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ASSESSING CRITICAL LENGTH OF DRY SPELL FOR CROP GROWTH BASED ON SOIL WATER BALANCE AT PENGALENGAN

(Pengkajian Deret Hari Kering Kritis berdasarkan Neraca Air di Pengalengan)

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ABSTRAK

Panjang deret hari kering dapat digunakan sebagai indikator untuk mengetahui apakah tanaman sudah mulai mengalami kekeringan atau belum. Dinamika perubahan kandungan air pada suatu lahan dapat diketahui dengan analisis keseimbangan air lahan. Penelitian ini ditujukan untuk mengevaluasi penggunaan model keseimbangan air lahan dengan model APSIM, menentukan panjang deret hari kering kritis bagi pertumbuhan tanaman dan menyusun model untuk menduga kandungan air tanah berdasarkan informasi kandungan air tanah awal dan panjang deret hari kering. Hasil analisis menunjukkan bahwa model APSIM dapat mensimulasi kandungan air tanah mengikuti pola perubahan kandungan air tanah pengamatan. Selanjutnya, kandungan air pada tanah yang mengalami kejadian deret hari kering sepanjang nilai tertentu (LDS) yang kandungan air tanah awalnya diketahui (ISM) dapat diduga dengan rumus berikut: $SM_{ADS} = 21.5 + 0.629\ ISM - 2.30\ Ln(LDS)$; R^2=88%. Dengan menggunakan persamaan di atas dan hasil kajian dampak cekaman air terhadap pertumbuhan tanaman diperoleh bahwa apabila kandungan air tanah awal berada pada kondisi kapasitas lapang (65 mm), tanaman kentang dapat bertahan terhadap kejadian kekeringan yang panjang 15 hari. Apabila kandungan air tanah awal 60 mm, tanaman akan mulai mengalami cekaman setelah mengalami deret hari kering lebih dari 5 hari. Tanaman cabe akan mengalami cekaman lebih cepat dari tanaman kentang.

Kata kunci : cekaman air, deret hari kering, model APSIM, neraca air lahan

INTRODUCTION

Soil of Pengalengan is very porous and very low clay content (Boer et al., 2001). Its capacity to hold water is relatively low. Maximum available soil water was less than 20% of volume. Farmers normally apply high amount of manure or tofu waste in order to increase water holdings capacity. Without manure application, the duration of soils to maintain water from field capacity to wilting permanent point will be shorter. With this property, short dry-spells may be enough to cause water stress to crops.

According to McCaskill & Kariada (1992) and Niewolt (1989), dry spell can be used as a reliable indictor to represent proneness of a region to drought. It was stated that dry spell with a length of 7 days or more has significant impact on crop yield. Castillo *et al*. (1992) found that if dry spell with length of 15 days occurred during panicle initiation, yield of rice crop could decrease to about 18% and 38%. Furthermore, it was found that dry spell with length of 16 days which occurred during vegetative stage could destroy crop up to 91% (Dikshit *et al.* 1987). Based on water balance analysis in West Jawa, dry spell with length of 15 days would reduce soil water up to 50% below field capacity (Hasan, 1997).

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Water balance analysis would be very useful to assess critical length of dry spell for crops. Soils with higher water holding capacity and exposed to long dry spell may not cause serious drought stress to crop. Whereas, soils with lower water holding capacity will suffer from drought even though they are exposed to shorter dry spell. By knowing critical length of dry spell for a given soils, farmers may be able to use this information for water management. This study was aimed (i) to evaluate the use of APSIM model for soil water balance analysis, (ii) to assess critical length of dry spell for potato and chili growth, and (iii) to develop equation for assessing water status of soil exposed to different length of dry spell at different initial soil water content.

