学位論文の内容の要旨

Optimum Water Management on Soybean under Deficit Irrigation（ダイズの節水栽培における最適灌漑法）

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Soybean commodity has important role in food security in Indonesia. In the year 2004 Indonesia must be imported 1.31 million tons of soybeans to meet 65% of national consumption. One of efforts to solve the problems is increasing of the soybean productivity. Lampung Province was the highest priority to conduct the increasing productivity programs of soybean in Indonesia. Two main type of soil in Lampung were Ultisol and Latosol, which covers around 32 % and 34.7 % of the total area, respectively.

Usually, soybean is planted in paddy fields after the second harvesting of the paddy rice at the end of rainy season. Therefore, water availability becomes a limiting factor of production, so that the possibility of implementing deficit irrigation method is inevitable.

The main approach to deficit irrigation practice is to increase crop water use efficiency by partially supplying the irrigation requirement and allowing water stress to planned plant during one or more periods of the growing season with the least impact on crop yield.

In order to quantify the effect of water stress it is necessary to derive the relationship between relative yield decrease ($1-Y_a/Y_m$) and relative evapotranspiration deficit ($1-ET_a/ET_m$) given by the equation: $1-Y_a/Y_m = K_y (1-ET_a/ET_m)$, where K_y is yield response factor.

The evapotranspiration under water stress condition when soil water content fell below the critical water content (θ_c), is referred to adjustment evapotranspiration ($ET_{c\ adj}$), which can be calculated by the following equation: $ET_{c\ adj} = K_s \times ET_c$, where $ET_{c\ adj}$ is the crop evapotranspiration under water stress condition, ET_c is the crop evapotranspiration under standard condition defined as $ET_c = K_c \times ET_o$, ET_o is evapotranspiration of reference crop, K_c is crop coefficient, and K_s is water stress coefficient.

Until now the value of K_y and K_s was using from the table, which based on the experiment result in several country, except Indonesia. So creating a new value of K_y and K_s were very important, both in laboratory and field. Based on the above description, a series of laboratory experiments has been conducted in Lampung, Sumatera Island, Indonesia, with the objectives:

1) To determine the critical water content (θ_c) and water stress coefficient (K_s), and 2) To investigate the influence of deficit irrigation at individual growth stages on yield of soybean.

To achieve the first objective, two laboratory experiment was conduct in the year 2000 with Ultisol soil and Willis cultivar's of soybean: an in 2003 with Andisol soil and Tanggamus cultivar's of soybean. These researches were conducted using a randomised complete block design with four replications. The treatments included five levels of water deficit (WD): WD1 (0-20%), WD2 (20-40%), WD3 (40-60%), WD4 (60-80%) and WD5 (80-100%) of available water.

The result showed that, the critical water content (θ_c) of soybean plant on Ultisol soil was 30.5% (234kPa) and was achieved at week IV, while θ_c of Andisol were 28.4% (162kPa) at week V, 32.7% (65kPa) at week VI, and 36.9% (51kPa) at week VIII. The water stress coefficient (Ks) of soybean at Ultisol was 0.78 in average with p = 0.5 for the whole growing period; where as the average of Ks value of Andisol were 0.82, 0.68, 0.52, and 0.38 if AW deficit were maintain at 20-40%, 40-60%, 60-80%, and 80-100% for the whole growing periods, respectively. The optimum yield of soybean plant with the highest yield efficiency was reached by p = 0.5 for the whole growing period, both in Ultisol with the average value of K_s was 0.78 and Andisol with average value of K_s was 0.68. The optimum yield of soybean plant in Ultisol was 7.88 g/pot and crop water requirement (CWR) was 372 mm, while in Andisol was 13.5 g/pot and CWR was 587 mm. The deficit irrigation, which maintains soil water at 40-60% of AW deficit, could conserve of water 10.1% in Ultisol, and 24.6 % of water in Andisol.

To achieve the second objective, the laboratory research was conducted using a factorial experiment in randomized complete block design with three replications. The first factor of treatment (S) consisted of four different growth stages: S1-early vegetative stage, S2-advance vegetative stage, S3-flowering stage, and S4-pod filling to early maturity stages. The available water deficit (D) was the second factor with four levels: D2 (20-40%), D3 (40-60%), D4 (60-80%), and D5 (80-100)%. Using Ultisol soil with Willis soybean cultivars.

The result showed that soybean is sensitive to water stress especially at flowering to early maturing stage, and the θ_c at these stages was around 50% of available water deficit or $0.26 m^3/m^3$. The θ_c at advance vegetative period of stress was $0.19 m^3/m^3$ (616kPa) and the θ_c at flowering, pod filling and maturing period of stress was $0.26\ m^3/m^3$(120kPa). The Ks value of S3 and S4 were 0.57 and 0.27 respectively. The values K_y of soybean plant with early vegetative, advance vegetative, flowering, and pod filling and maturing periods of stress were 0.96, 0.42, 0.46, 1.20, respectively. The water deficit at early vegetative and pod filling to early maturing influenced the relative decrease of yield. The damage caused by water deficit at early vegetative stage could be recovered by full irrigation after advance vegetative stage. All the levels of water deficit at pod filling to early maturing stage decreased yield efficiency extremely, which means that the deficit irrigation applied after the pod filling stage could not be tolerated.