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Land management and its impact on the fertility status of southern Al Jabal al Akhdar, Libya

Yousuf[1], M. S., G. Abdel-Nasser[1], A. H. A. Hussien[1], M. M. Aburass[2],Hoda A. Mahmoud[1]

[1] Soil and Agricultural Chemistry Dept., Faculty of Agriculture Saba Basha, Alexandria University, Egypt

[2] Soil and Water Department, Faculty of Agriculture, Omar Al-Mukhtar University, Libya

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ABSTRACT: Sustainable land management is a great challenge for land users and other stakeholders around the world. Disturbance of dryland ecosystems can quickly lead to severe land degradation and thus desertification. This study evaluated the management methods that have been adopted for the semi-arid slopes in the Southern Al Jabal al Akhdar, and their effects, by measuring some field and laboratory indicators, the soil fertility status, and some physical and chemical properties of the bare and cultivated areas. The results indicated that there are relative differences in some soil quality-related parameters when cultivated and bare lands are compared. Higher CEC values, as well as a significant increase in soil content of organic matter and total nitrogen, were recorded within the cultivated land compared to the bare land. The study showed that the applied land management practices have improved some soil properties that are directly related to the production function and quality, as a result, more fertile and productive areas were available within these semi-arid cultivated lands. Considering the output of the present research, it can put forward some recommendations to be used for strengthening sustainable land management practice and to relieve the negative impact of land degradation and soil fertility deterioration. This recommendation could include adapting the recent agricultural technology, establishing sustainable land management practices, efficient use of both organic and chemical fertilizers. In addition, more research for soil fertility management practices will be essential for the success of future soil conservation plans within these fragile areas. .

Keywords: land management, soil fertility, land degradation, sustainable land management.

INTRODUCTION

In drylands, characterized by severe climatic conditions and water scarcity, it is especially difficult to earn benefits from the land without degrading resources. Disturbance of dryland ecosystems can quickly lead to severe land degradation and thus desertification. Desertification is defined as ‘‘land degradation in arid, semi-arid, and dry subsumed areas resulting from various factors, including climatic fluctuations and human activities’’ (unccd, 2008). Combating desertification is complex and usually requires changing the very land management that contributed to desertification in the first place (wwap, 2012).

Attention to land management to increase production capacity is an important aspect, and the best production rate can be achieved when conditions and factors improve soil fertility. The quickest acceptable aspect of management is to address the problems of soil fertility that may result from poor management of these lands, such as incorrectly adding fertilizer or implementing service operations that exacerbate the loss of their conditions. Land assessment is an assessment of its effectiveness and performance when used for a particular purpose. The continuous increase in population requires an increase in world food production and the preservation of land resources from degradation to make their use sustainable (fao, 1985). The lack of sound management leading to land degradation can be observed and measured by indicators of decreasing soil fertility and reduced productive capacity (yousuf, 2017). Thus, some of the indicators used to assess land degradation can also be used to assess the adverse state of the land. In other words, the soil is the medium that reflects many changes in the appearance of the earth's surface and is a measure of land fertility (stocking and murnaghan, 2001). According to the above, it is possible to use indicators showing soil fertility because of its relative ease of measurement and its direct link to soil productivity reduction and management (stocking and murnaghan 2001). The assessment of the soil fertility conditions is carried out through field measurements as well as laboratory measurements to determine the extent to which the land can supply nutrients to the plant. Hence, the result is the realization of a fertility status while applying the management systems (bear, 1953).

