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Ecosystem Design Controlling Automatic Watering and Fertilization Based on Scheduling According to Fertilization Recommendations

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ABSTRACT: Soil is a growing medium for plants because it contains minerals needed for plants to grow and develop. The availability of minerals in the soil can gradually decrease and have an impact on plant development. Providing fertilizer to meet the nutrient needs of plants is still carried out at doses that have not been scientifically proven, which can have an adverse impact on plant growth. In the research, the system was designed with two setting modes for watering and fertilizing, namely automatic or manual. Automatic mode utilizes Internet of Things (IoT) technology as a remote control via website applications and mobile apps. Watering and fertilization controls are automatically adjusted based on scheduling on the website and mobile apps or manually according to the user's wishes, facilitated by fertilizer recommendations according to soil and plant type. This recommendation is obtained through the analysis of data sets such as soil type and plant characteristics, which are stored in the cloud via a website application to help farmers fertilize according to the plants they cultivate.

KEYWORDS: Fertilizer Recommendation, Planting Media Soil, Fertilization, IoT

INTRODUCTION

Soil is a planting medium because it contains minerals that plants need to grow and develop. The minerals contained can vary depending on the type of soil (Mulyana & Sofyan, 2015; Gunawan et al., 2019). Plants will absorb minerals contained in the soil to support their development process (Bhatla et al., 2018). These substances are used by plants in the process of photosynthesis. The availability of minerals in the soil can gradually decrease and have an impact on disturbed plant development, such as a lack of nitrogen in the soil resulting in changes in the color of the leaves which turn pale yellow because the need for nitrogen as a protein provider in the formation of chlorophyll is not fulfilled. Mineral deficiencies also cause plants to appear stunted compared to their normal state, and in the most severe cases can cause plants to fail to grow and then die. Plant growth can be optimal because it is influenced by the application of fertilizer and water to the appropriate type of soil and the appropriate time of watering or fertilizing (Supriadi et al., 2018; Baba et al., 2019). Lack of information regarding fertilizer doses causes fertilizer application to be inappropriate because it has not been scientifically proven (Kurniadinata et al., 2018; Villalobos et al., 2020; Mucheru-Muna et al., 2021). In some situations, farmers still apply fertilizer more than the standard dose without knowing that it can have a bad impact on plants for the reason of speeding up the growth process. In other circumstances, farmers can only provide fertilizer at a modest rate or below the standards that have been set because they are limited by a lack of funds to purchase fertilizer. Therefore, information is needed on the provision of fertilizer to fulfill the nutrients in the soil planted with plants by selecting fertilizer that suits the needs of the plants (Anwar et al., 2018; Hossain et al., 2020). Several important things to pay attention to in the fertilization process are providing an appropriate fertilizer source, appropriate quantity or amount of fertilizer given, giving the right type of fertilizer to the right type of soil, and timing of fertilizer application according to the plants to be planted (Husnain et al., 2016; Santosa et al., 2016; Hartono et al., 2022; Sogoni et al., 2021; Das et al., 2022; Silva et al., 2023).

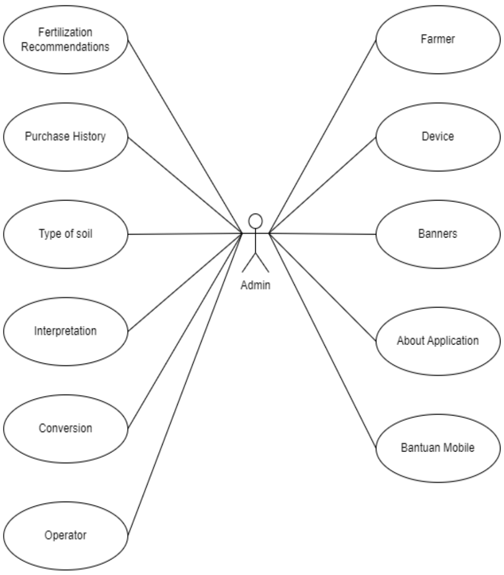
In the current era of digital agriculture, parameters related to agricultural activities can be monitored and regulated remotely by utilizing Internet of Things (IoT) technology (Gaol et al., 2020; Mulyana et al., 2022; 19. Araújo et al., 2021; Javaid et al., 2022; Hernández-Morales et al., 2022; Raj et al., 2022). One example is the watering and fertilization process with a drip irrigation system which can control soil moisture automatically by flowing water when the water content is lower than the threshold value. Research by Wahjuni et al. (2022) has implemented automated control of drip irrigation based on soil moisture conditions. However, in this research, fertilization was still carried out separately. Apart from controlling the water used for watering, fertilizer distribution can be implemented simultaneously with watering in a drip irrigation system to achieve cultivation efficiency in plants

(Baba et al., 2019). Watering with a combination of water and fertilizer can provide benefits in water use efficiency (Wu et al., 2019). Fertilization recommendations are needed which are obtained from analyzing soil and plant types before planting so that the availability of the nutrients provided is appropriate (Gunawan et al., 2019).

