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Spatial variation of the (moist) damp soil properties in Al-Qadisiyah Province, Iraq

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ABSTRACT

The present study aims to reveal about spatial variations in order to assess soil moisture at field capacity as well as the point of wilt and ready water in the soil of Qadisiyah Province, Iraq, variation of those properties are illustrated among the surface appearances in the province according to the cases and determine the reasons of spatial variations of those characteristics because of its great importance. Spatial search boundaries were represented at Al-Qadisiyah governorate, representing the middle Euphrates region. The study area extends between two viewing circles, i.e., 31º 6′ 17″ and 32º 42′ north , and also longitude 34º 44′ and 45º 6′ 49″ east. Administrative boundaries are formed for the study area shared borders with five provinces including Babylon from the north and Muthanna from the south, as for the governorate of wasit and Dhi Qar, which is bordered from the east and north east, while bordered Najaf Province from the west. The study was based on collecting and analyzing samples from 164 depth sites including 30-0 and 60-30 cm and distributed between the following points including soils of the rivers and their basins, lowlands, Al- Dalamj, sandy dunes, sandy soils and the western plate soil. It was found that there is a variation in their values in the soil of the Qadisiyah governorate due to an effect of a group of factors, the most important of which are climate and natural vegetation and agricultural practices by farmers and not to use the agricultural cycle from what resulted in variation in soil moisture values at field capacity withering point and ready water in Al- Qadisiyah governorate soil.

Keywords: Spatial variation, Soil, Al-Qadisiyah Province.
Article type: Research Article.

INTRODUCTION

Evaluating the moisture content of soil is of great importance because of its role in influencing many of the processes performed by the plant, as there should be quantities of water appropriate to the needs of the plant for water to compensate for the shortfall resulting from the evaporation processes of transpiration to build its tissues. In addition, water is an important element that enters the physical, chemical and biological processes taken place in the soil. The study area was represented by Al-Qadisiyah Province and represented the central part of the flood plain within the Middle Euphrates region. In the case of the main research problem, it was represented by the following question: Is there a spatial variation in the values of moisture soil properties in Al-Qadisiyah Province? The main problem included a secondary problem represented by the following:

What are the geographical factors affecting the variability of the values of the soil moisture characteristics in the Qadisiyah Province soil? In the case of the research hypothesis, it was represented by the following answer: The values

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of moisture soil properties vary spatially in Al-Qadisiyah Province. The values of the moisture soil properties in the Qadisiyah Province soil vary due to the influence of a group of natural and anthropogenic factors?

There are many studies about effects of soil charactristics in agriculture around the world (Gholubi *et al.* 2019; Vural *et al.* 2020; Demina *et al.* 2020; Dalir *et al.* 2021; Zinchenko *et al.* 2021). However there are few studies about role of soil in retaining water and moisture. The present study aims mainly to detect spatial variations of soil moisture values at field capacity, wilt point and ready water in Al-Qadisiyah Province.

MATERIALS AND METHODS

In the presented study, we adopted the analytical method that focused on identifying the elements of the studied phenomenon and finding spatial relations between its elements and linking them spatially with different geographical phenomena, by adopting the inductive method to reach colleges and finals as they constitute generalizations that lead to morphological laws. As for the spatial research locality, it included Al-Qadisiyah Province, which represents the central part of the flood plain within the Middle Euphrates region, as the study area extends between the latitudes 31˚ 17′ - 42˚ 32′ N, and longitude 44˚ 34′ - 45˚ 49 ′ E.

The administrative boundaries of the study area form a common border with five governorates, which are Babel from the north and Muthanna from the south, while the governorates of Wasit and Dhi Qar are limited to the east and northeast, albeit Najaf is bounded to the west. The total surface area of the governorate is 8,153 km^2, and it consists of fifteen administrative units, with four province and eleven districts (Fig. 1).