METHODOLOGY

For the purpose of model validation, soil samples were collected at interval of three days from four villages from bare soils, i.e. Pulosari, Warnasari, and Margamekar. The samples were taken with two replications for each village from March 11, 2003 to June 29, 2003. In each location, rain gauge was installed. The soil water content was measured using gravimetric method. The weight of soil samples at the time of sampling (BB) were weighted and then stored in the oven for 2-3 hours under temperature of 220°C. After that, the samples were weighted again (BK). Percent of water contents were calculated as follows:

$$\% \text{ water content} = (BB-BK)/BB \times 100\%$$

APSIM (Agriculture Production system Simulator) which was developed by APSRU Australia (Hammer *et al.*, 1999) was validated using the soil moisture data collected during the above period. The validated APSIM was then used to simulate water balance at Malabar, a site close to the three sites which has daily rainfall data from 1994 to 2000. The relationship between soil moisture conditions with length of dry spell was developed using regression equation. This regression equation was then used to develop a spatial map showing moisture content of the soil which was exposed to *n* consecutive dry spell at different initial soil moisture content. The map was developed using *surfer*.

RESULT AND DISCUSSIONS

Outputs from APSIM can simulate soil moisture contents quite well. The simulated data can follow the pattern of observed data (Figure 1). Based on statistical *t*-pair test, it was found that outputs of APSIM from the three sites were not significantly different from the observed data. This suggests that the APSIM can be used to assess variability of soil moisture data in the site by running the model using long term climatic data.

The simulated time series soil moisture data was used to develop an equation that relates soil moisture at a given time after being exposed to *n* dry spell (SM_{ADS} in mm) with initial soil moisture content before the soil was exposed to the dry spell (ISM in mm) and the length of the dry spell (LDS in days)). The analysis suggests that the initial soil moisture and length of dry spell could explain 88% of variation of the soil moisture data (Figure 2). The form of the equation is as fllows :

$$SM_{ADS} = 21.5 + 0.629\ ISM - 2.30\ Ln(LDS);\ R^2=88\% \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

