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Review Article

Advances in Automation System for Agricultural Irrigation System

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I N F O

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A B S T R A C T

Fertigation is most important in agriculture due to the growth of crops, and their yields depend upon it. If the ratio of fertilizer and water is either higher or lower, it produces various crises. In today's growing technology and automation, many feasible ways can be used efficiently and anywhere with proper access. With the help of a microcontroller unit, various automatic systems like IoT, PLC system, proportional-integral-derivative, and PID with a fuzzy algorithm, the fertigation system has been implemented. With the help of sensors, this system can detect the soil moisture and water level and stops the water supply. The time can be scheduled as per the choice of the user. This system will ease the farmers to work efficiently, and more time is reduced than the time needed for human interference.

Keywords: Internet of Things (IoT), Programmable Logic Controller PLC, Proportional-Integral-Derivative PID, Agriculture, Sensors, Micro-Controller Unit MCU

Introduction

In ancient days, the manures and by-products of plants were used as fertilizers, also called organic fertilizers. Years after, many chemical kinds of research were done, and the two German chemists, Fritz Haber and Carl Bosch discovered transforming nitrogen from the air into fertilizer. Soil is a block of three primary nutrients nitrogen, phosphorous, and potassium. If these three nutrients decrease, we will face problems like low yields, plants' weak health, and many others. If these nutrients exceed them, it will be like a bite off more than one can chew. The compost made from the waste of plants and animals have already the presence of NPK, and it is natural too. These fertilizers are suitable for the yields and the health of plants and humans.

But as days passed, organic fertilizer was reduced, and the industrially made chemical fertilizers were used more. However, most of these fertilizers are toxic and are misleading to the ecosystem. The long-term use of these fertilizers can irregulate the nutrients ratio in the soil and change the soil's pH value. These industrially produced fertilizers destroy the environment and health and are economically unsustainable. Precision delivery of the fertilizers is not possible when supplied; for example, urea fertilizer is used by directly mixing in the soil. It is soluble in water; it may be provided in liquid form. The liquid from fertilizer was supplied by human interference using an agriculture sprayer.

After some days, irrigation supply was introduced, making it easier to supply the water to the plants at the root zone. This reduced the problems like the over use of water supply. Also, this system gave an idea for using chemical fertilizers better even though these fertilizers have some disadvantages. The soluble fertilizers in water are adequately mixed and further passed through the irrigation supply. This mixture reaches the plant's root zone, which can be efficient. Thus the combination of fertilizer and irrigation gives us "fertigation."

Various irrigation systems can be used in fertilizers like drip, sprinklers, or even drones. And with that, either IoT-based or PLC, GUI-based, or any other automation system can be used to get a better result. With these systems, there are many benefits like less human interference, the precise amount of water and fertilizer, and mainly time-based systems can help us avoid over use of water and fertilizer. This will help us get higher efficiency and higher agricultural product yields. This system can be used in farming systems like greenhouse system agriculture, hydroponic system, or usual agrarian system.

This can encourage the farmers to get their agricultural work done smoothly and fruitfully. Many farmers have problems regarding water or the land situation, that is, soil properties. To overcome these problems, we can use a fertigation system. This method cannot solve not all issues, but it is better to have something than nothing. This system can cure some of those problems.

Pipeline System Design in the Fertigation System

The water supply pipeline, irrigation pipes, pipeline for fertilizer injecting, filtration device to filter the mixture before supplying to the central area, and other measuring equipment. Some equipment is used for water supply pipelines, such as centrifugal pumps and pressure control instruments. The kits used for irrigation supply units are solenoid valves, pressure control instruments, and the water temperature meter. The five channels are set up for the fertilizer injecting pipeline, and each track consists of the solenoid valve, flow control instrument, venturi meter, and filtration device. This design also consists of the channel through which the mixed fertilizer is supplied, which is done with the help of instruments like a mixing device for fertilizer, a filter, and sensors like EC and pH. The intelligent controller controls the signal outputs, EC and pH value sensors, and pressure regulating devices. The electrical control system holds over the solenoid valve, centrifugal pump, and solenoid valves used to inject fertilizer.[5]