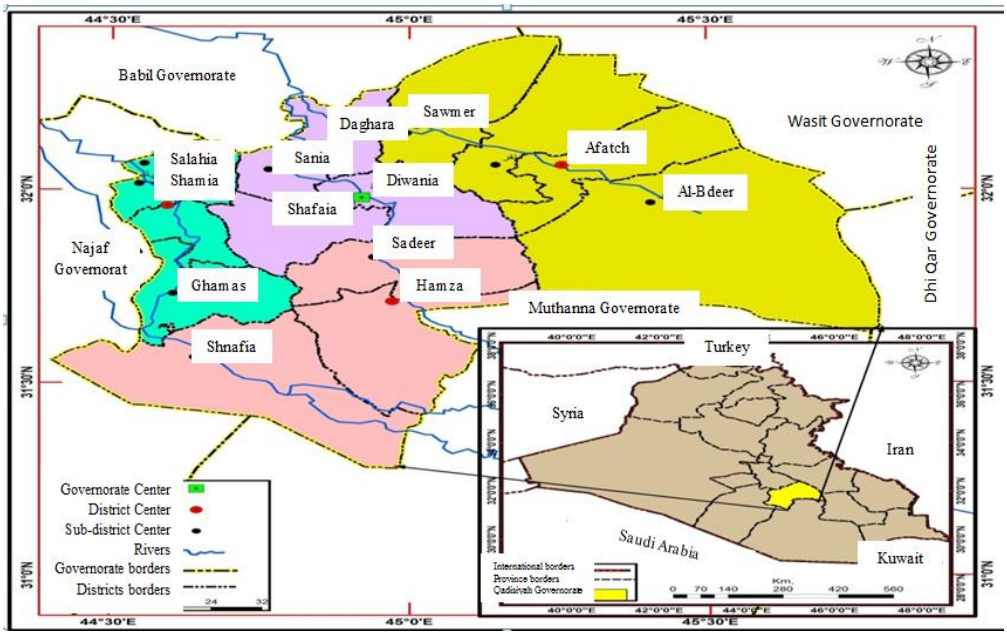

Fig. 1. Location of Al-Qadisiyah Governorate from Iraq and its administrative units (GSA 2018).

In the case of the objective limits, they were determined by studying the spatial variation of the values of the soil moisture characteristics in the province soil. The temporal limits include the analysis of soil samples and their properties for the year 2018, while we rely on the average climate data from 1988-2018. The study relied on collecting and analyzing samples from 164 sites at a depths of 0-30 cm (first depth range) and 30-60 cm (seconf depth range) and distributed between the riverside hill soil, river basin soil, depression soils, hills of Dalamage, sand dunes, sandy soil and western plateau soil (Fig. 2). The samples were distributed on the surface of six appearances in the province, the number of sites for each appearance was calculated, while the number of sites for each district in the province was also determined depending on the area of the district from the province, so the number of sites for each district in Qadisiyah Province was extracted.

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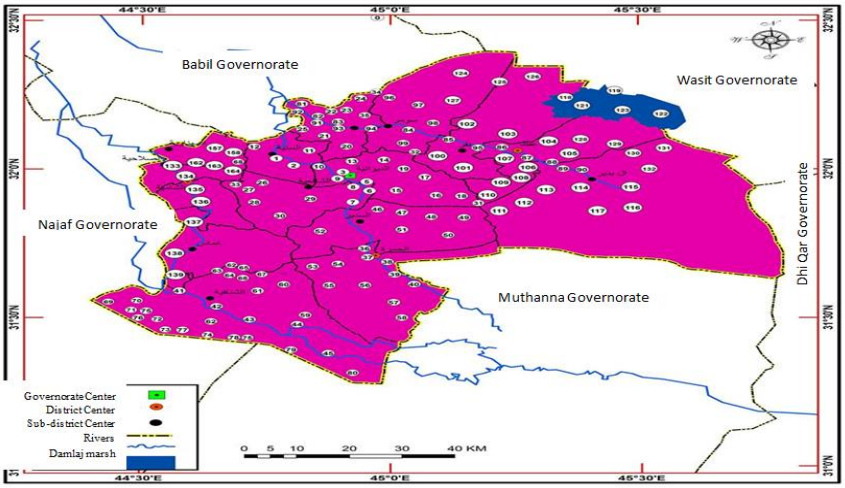

Fig. 2. Spatial distribution of soil sample sites in Al-Qadisiyah Province in the present study.

RESULTS AND DISCUSSION

The first topic was geographical factors affecting the moisture soil properties in the Al-Qadisiyah province soil. There are a group of geographical factors (including natural and anthropogenic) that affect the properties of moisture soil in Al-Qadisiyah Province, and therefore it is necessary to identify the most important factors:

Climate: from the point view of the importance of climate to emerge as an influencing factor in the values of moisture soil properties, it is necessary to study the most important elements of climate affecting the variation of the values of each of them separately:

Temperature: According to Table 1, the average annual temperature increase in the province is high, as it reached 24.3 ºC. The highest temperature is recorded in July, when it reached 35.8 m, while the lowest in January (11.2 ºC) indicating that the temperature rises in summer and decreases in winter, resulting in losing the soil moisture at higher temperatures.

Rain: It is obvious from Table 1 that the rain is characterized by its low quantities, seasonality and fluctuation, and that the annual total does not exceed 102.3 mm, and that the highest amounts of rain fall in January as it reached 21.7 mm, leading to a lack of moisture content in the soil with seasonal variations between winter and summer.

Relative humidity: As shown in Table 1, the annual average relative humidity in Al-Qadisiyah Province was 41.8%, and that the highest humidity recorded in January was 68.7%, while the lowest relative humidity in June (26.4%), indicating that humidity decreases due to the characteristics of desert climate and high temperature, and thus leads to soil loss of moisture (MTC 2014).

Table 1. Climatic characteristics in Al-Qadisiyah Province for the period of 1988-2018 (QGAD, 2014a).

Months	Average temperature (ºC)	Rain (mm)	Relative humidity (%)
January	11.2	21.7	68.7
February	13.5	15.2	59.2
March	18.3	11.5	50.1
April	24.4	15.3	41.6
May	30.2	3.8	31.2
June	33.8	0	26.4
July	35.8	0	26.5
August	35.1	0	28.8
September	32.2	0.6	31.9
October	26.7	4.3	40.1
November	18.4	15.4	56.8
December	13	14.5	64.4
Average / total	24.3	102.3	

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Natural plant: Desert plants are predominant over the natural plant in the region, including Choueil, Al-Arash, Tara'i and other plants, as well as cultivating natural plants on the banks of rivers, scraping diwaniyah, including willow and halva grasses, and the natural plant has a big role in preserving soil moisture and its lack leads to lack of soil moisture.

