Estimate of Available Soil Water and The Physical Condition of Soil for Different Use Soils

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Abstract. Three sites of different soils have been identified. The soil of the first site is planted with a field crop (wheat plant), the soil of the second site planted with a horticultural crop (Loquat plant) and the soil of the third site (uncultivated) in Dhuluiya district of Salah al-Din Governorate. Many laboratory tests were conducted, represented by measuring: Moisture tensile, bulk density, texture, total porosity, gravimetric and volumetric humidity, electrical conductivity EC, degree of soil interaction PH, organic matter OM, estimation of bicarbonate and carbonate and after obtaining the data were treated with several mathematical programs: RETC, SAWcal in order to find several indications Physics such as PAW100, PAW330, and soil physical quality index (S), and the following results were obtained: The decrease in the bulk density values of the soil of the third site (not cultivated), as it reached 1.43, 1.29 and 1.23 g / cm³ compared to the soil of the first site (wheat) 1.55, 1.58 and 1.61 g / cm³ and the soil of the second site (Loquat), which reached 1.6 and 1.6 g / cm³ due to the high clay content in the third site, which leads to a decrease in bulk density. The water holding capacity of soil, represented by the values of ready soil water at 1 bar and 0.3 bar, was higher in the soil of the third site compared to the first and second sites, due to the high values of water conductivity in the soil of the first site. The high values of the water conductivity in the soil of the third site (not cultivated), as it reached 0.015037, 0.015872 and 0.021653 cm / min compared to the soil of the first site (wheat), as it reached 0.008577, 0.007209 and 0.004241 cm / min, and the soil of the second site (Loquat) It was 0.003955, 0.00507, and 0.006741 cm / min. The physical quality of the soil obtained through the previous indicators showing that the soil of the first site (wheat) possesses a (good) physical quality, then the soil of the second site (Loquat) possesses a (good) physical quality as well while the soil of the third site (not cultivated) possesses (very good) physical quality.

1. Introduction

Water scarcity is a major obstacle to agricultural production in dry and semi-arid areas [1]; [2]. Since soil is the main source of water taken by the roots of the plants, therefore the management of soil water in dry and semi-dry areas is very necessary [3]; [4]. The scarcity or lack of moisture in the soil is not only due to low of the seasonal rainfall and the rain is not distributed well, it is also the result of mismanagement of irrigation processes. Poor soil structure leads to significant water losses in agricultural fields as well as limited water absorption capacity and field crop absorption capacity. Physical soil quality is a recently widespread term known by [5] as: the ability of a particular type of soil to operate within the boundaries of the natural ecosystem to maintain plant productivity, maintain water and air quality and support human health and housing. The concept of soil Physical quality and the evolution of its use as indicator has recently been used to assess the degradation or improvement of the soil and thus to determine appropriate soil management for sustainable cultivation and for the preservation of the environment on the one hand and the health of animals and plants on the other. [6];[7]. Mismanagement and improper land management practices as a result of the expansion of agricultural land at the expense of forest and pasture land can cause physical degradation of soils such as stacking, lowering soil porosity and raising their bulk density values [8], Which leads to a deterioration in the physical quality of the soil to a lousy level. (poor) [9].
Therefore, the aim of the study is to: Assessing the quality of physical soil using dexter,S indicator values.
2- Using moisture content in tensions that confined between saturation amplitude and wilting point to compare dexter indicator under different soil use conditions.
3- Finding the relationship between Dexter's values with some physical qualities of the soils study

2. Materials and Methods

Three soils were taken from different fields used in Dhuluiya district of Salah al-Din Governorate, the first, the soil of a field planted with wheat crop, the second, the soil of an orchard planted with the trees of The Ankdonia and the third uncultivated soil. Some of the following physical and chemical soil properties were estimated after the soil samples were dried and passed through a 2mm vent sieve:

- Analysis of soil particles volumes: Estimated in hydrometer method as it described by [10]; [11]; [12]. And the bulk density was estimated by the core sampler of the cylinder with a diameter (5) cm and height (5) cm. And the total porosity: was calculated from the values of bulk density and true density of soil [13]. The saturated water receipt was estimated by following the stable water column method suggested by Klute as stated in [14]. By following Darcy's law.

\[ q = \frac{Q}{At} = k \frac{\Delta h}{L} \]  

Curve of the moisture description: Curve of the moisture description for all the study soils was estimated by using a pressure disc device for the low tensions and the pressure membrane for the high tensions (Pressure Plate apparatus) model (1500 F1 Pressure Extractor) for tensions 1500,100,500,100,33,20,10.0 kPa.

