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Pedological Characteristics of Soils under Different Cultivation Periods in Harrad Center and Al-Kharj, Kingdom of Saudi Arabia

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MAOAH and MSAS designed the study, performed the field studies survey and wrote the first draft of the manuscript. Author ASS managed the analysis of the experiment and literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A detailed pedological characterization of soils earmarked as benchmark soils of Harrad Center and Al-Kharj region, Saudi Arabia, was carried out to provide data required for planning and execution of soil fertility studies and transfer of technology in the regions. The present study aims to study the effect of cultivation periods on the morphological properties of soil profiles represented by a number of farms in the Haradh center and Al-Kharj governorate. The field morphology rating scale was used to compare adjacent horizons to calculate a relative profile development in soils. Soil samples representative of the benchmark soil profiles were described and analyzed for their pedological characteristics. The results indicated that, the relative horizon distinctness (RHD) values of the Haradh center profiles showed the highest values (10-17) in the surface layers only, and it

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decreased with soil depth, except for profile No.9. The results data did not show a uniform distribution of RHD values in the deeper layers. The most morphological characteristics affected by soils cultivation and contributing to the RHD values are color in dry and moist state followed by decaying organic matter, and soil consistence. Other morphological characteristics have a limited contribution on RHD values, such as structure and soil mottles, with various contributions to some other morphological properties such as textures and boundaries between layers in soil profiles. The boundaries between layers show converging contribution to RHD values in Harrad and Al-Kharj profiles. The data obtained through this study presents a substantial base for sound land use planning and will facilitate transfer of technology from one area to another with similar ecological conditions.

Keywords: Soil morphology; genesis; physical properties; chemical properties; Saudi Arabia.

1. INTRODUCTION

For sustainable production of agricultural crops pedological information is an important aspect which guides the farmer about land usage and making decisions regarding management practices and crop cultivation. Pedological characterization also provides a chance to identify the limitation and potential of soil for their proper planning regarding different uses to achieve maximum benefits. Soil morphology and the relative development of profile have been used significantly in the determinations of degree of development of soils [1,2]. Bilzi and Ciolkosz [3] described a system for rating soil morphology and profile development using field morphological characteristics. Pedological information is important to land users especially farmers who use the data to make decisions on what crops and management practices are best for optimal and sustainable crop production [4]. Pedological characterization provides knowledge on soil properties [5]. Pedological characterization is a pre-requisite for sustainable soil management and proper use of soil resource.in addition, soil information obtained through systematic identification, grouping and delineation of various soils present in the locality are important for particular use for effective planning of different land uses, as they provide information related to potentials and constraints of the land [6]. In addition, environmental characteristics such as climate are also important elements in pedological characterization to provides data and knowledge on soil properties related to the site characteristics which included vegetation, slop and color [7]. According to [8], parent material, climatic, biota, relief and time are soil forming factors that influence the characteristics of soil. Understanding of soil genesis, morphology and other key soil properties is a pre-requisite to sustainable use of soil resources.

Although Saudi Arabia has long history of soil survey [9], this has only been concentrated in a few selected high potential areas. Thus, the available information remains rather scanty relative to the study area. In addition, the information on pedogenesis of soils using soil morphology rating for Saudi Arabia is scanty [10].

The present study attempts to evaluate pedological variation in terms of developments of soils of Harrad Center and Al-Kharj region, Saudi Arabia using field morphological rating system.

2. MATERIALS AND METHODS

2.1 Geographical Setting, Relief and Climate

Al-Kharj governorate (Fig. 1) lies southeast of Riyadh, the capital of Saudi Arabia. Al-Kharj governorate lies between (24°8′ 54″ N, 47°18′ 18″ E) covering an area of about 11000 km^2. It has grown into a flourishing agricultural oasis, producing cereals, dates, vegetables, and fruits. It has a climate characterized by high temperatures in the summer, bar and rainy in the winter season. Al-Kharj governorate are located within the formation of the Arab shelf of the Kingdom, which includes in its formations the eastern plateaus, sand dunes and the eastern coastal plain, in addition to the eastern part of the Najd plateau.

Haradh center (Fig. 2) lies between (21°38’43”N, 40°02’19”E) and located 265 kilometers southeast of the city of Riyadh, and 303 km southwest of Dammam, at an altitude of 310 m above sea level. Relative high rainfall. The soil was created under the influence of various soil formation factors, the most important of which are the illiterate material and the climate.