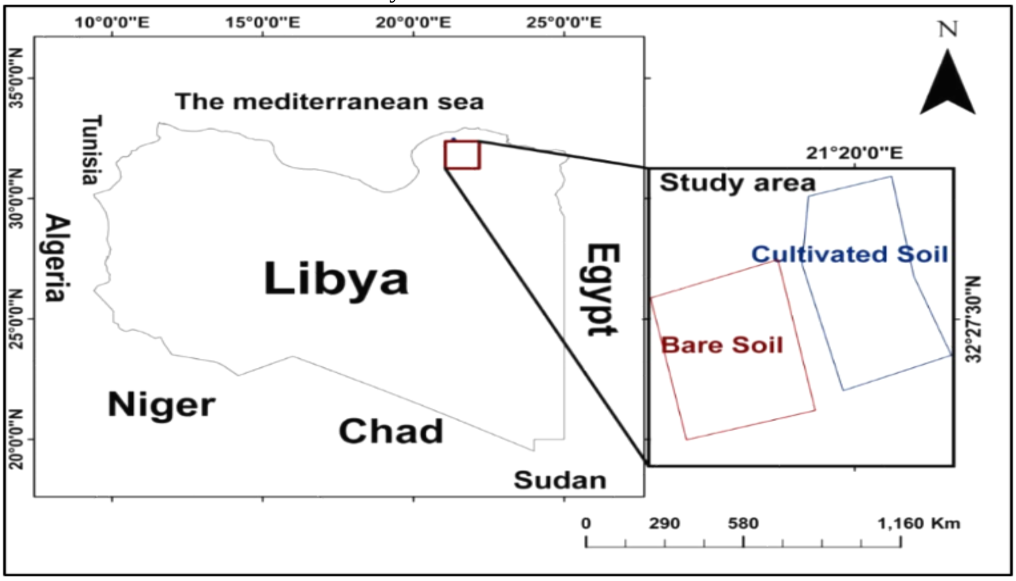
The soil of dry and semi-dry territory as fragile and vulnerable will be a priority in pursuing management that increases its productive capacity or maintains its fertility. Ben mahmoud (1995) has shown that attention to managing the soil, reducing its loss through loss factors such as erosion, and improving its characteristics will contribute to improving its fertility. Protecting soil, especially those that are said to lose their testicles, such as aridisols, is considered a priority in pursuing sound management that contributes to maintaining their fertility. The libyan soil, which is capable of agricultural production if water is available, is only 10% and varies in characteristics from region to region as well as within region (alkhubuliu *et al*., 2014). Considering that aridisols are most prevalent in the territory of south al jabal alkhdar and are subject to rapid and alarming degradation, the most important causes of this accelerated degradation are unrivaled human activity such as overgrazing, tillage of marginal land, and inappropriate exploitation of a fragile and resource-limited environment (aburas, 2009).

Therefore, the management methods that have been adopted for the aridisols of south al jabal alkhdar and their effects on the adversarial state will be evaluated by measuring some of the field and laboratory indicators.

MATERIALS AND METHODS

The study area:

An assessment of the adversarial status of the study area was carried out along a longitude (°21.334581-°21.326403), latitude (°32.464413 – °32.453215), in which a comparison was established between the cultivated land against the bare land to achieve the study objectives, map (1):



Map (1). Map showing the location of the study area in the southern Al Jabal Al Akhdar, Libya

The climate of the study area, in general, is the Mediterranean climate, which is characterized by warm and rainy winters, and hot and dry summers, and the prevailing winds are from north to northwest in Winter, while northeast, and sometimes southern at summer. The data were obtained from the NASA website (NASA, 2021) issued by the Shahat weather station from1985 to 2019 as shown in Table (1).

The soil type was determined by a map prepared by Selkhoz Prom Express (1980). Two areas of the study (cultivated and bare) were identified for each of 29 ha. For cultivated areas, some management regulations were applied in 2004, such as contour tillage, protection against grazing, and human activities.

Fieldwork:

Primary selection of 10 profile points representing each profile point was identified in the Google Earth Map of the study area and determined with GPS value in study areas A (cultivated soil) as well as study area B (bare soil), Map (2). At the field scale, the profiles were carefully chosen based on the different physiographic landforms (Map 2) that existed in the study area in 2020. The selected profile points were selected from google earth maps and correction was applied if necessary and were excavated, the layers for each profile were identified, the morphological properties were determined according to a proposal of FAO (1990). The samples were then collected from each layer of the profile, air-dried, sieved with a 2 mm sieve diameter, and preserved for chemical and physical analysis.

Laboratory soil analysis:

Electrical conductivity (EC) of soil: water extract, 1:1 (w/v) was measured using a conductivity meter according to Jackson (1973).

Soil pH was determined in the 1:1, soil: water suspension using a pH meter (Jackson, 1973).

