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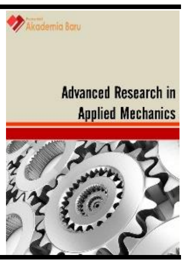

Preliminary Study on Perlis State Soil Series and Its Implication on Water Storage and Irrigation

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ABSTRACT

The over irrigation method applies to meet crop demand may not be a sustainable approach in the near future. Considering agricultural water demand constitutes a huge water consumption than the portable demand, alternative to the over-irrigation practice could be explored as over-irrigation could lead to water wastage and groundwater pollution. The current study investigates the Perlis state soil by determining the minimal water storage in the soil to maintain crop water demand. All the soil series in the state were identified and classified into soil texture based on its sand, silt, and clay composition. The soil water characteristic curve was determined to relate the soil water content to soil particle suction pressure, which then used to determine the soil wate r content field capacity and permanent wilting point. Subsequently, the plant available water can be determined. The Chengai, Kangar, Hutan, Sogomana, Gajah Mati, Kundor, and Tualang soil series constitute the highest plant available so that it could store more water for crop usage than the other soil series. The study concludes that crop irrigation at field capacity was necessary to avoid water wastage than irrigation at fully saturated soil water content.

Keywords:
Soil moisture content; water flow; gravitational drainage; Perlis soil series; Perlis soil textures

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1. Introduction

Self-sustaining water supply is an important factor for socio-economic development in any region [1]. According to the Northern Corridor Implementation Authority (NCIA) report [2], the ability of Perlis state in Malaysia to sustain its water supply needs to depend on its ability to expand the water supply capability, and to repair leakage of the current supply system to enhance water delivery system. In addition, water irrigation efficiency necessary to assure the sustainability of water resources because agricultural activities account for 70% water usage of withdrawal from groundwater and water courses [3]. The others 20% and 10% correspond to industry and domestic consumption. Based on the National Water Resources Study report [4], the normal agricultural practice of farmers were to over-irrigate the crop field due to high value crop over the low cost of water supply.

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Excessive supply of water to soil would lead to water ponding [5] and also potential water pollution in groundwater due to contaminant transport by dissolve herbicides/pesticides and fertilizers [6]. Inadequate water irrigation could cause crop production decrease or worst, crop failure [7]. Hence, irrigation goal is to achieve adequate water supply to prevent drought and to prevent deeper water penetration to groundwater or water ponding on the topsoil. The amount of water present in the soil that characterizes these criteria are the soil water content level at permanent wilting point (PWP) and field capacity (FC), respectively.

A saturated soil drains by gravitational force reaches a soil water content level known as FC [8], [9]. Evaporation [10] and crop roots uptake [11] further decline the soil water amount in the soil. At certain point of soil water decline, the soil condition reaches a stage called permanent wilting point (PWP) [12]. The name wilt indicates a condition where insufficient amount of soil water content to maintain basic water transport operation in crop water consumption. Hence, the condition approaches potential crop production decline [13], [14] and crop failure. The difference between FC and PWP indicates plant available water (PAW) indicates the amount of water available in the soil for plant absorption to grow and produce [15]. These parameters were not yet available for Perlis state of Malaysia.

The FC, PWP, and PAW relates to water irrigation efficiency. Supplying adequate amount of water without exceeding FC avoided water wastage resulted by gravitational drainage process. The aim of this study is to determine the soil water holding capacity adequately to meet the water demand of crop production in Perlis state, Malaysia. The objectives of the study are to (1) identify the soil series in Perlis, (2) classify the soil series into soil texture, and (3) determine the FC, PWP, and PAW of the soil series.

2. Methodology

2.1 Perlis State Soil Series Determination

The Soil Survey Staff [16] was used to identify the number of soil series in Perlis state. The name of the soil series does not necessary indicates the location of the soil serie s. The name given refers to the characteristic of a series when it was first discovered. Generally, the soil composition was divided into percentages of clay, sand, and silt. This information was used for the determination of the type of soil texture.

2.2 Soil Texture Classification

The composition of silt, sand, and clay information gathered for each soil series was used to determine the soil texture. A publicly available soil texture calculator was used to achieve this purpose [17]. Generally, apart from sand, silt, and clay, there are twelve soil textures ranging from coarser texture like loamy sand to moderately coarse like sandy clay loam to fine texture like silty clay.