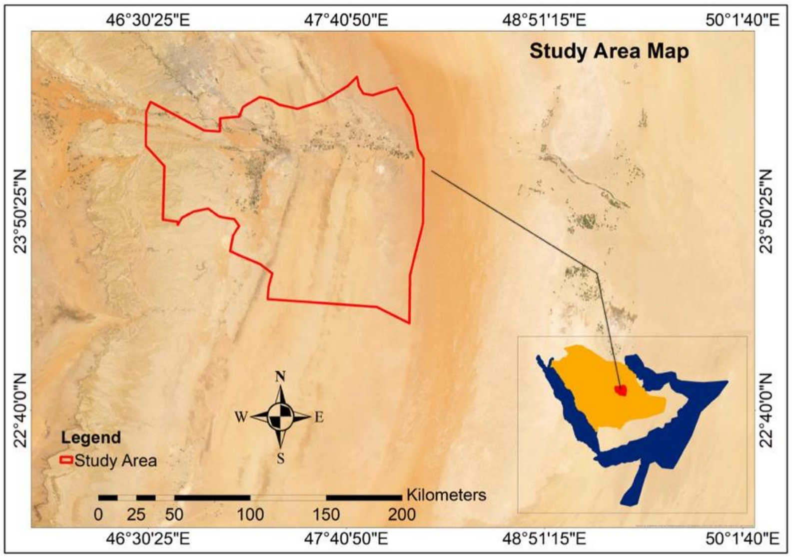

Fig. 1. Study area of Al-Kharj region, Saudi Arabia

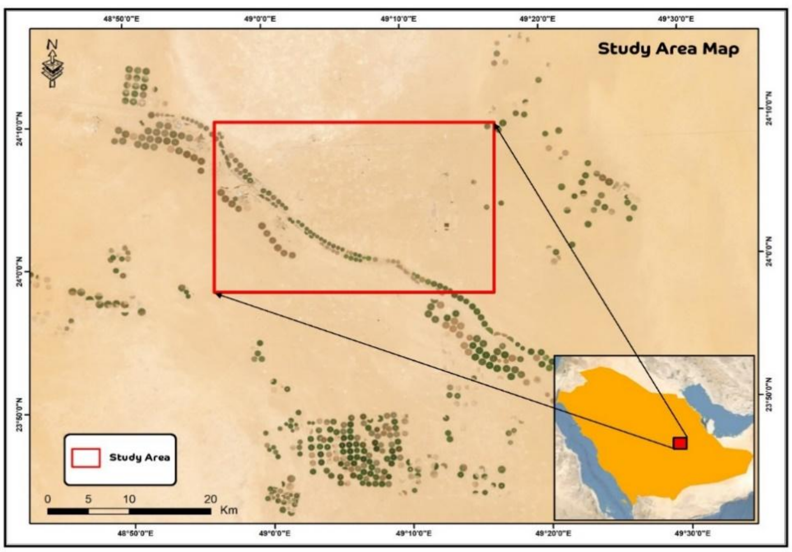

Fig. 2. Haradh center study area, Saudi Arabia

2.2 Field Methods

Reconnaissance survey was done in the Haradh and Al-Kharj regions scheme using transect walks and soil auguring to delineate sampling units based on the land morphology and orientation, soil physical attributes, cropping systems and vegetation.

Exact locations of the sites in terms of international coordinates were determined using Sony Global Positioning System (GPS) Receiver. A number of agricultural sites were selected in the Al-Kharj and Haradh regions, which represent differences in cultivation periods (less than 5 years, 15, 20, 25 and 40 years) in addition to uncultivated soils, as well as differences in the irrigation systems used (pivot irrigation, flood irrigation, irrigation drip), and cropping structures (field crops, vegetables and palms).

Two agricultural sites were selected in the Haradh area, representing two cultivation periods (less than 5 years and 25 years), and the first site worked with six profiles numbers (1, 2, 3, 4, 5 and 6), representing a cultivation period (less than 5 years), which included the cultivation of field crops. (Corn and Alfalfa), and following the pivotal irrigation system. The second site had four profiles with numbers 7, 8, 9, and 10 to represent a cultivation period (more than 25 years), which included planting field crops and following the flood irrigation system since the beginning of agriculture in 2005. After that it was changed by the sprinkler irrigation or the drip irrigation system for field and vegetable crops and the continuation of the pond irrigation system for palm trees. Two agricultural sites were selected in the Al-Kharj region, representing four cultivation periods (15, 20, 25 and 40 years). The first site represents cultivation periods of 15, 20, and 25 years, and 8 profiles were employed in it, the numbers of which are 11, 12, 13, 14, 15, 16, 17 and 18 were cultivated with field crops (corn, alfalfa, Rhodes) and followed the pivot irrigation system. As for the second site, two profiles No. 19 and 20 represented soils planted with palms for 40 years under the pond irrigation system and uncultivated land (virgin).

A complete morphological description of the surface area represented for each profile was carried out, including topography, slope, and material of origin, in addition to vegetation, drainage and surface cover. The sequence of the strip layers, the depth of each layer, and its color in the dry and wet state were described using the Munsell color book, as well as the texture and construction, in addition to the degree of cohesion in the wet, wet and dry state, cohesion and stains, the extent of the presence of calcium carbonate, in addition to the boundaries between the layers and any other morphological phenomena according to standard methods [11].

The extent of change in the morphological properties of different soil horizons was evaluated by applying the morphological evaluation system as defined by Bilzi and Ciolkosz [3].

2.3 Laboratory Methods

Disturbed composite soil samples were used for determination some of physical and chemical properties of soils. Particle size analysis was determined by hydrometer method after dispersion with 5% sodium hexametaphosphate [12]. pH was measured potentiometrically in water and in 1M KCl at the ratio 1/2.5 soil-water suspension. Organic carbon was determined by wet oxidation method [13] and converted to organic matter by multiplying by a factor of 1.72.

3. RESULTS AND DISCUSSION

The relative horizon distinctness (RHD) for the cultivated and non-cultivated profiles based on the morphological description of the studied profiles in Haradh and Al-Kharj regions are summarized in Table (1). One point is assigned for any class change in hue and for any unit change in value or chroma. One point is assigned for each class change on the textural triangle. In addition, a change from non-gravelly to gravelly [coarse fragments (35%)] is assigned one or two points, respectively. One point is assigned for any change in type of aggregated structure, for each unit change in grade (1, 2, 3) and for each class change in size. If the type of structure is different, one- point change is assessed for type. One point is assigned for each class change in dry and moist consistence. One point is assessed for gradual boundary, two points for clear boundary and three points for an abrupt boundary. By giving one point for each degree of change in the elements of color, which is the location of the color (Hue) in the Munsell soil color book, color value, Choroma in both dry and moist condition. As well as one point for each change soil texture in the triangle of textures and two points when crossing through one section of the triangle and so on for all used morphological characteristics. The results showed that, the morphological characteristics depend on color in the dry and moist state, texture, structure, and boundaries between layers.