VanGenuchten Equation: The VanGenuchten equation applied soil moisture tensile data (h tensile values and humidity content) measured in the laboratory, humidity range 0-1500 kPa and calculating the values of the constants \( \alpha \) and \( n \) equation coefficients above [15]

\[ \theta = \frac{\theta_s}{g^{2.8}} \left( \frac{\theta - \theta_r}{g^{2.9}} \right) \left[ 1 + \frac{(ah)}{g^{2.4}} \right] \left[ g^{4.67} \right] \left[ g^{2.89} \right] \left[ g^{2.87} \right] \left[ g^{4.675} \right] \]  

Where \( \theta_s \) represent the volumetric moisture content of the soil when it is saturating and \( \theta_r \) the remaining volumetric moisture content in the soil. And \( \theta \) the volumetric moisture content of the soil at structural tension (h).

Soil Physical Quality Index Calculation [16]: Dexter-S Represents a decline in the soil moisture tensile curve (SWRC) at the point of the coup, when drawing the relationship between the weighty moisture content (w) and the natural logarithm of the soil moisture tension of ln (h). This indicator is calculated using the VanGenuchten model [6]. The value of \( \frac{dw}{d \ln h} \) (S) is calculated at the coup point of the following relationship:

\[ S = -n \left( w_s - w_r \right) \left[ 2n - 1 \right] \left[ \frac{2n - 1}{n - 1} \right] \]  

Where N represents the VanGenuchten equation coefficient. \( \theta_s \) and \( \theta_r \) are moisture content when satisfying and the residual moisture content expressed in weight units (kg-1) [6]. The \( S \) value is always negative, so the absolute value (\( |dw/dlnh| \)) is used.

Statistical calculations and analysis:

2.1.Retention Curve Program and it's code RETC:

is a computational driver used to extract \( \alpha \) values and n only needs information about moisture tensile, volumetric humidity and then the close-\( \alpha \), n values were extracted to be used in sawcal program, which gives us paw, LLWR, IWC, EI accounts it is an easy-to-use program and also contains the data charts section of the program.

2.2.Soil Available Water, calculation, SAWCal:

SAW Cal is an automated driver that is easily installed from an executable program, the user must determine the types of soil water, electrical receipt values in the main window. This program is used to calculate the available soil water, PAW, LLWR, IWC and any related material or quantity. It is also calculate the Physical Quality Index of Soil (S) and the humid tension curve at the reflection point which Proposed by [6]; [16]; [17]. Calculated S, PAW100 and PAW330 values appear.
3. Results and Discussions
3.1. Physical and chemical properties of the study soil
Table (1) shows the variation of the texture in the three locations, where the silt mixture was in the first location (the field planted with wheat crop) and the second site was a mixture (the field planted with the ankdonia trees) and the third site was a clay mixture (uncultivated soil). It was noted that the bulk density values were higher in the soil of the first and second site compared to the density values in the third location, at 1.55, 1.58 and 1.61 mega grams/m³ for the first site soil. It was 1.61, 1.61 and 1.61 mega gram/m³ for second site, while it was 1.43, 1.29 and 1.23 mega gram/m³ in the soil of the third site (uncultivated). The reason for the increase in the proportion of clay, which leads to increased the proportion of voids in the clay soil and thus increase the size of the granules, which leads to a decrease in the bulk density in addition to the lack of exploitation of the land and lack of movement in it, as confirmed. As for porosity, there is an inverse relationship between total porosity and bulk density, which was confirmed so the porosity values in the soil of the third site increased to 46.03, 51.28 and 53.58%, while it was 41.51, 40.37 and 39.24% for the first site, which amounted to 39.62, 39.62 and 39.62% for the soil of the second site respectively.

As for the organic material (OM), its value was higher in the soil of the first and second site compared to the third site, which was 1,05, 1.04 and 1.04 g/kg⁻¹ for the first site, 0.936, 0.945 and 0.948. g/kg⁻¹ for the soil of the second site, while it was 0.68, 0.69 g/kg⁻¹ in the soil of the third site, This is because the soil of the first and second site is rich in plant residues as a result of agriculture and the third site is not cultivated so poor with organic matter.