Soil Specification

The water potential varies for a different types of soil, as the soil texture and composition vary. The variables such as field capacity, wilting point, and saturation point figure 1, give the ground characteristics. The water is let out to drain thoroughly, and then the water content remains, i.e., the amount of moisture in the soil is the field capacity of the soil. The saturation point in the soil is when the maximum amount of water closes most of the soil's pores. The soil becomes muddy as the level of water is high. The minimum water should be present in the soil to avoid dropping the plant. If the water level reaches this point, there is no way back to its better growth even though the water level is tried to keep at saturation level.

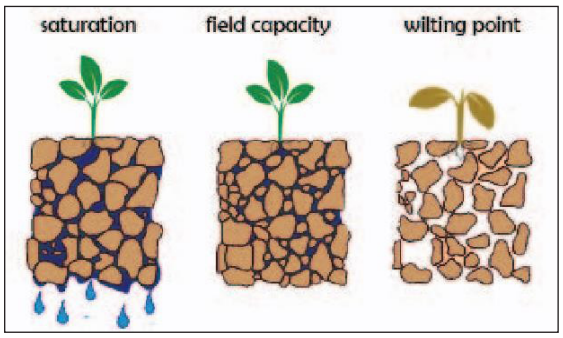

Figure 1.Soil conditions with the respective water level[8]

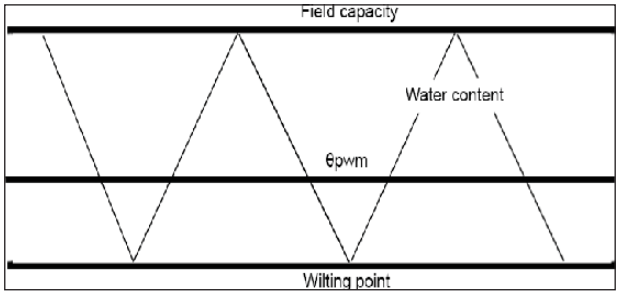

Figure 2.Simplified demonstration of the limits to irrigation[8]

The aim is to set the water level when reached at that specific wilting point or below it figure 2, then the irrigation system is activated. The temperature also matters here since, in one of the research, it has been seen that the soil does not absorb water above the limited temperature for blueberry plants. As per the required enormous parameters, the algorithm is designed for the automatic system of fertigation. This is done by using an automation system, such as PLC or any other method.[8]

Literature Survey

Saiful Farhan et al.[1]

In this paper, the author has demonstrated the design of a fertigation system that provides and controls the mixing process of fertilizer uses the proportional pump injector flow rate, including the injector, which is time-based at the pre-decided value of electrical conductivity suggested according to the plant nutrient. This irrigation system is introduced according to the state of development of plants

and the characteristics of soil and climate accordingly, which will help improve the yield and quality of plants. In this paper, the system, which has an auto-mixing process, monitors the drip irrigation system at the plants' root zone and regulates the irrigation according to the flow rate of the water pump, whose value is set first only and also governs the duration of irrigation. The automatic pumping section looks after storing water in a tank to supply water to the drip irrigation system.

J. E Mohd Salih et al.[2]

In this paper, the researcher has investigated the profit gained by the farmers using a fertigation system in the production of vegetables and fruits as we know that fertigation helps supply the specified amount of nutrients with water at the root zones of the plants. This researcher has built up a system with three pre-set digital timers used to turn on/off the injector and irrigation pumps for mixing the fertilizers and setting daily irrigation frequency. The quality of nutrients solution level in fertilizer is the electrical conductivity (EC) which we check manually. The cultivation done by using this automatic system is controlled by the electrical conductivity value, which was assigned before. The system is governed by solar energy and has checked the performance of preventing the fertilizers from mixing and supplying the nutrients as per the rate of growing plant, and at the same time, it monitors the critical parameters in this fertigation system. This system is based on the solar system; it can be used in rural and remote locations, which helps us cost-efficient and yields higher agricultural production yields.