2.3 The Field capacity, Permanent Wilting Point, and Plant Available Water Determination

The soil texture was used to determine the soil water characteristic curve. The characte ristic curve determines the relation between soil water content and soil moisture suction pressure. The field capacity (FC) soil water content was determined at suction pressure of -330 cm, whereas the permanent wilting point (PWP) was estimated at suction pressure of -15000 cm. The plant available water (PAW) was simply determined by the difference given by FC minus the PAW.

3. Results and Discussion

3.1 Soil Series of Perlis State

Based on the current land space classification given by Department of Agriculture, Perlis state in generally can be broadly divided into soil series, steep land, and lake and pond. The state soil was broadly divided into ten soil series. They were Chengai, Kangar, Telemong-Akob-Lanar Tempatan, Hutan-Semberin, Sogomana-Sitiawan-Manik, Holyrood-Lunas, Harimau-Tampoi, Gajah Mati-Munchong-Melaka, Kundor-Sedaka-Kangkong, and Tualang-Idris.

3.2 Perlis State Soil Texture

The identify soil series was classified into the soil texture. Whenever there were two or more soil series in a group, the soil series appear first was taken as the most dominant soil series of the site. Perlis state soil series were found to be dominated by clay soil texture. Then, follow by sandy loam and sandy clay loam. The Harimau-Tampoi was found to be sandy clay loam, while Telemong-Akob-Lanar Tempatan and Holyrood-Lunas were found as sandy loam. The rests of the soil series were classified as clay soil texture.

3.3 Soil Water Content of FC, PWP, and PAW in Perlis State

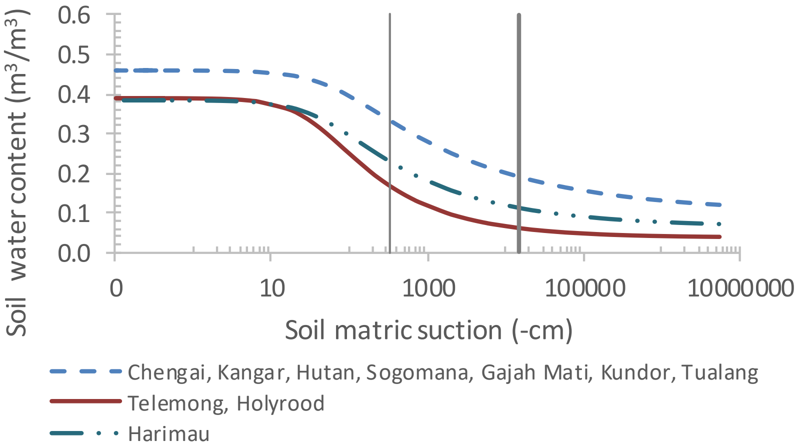

Fig. 1. The characteristic curve of the characterized soil series. Note that the vertical lines indicate field capacity and permanent wilting point at suction pressures of -330 and -15000 cm, respectively

The three soil textures identified on the Perlis state soil series were subjected to determination of water characteristic curve. The curve relates the state of soil suction pressure and water amount in the soil. Figure 1 shows the water characteristic of the soil series. The soil series of Chengai, Kangar, Hutan, Sogomana, Gajah Mati, Kundor, and Tualang have the greatest FC (0.33 m^3/m^3), PWP (0.19 m^3/m^3), and PAW (0.14 m^3/m^3), while Telemong and Holyrood soil series have the least FC (0.17 m^3/m^3), PWP (0.06 m^3/m^3), and PAW (0.11 m^3/m^3). Since the former soil series has the greatest PAW, it means the soil retained more readily available water for plant consumption, and it requires lesser frequency of irrigation, hence, potentially the soil texture is more energy efficient to maintain the crop water demand than the latter soil. In addition, Figure 1 shows that FC is significantly lesser than saturated soil water content. Hence, over supply of water to the soil resulting in gravitational draining, ultimately, leads to water wastage.

4. Conclusions

Ten soil series were identified in Perlis state. The soil series were largely dominated by clay soil with few fell under sandy clay loam and sandy loam. The Chengai, Kangar, Hutan, Sogomana, Gajah Mati, Kundor, and Tualang soil series exhibit the greatest PAW which indicates the soil could store more water for crop usage than the other three soil series. While keeping the soil water content at FC sufficiently address the crop water need, over irrigate the soil to fully saturated soil water content would result in water wastage because of drainage by gravitational pull.

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