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学 位 論 文 要 旨
Dissertation Abstract

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学位論文題目：
Title of Dissertation

Yield and physiological responses of soybean to different soil moisture status and drip irrigation
（異なる土壌水分条件および点滴潅がいに対するダイズの収量および生理反応）

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Soybean cultivation is deleteriously affected by drought stress in different regions where rainfall or irrigation facilities are insufficient. Stress caused by water deficiency in soybean largely depends on soybean growth stages and time exposed to drought. To solve this problem, complementary irrigation in soybean cultivation could alleviate drought stress, even for a short period, and contribute to increasing yield. Although the effect of irrigation on soybean cultivation in Japan is uncertain because average annual rainfall in Japan has approximately twice the average world rainfall, soybean yield from irrigation was greater than the yield from rainfed cultivation in a year receiving low rainfall. Hence, the growth and yield stability under various soil moisture conditions is necessary for soybean production in Japan, rather than the ability to survive under extreme drought. Therefore, this research has focused to assess whether using drip irrigation on soybean cultivation in Kagawa Prefecture increases the growth and yield of the Japanese determinate soybean cultivars "Hatsusayaka" and "Sachiyutaka". This study also aims to evaluate the phenological and physiological responses and dry matter production under a wide range of irrigation levels in both cultivars. Irrigation treatment is set from the blooming to the full-seed stage due to drought stress during the reproductive stages severely decreases soybean yield.

Three years of consecutive field experiments with two treatments (drip irrigation; Drip, and rainfed; Rainfed) were conducted to assess the effect of using drip irrigation on the growth and yield of two Japanese soybean cultivars in Kagawa Prefecture, which has the second-lowest rainfall in Japan. The results showed that the largest seed yield was achieved in 2017, followed by 2018 and 2016. This order corresponded to the total water input (TWI, the sum of effective rainfall and irrigation)

throughout cultivation. TWI was the main factor affecting the variation of yield and its components among years as well as the higher TWI in Drip than in Rainfed contributed to the higher yield in Drip than in Rainfed within each year. ANOVA detected a significant effect of drip irrigation on total seed yield, above-ground dry matter (AGDM) at maturity, and numbers of branches, nodes, and fertile pods. AGDM had a significant correlation with the mean crop growth rate (CGR) during the treatment, and CGR was closely correlated with the mean net assimilation rate (NAR). A significant correlation among NAR, radiation-use efficiency, and leaf water potential (Ψ_L) suggested that drip irrigation prevented the decrease of plant water status that contributed to maintaining dry matter production. The advantage of using drip irrigation for soybean cultivation at the experiment site would be suppressing yield decline in years with low rainfall rather than achieving higher yield than standard in years with normal or high rainfall.

We further studied the assessment of dry matter production and physiological responses to a wide range of irrigation levels (100% of field capacity (control), 80%, 60%, 40%, and 20% of control) in soybean cultivars. "Hatsusayaka" and "Sachiyutaka" were grown in 1/2000a Wagner pots (well-drained loam soil) at a non-air-conditioned greenhouse. The results showed that the response of seed yield to irrigation levels was increased proportionally with the amount of irrigation up to a certain level (at 80% of control), and after that, it reached a threshold. Moreover, our results revealed that the proportional decrease in irrigation levels resulted in a decrease of stomatal conductance with decreasing Ψ_L, which contributed to the reduction of photosynthesis rate as well as low total dry matter production. Although Hatsusayaka had higher Ψ_L and total dry matter than Sachiyutaka in some irrigation levels, there is no clear evidence indicating the difference between Hatsusayaka and Sachiyutaka on drought tolerance.

Overall, our results revealed that using drip irrigation for soybean cultivation at the experiment site would be suppressing yield decline in years with low rainfall rather than achieving a higher yield than standard in years with normal or high rainfall. More information is needed to estimate the rainfall-threshold, which is expected to have a significant effect on using drip irrigation in this region. Besides, seed yield response to irrigation levels increased proportionally with the amount of irrigation. It is worth noting that both experiments showed that maintaining plant water status is the main factor of mitigating drought stress and would be suppressing the decrease in soybean yield.