The second topic

Factors affecting the moisture soil properties in the pronince soil

The anthropogenic factors include the works done by farmers affecting the values of moisture soil properties in the soil, including:

1. **Agricultural policy**: represents fertilizers, agricultural pesticides, and expansion in summer agriculture. It was found through the field study within the study area that the process of adding chemical fertilizers to the plant takes place without taking into account scientific methods, as some farmers carry out the process of spreading chemical fertilizers to plants by hand, which leads to an imbalance in the distribution of fertilizers inside the field and thus affects the amount of moisture in soil. The average amount of urea fertilizer used in Al-Qadisiyah Province for the agricultural season 2013-2014 for rice yield ranged between 50 - 60 kg per acre, while that of compound fertilizer reached 125 kg per acre (QGAD 2014b). In the case of wheat crop, the average compound fertilizer quantity used ranged 20 - 35 kg / dunum (QGAD 2014c). In the case of organic fertilizers, they are represented by animal fertilizers, which are very important, as they improve the physical properties of the soil and make the soil more able to retain water (QGAD 2014d). It is common in the study area that the use of organic fertilizers is very little. In the case of agricultural pesticides, their use is considered one of the important modern methods in developing agricultural production, despite the caveats involved, as the heavy use of these pesticides leads to the concentration of a large part of them in the soil and their transmission to agricultural crops, and thus the start of their pollution. The reason for the expanded cultivation of summer vegetables compared to the winter ones in Qadisiyah Province is the large area cultivated with wheat and barley crops, leading to a narrow area for winter vegetables such as sunflower and cotton. The area of agricultural lands for summer vegetables in the province reached 23610 dunums (acre), at a rate of 37.43%, while the area of agricultural land for winter vegetables was 10939 dunums (56.95%; QGAD 2015), since the high temperatures accompanying the cultivation of crops in this season leads to the evaporation of a large percentage of irrigation water.

2- Overgrazing: Al-Qadisiyah is considered as one of the provinces characterized by animal husbandry and in relatively large quantities, and there are many types of animals, the most important of those are sheep, goats, cows, buffalo, camels. The number of sheep in the study area reached 392810 to account for the first rank of the total animals by 80.17%, and they are distributed differently among the administrative units (QGAD 2014a). The pastoral excess leads to an increase in the degree of albedo and then deepends on dry conditions, especially during periods of rain retention, which leads to dryness of the soil and less moisture in some parts of Al-Qadisiyah Province due to overgrazing.

Soil moisture: Evaluation of the moisture content of the soil is extremely important because of its role in influencing many of the processes performed by the plant. There should be quantities of water appropriate to the needs of the plant for water to compensate for the shortage resulting from the processes of evaporation transpiration to build its tissues. In addition, water is an important element that enters the physical, chemical, and biological processes taking place within the soil, and soil moisture is a variable condition according to the variables affecting it. Furthermore, it is one of the most important physical characteristics of the soil due to its direct importance to other characteristics such as porosity, hardness, coefficient of friction and volumetric weight of the soil (Al-Banna 1990). Soil moisture is a constantly changing condition depending on the factors affecting it, such as rain or irrigation. So it will be studied from the point view of the limits of water constants, as described below:

A- Field capacity: The loop capacity is defined as the amount of water held in homogeneous soil in the field after it has completely moistened and the puncture in it has become neglected (Jimny et al. 1980). The percentage of the soil moisture content held by the soil for a period ranging between 1-3 days from the irrigation process in the form of abundant irrigation or after heavy amounts of rain water needs gravity to release through big pores (Maoud 1976).

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The values of field capacity vary from one soil to another depending on the soil tissue, the ratio of the organic matter and the type of clay mineral, where there is a direct relationship between the soil tissue and the organic matter on the one hand and the ability of the soil to retain water when its field capacity on the other hand. The more smoothness the soil tissue, the greater the proportion of the material. The membership increased its ability to maintain, and the values of the field capacity of the soil are used to know the percentage of ready water for the plant, as well as to arrive at knowing the amount of water that the soil can keep (Al-Abdullah 1999). The spatial variation of the field capacitance values of the province soil will be clarified according to its location according to the surface manifestations as follows:

1. The values of the field capacity of the flood plain soil

Table 2 and Fig. 3 show a variation of the values of the field capacity of the shoulders soil, the basins of rivers, depressions, sand dunes, sandy areas and the Dalmurj hills. The studied sites, we found that their values ranged from 29.44% for the soil of Diwaniyah district to 30.98% for that of Afak district. The overall rate of districts reached 29.86%. The average of the first depth range reached 30.21%, and a variation of our location appeared in the values of this depth. We found that its values ranged between 29.27% for the soil of Diwaniyah district to 31.61% for that of Afak district. The average of second depth range reached 29.51%, and this rate is an average according to Table 3, hence a variation of our location appeared in the values of this depth among the districts. So we found that its values ranged from 28.82% for the soil of Al-Shamiya district to 30.35% for that of Efag district.