Wang Jianlun et al.[3]

This paper focuses on the automatic fertigation system for the growth of strawberry greenhouse farming. The system uses the algorithm based on fuzzy comprehensive evaluation irrigation based on programmable logic controller and the configuration software, and also have built a remote control system. The properties of soil present in the greenhouse are measured, which is a must, and the data of moisture content for the strawberry plant. The sensor for measuring soil moisture is set according to the obtained information. With the help of the equation of fuzzy comprehension method, the automatic regulator algorithm for irrigation can be developed for handling multi-sensor data according to strawberry. The results obtained after checking the system tell us that the algorithm is well built and can be well implemented with the cultivation of strawberries.

Shah Abd Hafiz et al.[4]

To encourage the use of technology in the agriculture sector, the author tried to work on a solution that can help to improve efficiency. By taking this in mind, the web-based monitoring system has been implemented in an automated fertigation system that reaches the destination of success. The researcher designed this system to make it easier for the farmers to look after their farms anywhere through their mobile devices. The Internet of things, also abbreviated as IoT, is also conquering the world of technology. So by using it, the fertigation system has been developed which can be monitored anywhere. The web-based monitoring system is designed so that the number of fertilizers, water level, flow-through valves, and pipes can be notified by web-GUI through mobile devices. One of the points of this technology is like the cherry on the cake, which means the emergency problems can be reported quickly and can be solved by stopping through the respected website. The schedule of the fertigation and the formulation of the fertilizer can be set by using the website on mobile devices. Another benefit of this system is that it is well equipped and needs fewer human resources. It is pretty ambiguous whether the IoT based will be helpful for the agricultural land, which is more than one-acre land but trying to bring up the concept to be implied fruitfully. Hence the main aim of this project is to enhance the fertigation system by using the Internet of things.

Junjin Ruan et al.[5]

This paper presents the intelligent fertilization system, which can realize automatic irrigation, fertilization, injecting, and mixing of fertilizer. The most existing but not too serious problem is the uneven mixing or control over the varying concentration of fertilizers. This paper introduces different control systems designation of the pipeline system. This system is based on three control algorithms: control over the amount of fertilizer, control over the mixing of fertilizer, and lastly on supplying, also called injecting the fertilizer. The experimental output of this system gives a positive result, like a chance to adjust the values of electrical conductivity and pH. More priority is given to these values to the used fertilizer, water, in the limit, and also to increase the atomization rate.

Deepa V. Ramane et al.[6]

In this paper, the researchers mainly investigate and focus on measuring nitrogen, phosphorous, and potassium in the fertilizer. The knowledge of soil contents like nitrogen, potassium, and phosphorous is essential so that amount to add these nutrients can be analyzed if they are in fewer amounts. This will help us to improve the yields and quality of plants. This helps improve the quality of fertilizer which will increase the rate of the agricultural yields. In the present work fiber, the optic-based color sensor has been developed to determine the soil sample's N, P, and K values. The color sensor is used, which works by absorbing the color of the solution. The measurement is carried out by calorimetric of a diluted solution of soil. This measurement helps to know the proportion of nutrients. It helps dispense only the

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required amount of fertilizers in the ground. The advantage of this system is that it does not allow to use the fertilizer above the limit. Fiber optic sensors are widely used in various industrial applications and agriculture for their inherent advantages such as being light weight, immunity to electromagnetic interference, economical, etc.