3.1 Relative Horizon Distinctness (RHD)

The results of the calculation of RHD value for profiles of cultivated soil for less than 5 years as shown in Table (2). The results indicated that, the RHD values ranged from 3 to 16 for the three profiles (1, 2, 3), and the highest values were reported for the surface horizons. In the profile No. 1, the RHD value between (Cky1/Ap) was 13 due to changes in morphological characteristics between Cky1 and Ap horizon. The most important characteristics that contributed to the RHD value are the color in the moist state, followed by the decomposing organic matter and the color in the dry state. The boundaries between the two horizons and the contribution of structure and texture were minimal, and the soil consistence characteristic in dry and wet state, as well as the characteristic of mottles had no contribution. In the case of (Cky1/Cky2), the RHD value was low (6), and the most affected characteristics were the presence of few reddish-colored patches (two degrees) and the color in the dry and moist state, as well as the presence of decomposing organic matter and the soil consistence in dry state, and each of them had a degree. In the case of (Cky2/Cky3), the RHD values was also low (5) and the most influential traits were the presence of some reddish patches (3), the color and soil consistence in dry state. In the case of profile 2 cultivated for a period of less than 5 years the RHD values were (10, 8, 7) The RHD values converge in this profile due to the great similarity in the morphological characteristics of the layers of the soil profile. The high RHD value between (Ap2/Ap1) is due to the color in moist state and the boundary between the two layers (3 points), followed by the color in dry state and then by both soil consistence and decomposing organic matter. The most important morphological characteristics affecting the RHD value between (Ck/Ap2) were the boundaries between the two layers, while the texture and color of dry and moist state and the soil consistence, as well as the decomposed organic matter, were the least contributors. The RHD value between (Cy/Ck) is 7 and most contributing morphological traits is color (dry) and the boundary between the two layers. Profile 3, uncultivated, RHD values ranged between 3-16 and the highest values are between (2Cky1/C1). The most contributing morphological properties are color in moist and dry state (6, 4 points) respectively, followed by soil consistence in dry state and then the boundary between the two layers. The rise in RHD may be due to the different nature of parent material, and this was apparent from the lack of continuity of parent material in profile (2Cky1/C1). The RHD value between 2 (Cky2/2Cky)1 is very low (3 points) and the effect of interlayer boundaries appeared to be the most influential characteristic with textures, reflecting that none of the variable characteristics associated with the culture effect contributed.

The RHD values of profiles 4, 5, and 6 representing cultivated and uncultivated soils ranged between 6-17, and the highest was in the values of surface layer change relative to the next in cultivated profiles. In Profile 4 the RHD values between (Cky/A) were 17 points. The most contributing properties were the color in moist state (6 degrees), the color in dry state (4 degrees), and the boundaries between the layers.

The sub-surface layers of profile 4 are characterized by the presence of some yellowish patches that contributed to the value of RHD between the layer (Cy1/Cky) in addition to the color in dry and moist state. The RHD value between (Cy2/Cy1) was low, and mottles had a greater role in this. Profile 5 implanted RHD values (Cky1/ Ap) converge with RHD values in profile 4 of the same layers. Where the color in the moist state showed the highest contribution, followed by the color in dry state, and then the boundary between the layers. The value of the RHD between (Cky2/Cky1) is (11 points) where the effect of the boundaries between the layers appeared. In the layer (Cky3/Cky2), the morphological properties most influencing the RHD values were the color in moist state followed by the boundaries between the layers and the color in dry state. For not cultivated profile, the RHD value was between (Ck2/Ck1) 11 degrees, which is low compared to cultivated soils (profile 4, 5), and between (Ck3/Ck2) was slightly more (13 points).

3.2 Cultivated Soil Profiles for a Period of 25 Years

The RHD values of the surface layers in the cultivated soil profiles in Table (2) are similar, and they are 14, 15, and 17. The most influential characteristic of the RHD values of profile 7 between (Ap2/Ap1) was the color in moist state and the least contribution was the texture. The slight decrease in the RHD values between the layers (C1/Ap2) is due to the similarity of the color in moist state between the two horizons and the contribution was clear for the color in dry state and the boundary between the two layers (3 degrees), and the sudden decrease between (C2/C1) was due to the similarity of properties both C1 and C2 and not many soil properties contribute to the RHD value, as they are of one parent material (wadis sediments) except for the boundaries between the two layers and the soil color in the wet state. The RHD values in Profile 9 were relatively high between (Ap2/Ap1) due to the contribution of color in dry and moist state (4 points), followed by the boundaries between the two layers and the decomposing organic matter, its coefficient values between (C/Ap2) were almost halved due to the decrease in the color contribution. The value between the two layers (2C/C) (14 points) reflects the discontinuity of the parent material due to the difference in morphological characteristics in the parent material. The fluctuation in the RHD values between the profile layers is due to the effect of agriculture on the color and the organic matter in the surface layers, while the effect was greater for the boundary, ductility and color characteristics in the deeper layers due to the non-continuity of the source material.

Table 1. Summary of the morphological characteristics of soils in the Haradh and Al Kharj regions