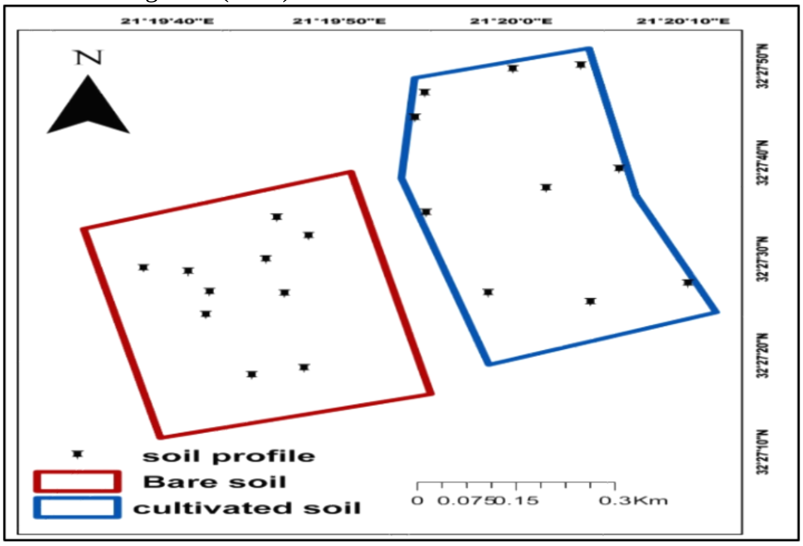
Organic carbon (OC) was determined using the modified Walkley-Blacks titration method (Carter and Gregorich, 2008). The organic matter content (OM) was calculated using the suitable constant (1.724).

Total carbonates content: was estimated using the calcimeter and calculated as calcium carbonate percentage according to Richards (1972).

Particle-size distribution (sand, silt, and clay %) was determined by the hydrometer method according to Carter and Gregorich (2008).

The soil bulk density of each soil sample was measured using the soil core method according to the weight of soil and the volume of packed cores (Evans et al., 1996).

Cation exchange capacity was determined using the method described by Gillman and Sumpter (1986).



Map (2).Map showing the locations of soil profiles in the southern Al Jabal Al Akhdar, Libya (scale 1:50000)

Available nitrogen in the soil was extracted using 0.5 N $NaHCO_3$ solution (pH 8.5) and was determined using spectrophotometer by Nessler's solution at a wavelength of 420 nm, extraction ratio 1:20 soil: $NaHCO_3$ **(Carter and Gregorich, 2008)**

Available phosphorus was extracted using 0.5 N $NaHCO_3$ solution (pH 8.5) and was determined using a spectrophotometer by ascorbic acid at a wavelength of 772 nm, extraction ratio 1:20 soil: $NaHCO_3$ **(Carter and Gregorich, 2008).**

Available potassium in the soil was extracted using 0.5 N $NaHCO_3$ solution (pH 8.5) and was determined by a Flame photometer, extraction ratio 1:20 soil: $NaHCO_3$ **(Carter and Gregorich, 2008).**

GIS maps

The following maps and programs were done:

- Climatic information from **NASA(2021).**
- Reports of inventory and classification of lands for the southern Al Jabal al Akhdar area from the **Selkhoze Prom(1980).**
- ArcGIS 10.5 (Esri, 2016): The ArcGIS desktop 10.5 program was used through several steps, including converting the collected data into digital images by entering spatial data and converting it into digital maps, then processing and analyzing the data by the tools attached to the program by signing geographical coordinates, rearranging data and layer boundaries to calculate the total area and produce a map for each property.

Statistical analysis

All obtained data of the present study were statistically analyzed according to the design used by the **Statistix (2019)** computer software program and were tested by analysis of variance. The revised least significant difference test at 0.05 level of probability was used to compare the differences among the means of the various parameter combinations as illustrated by **Duncan (1955) and Gomez and Gomez (1984).**

Table (1). Climatic parameter of the study area during the period of 1985-2019.

Parameters	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Maximum Temperature at 2m (C°)	14.68	15.12	17.56	21.11	24.90	28.48	29.68	30.19	28.63	25.03	20.42	16.24
Minimum Temperature at 2m (C°)	9.28	8.99	10.00	12.19	15.38	18.86	20.90	21.79	20.53	17.74	14.14	11.02
Relative Humidity at 2m (%)	75.89	73.89	70.03	63.93	60.85	58.47	63.15	65.11	64.44	66.86	69.83	74.62
Maximum Wind Speed at 10m (m/s)	7.91	8.16	7.67	7.39	6.49	6.29	6.80	6.68	6.40	6.27	6.92	7.75
Precipitation (mm month^{-1})	78.33	71.25	40.41	16.66	13.75	2.92	1.25	1.25	14.58	42.08	47.50	91.25
Dew/Frost Point at 2m (C°)	7.33	6.90	7.70	8.86	11.34	14.08	16.93	18.11	16.51	14.07	10.94	8.65
Pressure (kPa)	98.26	98.33	98.03	97.97	97.99	97.69	97.87	97.89	98.09	98.26	98.31	98.39

RESULTS AND DISCUSSION

Physiographic properties

The physiographic characterization of the cultivated and bare soil areas was illustrated in Tables (2 and 3).

