RINGKASAN

Model pertumbuhan dan perkembangan tanaman memiliki peran penting dalam memahami interaksi kompleks antara faktor lingkungan dan proses internal tanaman secara kuantitatif. Model dapat memprediksi laju akumulasi biomassa dan respon tanaman terhadap perubahan kondisi lingkungan, sehingga menjadi alat strategis dalam perencanaan dan optimalisasi sistem budidaya. Terbatasnya lahan dan air akibat urbanisasi, yang menuntut efisiensi tinggi dalam produksi pangan. Dalam konteks tersebut, sistem Fertigasi Otomatis Nirdaya (FONi) hadir sebagai solusi inovatif pertanian perkotaan (*urban farming*) yang memungkinkan budidaya tanaman di area sempit dengan pengelolaan air dan nutrisi secara otomatis dan efisien. Penerapan model pada sistem FONi menjadi sangat relevan karena dapat menyimulasikan dan memprediksi produktivitas tanaman berdasarkan variasi kondisi lingkungan dan pengaturan air. Penelitian ini bertujuan untuk menerapkan model untuk menduga biomassa tanaman caisim yang ditanam di berbagai komposisi media tanam pada sistem Fertigasi Otomatis Nirdaya (FONi) dengan ketinggian air 5 cm dan 10 cm. Kalibrasi dan validasi model dilakukan berdasarkan nilai *light use efficiency* (LUE) selama proses pertumbuhan dan perkembangan tanaman caisim.

Model pada penelitian ini terdiri atas sub model pertumbuhan, sub model perkembangan, dan sub model neraca air. Ketiga sub model tersebut saling berkaitan dalam menentukan biomassa yang dihasilkan tanaman. Sub model pertumbuhan membutuhkan skala perkembangan tanaman (s) dari sub model perkembangan dan nilai faktor ketersediaan air (fw) dari sub model neraca air. Nilai s menentukan proporsi alokasi biomassa total ke setiap organ tanaman, sedangkan nilai fw menentukan biomassa aktual. Skala Penelitian dilaksanakan di lingkungan Fakultas Pertanian Universitas Jenderal Soedirman pada Bulan Februari hingga Mei 2025. Data yang dikumpulkan yaitu data cuaca harian di sekitar area penelitian (radiasi matahari, suhu, hujan, kelembaban, dan kecepatan angin), irigasi, drainase, radiasi tajuk atas dan bawah tanaman, berat kering organ tanaman (akar, batang, dan daun).

Pada penelitian ini, model berhasil dikalibrasi dengan rentang LUE fase awal 0,22–0,37 g MJ^{-1}, sedangkan pada fase akhir meningkat menjadi 0,87–3,74 g MJ^{-1}. Grafik hasil simulasi model mengikuti tren yang serupa dengan hasil observasi dengan nilai koefisien determinasi (R^2) mendekati 1. Galat pada model ini yaitu 36,09% (biomassa akar), 24,32% (biomassa batang), dan 26,89% (biomassa daun). Meskipun demikian, model tetap dapat merepresentasikan tren pertumbuhan dan akumulasi biomassa tanaman secara relevan terhadap data observasi.

SUMMARY

Plant growth and development models play a crucial role in quantitatively understanding the complex interactions between environmental factors and internal plant processes. Models can predict the rate of biomass accumulation and plant responses to changing environmental conditions, thus becoming a strategic tool in planning and optimizing cultivation systems. Limited land and water resources due to urbanization demand high efficiency in food production. In this context, the Powerless Automated Fertigation (FONi) system presents itself as an innovative urban farming solution that enables crop cultivation in limited areas with automated and efficient water and nutrient management. The application of the model to the FONi system is highly relevant because it can simulate and predict crop productivity based on variations in environmental conditions and water management. This study aims to apply the model to estimate the biomass of Chinese cabbage (caisim) grown in various planting media compositions in the Powerless Automated Fertigation (FONi) system with water levels of 5 cm and 10 cm. Model calibration and validation were carried out based on light use efficiency (LUE) values during the growth and development of Chinese cabbage (caisim) plants.

The model in this study consists of a growth sub-model, a development sub-model, and a water balance sub-model. These three sub-models are interconnected in determining the biomass produced by plants. The growth sub-model requires a plant development scale (s) from the development sub-model and a water availability factor (fw) from the water balance sub-model. The s value determines the proportion of total biomass allocated to each plant organ, while the fw value determines the actual biomass. The study was conducted at the Faculty of Agriculture, Jenderal Soedirman University, from February to May 2025. Data collected included daily weather data around the study area (solar radiation, temperature, rainfall, humidity, and wind speed), irrigation, drainage, upper and lower canopy radiation, and dry weight of plant organs (roots, stems, and leaves).

In this study, the model was successfully calibrated with a LUE range of 0,22–0,37 g MJ^{-1} in the initial phase, while it increased to 0,87–3,74 g MJ^{-1} in the final phase. The model simulation results graph follows a similar trend to the observed results with a coefficient of determination (R^2) value approaching 1. The model error is 36,09% (root biomass), 24,32% (stem biomass), and 26,89% (leaf biomass). Nevertheless, the model can still represent the growth trend and accumulation of plant biomass relevant to the observed data.