Table 2. Field capacity rates for Qadisiyah Province soil (Ismail 2001).

Administrative units	Depths	Surface manifestations						
		Flood plain		Depressions	Sand dunes	Sandy areas	The western plateau	Al-Dalj Hill
		Shoulders	Basins					
Al-Diwaniyah District	0-30	29/27	30/32	30/78	-	-	-	-
	30-60	29/61	30/46	30/27	-	-	-	-
	Two depths rate	29/44	30/39	30/53	-	-	-	-
Hamza Distric	0-30	29/64	29/78	29/86	-	14/75	24/52	-
	30-60	29/25	29/97	29/63	-	14/66	23/75	-
	Two depths rate	29/45	29/88	29/75	-	14/71	24/14	-
Aflak District	0-30	31/61	29/97	-	14/61	-	-	32/83
	30-60	30/35	29/83	-	14/50	-	-	32/69
	Two depths rate	30/98	29/68	-	14/56	-	-	32/76
Shamiya District	0-30	30/30	29/80	31/72	-	-	-	-
	30-60	28/82	29/90	32/57	-	-	-	-
	Two depths rate	29/56	29/85	32/15	-	-	-	-
The Province	0-30	30/21	29/97	30/79	14/41	14/75	24/52	32/83
	30-60	29/51	30/04	30/82	14/50	14/66	23/75	32/69
	Two depths rate	29/86	30/00	30/81	14/56	14/71	24/14	32/76

Table 3. Evaluation of water stored in soil at field capacity (-1/3 bar).

Evaluation	Soil moisture at field capacity under a moisture strain (-1/3 bar)
Very low	12>
Low	12-24
Intermediate	24-36
High	36-48
Very high	> 48

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Table 2 and Fig. 3 show variations of the field capacity values in the river basins of Al-Qadisiyah Province . So that, these values for the Afak and Diwaniya district soils are 30.39% and 29/44 % respectively, with the general average of 30.00%, and according to Table 3, their values are in medium category. While the average of the first depth range reached 29.97%, and a site variation appeared in the values of this depth among the districts, we found that their values ranged between 29.78% and 30.32% for the Hamza and Diwaniya districts respectively. According to Table 3, these values are medium. Although the average of second depth range was 30.04%, and a variation of our location appeared in the values of this depth between the districts, we found that their values ranged between 29.83% and 30.46% for the soil of Afak and Diwaniyah districts, and based on Table 3, these values were also medium. In the case of Qadisiyah soil depressions, according to Table 2, the general average value was 30.81%, ranging from 29.75% in Al-Hamza to 32.15% in Al-Shamiya districts (Fig. 3). Although the average of the first depth range reached 30.79%, and a site variation appeared in the values of this category between the districts, we found that their values ranged between 29.86% for the Hamza to 31.72% for the Shamiya district soils which are in the intermediate category (Table 3). While the average of the second depth range was 30.82%, and a variation of our location appeared between the districts, we found that their values ranged between 29.63% for the Hamzah to 32.57% for the Shamiya, and based on Table 3, these values were also intermediate. Table 2 and Fig. 3 illustrate that the overall average values of field capacity of sand dune soil in the Afak district was 14.56%, which is placed in small class (Table 3). A comparison of the overall average of the flood plain and lowland soils in Al-Qadisiyah Province shows that the average of the first range reached 14.61%, while that of the second range reached 14.50%. It was found that the rates of field capacitance values rise in the first depth range compared to the second one which may be due to the fact that the first depth contains a higher percentage of organic matter compared to the second one, resulted in raising the values of field capacity in this depth. According to Table 2 and Fig. 3, the overall average values for the field capacity of sandy soils in Al-Qadisiyah Province was 14.71% for the soil of Al-Hamzah district. For the first depth range it was 14.75%. The average for the second one was 14.66%. These values are placed in the low category (Table 3). Based on Table 2 and Fig. 3, the general average of field capacity of Al-Dalamurj soil in the province appeared in Afak district reached 32.76%, and that of the first depth range was 32. 83%, while that of the second one was 32.69%. These values are placed in the intermediate category (Table 3). According to Table 2 and Fig. 3, the general average values of the field soil capacity of the western plateau in the province was 24.14% for the soil of Al-Hamza district, as the average first depth range reached 24. 52%, while that of the second one was 23.75%, placing in the intermediate category (Table 3). According to the abovementioned notes, it becomes apparent that the soil moistures at the field capacity of the river basins and depressions were higher than their values for the rocks of the rivers. Capacity to conserve water higher than the shoulders' soil, in addition to having a good percentage of organic matter, especially in the lowlands of Al-Qadisiyah Province increase its ability to retain water and the presence of vegetation and agricultural service (tillage, modification and fertilization , irrigation, etc.). So, we see all of these factors available in the sites of Kutuf soil, river basins, and lowlands of the province. By comparing the soil of Kutuf and rivers of the province, we found the spatial variation between the study sites which may be due to the variation in the practice of soil service factors between the depths and the geographical locations studied in the province.