Profile no.	Color		Texture	Structure	Consistence		Organic matter	Gatherings blotches	Boundary
	Dry	Moist			Dry	Moist			
1	10 YR 8/3	10 YR 6/4	LS	wfsb	s-firm	non-p	some	....	clear
	10 YR 8/1	10 YR 7/1	SL	m	sh	sp	very few	few	diffuse
	10 YR 8/2	10 YR 7/2	SL	m	h	sp	....	some	diffuse
	10 YR 8/1	10 YR 7/2	SL	m	ex-h	sp	....	some	....
2	10 YR 6/4	10 YR 4/6	LS	wfsb	so	non-p	very few	....	abrupt
	7.5 YR 7/4	7.5 YR 4/4	LS	wfsb	sh	non-p	very few	....	abrupt
	7.5 YR 6/4	7.5 YR 5/4	SL	m	h	sp	....	....	clear
	7.5 YR 8/4	7.5 YR 6/4	LS	m	vh	non-p	....	....	....
3	10 YR 7/4	10 YR 4/6	LS	m	so	non-p	....	....	clear
	5 YR 8/3	5 YR 6/4	SL	m	vh	sp	....	....	clear
	5 YR 8/3	5 YR 6/4	LS	m	vh	non-p	....	....	clear
	5 YR 7/4	5 YR 5/4	SL	m	vh	non-p	....	....	…….
4	10 YR 7/4	10 YR 3/6	S	sg	firable	non-p	very few	....	abrupt
	7.5 YR 8/2	7.5 YR 7/4	LS	m	firable	non-p	....	few	clear
	10 YR 8/3	10 YR 6/4	LS	m	firm	non-p	....	some	clear
	10 YR 8/3	10 YR 7/4	LS	m	firm	non-p	....	some	....
5	10 YR 7/4	10 YR 5/6	LS	wfsb	so	non-p	very few	....	abrupt
	7.5 YR 8/2	7.5 YR 8/4	SL	wfsb	so	sp	....	....	abrupt
	10 YR 8/1	10 YR 7/4	LS	wfsb	vh	non-p	....	....	abrupt
	5 YR 8/1	5 YR 7/1	LS	wfsb	vh	non-p	....	....	....
6	10 YR 8/4	10 YR 5/6	SL	wfsb	so	sp	....	....	clear
	10 YR 8/3	10 YR 4/6	SiL	m	vh	p	....	....	clear
	10 YR 8/2	10 YR 7/3	SL	m	vh	sp	....	....	clear
	10 YR 8/1	10 YR 7/1	SL	m	ex-h	sp	....	....	....
7	7.5 YR 6/2	7.5 YR 3/2	SL	wfsb	so	sp	some	....	clear
	7.5 YR 6/4	7.5 YR 5/6	LS	wfsb	so	non-p	very few	....	abrupt
	7.5 YR 7/6	7.5 YR 5/6	S	sg	lo	non-p	....	....	clear
	7.5 YR 7/6	7.5 YR 5/8	S	sg	lo	non-p	....	....	....
8	10 YR 6/3	10 YR 3/3	LS	m	h	non-p	few	....	clear
	7.5 YR 7/4	7.5 YR 5/6	LS	m	h	non-p	few	....	clear
	7.5 YR 7/4	7.5 YR 4/6	S	sg	lo	non-p	very few	....	diffuse
	7.5 YR 7/6	7.5 YR 4/6	S	sg	lo	non-p	....	....	....
9	10 YR 7/2	10 YR 4/4	LS	wfab-sb	sh	non-p	some	....	abrupt
	7.5 YR 8/4	7.5 YR 5/6	SL	wfab-sb	sh	sp	some	....	clear
	7.5 YR 7/4	7.5 YR 5/6	SL	wfab-sb	h	sp	few	....	clear

	7.5 YR 7/6	7.5 YR 4/6	S	m-sg	lo	non-p	....	....	clear
	7.5 YR 7/4	7.5 YR 5/6	LS	m-sg	sh	non-p	....	....	abrupt
	7.5 YR 8/6	7.5 YR 5/8	S	m-sg	lo	non-p	....	....	....
10	10 YR 5/3	10 YR 3/3	LS	mfsb	so	non-p	some	....	abrupt
	7.5 YR 7/4	7.5 YR 4/6	LS	wfsb	so	non-p	some	....	diffuse
	7.5 YR 7/4	7.5 YR 5/4	S	sg	lo	non-p	....	....	diffuse
	7.5 YR 7/4	7.5 YR 5/4	S	sg	lo	non-p	....	....	diffuse
	10 YR 7/4	10 YR 4/6	S	sg	lo	non-p	....	....	....
11	10YR 7/4	10YR 4/6	L	mfsb	so	p	some	....	clear
	10YR 7/4	10YR 5/8	CL	mfsb	so	p	few	....	clear
	10YR 8/6	10YR 5/8	SL	mfsb	so	p	very few	....	diffuse
	10YR 6/6	10YR 5/8	C	mfsb	so	p	few	....	diffuse
	10YR 6/6	10YR 4/6	SL	mfsb	so	p	very few	....	clear
	7.5YR 6/6	7.5YR 5/6	LS	sg	so	non-p	....	....	……
12	2.5 Y 7/2	2.5 Y4/4	SL	mfsb	so	sp	some	....	clear
	7.5 YR7/4	7.5 YR5/6	C	mfsb	so	vp	some	....	clear
	10 YR7/4	10 YR4/6	CL	mfsb	so	vp	very few	....	clear
	7.5 YR7/4	7.5 YR5/6	SCL	mfsb	so	p	few	....	clear
	7.5 YR5/8	7.5 YR5/6	S	sg	friable	non-p	....	....	………
13	10 YR7/4	10 YR4/6	SL	m	h	sp	....	....	clear
	7.5 YR 6/4	7.5 YR5/4	SL	m	ex-h	sp	....	....	clear
	7.5 YR 6/4	7.5 YR4/6	SL	m	ex-h	sp	....	....	clear
	7.5 YR 7/4	7.5 YR 5/6	CL	vwfsb	ex-h	p	....	....	clear
	7.5 YR 7/4	7.5 YR4/6	SL	vwfsb	ex-h	sp	....	....	clear
	7.5 YR 6/6	7.5 YR 5/6	LS	m-sg	vh	non-p	....	....	…….
14	10YR 6/4	10YR 4/6	LS	wfsb	so	p	few	....	clear
	10YR 4/6	10YR 6/6	LS	wfsb	so	p	some	....	abrupt
	7.5YR 6/4	7.5YR 6/4	SL	wfsb	so	p	few	....	abrupt
	7.5YR 6/6	7.5YR 4/6	S	wfsb	so	p	very few	....	abrupt
	7.5YR 7/4	7.5YR 5/6	CL	wfsb	so	p	very few	....	abrupt
	7.5YR 7/4	7.5YR 5/6	SL	sg	lo	non-p	....	....	abrupt
	10YR 7/4	10YR 4/6	SiL	sg	lo	p	few	....	…….
15	10YR 7/4	10YR 4/6	SL	mfsb	so	p	some	....	diffuse
	10YR 6/4	10YR 5/6	SL	mfsb	sh	p	some	....	abrupt
	10YR 7/4	10YR 5/6	SiCL	wfsb	hr	p	some	....	abrupt
	10YR 7/4	10YR 5/6	SiCL	wfsb	vh	p	some	....	clear
	7.5YR 6/6	7.5YR 5/6	SL	wfsb	vh	p	....	....	clear
	7.5YR 6/6	7.5YR 4/6	S	sg	vh	non-p	....	....	……
16	10YR 7/4	7.5YR 4/6	SiL	wfsb	sh	p	....	....	clear