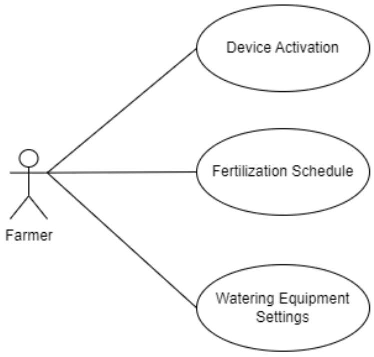
The general aim of this research is to build an ecosystem of intelligent devices to regulate watering and fertilization of plants. The system can regulate the pump flame to distribute water and liquid fertilizer to water and fertilize plants automatically based on scheduling via the application or can be done manually with information on fertilization recommendations via the website and mobile apps.

Research is carried out by going through the stages of analyzing the problem, collecting related data, designing the system, and then conducting testing. The system is designed with two control modes for watering and fertilization, namely manual or automatic. Manual mode can be set directly by the farmer as the user. Different from manual mode, automatic mode utilizes Internet of Things (IoT) technology as a remote controller via website applications and mobile apps. In the application, the system is designed to be used by two actors, namely Admin and Farmers in accordance with Figure 1. Based on access rights, admins have full access to change and manage content on the website with detailed menus in Table 1, while farmers have access to control and set schedules on the device via the mobile application.

RESEARCH METHOD



(a)



(b)

Figure 1. Use Case Diagram for Actors (A) Admin and (B) Farmer to Access Nutriferads Application

Table 1. Use Case Description

Num.	Use Case	Description
1	Fertilizer Recommendation	The process of adding commodity data
2	Purchase History	The process for viewing commodity purchase history
3	Soil Type	The process for adding soil type data
4	Interpretation	The process of setting plant element data
5	Conversion	Extractant to Mehlich conversion process 1
6	Operator	The process for adding an admin account
7	Farmer	The process for adding a farmer account
8	Device	The process for adding device data
9	Banner	The process for adding banner data that will be displayed on mobile apps
10	About Application	The process for adding data about what will be displayed on mobile apps
11	Mobile Help	The process for adding help data that will be displayed on mobile apps

12	Device Activation	Process for device activation
13	Fertilizer Schedule	The process of creating a fertilizer schedule
14	Watering setting	Watering setting process

In the application created, control on the device can be set in automatic or manual mode. Figure 2 shows the settings made for device activation by determining whether watering will be done automatically or manually.

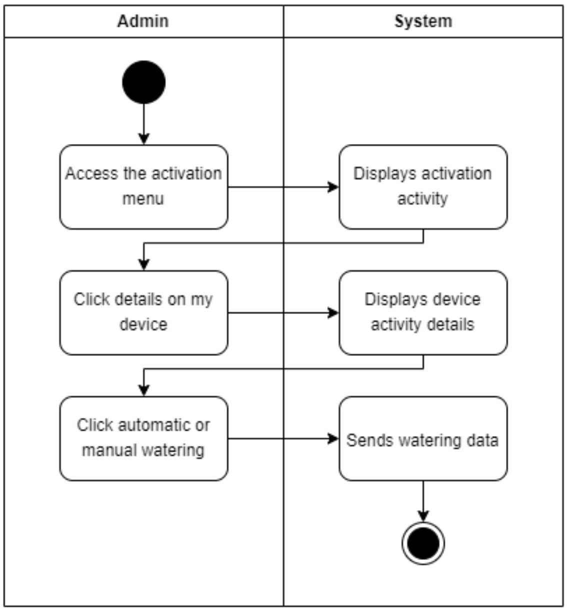


Figure 2. Activity Diagram Admin for Irrigation Control Setting

In automatic mode, control is carried out on the water and fertilizer distribution pump installation, where the pump flame is adjusted to the schedule that has been input via the website and mobile apps. A complete depiction of how the system works is as shown in Figure 3.