The slop degree ranged between 2 and 6 for the cultivated area with shapes as flat and convex, while for bare soil area, the slope ranged between 1 and 6 with the shape of flat and convex. Soil profile depth ranged between 9 and 52 cm for cultivated, while for bare soil area ranged between 18 and 48cm

Table (2). Profile locations and physiographic properties of cultivated soil area

Profile No.	Site Coordination		Slope Degree	Slope Shape	Slope Direction	Depth (cm)
	N	E				
1	º32.463898	º21.334446	4	convex	East to west	35
2	º32.463800	º21.333350	4	concave	East to west	19
3	º32.460918	º21.335056	3	flat	East to west	52
4	º32.460370	º21.333875	6	concave	East to west	27
5	º32.457622	º21.336155	2	flat	East to west	12
6	º32.457092	º21.334579	6	concave	East to west	24
7	º32.463115	º21.331923	4	flat	East to west	18
8	º32.462400	º21.331763	3.5	flat	North to south	16
9	º32.459668	º21.331933	6	concave	North to south	24
10	º32.457355	º21.332927	5	convex	North to south	9

Table (3). Profile locations and physiographic properties of bare soil area

Profile No.	Site Coordination		Slope Degree	Slope Shape	Slope Direction	Depth (cm)
	N	E				
1	º32.459530	º21.329521	1.5	convex	East to west	38
2	º32.459006	º21.330033	6	concave	East to west	38
3	º32.458337	º21.329342	1	convex	East to west	31
4	º32.458084	º21.327364	6	convex	East to west	26
5	º32.457988	º21.328086	3	convex	North to south	17
6	º32.455002	º21.329101	1	concave	North to south	29
7	º32.455200	º21329948	1	convex	East to west	21
8	º32.457351	º21.329638	4	convex	East to west	48
9	º32.457397	º21.328429	1.5	concave	North to south	36
10	º32.456740	º21.328365	5	flat	East to west	18

Photo(1). Picture of the bare soil area

Photo (2). Picture of the cultivated soil area

Soil physical properties

The soil physical properties of the cultivated and bare soil areas were illustrated in Tables (4and 5).

For cultivated soil profiles (Table 6), the clay content ranged between 12.83 and 36.49% with an average of 26.91%, the silt content ranged between 15.81 and 39.38% with an average of 28.17%, while the sand content ranged between 33.70 and 57.96% with an average of 44.90%., in addition, soil bulk density ranged from 1.19 to 1.57 g/cm^3 with an average of 1.40 g/cm^3

Table (4). Some physical properties of cultivated soil profiles

Profile No.	Soil layers	Depth (cm)	Physical properties			
			Clay (%)	Silt (%)	Sand (%)	Bulk density (g/cm^3)
1	**Surface**	**15**	**27.12**	**30.20**	**42.55**	**1.48**
	Subsurface	**20**	**12.83**	**39.27**	**47.90**	**1.48**
2	**Surface**	**10**	**33.79**	**26.42**	**39.79**	**1.42**
	Subsurface	**9**	**26.02**	**31.73**	**42.25**	**1.42**
3	**Surface**	**24**	**25.95**	**26.42**	**47.62**	**1.43**
	Subsurface	**28**	**19.27**	**25.19**	**55.35**	**1.43**
4	**Surface**	**15**	**20.79**	**29.11**	**50.10**	**1.25**
	Subsurface	**12**	**12.93**	**29.11**	**57.96**	**1.25**
5	**Surface**	**12**	**25.82**	**34.08**	**40.10**	**1.57**
6	**Surface**	**17**	**30.85**	**15.81**	**53.33**	**1.49**
	Subsurface	**7**	**36.30**	**15.94**	**47.76**	**1.49**
7	**Surface**	**10**	**31.34**	**29.19**	**39.48**	**1.36**
	Subsurface	**8**	**36.49**	**21.26**	**42.25**	**1.36**
8	**Surface**	**8**	**25.68**	**28.73**	**45.58**	**1.42**
	Subsurface	**8**	**28.79**	**31.89**	**39.32**	**1.42**
9	**Surface**	**11**	**24.01**	**39.38**	**36.61**	**1.36**
	Subsurface	**13**	**34.56**	**18.96**	**46.48**	**1.36**
10	**Surface**	**9**	**31.89**	**34.42**	**33.70**	**1.19**
Min		**7**	**12.83**	**15.81**	**33.70**	**1.19**
Max		**28**	**36.49**	**39.38**	**57.96**	**1.57**
Average		**18**	**26.91**	**28.17**	**44.90**	**1.40**