	7.5YR 7/4	7.5YR 5/6	SL	wfsb	hr	p	....	....	clear
	10YR 8/4	7.5YR 5/6	SL	wfsb	vh	p	....	....	clear
	7.5YR 6/6	7.5YR 5/6	SL	mb	vh	non-p	....	....	clear
	7.5YR 6/6	7.5YR 5/6	S	mb	vh	non-p	....	....	clear
	7.5YR 6/8	7.5YR 5/6	S	sg	lo	non-p	....	....	clear
	7.5YR 7/6	7.5YR 5/6	SL	m	vh	p	....	....	…….
17	10 YR 6/4	10 YR 3/6	S	wfsb	so	non-p	few	....	clear
	10 YR 5/6	10 YR 4/6	LS	m-sg	so	non-p	few	....	clear
	10 YR 7/4	10 YR 5/6	SCL	wfsb	s-firm	p	very few	....	clear
	10 YR 6/4	10 YR 5/8	L	wfsb	firm	p	....	....	clear
	10 YR 7/3	10 YR 4/6	L	wfsb	v-firm	p	....	....	…….
18	7.5 YR 7/4	7.5 YR 4/6	SL	wfsb	sh	sp	....	....	clear
	7.5 YR 7/6	7.5 YR 5/6	SL	m	h	sp	....	....	clear
	10 YR 8/4	10 YR 5/6	L	m	vh	p	....	....	clear
	10 YR 7/4	10 YR 8/5	L	m	vh	p	....	....	clear
	10 YR 7/4	10 YR 4/6	L	vwfsb	vh	p	....	....	…….
19	10 YR 6/4	10 YR 3/6	LS	wfab	so	non-p	some	....	clear
	10 YR 7/4	10 YR 4/6	SL	wfab	so	sp	some	....	abrupt
	7.5 YR 7/6	10 YR 4/6	LS	wfab-sb	so	non-p	few	....	clear
	10 YR 7/2	10 YR 4/6	SiL	wfab-sb	sh	p	some	....	abrupt
	7.5 YR 6/6	7.5 YR 4/6	LS	wfab-sb	so	non-p	few	....	clear
	10 YR 7/4	10 YR 4/4	CL	wfab-sb	h	p	very few	....	....
20	10 YR 6/4	10 YR 4/6	LS	m	so	non-p	few	....	clear
	10 YR 7/4	10 YR 4/4	SL	m	sh	sp	....	....	abrupt
	7.5 YR 6/6	7.5 YR 4/6	S	sg	lo	non-p	....	....	clear
	7.5 YR 6/6	7.5 YR 4/6	S	sg	lo	non-p	....	....	diffuse
	7.5 YR 6/4	7.5 YR 4/6	S	sg	lo	non-p	....	....	....

NOTE: Profiles (1-10) belongs to Haradh aera while profiles (11-20) belongs to Al-Karji; Codes for types of soil structure; sl: sandy loam. ls: loamy sand. sil; silty loam. sicl: silty clay loam. cl: clay loam. c; clay. l: loam p: plastic. s: sticky. so: soft. lo: loose. sh: slightly hard. h: hard. r blocky. vh: very hard. wfsb: weak fine subangular blocky. mfsb: moderately fine sub angulamb: massive broken; m: massive. sg: single grain; sand

Table 2. Detailed characteristics and field morphology ratings of soils in Haradh region

Profile No.	Horizon	Textures	Structure	Color		Boundary	Soil consistence		Organic matter	Gatherings blotches	RHD
				Dry	Moist		Dry	Moist			
1	Ap/Cky1	1	1	2	4	2	0	0	3	0	13
	Cky1/Cky2	0	0	1	1	0	1	0	1	2	6
	Cky2/Cky3	0	0	1	0	0	1	0	0	3	5
2	Ap1/Ap2	0	0	2	3	3	1	0	1	0	10
	Ap2/Ck	1	0	1	1	3	1	0	1	0	8
	Ck/Cy	1	0	2	1	2	1	0	0	0	7
3	C1/2Cky1	1	0	4	6	2	3	0	0	0	16
	2Cky1/2Cky2	1	0	0	0	2	0	0	0	0	3
	2Cky22Cky3	1	0	2	1	2	0	1	0	0	7
4	A/Cky	1	1	4	6	3	0	1	1	0	17
	Cky/Cy1	0	0	2	2	2	1	0	0	2	9
	Cy1/Cy2	0	0	0	1	2	0	0	0	3	6
5	Ap/Cky1	1	1	4	6	3	0	0	1	0	16
	Cky1/Cky2	1	0	2	2	3	3	0	0	0	11
	Cky2/Cky3	0	0	2	5	3	0	0	0	0	10
6	Ck1/Ck2	3	0	1	1	2	3	1	0	0	11
	Ck2/Ck3	3	0	1	6	2	0	1	0	0	13
	Ck3/Cky	0	0	1	2	2	1	0	0	0	6
7	Ap1/Ap2	1	0	2	6	2	0	0	3	0	14
	Ap2/C1	1	1	3	0	3	1	1	1	0	11
	C1/C2	0	0	0	2	2	0	0	0	0	4
8	Ap/C1	0	0	3	6	2	0	0	2	0	13
	C1/C2	1	1	0	1	2	3	1	2	0	11
	C2/C3	0	0	2	0	0	0	0	1	0	3
9	Ap1/Ap2	1	0	4	4	3	0	0	3	0	15
	Ap2/C	0	1	1	0	2	1	0	3	0	8
	C/2C	2	1	2	1	2	3	1	2	0	14
	2C/2C2	1	0	2	1	2	2	1	0	0	9
	2C2/2C3	1	0	3	2	3	2	1	0	0	12
10	A1/A2	0	1	4	6	3	0	0	3	0	17
	A2/C	1	1	0	3	0	1	1	3	0	10
	C/C2	0	0	0	0	0	0	0	0	0	0
	C2/C3	0	0	1	4	0	0	0	0	0	5

Profiles numbers (1, 2, 3, 4, 5 and 6), representing a cultivation period (less than 5 years); profiles with numbers 7, 8, 9, and 10 to represent a cultivation period (more than 25 years). Profiles number (3, 6 and 8) uncultivated

The highest RHD values in profile 10 were between (A2/A1) was17 degrees and the most influential characteristic was the color in the wet state followed by the color and the organic matter groupings. The (C/A2) layer has low RHD values and is absent between the two (C2/C) layers due to the complete similarity between the characteristics of these two layers, and then increases slightly between (C3/C2). The uncultivated profile 8 has the RHD values close to profile 7 where the RHD value was between (C1/Ap) 13 degrees and the contribution of soil color to the wet state was very large (6 points), possibly due to the organic matter.