Table 1. The following table shows the physical and chemical characteristics of the study soil

| Soil type     | sand | silt | Clay | Texture | BD  | Porosity | OM  | EC   | PH  | Carbons | Bicarbons |
|---------------|------|------|------|---------|-----|----------|-----|------|-----|---------|------------|
| Wheat 1       | 36   | 51   | 13   | Silt Loam | 1.55 | 41.51    | 1   | 0.68 | 8.4 | 3.6     | 2          |
| Wheat 2       | 37   | 51   | 12   | Silt Loam | 1.58 | 40.37    | 1.05| 0.67 | 8.39| 2.95    | 1.55       |
| Wheat 3       | 34   | 53   | 13   | Silt Loam | 1.61 | 39.24    | 1.04| 0.64 | 8.35| 3.34    | 2.06       |
| Mean          | 35.66| 51.66| 12.66| Silt Loam| 1.58 | 40.37    | 1.03| 0.66 | 8.39| 3.3     | 1.87       |
| Ankdonia 1    | 30   | 47   | 23   | Loam    | 1.6  | 39.62    | 0.936| 0.524| 7.76| 2.4     | 0.2        |
| Ankdonia 2    | 31   | 49   | 20   | Loam    | 1.6  | 39.62    | 0.945| 0.575| 7.75| 2.11    | 0.37       |
| Ankdonia 3    | 30.5 | 49   | 20.5 | Loam    | 1.6  | 39.62    | 0.948| 0.569| 7.71| 2.51    | 0.22       |
| Mean          | 30.5 | 48.33| 21.16| Loam    | 1.6  | 39.62    | 0.943| 0.556| 7.74| 2.34    | 0.26       |
| Uncultivated 1| 21   | 48   | 31   | Clay Loam| 1.43 | 46.03    | 0.68| 3.22 | 7.79| 2       | 1          |
| Uncultivated 2| 24   | 47   | 29   | Clay Loam| 1.29 | 51.28    | 0.69| 3.12 | 7.7 | 2.2     | 0.95       |
| Uncultivated 3| 22   | 45   | 33   | Clay Loam| 1.23 | 53.58    | 0.69| 3.2  | 7.91| 1.97    | 0.88       |
| Mean          | 22.33| 46.66| 31   | Clay Loam| 1.31 | 50.30    | 0.69| 3.18 | 7.8 | 2.05    | 0.94       |

Table (1) also shows the high electrical conductivity values in uncultivated soils and it were 3.22, 3.12 and 3.2, and their values in the first location decreased to 0.68, 0.67 and 0.64, while in the second position they were 0.524, 0.575 and 0.556. With regard to carbons and bicarbonate, which affect the characteristics of the moisture curve of the soil through its effect on the composition of building units with large surfaces, and their contribution to reducing the conservation of water [18], or they are deposited in the clay spaces of the soil, increasing the strength of water catch by reducing the volume of vacuums, and in the end it is affecting the amount of moisture at high tension [19].
3.2. Available water indicators of the plant, physical soil quality index:
Table (2) calculates the values of available water indicators (Plant available water, PAW) and physical soil quality index (Dexter, s,S) from data obtained from the three sites.

Table 2. Physical properties specified for the state of the physical soil of the study sites

| SOIL          | α hPa⁻¹ | n (-) | BD  | S     | PAW100** | PAW330  |
|---------------|---------|-------|-----|-------|----------|---------|
| Wheat1        | 13.09   | 1.357 | 1.55| 0.048 | 0.025    | 0.015   |
| Wheat 2       | 7.22    | 1.39  | 1.58| 0.049 | 0.025    | 0.014   |
| Wheat 3       | 8.35    | 1.36  | 1.61| 0.045 | 0.028    | 0.016   |
| Mean          | 9.55    | 1.37  | 1.58| 0.047 | 0.026    | 0.015   |
| Ankdonia 1    | 8.343   | 1.37  | 1.6 | 0.036 | 0.021    | 0.012   |
| Ankdonia 2    | 8.698   | 1.36  | 1.6 | 0.036 | 0.021    | 0.012   |
| Ankdonia 3    | 11.718  | 1.34  | 1.6 | 0.034 | 0.022    | 0.013   |
| Mean          | 9.586   | 1.35  | 1.6 | 0.035 | 0.021    | 0.012   |
| Uncultivated 1| 12.68   | 1.307 | 1.43| 0.045 | 0.033    | 0.020   |
| Uncultivated 2| 9.991   | 1.23  | 1.29| 0.050 | 0.035    | 0.021   |
| Uncultivated 3| 17.175  | 1.264 | 1.23| 0.054 | 0.056    | 0.023   |
| Mean          | 13.282  | 1.267 | 1.31| 0.050 | 0.034    | 0.021   |