B. Permanent wilting point

The permanent wilt point is defined as the percentage of water present in the soil at a moisture tensile of -15 bar (Al-Abdullah 1999), at which the plants wither permanently, and this point may be called the wilt factor. The results of laboratory analyses of soil samples in the province showed different values for the wilt point according to depths and its location based on surface manifestations.

1- The wilt point values for the soil of the flood plain: As shown in Table 3, there is a variation in the wilt point values for the Kutuf soil and the rivers of the Province rivers. Among the studied sites, we found that their values ranged between 18.69% for the soil of Al-Hamza district to 20.34% for that of Al-Diwaniyah district (Fig. 4). The average of the first depth range reached 20.19%, and a site variation appeared in the values of this depth between the districts. It was found that their values ranged between 18.80% for the Hamza district soil to 20.98% for the Afak district. The average of the second depth range reached 19.83%, which is lower than the general rate of the province, and also

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lower than the first depth rate. In addition, a spatial variation appeared in the rates of this depth between the districts, since it ranged between 18.58% in Hamza district (lowest value) to 20.33% in Afak district, similar to the the wilt point values for the soil of the rivers in the province basins (Table 3 and Fig. 4). In the present study, the location varied in the depth rates of the wilt point values between the studied sites. The Shamiya district soil exhibited its lowest value (20.12%), while that of Afak district was the highest, and the overall rate of districts reached 19.91%.

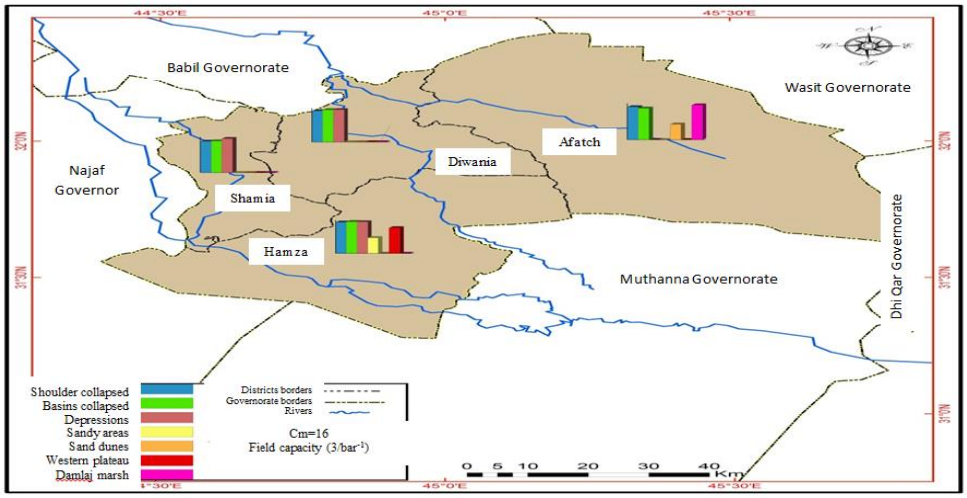

Fig. 3. Depth ratios for field capacity values (-1/3 bar) for soil in Al-Qadisiyah Province (Ahmed 1987).

The high wilt point values in the soil of the river basins of the province is due to the nature of its texture represented by the rise in the mud and silt minutes, which increases the soil ability to retain water and thus elevates its moisture. The average of the first depth range was 19.94%, which is lower than the general rate for the two depth ranges, and higher than the average of the second one. In addition, the high wilt point rate for the first depth range is due to the proximity of the surface layer to the water supply source. However, this water is prone to loss due to being affected by climatic elements such as high temperatures, evaporation and wind speed, and thus lose their moisture.

The study site varied in the values of this depth between the districts, so we found that their values ranged between 19.57% for the soil of Al-Shamiya district and 20.34% for that of Diwaniyah. While the average of the second depth range reached 19.88%, and a variation of our location appeared in the values of this depth range between the districts, we found that their values ranged between 19.77% in Shamiya and 20.15% in Afak district. The average of second depth range was lower than the general average for districts and also lower than the first depth range. The reason for the decreased wilt point values in the second depth range was the distance of this layer from the water supply source, leading to a decrease in the wilt point values in this depth, as well as the lack of its organic matter, which results in a decreased water content values at the withering point.

2- The wilt point values for the province depression soil: The quantitative data in Table 4 and Fig. 4 indicate a variation in the wilt point values for the province depression soil between the two depth ranges. In the first depth range, the overall average of districts was 20.98%, while the mean wilt point values ranged from 20.08% in Diwaniyah (as the lowest) to 22.70% in the Shamiya (as the highest). The average of the second depth range varied between 19.60% in Hamza District to 22.96% in Al-Shamiya, with a general average for this depth as 20.87%. The reason for the high wilt point values of the first depth rate compared to the second one and vice versa is the proximity of the surface layer to the water supply source, resulting in the high wilt point values in the first depth range. Fig. 4 illustrates that there is a spatial variation in the spatial wilt point values for the two depth rates in the province soil, where the values were restricted between 19.88% in Hamzah and 22.83% Al-Shamiya.

The overall rate of wilt point in the province in both two depths reached 20.93%. The overall rate of wilt point values was high compared to the soil of the flood plain which may be due to its high mud minute, hence increases the susceptibility of the soil to water retention.