3.3 RHD Value of the Al-Kharj Soil Profile Cultivated for a Period of 15 Years

Table (3) shows the RHD values for the prospects for the cultivated profiles (11, 12) and the non-cultivated profile 13. The RHD values for profile 11 ranged from 7 to 12, being between (Ap2/Ap1) medium (10 points). The most contributing morphological characteristics are the color in moist state and the appearance of decomposing organic matter, and it is similar between (Ck1/Ap2). The RHD value decreases between (2Ck2/Ck) slightly due to the lack of continuity of the parent material. The texture and color of moist state were the most important morphological properties affecting the RHD values between (2Ck3/2Ck2) and slightly increased between (2Ck4/2Ck3) due to the contribution of many other morphological properties. The RHD values were high in Profile 12, especially between (A2/A1) (19 points), and the most contributing characteristics were the color in moist state, then the dry state, followed by the texture and the decomposing organic matter, the value of the RHD between (Ck/A2) was almost halved due to the change color and texture. The convergence of the value between (Ck2/Ck) with the value of (Ck/A2) is observed for the similarity of most of the morphological characteristics except for the low of organic matter content. The increase in the RHD value between (2Ck3/Ck2) is due to the difference in the parent material and this was evident through the morphological description of the soil profile.

The decrease between (Ck2/Ck1) was due to the great similarity between the properties of the two horizons, where the contribution of many traits did not appear. It was also noted that there was a slight increase in the RHD value between (Ck3/Ck2) for the change in texture. While it is similar between (2Ck4/Ck3) and (2Ck5/2Ck4).

3.4 Cultivated Soils Profiles for a Period of 20 Years

Table (3) indicated that, the RHD values for the cultivated profiles 14, 15 and the non-cultivated profile 16. The values appeared close in the horizons for profile No. 14 (9-15), and the discrepancy was greater in the values of profile 15 (6-12 degrees), while they converged. The values of RHD in most of the non-cultivated profile horizons (16) except for the horizons that reflected the discontinuity of the parent material (2Ck5 / Ck4) as well as between the horizon (2Ck7/2Ck6). The results showed the contribution of organic matter clusters clearly in cultivated soils in Profile 14, 15 especially the surface horizons, while they had no effect in the non-cultivated profile (16). The effect of changing the soil texture was evident between the different horizons of the cultivated soil profiles, especially Profile 14, which led to a contribution to raising the RHD values. This was not evident in the uncultivated soils except for the layers that showed discontinuity such as (2Ck5/Ck4).

3.5 Cultivated Soils Profiles for a Period of 25 Years

Profile 17 represents soils cultivated for a period of 25 years, in which the RHD values of the layer (A2/A1) appear 10 degrees, and the most morphological characteristics contributing to this value are the color in dry state (3 points), followed by the boundaries between the layers and the appearance of decomposing organic matter. The value of the RHD between (Ck1/A2) was high (16 points) and the texture and color in dry state contributed significantly (4 points), then decreased between (Ck2/Ck1) to 9 degrees. The non-cultivated profile 18 in which the RHD values converge between (7-10). The contribution of the boundaries between the layers is the largest between the two layers (Ck/A). The value of the RHD between (2Ck2/Ck) reflects the difference of parent material as it was greater than it between (Ck/A) reflects uneven coloration and boundary. The RHD value between (2Ck3/2Ck2) shows a greater degree of similarity between the two horizons as well as between (2Ck4/ 2Ck3).

The RHD values reflect the effect of different layer textures in profile 17 as well as the presence of decomposing organic matter. The color in both dry and moist conditions increased the RHD value of both profiles in all their layers. The spots did not contribute to any degree to the RHD values of both profiles, as it was evident that the boundaries between the layers contributed to a constant extent.

3.6 Profiles of Cultivated Soils for a Period of 40 Years

The profile represents 19 soils planted with palms for 40 years. The RHD values increased in deep layers and color contribution to large degrees is noted. The lowest values were between (A2/A1) and the contribution of decomposing organic matter was the largest (3 points), followed by the contribution of the boundaries between the layers. The contribution of color increases with dry state and organic matter as well as the boundaries between the layers between (C/A2). The RHD value increases between (BC/C) and (2C1/BC) due to the large contribution of dry-state color and this reflects the pronounced morphological differences between these layers compared to the surface layers. The RHD values in the uncultivated profile 20 were clearly variable.

3.7 Comparison between Soils Cultivated during Different Times

From the above it is clear that the soil cultivation, even if for a short period (less than 5 years), led to an increase in the RHD values of the cultivated profiles, especially in the surface layers, and that the most common characteristics of that color were in the wet state and then the dry state in the surface layer, and the boundaries between the layers also had an effect on increasing RHD values.

When comparing the two studied sites the Haradh area, there was no clear effect of the cultivation periods on the RHD values, but there was a clearer effect of the decomposing organic matter concentrations in the sediments of the cultivated valleys for a period of 25 years, while in gypsum or calcareous soils cultivated for less than 5 years, the increase in RHD values was due to the presence of morphological phenomena resulting from the presence of characteristic concentrations of lime, gypsum, or organic matter in the subsurface layers. The similarity of the asset had an effect in reducing the values of relative clarity in the deep horizons, while the lack of continuity had an effect in raising these values in some profiles.

