KARAKTERISASI STOMATA PADA APLIKASI CAHAYA ARTIFISIAL DALAM MENDUKUNG PENGEMBANGAN SMART FARMING DI INDONESIA

ABSTRAK

Selain faktor unsur hara, baik buruknya pertumbuhan tanaman juga bergantung pada kondisi alam, dengan kata lain kegiatan budidaya tanaman memiliki risiko tinggi jika tidak memperhatikan faktor alam. Kondisi alam yang mendukung merupakan faktor determinan bagi capaian produksi pertanian, baik dari aspek kuantitas maupun kualitas. Salah satu upaya yang dapat dilakukan untuk mengatasi keterbatasan ketersediaan pangan karena kondisi alam adalah menjaga kualitas dan kontinuitas produk pertanian dengan peran teknologi. Salah satu teknologi yang dikembangkan adalah penerapan teknologi cahaya artifisial dalam *growth chambar* sebagai upaya pengembangan *smart farming*. Penerapan teknologi cahaya artifisial budidaya tanaman dalam *growth chamber* telah banyak dilakukan baik di dalam maupun luar negeri, namun kajian mengenai karakteristik stomata kaitannya dengan pertumbuhan tanaman di bawah perlakuan cahaya artifisial masih kurang. Hal ini yang mendorong perlu dilakukan penelitian lebih lanjut. Tujuan penelitian ini menyusun model untuk memperoleh faktor dominan yang berpengaruh pada karakteristik stomata (jumlah, ukuran, kerapatan, indeks stomata), merumuskan hubungan karakteristik stomata dengan variasi pemberian air irigasi, merancang model prediksi karakteristik stomata berdasarkan iklim dalam *growth chamber*, dan membuat rekomendasi budidaya tanaman di dalam *growth chamber* dalam upaya pengembangan *smart farming*. Metode penelitian terdiri tiga tahap. Tahap pertama mengidentifikasi karakteristik stomata pada kondisi alami. Hasil pengamatan karakteristik stomata dianalisis dengan JST, regresi dan koefisien korelasi. Tahap kedua menganalisis karakteristik stomata pada kondisi variasi pemberian air irigasi dengan perlakuan 30%xETc, 100%xETc, dan 150%xETc. Tahap terakhir menganalisis karakteristik stomata di dalam *growth chamber* dengan 9 variasi cahaya berdasarkan intensitas dan lama penyinaran. Hasilnya dibuat model prediksi karakteristik stomata. Hasil penelitian menunjukkan tanaman cabai yang ditanam pada kondisi alami rata-rata memiliki jumlah stomata 12,89, luas stomata 120,04 μm^2, kerapatan stomata 273,551 mm^2,dan indeks stomata 0,319. Analisis *neural network* dan regresi berganda menunjukkan intensitas cahaya adalah faktor iklim yang paling dominan terhadap perubahan karakteristik stomata dengan nilai bobot 100% pada analisis *neural network* dan p *value* 0,0071 pada analisis regresi berganda. Faktor pemberian air irigasi juga berdampak pada karakteristik stomata, jumlah stomata terbanyak pada perlakuan 150%xETc yaitu 16 dan yang paling sedikit adalah 10 pada perlakuan 30%xETc. Luas stomata terbesar pada perlakuan 100%xETc

yaitu 145,14 µm^2 dan paling kecil pada perlakuan 30%xETc yaitu 113,17 µm^2. Saat tanaman cabai ditanam pada kondisi perlakuan variasi cahaya di dalam *growth chamber* menunjukkan perlakuan intensitas cahaya 70.000 lux dan lama penyinaran 15 jam memberikan nilai paling tinggi pada parameter jumlah stomata, luas stomata, dan kerapatan berturut-turut yaitu 12 , 120 µm^2, 143 mm^2. Pada intensitas 20.000 lux dengan lama penyinaran 9 jam memberikan nilai jumlah stomata 5, luas stomata 55,95 µm^2, dan kerapatan 58,88 mm^2. Dari perlakuan 1 hingga perlakuan 9 dapat dilihat hasil pertumbuhan tanaman yang paling baik adalah perlakuan 9 dengan jumlah stomata 12. Tanaman dengan cahaya artifisial dapat meningkatkan pertumbuhan tanaman lebih cepat 17,89% pada tinggi tanaman dan 23,07% pada jumlah daun. Hasil ini dapat menjadi rekomendasi budidaya tanaman dalam *growth chamber* sebagai upaya pengembangan *smart farming* di Indonesia.

Kata kunci: cabai merah, cahaya artifisial, *neural network*, stomata

STOMATAL CHARACTERIZATION ON ARTIFICIAL LIGHT APPLICATION IN SUPPORTING SMART FARMING DEVELOPMENT IN INDONESIA

ABSTRACT

In addition to nutrient factors, plant growth also depends on natural conditions, thus in other words, plant cultivation activities have a high risk. Favorable natural conditions are determinants for the achievements of agricultural production in quantity and quality. One effort that can be made to overcome limited food availability due to natural conditions is to maintain the quality and continuity of agricultural products. The application of artificial light in growth chambers is one technology developed as an effort to promote smart farming. The application of artificial light technology in plant cultivation in growth chambers has been widely carried out locally and abroad. However, studies on stomata characteristics related to plant growth under artificial light treatment are still lacking. This issue encourages further research to be conducted. The purpose of this study was to compile a model to reveal which dominant factors affect stomata characteristics (number, size, density, stomatal index), to formulate the relationship between stomatal characteristics and variations in irrigation water, to design a stomatal characteristic prediction model based on the climate in the growth chamber, and to suggest recommendations for plant cultivation in the growth chamber to develop smart farming. The experimental method consists of three stages. The first stage identified the stomatal characteristics under natural conditions. The observation results were analyzed with the artificial neural network, regression method, and correlation coefficients. The second stage examined the stomatal characteristic under various conditions of irrigation water administration treatment of 30% ETc, 100% ETc, and 150% ETc. The last step analyzed stomatal characteristics in the growth chamber with nine light variations based on light intensity and irradiation duration. The obtained data was then modeled to predict the plant's stomatal characteristics. The results showed that, on average, chili plants grown in natural conditions had a stomatal number of 12.89, a stomatal area of 120.04 μm^2, a stomatal density of 273.551 mm^2, and a stomatal index of 0.319. The result of neural network analysis and multiple regression showed that light intensity was the most dominant climate factor for changes in stomata characteristics, with a weighted value of 100% in the neural network analysis and a p-value of 0.0071 in the multiple regression analysis. The irrigation water factor also impacts stomatal characteristics; the highest number of stomata in the 150% ETc treatment was 16, and the least was 10 in the 30% ETc treatment. The largest stomatal area in the 100% ETc treatment was 145.14 μm^2, and the smallest in the 30% ETc treatment was 113.17 μm^2. When chili plants were planted under light variations

treatment in the growth chamber, it revealed that the 70,000 lux light intensity treatment and the 15 hours irradiation duration gave the highest value on the parameters of stomatal number, stomatal area, and stomatal density of 12, 120 μm^2, 143 mm^2 respectively. At the 20,000 lux intensity with 9 hours irradiation duration, it showed a stomata number of 5, a stomata area of 55.95 μm^2, and a stomata density of 58.88 mm^2. From the 1st to the 9th treatments it was obvious that the best plant growth results were the 9th treatment with a stomata number of 12. Eventually, plants with artificial light showed plant growth increase by 17.89% in plant height and 23.07% in leaves number. These experimental results can be an appropriate recommendation for cultivating plants in the growth chamber to develop smart farming in Indonesia.

Keywords: red chili, artificial light, neural network, stomata