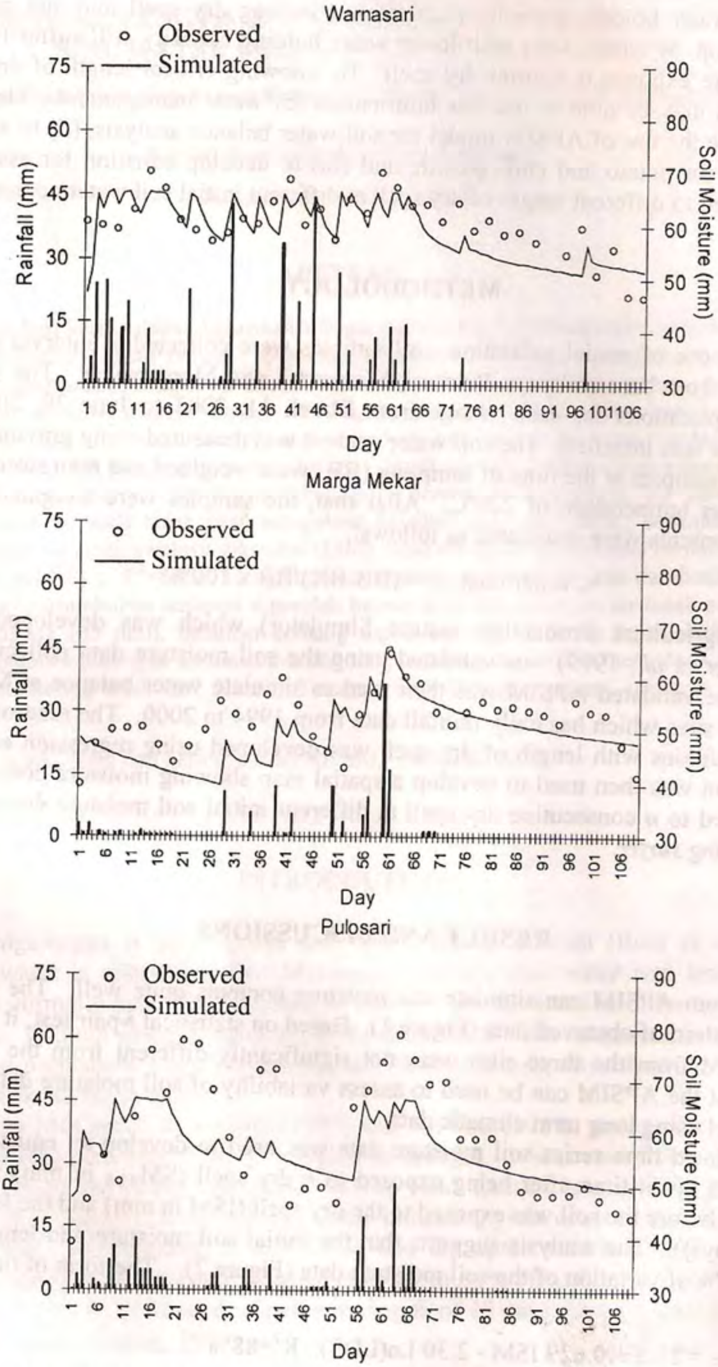

Figure 1. Comparison between observed and simulated soil moisture at 15 cm depth.

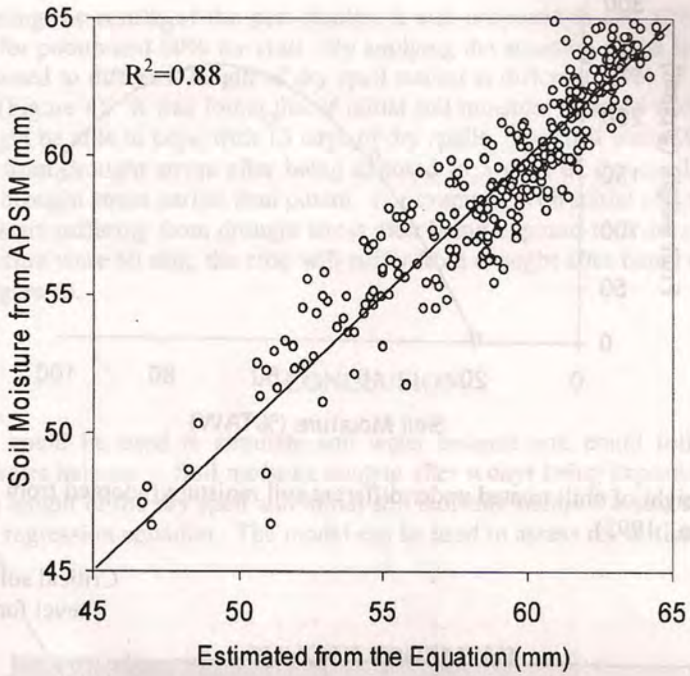

Figure 2. Relationship between soil moisture from APSIM with estimated soil moisture from the equation

Based on past studies, it was indicated that optimum soil moisture for potato at a depth of 15 cm should not be less than 50% of filed capacity (Smith, 1977). If soil moisture were already less than 50% of total available water[1], the water should be given. If water were not given until the soil moisture reached 25% of field capacity, the yield loss would be high (Smith, 1977). Optimum soil water for chili is a bit higher than potato. Kusandriani and Sumarna (1993) found that the optimum soil moisture for this crop is between 60% and 80% of total available water. Higher soil moisture (~80%) is required during active vegetative phase and during flowering and fruit setting. If the soil moisture were higher than 80% or less than 60% of total available water, the yield would decrease (Figure 3)

[1] Total available water is the difference between available water at field capacity and permanent wilting point.