S M Shamsi et al.[7]

In this paper, the researcher has tried to implement the project of fertigation by using the system for monitoring the water nutrients, which will be wireless. The display unit, a wireless system, is provided to display the data received from the integrated pH and electrical conductivity module, which collect data on water nutrients in the crop through the fertigation system. The graphical user interference in the blink application, which will be installed on the user's mobile device, will show the visual representation of data on water nutrients. This paper also demonstrates the need to monitor fertilizer supply to check the proper quantity of the nutrient content for the particular plant. As the use of fertigation is increasing, the researcher has developed a new idea in the traditional method by monitoring two vital parameters, water pH and EC, i.e., electric conductivity. This can be analyzed manually, but the wireless agricultural monitoring system has been developed to reduce the use of time and energy manually. This wireless system consists of one of the processing units, Arduino Uno, and a communicating unit, a Wi-Fi module. This module will help to send the data through the mobile device application to the respective user.

Nuno Simões Martins et al.[8]

The researcher has focused on factors like achieving good yields and quality of mainly fruit plants like blueberries in this paper. The automatic fertigation system was introduced using programmable logic control to keep the tremendous growth of the plants for the long-term. This researcher has used unique parameters such as data on temperature and humidity so that the system can supply the required water only in a specific period with the help of PLC. This system is also capable of using the webpage developed for it. The system can be adapted to other kinds of orchards or managed according to the season, plant ages, and soil texture. The user has the choice to change the system's functioning as there are many ways of introducing wireless communication with the used sensors put near the plants.

Padma Nyoman Crisnapati et al.[9]

The researcher has investigated the hydroponic systems in which the plants are grown without soil. But this paper has tried to implement the fertigation system in the hydroponic system. The decrease of the agricultural land in the growing hydroponic system, such as nutrient film technique (NFT), has become a massive challenge for the farmers. This system needs specific parameters that should be looked after carefully. Those parameters are water level, water temperature, pH level, and nutrients required for the plant. The researcher monitored and collected information from NFT hydroponic system users and systematically evaluated and analyzed it. By human interference, the nutrients may be controlled, but it takes so much time. So to make it easy, this paper gives us a solution, and that is to make the system automatic by using sensors connected to the microcontroller Arduino Uno, Wi-Fi module, and Raspberry Pi microcomputers as the web server with the concept of Internet of Things, in which each block hydroponic farming can communicate with the webserver. The web allows us to monitor the control of NFT hydroponic farming—this web interference management system uses a responsive web framework such as Java Script libraries. The outcome of this system is that it helps the user to handle the NFT hydroponic farms more easily as monitoring and controlling have become more accessible.

R. Raut et al.[10]

In this paper, the researcher has demonstrated that the system measures the soil's proportional values of nitrogen, phosphorous, and potassium. With this amount of nutrients from the ground, the quantity of fertilizer is supplied to reach the required nutrient level. This data will update from time to time through the user's mail-id. The decrement in the water level and the low rain-fall have kept the problem for the farmers. So to overcome this problem, the IoT-based automatic fertigation system has been introduced by the researcher who sends the operational updates to the user's mail-id. This system checks the nutrients from the soil solution sample and compares it with a color chart from which we get to know the proportion of each nutrient. This process can be done either with human interference or without human interference. The sensors can sense changes in the environment like humidity or temperature and send an alert signal to the processing unit.

Yong Wu et al.[11]

The author has thoroughly studied of greenhouse agriculture system and gave a positive view of the effect of fertigation using optimal control algorithms. The purpose of the greenhouse effect is that it provides favorable growing conditions for the plants having a covering that is transparent or partially transparent. To improve the performance of the fertigation, two new algorithms based on the microcontroller unit were developed, which are controlled by the electric conductivity of the soil nutrients in the greenhouse. The first algorithm used is based on incremental proportional-integral-derivative (PID), and the second is a two-stage combination algorithm (PID+fuzzy). The multi venturi-line mixing was improved, and many tests based on fertilizer absorption were done by considering two

conditions: the first condition- with an EC target value in mS/cm, which is constant, and opening of various suction pipes, the steady-state times is set corresponding to the beginning of one to four suction pipes, respectively, for PID+fuzzy control. The second condition is that the EC values are varied, and the shortest response time and the minimum overshoot were obtained for PID+fuzzy control with the required target of EC value. The two control trategies can adjust the EC value to the target value of real-time control, but the combined algorithm helps the system work more rapidly, accurately, and steadily than alone PID control. The combination of PID and fuzzy logic helps get the efficiency of the fertigation in the greenhouse agriculture system. The bias decreased when the target EC was set to an enormous value. This system helps to provide an optimal way of water and fertilizer management for crops in greenhouses which will contribute to water and fertilizer saving.