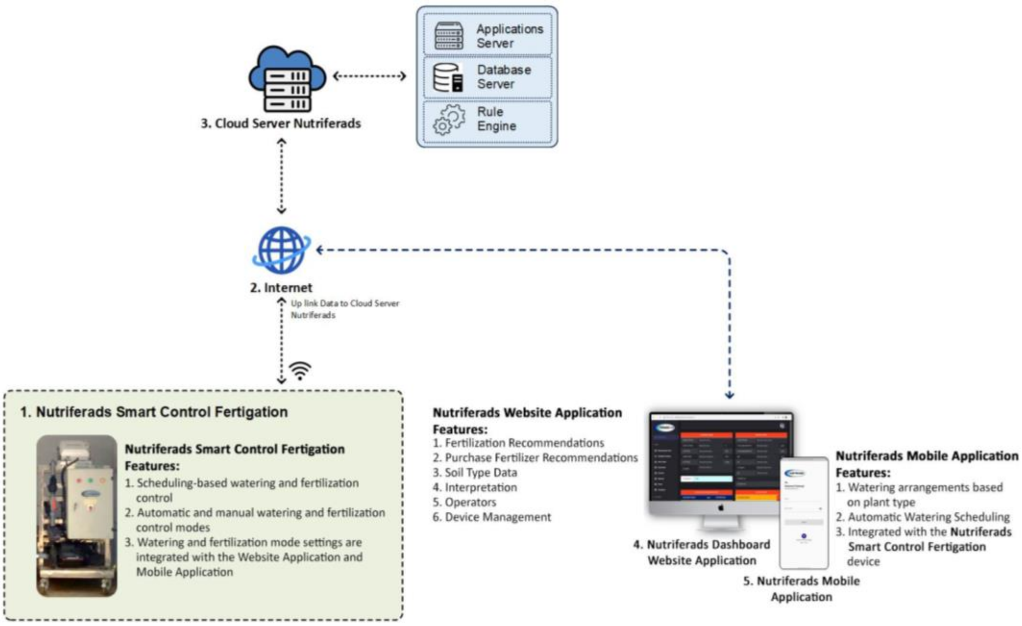


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Figure 3. Nutriferads System Architecture

The Nutriferads device (1) becomes part of the pump control execution, and is connected via the internet (2) to a server located in the cloud (3). This server is used to store soil condition data entered by the user and also as an application server that provides appropriate fertilizer recommendations. Websites and mobile apps (4) become a link between farmers and devices to control pumps remotely through scheduling that has been input into the website or mobile apps. Details of the use of each system are explained in Table 2. The features on the website provide information to farmers regarding soil types and fertilizer formulations to be recommended to users according to the characteristics of the plants to be planted (Anwar et al., 2018). Through a mobile application, farmers can control watering and fertilization based on the schedule they have created. Fertilization recommendations can meet the nutrient needs of plants so that their growth can be optimal.

Table 2. Nutriferads System Feature Details

Num.	System Name	Function	Detail
1	Nutriferads Device	Manage watering and fertilization of plants manually or automatically based on scheduling via the application	1. Automatic Pump Control 2. Manual Pump Control 3. Automatic and Manual Watering Mode 4. Automatic and Manual Fertilization Mode
2	Website	Displays information regarding fertilizer recommendations	1. Soil Analysis 2. Soil Type 3. Interpretation of Soil Fertility 4. Fertilizer Choice 5. Fertilizer Application Formula 6. Fertilization Recommendations 7. Fertilizer Purchase Recommendations
3	Mobile Apps	Manage device operation	1. Device Activation 2. Device Information 3. Watering Mode 4. Watering Schedule

RESULTS AND DISCUSSION

Watering and fertilizing can be done in two modes, namely automatic or manual. In automatic mode, controlling the flame of the pump as a distributor of water and liquid fertilizer is adjusted to the schedule made by the farmer on the website or mobile apps. Meanwhile, in manual mode, the pump will be controlled directly by the farmer by turning it on or off manually. The website application provides information regarding important parameters related to fertilization such as soil type analysis, fertilizer recommendations, and recommendations for purchasing the fertilizer needed so that farmers can apply fertilizer to plants according to the characteristics of the plants and the type of soil on their agricultural land.

1. Nutriferads Modul

In Figure 4, the hardware device is shown, namely the controller in the Nutriferads system to regulate the ignition of the water filling pump in the reservoir. The test was carried out using manual mode to turn on the pump after the device was integrated with the pump installation. When the device is turned on, the pump will turn on and start filling the reservoir with water from the water source.