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Table 4. Average of wilt point rates for soil in Al-Qadisiyah Province.

Administrative units	Depths	Surface manifestations						
		Flood plain		Depressions	Sand dunes	Sandy areas	Western plateau	Al-Dalj Hill
		Shoulders	Basins					
Al-Diwaniyah District	0-30	20/46	20/34	20/08	-	-	-	-
	30-60	20/22	19/86	20/05	-	-	-	-
	Two depths rate	20/34	20/09	20/07	-	-	-	-
Hamza Distric	0-30	18/80	19/75	20/15	-	12/44	18/48	-
	30-60	18/58	19/75	19/60	-	12/45	18/44	-
	Two depths rate	18/69	19/75	19/88	-	12/45	18/46	-
Aflak District	0-30	20/98	20/09	-	12/14	-	-	23/70
	30-60	20/33	20/15	-	11/38	-	-	23/40
	Two depths rate	20/66	20/12	-	11/76	-	-	23/55
Shamiya District	0-30	20/53	19/57	22/70	-	-	-	-
	30-60	20/17	19/77	22/96	-	-	-	-
	Two depths rate	20/35	19/67	22/83	-	-	-	-
The Province	0-30	20/19	19/94	20/98	12/14	12/44	18/48	23/70
	30-60	19/83	19/88	20/87	11/38	12/45	18/44	23/40
	Two depths rate	20/01	19/91	20/93	11/76	12/45	18/46	23/55

3- The values of the wilt point for sand dunes in Al-Qadisiya Province: Table 4 and Fig. 4 depict that the general average of wilt point values for sand dunes in Afak district reached 1.76%, which is low compared to the soil types in the other sites in the province. It was 12.14% in the first depth while 11.38% in the second one. We noticed that the average wilt point values for sand dune soils decrease in the second depth compared to the first one. The reason is that sandy soil is light and fragile with large atoms with wide pores and this large size of their atoms and the amplitude of their pores leads to a high degree of permeability and thus it reduces its ability to retain water. Due to the lack of rain in the area, and therefore no enough filtration, the whole sandy soil is characterized by its low ability to retain water and hence low humidity.

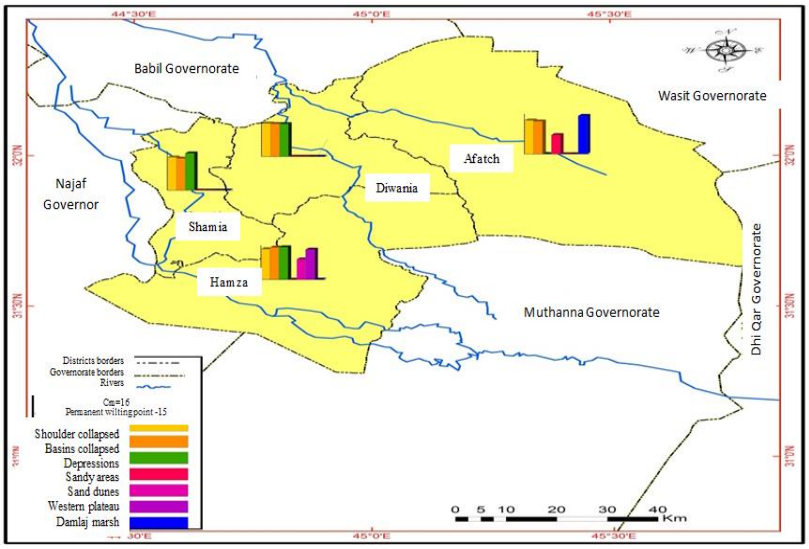

Fig. 4. the two depth rates of wilt point values (%) for soil in Al-Qadisiyah Province.

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4- The values of the wilt point for the soil of sandy areas: Table 4 and Fig. 4 indicate that the average rate of the wilt point of the soil of sandy areas in Al-Qadisiyah Province reached 12.45% for the dunes of the sandy soils in the Hamza District. It was 12.44% in the first depth rate, while was 12.45% in the second one. We noted that the rates of wilt point values rise in the second depth compared to the first one. It may be due to the nature of the tissue of its soil, which resulted in higher values of the wilt point in the second depth compared to the first one.
5- The Western Plateau: Table 4 and Fig. 4 depict that the average rate of wilt point values for the western plateau soil in the province reached 18.46% for the Afak district soil, which is lower than the general average for the flood plain soils and soils of depressions and higher than the general average for sand dunes and sandy areas. The reason is due to the nature of the soil texture. The first depth reached 18.48%, while the second one reached 18.44%.
6- The wilt point values for the Hill of Dalamij soil: Table 4 and Fig. 4 illustrate that the overall average point of the wilting point in the Hill of Dalamij soil was 23.55%, which is high compared to the rates for other surface sites. In the cases of flood plain, lowland soils, sand dunes, sandy areas, western plateau soils and Al-Dalamj soil, it reached 0.01%, 19.91%, 20.93%, 11.76% and 12.45% respectively. Due to soft texture, clay minute exhibits high values because it is poorly drained which elevates the susceptibility of the soil to water retention. So, its soil is moisty. The average for the first depth reached 23.70%, while for the second one was 23.40% .

