PENGEMBANGAN SISTEM KENDALI NUTRISI OTOMATIS BERBIAYA RENDAH BERBASIS *INTERNET OF THINGS* (IoT) PADA *SMART GREENHOUSE*

INTISARI

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Budidaya hidroponik di dalam *greenhouse* menjadi terobosan teknologi karena dapat mengendalikan kondisi lingkungan di dalamnya, di antaranya EC (*Electrical Conductivity*) dan pH larutan nutrisi. Namun, petani masih melakukan pengendalian secara manual pada pagi dan/atau sore hari. Padahal, fluktuasi nilai EC dan pH dapat terjadi setiap saat. Oleh karena itu, alat automasi yang dapat mengukur dan mengendalikan secara akurat dan presisi larutan nutrisi hidroponik diperlukan. Inovasi sistem tersebut telah banyak dikembangkan namun masih berbiaya tinggi sehingga perlu pengembangan sistem berbiaya rendah. Penelitian ini mengembangkan sistem kendali nutrisi otomatis berbiaya rendah berbasis *Internet of Things* (IoT) pada *Smart Greenhouse*. Mikrokontroler Arduino Uno bertindak sebagai pemrosesan dengan input berupa sensor EC *Gravity analog TDS sensor* dan sensor pH *Gravity analog industrial pH meter*. Pompa peristaltik sebagai aktuator akan memompakan pekatan AB *mix* bila EC<1,4 mS/cm dan memompakan cairan pH *down* bila EC>7,0. Jika EC > 1,8, pompa air baku dihidupkan untuk mengencerkan larutan nutrisi. Terdapat fitur tambahan berupa pengamatan suhu udara, suhu air, dan RH. Uji regresi linear sederhana, MAPE, dan RMSE digunakan untuk mengevaluasi efektivitas sistem. Berdasarkan hasil pengujian, didapatkan nilai R^2, MAPE, RMSE masuk kategori sangat baik untuk semua sensor kecuali RH yang masuk kategori baik. Berdasarkan perhitungan HPP dan penentuan harga jual, didapati harga prototipe yang kompetitif, yakni Rp7.519.500. Namun demikian, hasil implementasi sistem pada *greenhouse* masih menunjukkan inkonsistensi pengendalian akibat pembacaan sensor yang fluktuatif. Dengan demikian, perbaikan sistem perlu dilakukan agar sistem berbiaya rendah ini dapat diproduksi dan dimanfaatkan secara luas.

Kata kunci: sistem kendali, nutrisi hidroponik, EC, pH, *Internet of Things*

DEVELOPMENT OF LOW-COST AUTOMATIC NUTRIENT CONTROL SYSTEM BASED ON INTERNET OF THINGS (IOT) IN SMART GREENHOUSE

ABSTRACT

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Hydroponic cultivation in a greenhouse is a technological breakthrough as it enables control over the environmental conditions inside, including EC (Electrical Conductivity) and pH of the nutrient solution. However, farmers still manually control these conditions in the morning and/or evening. Yet, fluctuations in EC and pH values can occur at any time. Therefore, an automated tool capable of accurately and precisely measuring and controlling hydroponic nutrient solutions is essential. While innovations in such systems have been developed extensively, they remain costly, necessitating the development of low-cost systems. This study develops a low-cost automatic nutrient control system based on the Internet of Things (IoT) in a Smart Greenhouse. The Arduino Uno microcontroller acts as the processor, receiving inputs from an EC Gravity analog TDS sensor and a pH Gravity analog industrial pH meter. A peristaltic pump serves as an actuator, pumping concentrated AB mix when EC is lower than 1.4 mS/cm and pH down solution when EC exceeds 7.0. If EC > 1.8, a raw water pump is activated to dilute the nutrient solution. Additional features include monitoring of air temperature, water temperature, and RH. Simple linear regression, MAPE, and RMSE tests are used to evaluate system effectiveness. Based on test results, R^2, MAPE, and RMSE values are categorized as very good for all sensors except RH, which is categorized as good. Based on Cost of Goods Sold (COGS) calculations and pricing determinations, a competitive prototype price of Rp7,519,500 is found. However, implementation results in the greenhouse indicate control inconsistencies due to fluctuating sensor readings. Thus, system improvements are necessary for this low-cost system to be widely produced and utilized.

Keywords: control system, hydroponic nutrition, EC, pH, Internet of Things