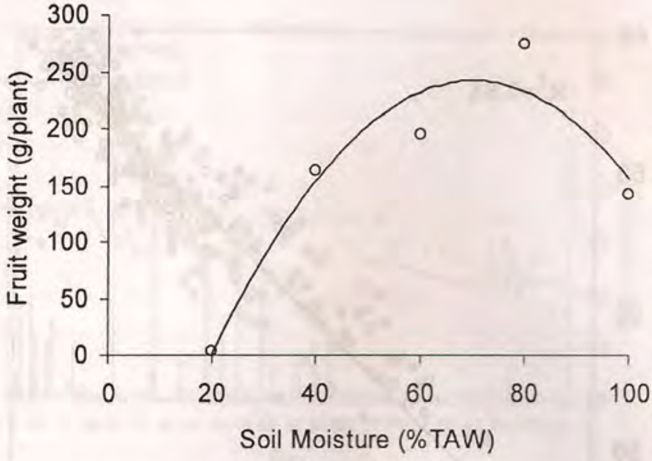

Figure 3. Fruit weight of chili treated under different soil moisture (adopted from Kusandriani and Sumarna., 1993)

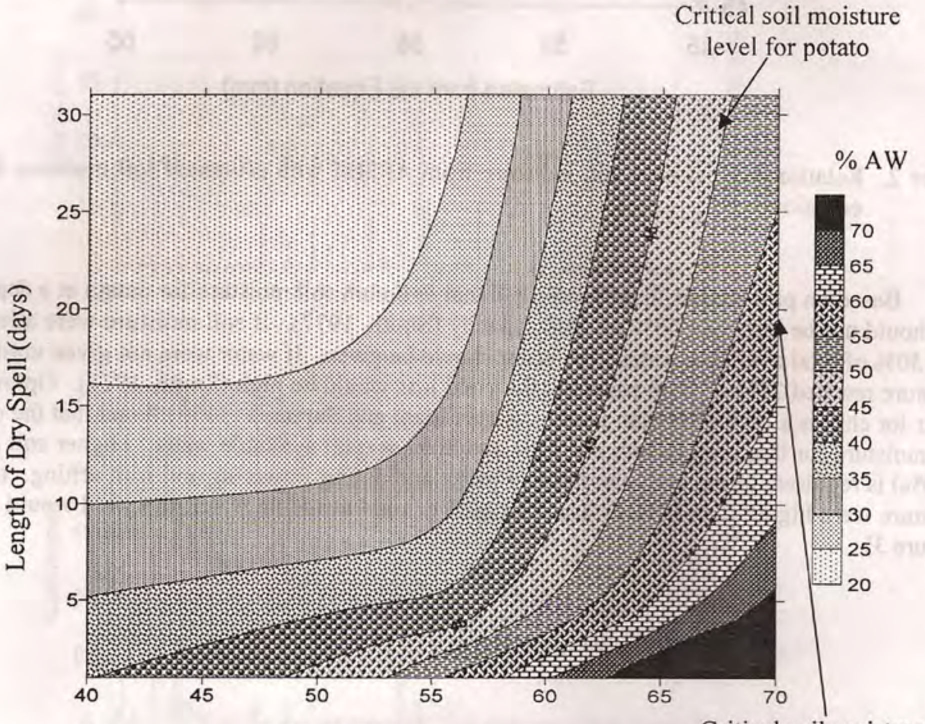

Figure 4. Percent available water after being exposed to a different length of dry spell and initial soil moisture

Considering the results of the past studies, it was proposed to use 50% as the critical soil moisture limit for potato and 60% for chili. By applying the equation 1, the level of soil moisture after being exposed to different length of dry spell started at different level of initial soil moisture can be known (Figure 4). It was found that if initial soil moisture were 65 mm (at field capacity), potato crop might be able to cope with 15 days of dry spells. But, if it were 60 mm, the crop may start suffering from drought stress after being exposed to 5 days of dry spell. Chili would start suffering from drought stress earlier than potato. For example, with initial soil water of 65 mm, the chili crop will start suffering from drought stress after being exposed to 5 days of dry spell. If the initial soil moisture were 60 mm, the crop will suffer from drought after being exposed to 2-3 days of dry spell (Figure 4).

CONCLUSION

APSIM could be used to simulate soil water balance and could follow the changes of observed soil water balance. Soil moisture content after *n* days being exposed to dry spell can be estimated from length of the dry spell and initial soil moisture before the soil being exposed to the dry spell using regression equation. The model can be used to assess the critical length of dry spell for crop growth.

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