For the bare soil profiles (Table 5), the clay content ranged between 10.13 and 33.61% with an average of 25.43%, the silt content ranged between 15.85 and 46.58% with an average of 28.19%, while the sand content ranged between 38.67 and 58.39% with an average of 46.07% and the soil bulk density was ranged from 1.31 to 1.57 g/cm^3 with an average of 1.45 g/cm^3. The relative decrease in bulk density in the cultivated soils could suggest the positive effect of plowing and contour farming on the semi-arid slopes south of Al-Jabal Alkhdar, while several studies on the Libyan Red Mediterranean soils showed the negative impact of overgrazing and unsustainable land uses on the physical soil properties and particularly bulk density (Aburas, 2015).

Table (5). Some physical properties of bare soil profiles

Profile No.	Soil layers	Depth (cm)	Physical properties			
			Clay (%)	Silt (%)	Sand (%)	Bulk density (g/cm^3)
1	Surface	7	25.75	15.85	58.39	1.45
	Subsurface	31	28.98	26.02	45.12	1.45
2	Surface	20	28.12	28.59	43.29	1.41
	Subsurface	18	10.15	38.97	50.88	1.41
3	Surface	19	25.49	23.38	51.13	1.53
	Subsurface	12	10.13	46.58	43.29	1.53
4	Surface	11	20.15	30.76	49.09	1.43
	Subsurface	15	16.27	35.00	46.31	1.43
5	Surface	10	30.54	25.88	43.58	1.57
	Subsurface	7	25.82	31.48	42.70	1.57
6	Surface	17	30.46	25.82	43.72	1.43
	Subsurface	12	25.75	28.81	45.44	1.43
7	Surface	17	28.34	26.22	45.44	1.46
	Subsurface	4	33.35	23.51	43.14	1.46
8	Surface	20	25.89	23.75	50.36	1.31
	Subsurface	28	23.74	24.44	49.06	1.31
9	Surface	11	30.77	23.51	45.72	1.45
	Subsurface	25	29.73	30.47	38.67	1.45
10	Surface	10	25.49	31.08	43.44	1.44
	Subsurface	8	33.61	23.69	42.70	1.44
Min		4	10.13	15.85	38.67	1.31
Max		31	33.61	46.58	58.39	1.57
Average		18	25.43	28.19	46.07	1.45

Soil chemical properties

Soil chemical properties of cultivated and bare soil areas were illustrated in Tables (6 and 7).

For cultivated soil profiles (Table 6), the electrical conductivity of soil paste extracts ranged between 0.51 and 2.50 dS/m with an average of 1.34 dS/m, the values of soil pH was ranged between 7.8 and 8.6 with an average of 8.11, while organic matter content (OM) ranged between 0.29 and 2.75% with an average of 1.25% and soil calcium carbonates were ranged between 11.28 to 37.0% with an average of 24.24%.

Table (6). Soil chemical properties of cultivated soil profiles

Profile No.	Soil layers	Depth (cm)	Chemical properties			
			EC (dS/m)	pH	OM (%)	$CaCO_3$ (%)
1	Surface	15	1.33	8.20	2.01	17.07
	Subsurface	20	1.29	8.00	1.77	28.00
2	Surface	10	1.25	8.00	1.38	25.00
	Subsurface	9	0.85	8.20	0.88	26.00
3	Surface	24	0.80	8.00	1.77	25.00
	Subsurface	28	0.99	7.80	0.79	11.28
4	Surface	15	1.26	8.10	1.47	22.00
	Subsurface	12	1.90	8.60	1.38	24.00
5	Surface	12	0.51	8.00	2.75	20.00
6	Surface	17	0.76	8.00	1.77	21.00
	Subsurface	7	1.36	8.10	1.47	20.00
7	Surface	10	0.86	8.20	1.38	23.00
	Subsurface	8	0.91	8.00	0.88	23.00
8	Surface	8	2.06	8.20	0.69	33.00
	Subsurface	8	2.50	8.10	0.79	28.00
9	Surface	11	1.71	8.20	0.29	37.00
	Subsurface	13	1.90	8.20	0.39	32.00
10	Surface	9	1.92	8.10	0.69	21.00
Min.		7	0.51	7.80	0.29	11.28
Max.		28	2.50	8.60	2.75	37.00
Average		18	1.34	8.11	1.25	24.24

