3. Kodali, Ravi Kishore, Nisheeth Rawat, and Lakshmi Boppana. "*WSN sensors for precision agriculture.*" In Region 10 Symposium, 2014 IEEE, pp. 651-656. IEEE, 2014.
4. Grace, K. S., Silja Kharim, and P. Sivasakthi. "*Wireless sensor based control system in agriculture field*." In Communication Technologies (GCCT), 2015 Global Conference on, pp. 823-828. IEEE, 2015.
5. Le, Tuan Dinh, and Dat Ho Tan. "*Design and deploy a wireless sensor network for precision agriculture.*" In Information and Computer Science (NICS), 2015 2nd National Foundation for Science and Technology Development Conference on, pp. 294-299. IEEE, 2015.
6. Bhanu, B. Balaji, K. Raghava Rao, J. V. N. Ramesh, and Muhammad Awais Hussain. "*Agriculture field monitoring and analysis using wireless sensor networks for improving crop production.*" In Wireless and Optical Communications Networks (WOCN), 2014 Eleventh International Conference on, pp. 1-7. IEEE, 2014.
7. Minwoo Ryu; Jaeseok Yun; Ting Miao; Il-Yeup Ahn; Sung-Chan Choi; Jaeho Kim, "Design and implementation of a connected farm for smart farming system," in SENSORS, 2015 IEEE, vol., no., pp.1-4, 1-4 Nov. 2015
8. Jayaraman, P.P.; Palmer, D.; Zaslavsky, A.; Georgakopoulos, D., "*Do-it-Yourself Digital Agriculture applications with semantically enhanced IoT platform,*" in Intelligent Sensors, Sensor Networks and Information Processing (ISSNIP), 2015 IEEE Tenth International Conference on, vol., no., pp.1-6, 7-9 April 2015.
9. Yamaguchi, N.; Sakai, Y.; Shiraishi, T.; Onishi, S.; Kowata, T., "*E-kakashi project, an agri sensor network using ad hoc network technology*," in SICE Annual Conference (SICE), 2011 Proceedings of vol., no., pp.2808-2810, 13-18 Sept. 2011.
10. Xufeng Ding; Gang Xiong; Bin Hu; Li Xie; Shengxian Zhou, "*Environment monitoring and early warning system of facility agriculture based on heterogeneous wireless networks*," in Service Operations and Logistics, and Informatics (SOLI), 2013 IEEE International Conference on vol., no., pp.307-310, 28-30 July 2013.
11. Tianchen Qiu; Hang Xiao; Pei Zhou, "*Framework and case studies of intelligence monitoring platform in facility agriculture ecosystem*," in Agro-Geoinformatics (Agro-Geoinformatics), 2013 Second International Conference on, vol., no., pp.522-525, 12-16 Aug. 2013.
12. Fu Bing, "*Research on the agriculture intelligent system based on IOT*," in Image Analysis and Signal Processing (IASP), 2012 International Conference on, vol., no., pp.1-4, 9-11 Nov. 2012.
13. Khelifa, B.; Amel, D.; Amel, B.; Mohamed, C.; Tarek, B., "*Smart irrigation using internet of things*," in Future Generation Communication Technology (FGCT), 2015 Fourth International Conference on, vol., no., pp.1-6, 29-31 July 2015.
14. Kassim, M.R.M.; Mat, I.; Harun, A.N., "*Wireless Sensor Network in precision agriculture application*," in Computer, Information and Telecommunication Systems (CITS), 2014 International Conference o*n*, vol., no., pp.1-5, 7-9 July 2014.
15. Filippo M. B., Alison R. B., Gilles C., Rodomiro O., Jose C., "Breeding schemes for the implementation of genomic selection in wheat (Triticum spp.)", "*Plant Science*", Vol. 242, pp. 23-36, January 2016.
16. Zhou, Q. Y., J. Shimada, and A. Sato, "Three-dimensional spatial and temporal monitoring of soil water content using electrical resistivity tomography", *Water Resource Res*., 37, 273 – 285, 2001.
17. Michot, D., Y. Benderitter, A. Dorigny, B. Nicoullaud, D. King, and A. Tabbagh, "*Spatial and temporal monitoring of soil water content with an irrigated corn crop cover using surface electrical resistivity tomography*", Water Resource Res., 39(5), 1138, 2003.
18. Samouelian, A., I. Cousin, A. Tabbagh, A. Bruand, and G. Richard, "*Electrical resistivity survey in soil science: A review*", *Soil Tillage Res*., 83, 173– 193, 2005.
19. Western, A. W., S. L. Zhou, R. B. Grayson, T. A. McMahon, G. Bloschl, and D. J. Wilson, "*Spatial correlation of soil humidity in small catchments and its relationship to dominant spatial hydrological processes*", J. Hydrol., 286, 113– 134, 2004.
20. Verstraeten, W. W., F. Veroustraete, C. J. Van der Sande, I. Grootaers, and J. Feyen, "*Soil humidity retrieval using thermal inertia, determined with visible and thermal space borne data, validated for European forests*", Remote Sens. Environment, 101, 299 – 314, 2006.
21. P. Reguera, D. García, M. Domínguez, M.A. Prada, S. Alonso, "A LOW-COST OPEN SOURCE HARDWARE IN CONTROL EDUCATION. CASE STUDY: ARDUINO-FEEDBACK MS-150", "*IFAC-PapersOnLine"*, Vol.48, Iss.29, pp. 117-122, 2015.
22. Vladimir V., Mirjana M., "*Raspberry Pi as a Sensor Web node for home automation*", Computers & Electrical Engineering, Vol. 44, pp. 153-171, May 2015.
23. Sugiura, R., N. Noguchi, and K. Ishii, "*Correction of low- altitude thermal images applied to estimating soil water status*", Biosyst. Engineering, 96, 301– 313, 2007.