(a) (b) (c)

Figure 4. Nutriferads Module On (A) Module And Pump Installation Integration, (B) Device Testing in Manual Mode, and (C) Filling The Pump In The Water Reservoir

2. Website Application

In the Nutriferads system, device control can be done via the website application as shown in Figure 5. In Figure 5(a) a list of devices connected to the system is shown. The pump starts in automatic mode according to the scheduling that has been made on the website (Figure 5(b)). The existence of this application helps farmers understand the composition or dosage of fertilizer that is appropriate for the plants to be cultivated. Based on the analysis data entered, the application will provide recommendations for the required fertilizer along with how to apply it (Figure 5(c)). Recommendations are generated based on the Mechlich1 extractor method

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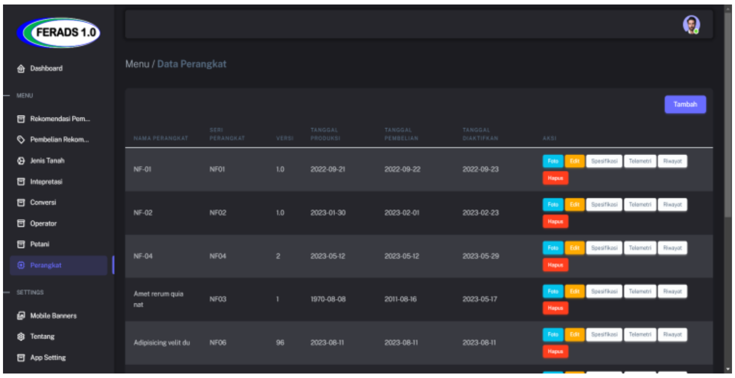


(a)

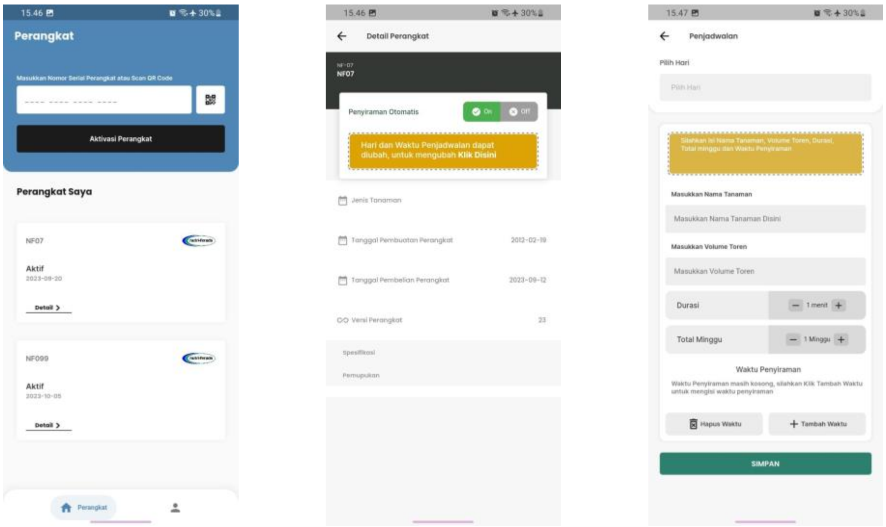
(b)

(c)

Figure 5. Website Application on (A) Device Menu, (B) Schedule Settings Menu, and (C) Fertilization Recommendations Menu

3. Mobile Apps

Controlling the Nutriferads device can be done anywhere and at any time with mobile apps that make it easier for farmers to control watering and fertilization remotely. Figure 6 shows the device activation menu with the aim of turning on the device without having to interact directly with where the device is located. The device status can be seen in the device details sub menu (Figure 6(a)). There is Information such as plant type, date and manufacture of the device, as well as device specifications. In this sub menu, farmers can also activate or deactivate automatic watering mode (Figure 6(b)). Via mobile apps, scheduling can be changed or made as a reference for controlling the pump on the device when it is in automatic mode (Figure 6(c)).



(a) (b) (c)

Figure 6. Mobile Application on Menu (A) Device Activation, (B) Device Details, and (C) Scheduling Settings

CONCLUSION AND RECOMMENDATION

The Nutriferads device can help the process of watering and fertilizing plants automatically based on scheduling that has been made via the website and mobile apps or done manually by farmers. By sending scheduling settings to the device, the device can then work independently, without depending on the availability of an internet connection. The website application can help in providing information regarding fertilizer recommendations based on previously stored data, namely soil type, plant type, and fertilizer composition. Farmers can take measurements to estimate fertilizer composition based on the Mehlich 1 extractor method via the website.

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Author contributions: for articles with several authors, please write each author's contribution in a brief paragraph. The authorship must be limited to those who have contributed, besides reading and agreeing on the final manuscript.

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