As for comparing soil profiles representing different cultivation periods in Al-Kharj area, it is evident that there is a great similarity in the effect of some morphological characteristics on the RHD values, such as the color in the dry and wet state, as it contributes significantly or obviously in all the studied profiles [14,15]. It is also noticed that the soils texture had a clear contribution to the RHD values in the soils of this region as a result of the difference in textures from one layer to another, which reflects the nature of the illiterate sedimentary material. There was no effect of spots on the RHD values in Al-Kharj area. The contribution of construction and soil softness was also shown to be very limited, and it is also evident that the RHD coefficient shows to a large extent the effects of culture on the morphological properties of the soil in the surface layers of the land profile, while the laboratories were important to show the variation resulting from the morphological characteristics in the event of a lack of continuity of the illiterate material in the ground profile. The lower value of RHD values (i.e., 2-5) is contributed by soil consistency and boundary between horizons, while the higher value i.e., 14 is contributed by texture, colour consistency and boundary. The RHD Values above 10 indicate differences that may well be due to geogenic, rather than pedogenic processes [16]. Therefore, RHD ratings of soils of Harrad Center and Al-Kharj region vary on the basis of the variation in consistence, soil texture and the nature of horizon boundary in the solum whereas for relatively older well differentiated soils. This occurs on the basis of colour, texture, structure and consistence that appear with weathering and soil formation. Similar findings were also reported by Sarkar et a*l*. [17] and Deka et al. [18]. The differences between soil profiles in Harrad Center and Al-Kharj region are mainly related to the presence and characterization of the soil horizon Ap formed under the influence of agriculture cultivation for different periods [19-22]. Rabie et al. [23] found that, the RHD values increased with increasing periods of cultivation. The average coefficient (RHD) for surface horizons was 2, 4.5, 7.5, and 15 for both uncultivated and cultivated soils for periods of 10, 20 and 30 years respectively [24,25]. The effect of cultivation periods is also evident on some pedogenic processes that affected the formation of mottles in the deeper layers, especially for the uncultivated soils. The effect of soil formation processes had an effect on increasing the RHD values in the surface layer, where the color of this layer appeared completely different from the color of the rest of the layers and this is what the morphological description shows through the discontinuity of the material origin of this profile [26,27].

Table 3. Detailed characteristics and field morphology ratings of soils in Al-Kharj region

Profile No.	Horizon	Texture	Structure	Color		Boundary	Soil consistence		Organic Matter	Gatherings Blotches	RHD
				Dry	Moist		Dry	Moist			
	Ap1/Ap2	1	0	0	3	2	1	0	3	0	10
	Ap2/Ck1	2	0	3	0	2	1	0	2	0	10
	Ck1/2Ck2	3	0	2	0	0	1	0	1	0	7
	2Ck2/2Ck3	3	0	0	3	0	1	0	2	0	9
11	2Ck3/2Ck4	1	1	1	2	2	3	1	1	0	12
	A1/A2	3	0	4	5	2	0	2	3	0	19
	A2/Ck	1	0	1	2	2	0	0	3	0	9
	Ck/Ck2	1	0	1	2	2	0	1	1	0	8
12	Ck2/2Ck3	5	1	6	0	2	2	2	2	0	20
	A/Ck1	0	0	2	4	2	2	0	0	0	10
	Ck1/Ck2	0	0	0	3	2	0	0	0	0	5
	Ck2/Ck3	2	0	1	1	2	0	2	0	0	8
	Ck3/2Ck4	2	1	0	1	2	0	2	0	0	8
13	2Ck4/2Ck5	1	1	3	1	2	1	0	0	0	9
	Az/A1	0	0	4	2	2	0	0	2	0	10
	A1/A2	1	0	5	3	3	0	0	3	0	15
	A2/Ck1	2	0	2	4	3	0	0	2	0	13
	Ck1/2Ck2	4	0	3	1	3	0	0	1	0	12
	2Ck2/2Ck3	2	1	0	0	3	1	1	1	0	9
14	2Ck3/2Ck4	2	0	1	2	3	0	1	0	0	9
	Ah/A1	0	0	1	1	0	1	0	3	0	6
	A1/A2	3	1	1	0	3	1	0	3	0	12
	A2/Ck1	0	0	0	0	3	1	0	3	0	7
	Ck1/2Ck2	3	0	4	0	2	0	0	3	0	12
15	2Ck2/2Ck3	2	1	0	1	2	0	1	0	0	7
	Ck1/Ck2	2	0	1	1	2	1	0	0	0	7
	Ck2/Ck3	0	0	2	0	2	1	0	0	0	5
	Ck3/Ck4	0	1	5	0	2	0	1	0	0	9
	Ck4/2Ck5	2	0	0	0	2	0	0	0	0	4
	2Ck5/2Ck6	0	1	2	0	2	4	0	0	0	9
16	2Ck6/2Ck7	2	1	3	0	2	4	1	0	0	13
17	A1/A2	1	1	3	1	2	0	0	2	0	10

	A2/Ck1	4	1	4	1	2	1	1	2	0	16
	Ck1/Ck2	2	0	1	2	2	1	0	1	0	9
	Ck2/2Ck3	0	0	2	3	2	1	0	0	0	8
	A/Ck	0	1	2	1	2	1	0	0	0	7
	Ck/2Ck2	1	0	4	1	2	1	1	0	0	10
18	2Ck2/2Ck3	0	0	1	4	2	0	0	0	0	7
	2Ck3/2Ck4	0	1	0	5	2	0	0	0	0	8
	A1/A2	1	0	1	1	2	0	0	3	0	8
	A2/C	1	1	3	0	3	0	0	3	0	11
	C/BC	3	0	5	0	2	1	1	2	0	14
	BC/2C1	3	0	6	1	3	1	1	3	0	18
19	2C1/2C2	3	0	4	3	2	2	1	2	0	17
	A1/A2	1	0	1	2	2	1	0	2	0	9
	A2/C	2	1	4	3	3	2	1	0	0	16
	C/2C1	0	0	0	0	2	0	0	0	0	2
20	2C1/2C2	0	0	2	0	0	0	0	0	0	2

Note: Profiles numbers (11, 12 and 13) representing a cultivation period for 15 years; profiles numbers (14, 15 and 16) representing a cultivation period for 20 years; profiles numbers (17,18) representing a cultivation period for 25 years; profiles numbers (19, 20) representing a cultivation period for 40 years. profiles numbers (13, 16 and 20) representing uncultivated soils