Mahyuzie Jenal et al.[12]

In this paper, the researchers have used the IoT-based system to expand the agriculture production standard and quantity. The development of inefficiency in agricultural cultivation has become more demandable as the requirement for food is more due to the increase in population. The system's effectiveness depends upon the sensor's performance under varying climates. To have efficient and higher operational capacity, the network and feedback system, which has a closed loop, is connected to the designed system and is a must. This project includes the module of sensors and micro-controller and Opto-isolator relay module. When the moisture level reaches a specific limit, the water supply stops. The system can be implemented in the future by using solar energy rather than through batteries. The various sensors like water level and soil moisture with different devices like water pump, LCD, solenoid valve, and battery are used in this project. The sensor is used to detect and send signals to Arduino. It will control the solenoid valve and water pump. The Blink application, a mobile application, monitors the soil moisture and water level. The LCDs give moisture level of the soil. This will help indicate when to stop the water supply depending upon the moisture level. The system can be developed by using renewable energy in the future, which can be cost-effective.

Amani Che Rus et al.[13]

The researcher demonstrated the proper management of supplying fertilizer and water using an optimal system created by substituting an algorithm in the control system to know the favorable conditions needed for soil, such as temperature, moisture, and other specific parameters. Under these conditions, schedules will also be created, and the actions taken in the previous program will also be known with the help of a monitoring system. Bluetooth connectivity is also provided to give inlet activities, or you can say input through mobile devices about the needed parameters for good results in the health or growth of the plants. The researcher carried out this experiment on the green mustard plant. This system has resulted in efficient and favorable plant development and can give plants a high rate of greenery, i.e., more time to stay healthy**.**

Diana Rose Rivera et al.[14]

The researcher demonstrated the automated system in this paper, which has given much more positive results than the fertigation system done manually or you can get in the traditional way. The system consists of mechatronics components like actuators, sensors, and PLC. There are also some mechanical components used in this system. All these types of equipment used help to control the supply of water and fertilizer as required for the growth of plants (in stepwise requirement). The researcher has experimented on cash crops, i.e., sugarcane. The design the researcher has implemented has used a specific software tool from which we can understand or view the optimal amount of fertilizer and water supply according to the requirement for the growth of the plant.

Automatic System for Fertigation		
IoT Based (Internet of Technology)	**PLC (Programmable logic Control)**	**Others**
• Closed loop system i.e. Feedback system [12] • Algorithm based on fuzzy comprehension [3] • Web-based monitoring System [4] • NFT (Nutrient film Technique) [9]	• Parameters such as data on temperature and humidity of soil. [8] • Using mechatronics components [14]	• Electric conductivity (EC values) PID + Fizzy [11] • Solar system pre-set digital timers used to turn on-off the injector [2] • Fiber Optic sensors Color sensors NPK values [6]

Figure 3

Short Comparison about The Systems

Conclusion

There are many ways of building the automatic system for fertigation, such as using IoT, PLC system, proportional-integral-derivative, and PID with the fuzzy algorithm. The main motto of this is to control the fertilizers' concentration and avoid the uneven mixing of it. Also, the main aim of the fertigation system is to increase the yields of agricultural production and also its quality. This system can be used in any agrarian system like greenhouse system agriculture, hydroponic system, or usual agricultural system. This system can be used in orchard farming and horticulture for better results. The main motto of this is to control the fertilizers' concentration and avoid the uneven mixing of it. The best results shall be evaluated, and any development needed in

the respective system can be made. Renewable energy can be used to run the systems like solar energy. This can help farmers have an efficient way of farming and encourage them to acquire different information about the fertigation systems and their automated systems.

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