C: Ready water = Available Water

It is defined as the amount of water retained by the soil between the field capacity and the point of wilt. The amount of ready water depends on both the total surface area of the soil minutes and the total interstitial pores and the distribution of their sizes (Al-Ani 1999). It is worth noting that the same factors that affect the amount of water in the soil at the field capacity and the wilt point, will also affect the percentage of ready water, in order to give a picture of the soil moisture, so it will be discussed as follows:

1- Ready water values for the flood plain soils: Table 5 shows the difference in the values of ready water for the first and second depths of the riverside hillock. For the first depth, these values ranged between 8.30% and 10.84% in the Diwaniya and Hamza districts. Consequently, these values are considered low to intermediate values according to the Table 6. The general average for the first depth range was 9.63%. The average of the second depth ranged between 8.25% and 10.64% in Al-Diwaniyah and Al-Hamza Judicial respectively, and these values are placed in the few to intermediate category for each one (Table 6). At the same time, a spatial variation appeared in the both two depths in the category of ready water for the Kutuf soil, according to the districts. Fig. 5 depicts that the lowest value of ready water appeared in the soil of Diwaniyah district at a rate of 8.28%, while the highest value appeared in Al-Hamza district at 10.74%. These values are few for the soil of Diwaniya district. The average for Al-Hamza reached 9.63%, which places in few category according to Table 6. In the case of values of ready water for the soil of the river basins, as shown in Table 5 and Fig. 5, a variation was found between the studied sites. We found that their values ranged between 10.09% for Al Hamza district (lowest value) and 10.55% for Diwaniya (highest one) and the overall rate of districts reached 10.33%. These values are all intermediate according to Table 6. It was also found from Table 5 that the general average of first depth reached 10.38% and a site-variation appeared in the values of this depth among the districts. We also found that their values ranged between 10.03% for Hamza district and 10.78% for Afak (Table 6). The average of second depth range was 10.27%, and a site variation appeared in the values of this depth between the districts. We found that their values ranged between 10.14% for Afak and 10.62% for Diwaniya. According to Table 6, these values are placed in intermediate category.

2- Ready water values for Qadisiyah depressions soil: From the data of Table 5, it was found that the general average values of ready water for the province soils is 9.73% which will be placed as low category (Table 6). A variation was found in the present study site among the two depth ranges for the ready-made water values between the studied sites. So that, we found that their values ranged between 8.87% in Shamiya Qadha and 10.47% in Diwaniyah (Fig. 5). These values are placed as few in Qada Shami and intermediate in Diwaniya district (Table 6). The average in the first depth range was 9.84%, which is placed as few category (Table 6). A variation was found in our site among this depth between the districts, so that, we found that their values ranged between 9.12% for Al-Shamiya and 10.70% for Al-Diwaniya. These values are placed as few to intermediate (Table 6). The average in the second depth range was 9.62%, which is placed in the few category (Table 6). A variation was found in our site among this depth range between the districts. So that, we found that their values ranged between 8.61% for Al-Shamiya and 10.23% for Diwaniyah, and these values are placed as few to intermediate (Table 6).

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Table 5. The rates of the ready water values for soil in Al-Qadisiyah Province.

Administrative units	Depths	Surface manifestations						
		Flood plain		Depressions	Sand dunes	Sandy areas	Western plateau	Al-Dalj Hill
		Shoulders	Basins					
Al-Diwaniyah District	0-30	8/30	10/48	10/70	-	-	-	-
	30-60	8/25	10/62	10/23	-	-	-	-
	Two depths rate	8/28	10/55	10/47	-	-	-	-
Hamza Distric	0-30	10/84	10/03	9/71	-	2/31	5/85	-
	30-60	10/64	10/15	10/03	-	2/21	5/64	-
	Two depths rate	10/74	10/09	9/87	-	2/26	5/75	-
Efag District	0-30	10/63	10/78	-	2/45	-	-	9/13
	30-60	10/00	10/14	-	3/12	-	-	9/25
	Two depths rate	10/32	10/46	-	2/79	-	-	9/18
Shamiya District	0-30	9/75	10/22	9/12	-	-	-	-
	30-60	8/62	10/17	8/61	-	-	-	-
	Two depths rate	9/19	10/20	8/87	-	-	-	-
The Province	0-30	9/88	10/38	9/84	2/45	2/31	5/85	9/13
	30-60	9/38	10/27	9/62	3/12	2/21	5/64	9/25
	Two depths rate	9/63	10/33	9/73	2/79	2/26	5/75	9/18

Table 6. Evaluation of water stored in soil at the value of plant ready water (%; Ismail 2001)

Evaluation	Ready water for plant (%)
Very low	< 5
Low	5-10
Intermediate	10-15
High	15-20
Very high	< 20

3- The values of ready water for sand dunes in Al-Qadisiya Province: Table 5 and Fig. illustrate that the overall average of ready-made water values for sand dunes in Al-Qadisiyah Province reached 2.79%, placing as very low according to Table 6 and low compared to the general average for overflowing soil and depression soils in the province. The average of first depth range reached 2.45%, while that of the second depth rate reached 3.12% which are placed in low category (Table 6). Noteworthy, the rates of ready water values in sand dunes are rising inn the second depth range compared to the first one which may be due to the decreased amounts of the field capacity and the wilt point in the sand dunes soil in the first depth, resulted in a reduced amounts of the ready water in this depth.