4. CONCLUSION

The following conclusions can be drawn from the results of the study:

1. The pedogenic development of the soils in Harrad Center and Al-Kharj assessed through field morphological rating system revealed that the RHD of the profiles help in judging the development of the soil.
2. The distribution of RHD values reflects the change in soil properties associated with management, cultivation processes and the variation in pedological properties of the soils.
3. The RHD values of undifferentiated of the studied soils varied according to consistence, coarse fragments and the nature of horizon boundary in the profiles.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Gile LH. Causes of soil boundaries in an arid region. I. Age and parent materials. Soil Sci. Soc. Am. Proc.1975;39:316-323.
2. Balster CA, Parsons RB. Geomorphology and soils, Willamette valley. Oregon State Agricultural Experimental Station. Special Report. 1968;265:8.
3. Bilzi AF, Ciolkosz EJ. A field morphology rating scale for evaluating pedological development. Soil Sci. 1977;124:45-49.
4. Munishi. Pedological characterization and assessment of agricultural potential of soils of selected districts of Mbeya Region, Tanzania. MSc dissertation, Department of Soil Science, Sokoine University of Agriculture, Morogoro, Tanzania. 2012; 136.
5. Moustakas NK, Georgoulias F. Soils developed on volcanic materials in the island of Thera, Greece. Geoderma. 2005; 129:125-138.
6. Mwasyika T. Influence of soil fertility on mineral nutritive quality of cereals and vegetables grown on typical soils of Dodoma Capital District, Tanzania. MSc dissertation, Department of Soil Science, Sokoine University of Agriculture, Morogoro, Tanzania. 2015;135.
7. Al-Barrak SA. Characteristics of some soils under date palm in Al -Hassa eastern oasis, Saudi Arabia. J. king Saud Univ., Agric. Sci. 1990;(2):115-130.
8. Meixner RE, Singer MJ. Use of a field morphology rating system to evaluate soil formation and discontinuities. Soil Sci.1982;131:114-123.
9. Al-Sayari SS, Zotl JG. Quaternary period in Saudi Arabia. I: Sedimentological, hydrological, hydrochemical, geomorphological and climatological investigations in central and eastern Saudi Arabia. Springer Verlag, New York; 1978.
10. Heakal MS, Al-Awajy MH. Long Term effects of irrigation and date–palm production on Torripsamments, Saudi Arabia. Geoderma. 1989;44:261- 273.
11. Soil Survey Staff. Soil Survey Manual. USDA Agric., Handb. 18. U. S. Gov. Print. Office, Washington, DC; 1993.
12. National soil service, Laboratory procedures for routine analysis. 3rd edition, Agricultural Research Institute, Mlingano Tanga, Tanzania; 1990.
13. Nelson DW, Sommers LE. Total carbon, organic carbon and organic matter. In: Methods of Soil Analysis, part 2, 2nd edition. (eds. A.L. Page, R.H. Miller and D.R. Keeney), ASA, SSSA Monograph no. 9, Madison, Wisconsin. 1982;539-579..
14. Verma KS, Saxena RK, Barthwal AK, Deshmukh SN. Remote sensing technique for mapping salt affected soils. Int. J. Remote Sensing. 1993, (15), No. 9.
15. Metternicht G, Zinck A. Remote sensing of soil salinization: Impact on land management, CRC Press: Boca Raton, FL, USA. 2008;377.
16. Oldeman LR, Hakkeling RT, Sombroek WG. World map of the status of human-induced soil degradation: An explanatory note, 2nd edition, International Soil Reference and Information Centre, United Nations; 1991.
17. Sarkar D, Sahoo AK, Nayak DC. Evaluation of pedological development through field morphological rating system J. Indian Soc. Soil Sci. 1997;45:141-146.
18. Deka B, Baruah TC, Dutta M, Karmakar RM. Land scape soil relationships and pedogenic evaluation of soils in Ghiladhari

watershed of the Brahmaputra valley of Assam. J. Indian Soc. Soil Sci. 2009; 57:245-252.
19. Beinroth FH, Eswaran H, Reich PF, Van den Berg E. Land related stresses in ecosystems. In: Virmani, S.M., J.C. Katyal, H. Eswaran, and I.P. Abrol. Eds.,. Stressed Ecosystems and Sustainable Agriculture. Oxford and IBH Publ. Co., New Delhi, India. 1994;441.
20. Vilanculos MF. Interlinkages of soil and land use using remote sensing and GIS, a case study of the Ping Valley, Chiang Mai, Thailand. M.Sc. Thesis. ITC, Enschede, the Netherlands; 1994.
21. Misak RF, Al-Awadhi JM, Omar, SO, Shahid SA. Soil degradation in Kabd, South western Ku-wait city, Land Degrad. Develop. 2002;(13):403-415.
22. Eswaran H. Soil resilience and sustainable land management in the context of Agenda 21,. In: Soil Resilience and Sustainable Land Use, Eds. D.J Greenland and I. Szabolcs, 21-32. Wallingford: CABI; 1993.
23. Karale RL, Seshagiri Rao, KV, Singh AN. Evalua-tion of landsat imagery for reconnaissance soil mapping, presented at Andhra Pradesh Apprecia-tion Seminar, New Delhi; 1978.
24. Rabie F, Sheta AS, E1–Sharif O. An approach to the use of field morphology rating system to evaluate changes in ma made soils. Proc. Of the 12th Intern. Cong. For Stat., Comp. Sci., Social and Dem. Res. Cairo Egypt. 1987;313-326.
25. Al-Abdela SI, Sabrah, REA, Rabie RK, Agid HMA. Evaluation of groundwater quality for irrigation in Central Saudi Arabia. Arab Gulf Journal of Scientific Research. 1997;15:361-377.
26. Sirocko, F. The evolution of the monsoon climate over the Arabian Sea during the last 24,000 years. Paleoecology of Africa. 1996;24:53-71.
27. Barth HJ. Desertification in the eastern province of Saudi Arabia. Journal of Arid Environments. 1999;43:399-10.

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