* BD: Bulk Density
** PAW: Plant Available Water

It was noted through table (2) that the physical soil quality index of the soil of the first site (wheat) was (0.0489-0.0482-0.0448) as it is described as "good" [6] and in the soil of the second site (Ankdonia) it was (0.0342-0.0362-0.0365) for the three repeaters respectively, as the physical soil quality of soil of this site is also described as (good) [6], while this indicator rose in the soil of the third sites (uncultivated) compared to the two sites to (0.054 -0.05 - 0.0452) which is described as (very good) [6]. From table (2) there is a slight increase in the values of Available soil water (PAW100) for soil first site (wheat) and it’s sum arrived to 0.0256, 0.0256 and 0.0248 cm³ cm⁻³ compared to the soil of the second site (Ankdonia) at 0.0213, 0.0213 and 0.0226 cm³ cm⁻³. As for the soil of the third site (uncultivated) was 0.0336, 0.0351 and 0.0359 cm³ cm⁻³. This is because the third site with high clay content has the ability to retain water compared to the other two sites and retain water more because of the large area of the specific surface of large volumes in addition to the variation of the ratio of soft particles in different aggregates, which may lead to increase disproportion of the micropores, which increases the susceptibility of the soil to water retention (Table 1), the reason why the soil in the third site retains available water at the limits of field capacity from the soil of the first and second site is that the soil of the third site has a high clay content and has a large surface area and high total porosity and thus increase its capacity to retain water and raise the values of available water in it [20]. Also the saturated water conductivity values in the soil of the third site (uncultivated) were higher than the soil, at 0.0150, 0.0158 and 0.0216 min/cm. While in the soil of the first site (wheat) the water conductivity values were 0.0085, 0.0072, 0.0042 min/cm and the soil of the second site (Ankdonia) the values were 0.003, 0.005 and 0.0067 min/cm this is due to increased porosity of the third site soil and its low bulk density values.

Also noted from table (2) increase of soil water values at the limits of field capacity there is a slight increase in the values of available soil water (PAW330) for soil of the first site (wheat) to 0.0149, 0.0145 and 0.0165 cm³ cm⁻³ compared to the soil of the second site (Ankdonia) which was 0.0123, 0.0123 cm³ cm⁻³, as for the soil of the third site (uncultivated) was 0.0204, 0.0215 and 0.0226 cm³ cm⁻³, due to the difference in soil in the capacity of its water retention due to the difference of textures between the study sites and this result is consistent with [21].
The relationship between the S Dexter Index, and the available soil water PAW100, PAW330:

Figure (1 and 2) shows the relationship between available water for the plant at tension 100 cm (PAW100) and 330 cm (PAW330) laboratory-measured and dexter-S physical soil quality index values, and the results showed a weak linear relationship and low-key identification values ranging from 0.441 to 0.536.

![Figure 1. The relationship between dexter's index and paw100 available soil water](image1)

![Figure 2. The relationship between available soil water PAW330 and Dexter, S](image2)

3.3. *The relationship between moisture tension and Dexter, S*

Figure (3) shows the relationship between laboratory moisture tension values and Dexter, S physical soil quality index which the value of the R2 coefficient of 0.797 shows that there is a high correlation. The relationship between available soil water PAW100 and PAW330. From the fig. (4) it is clear that there is a high linear relationship between the values of available soil water at tension of 100 and 330 kPa where The R2 selection factor was 0.957.
Figure 3. The relationship between moisture tension and dexter\_s

![Graph 1](image1.png)

Figure 4. The relationship between available soil water in a tension of PAW100 and available soil water in a tension of PAW330.

![Graph 2](image2.png)

4. Conclusions

Conclusions: It can be concluded that: Paw100 and PAW330 available water values were higher in the soil of the third site (uncultivated) compared to the soil of the first site (wheat) and the second site (Ankdunia) due to the high clay content in the soil of the third site. The physical soil quality index values are higher in the soil of the third site (uncultivated) compared to the soil of the first site (wheat) and the soil of the second site (Ankdunia) due to low bulk density, high porosity values and high water conductivity values. Soil management, such as soil tilling and irrigation, plays a role in influencing physical quality indicators through their effect on the distribution of pore size. Proposal: on the study, we suggest: Adoption of the Physical Soil Quality Index, S(Dexter), to determine available water in different soils of textures. Adoption of the Physical Soil Quality Index, S(Dexter) as a guide to assess the quality of physical soil properties. Adoption of the minimum guide for available water in soils that follows the behavior of the sandy soil at the humid tension of 10 kPa and 33 kPa for mud soils. We recommend further research in this area and link the relationship of the physical soil factor Dexter, S with some dynamic qualities such as soil stacking or breakage coefficient as well as the weighted diameter rate.
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