4- The values of the ready-made water for the soil of sandy areas in Al-Qadisiyah Province: Table 5 and Fig. 5 illustrate that the general average of the values of ready-made water for the sand dunes in the provinse reached 2.26% in Hamza district. This rate is very few according to Table 6. The average of first depth range reached 2.31%, while that of the second one reached 2.21%. The average value of the ready water in the first depth increased compared to that in the second one, placing in very few category (Table 6). It is noted that the mean wilt point values reduced in the soil of sandy areas in the second depth range compared to the first one. The decreased values of field capacity and wilt point for this depth range in the same soil, resulted in a reduced wilt point amounts in its soil.

5- Al-Dalmurj Hill: The quantitative data in Table 5 and Fig. 5 indicate that the overall average of ready-made water for this district was 9.18%, and this rate is placed as few according to Table 6. The average of first depth range was 9.13%, while that of the second one was 9.25%, placing in few category (Table 6). We found high values of ready water in the second depth range compared to the first one.

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The values of ready water for the soil of the western plateau: The data of Table 5 and Fig. 5 exhibit that the general average of the values of ready water for the soil of the western plateau in reached 5.75% for the soil of Afak district, placing in few category (Table 5). This rate is lower than the rate of flood plain and depression soils, which is higher than the average value of ready water in sand dunes and sandy soils in the province. It is due to the decreased field capacity and the point of wilt in its soil compared to the flood plain and depression soils. So that, their values were higher compared to sand dunes and sandy areas in the province, and in the first depth reached 5.85%, while in the second one to 5.64%.

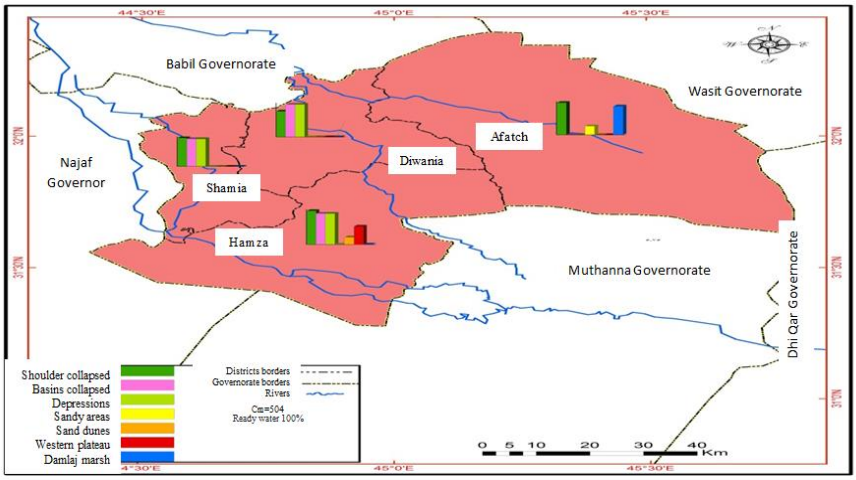

Fig. 5. The geographical distribution of rates of ready-made water ratios (%) for the soil in Al-Qadisiyah Province.

CONCLUSION

1- It was found through the study that climate elements represented by temperature, rain and relative humidity have an impact on soil moisture in Al-Qadisiyah Province. So that high temperatures have led to the loss of soil moisture, with an annual average of 24.3 ºC. The rain was characterized by its low quantity and fluctuation with the sum total annual of 102.3 mm, leading to less soil moisture content, with seasonal differences between winter and summer. In the case of relative humidity, it decreased in the study area due to the characteristics of the desert climate and high temperatures, and consequently the soil lost its moisture, as its annual rate in the Qadisiyah Province reached 41.8%.

2- From the study of the soil moisture of Al-Qadisiyah Province, a spatial variation appeared in its values between the river beds, river basins, depressions, dune marshes, dunes, sandy areas and western plateau soil, for each of the field capacity, wilt point and ready water. The depth of field capacity values (29.86, 30.00, 30.81, 14.56, 14.71, 24.14 and 32.76%), as well as the presence of spatial differences in soil moisture between the districts. The overall rate of the wilt point values for the same types of soils were 20.01, 19.91, 20.93, 11.76, 12.45, 18.46 and 23.55%, while the overall average values of ready water in the province for the same types of soil were 9.63, 10.33, 9.73, 2.79, 2.26, 5.75 and 9.18%, confirming the study hypothesis, i.e., there is a variation in the soil moisture of Al-Qadisiyah Province at the field capacity and wilt point and also ready water.

3- It is obvious that the province soil was close to its rates for ready water despite the appearance of a slight variation in these rates, and those rates were placed between intermediate and low values.

4- All factors affecting soil moisture at field capacity and withering point are the ones that affected soil moisture rates at ready water and spatial variations appeared between districts, resulting in a variation in soil moisture.

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