For bare soil profiles (Table 7), the electrical conductivity of soil paste extract ranged between 0.60 and 6.75 dS/m with an average of 1.67 dS/m, soil pH values were ranged between 7.8 and 8.8 with an average of 8.28, soil content of organic matter (OM) was ranged between 0.10 and 2.06% with an average of 0.83%, and soil calcium carbonates were ranged from 15.0 to 48.0% with an average of 32.39%. Soils under cultivation showed a relative decrease in soil PH which could indicate the positive effect of plant roots and organic material additions to the soils.

Table (7). Soil chemical properties of bare soil profiles

Profile No.	Soil layers	Depth (cm)	chemical properties			
			EC (dS/m)	pH	OM (%)	$CaCO_3$ (%)
1	Surface	7	2.24	8.7	1.38	38.00
	Subsurface	31	1.57	8.8	1.62	45.93
2	Surface	20	1.09	8.3	0.39	35.00
	Subsurface	18	0.90	8.8	0.20	48.00
3	Surface	19	0.94	8.7	0.59	45.00
	Subsurface	12	0.60	8.4	0.10	38.00
4	Surface	11	2.00	8.2	0.98	31.00
	Subsurface	15	1.38	8.1	0.54	27.01
5	Surface	10	1.04	8.4	0.20	36.00
	Subsurface	7	0.84	8.4	0.59	36.00
6	Surface	17	0.88	8.8	2.06	48.00
	Subsurface	12	1.36	8.3	1.87	31.00
7	Surface	17	1.65	8.1	0.39	34.00
	Subsurface	4	1.64	8.2	0.98	35.00
8	Surface	20	4.29	7.8	0.98	20.00
	Subsurface	28	6.75	8.1	0.69	29.30
9	Surface	11	0.85	8.0	0.79	20.00
	Subsurface	25	1.10	7.9	0.59	18.63
10	Surface	10	1.38	7.8	0.88	15.00
	Subsurface	8	0.82	7.8	0.79	17.00
Min.		4	0.60	7.80	0.10	15.00
Max.		31	6.75	8.80	2.06	48.00
Average		18	1.67	8.28	0.83	32.39

Cultivated soil has a higher value of OM than bare soil due to land management by the cultivation of plowed lines with broad-leaved forest trees (*eucalyptus tereticornis*) and (*Pinus halepensis*). The decomposition of dead leaves enriched the soil with organic matter. Contour plowing resulted in a decrease in calcium carbonates.

Soil fertility status

The soil fertility status of cultivated and bare soil areas was illustrated in Tables (8 and 9).

For the cultivated soil profiles (Table 8), the available soil nitrogen content (N) ranged from 4.80 to 16.28 mg/kg with an average of 9.02 mg/kg, while the available phosphorus content ranged between 2.09 and 10.87 mg/kg with an average of 5.78 mg/kg, and the available potassium content (K) ranged from 350 to 800 mg/kg with an average of 529.50 mg/kg. The CEC for the soils under cultivation were ranged between 8.6 and 31.50 meq/100 g soil with an average of 15.02 meq/100 g soil.

Table (8).Soil fertility status of cultivated soil profiles

Profile No.	Soil Layers	Thickness (cm)	Fertility status			
			CEC (meq/100g soil)	N (mg/kg)	P (mg/kg)	K (mg/kg)
1	Surface	15	29.12	10.01	6.51	483.96
	Subsurface	20	11.80	8.89	6.20	350.00
2	Surface	10	12.20	16.28	2.09	550.00
	Subsurface	9	11.20	9.37	3.21	750.00
3	Surface	24	13.80	7.70	5.67	550.00
	Subsurface	28	31.50	9.41	10.87	496.74
4	Surface	15	13.00	8.67	9.42	500.00
	Subsurface	12	12.60	9.90	6.25	400.00
5	Surface	12	19.20	8.89	7.17	350.00
6	Surface	17	15.00	9.90	3.38	500.00
	Subsurface	7	14.60	9.46	7.67	650.00
7	Surface	10	14.20	9.59	4.90	800.00
	Subsurface	8	13.80	8.32	5.30	400.00
8	Surface	8	13.60	8.62	6.38	500.00
	Subsurface	8	13.80	8.23	5.38	700.00
9	Surface	11	8.60	8.93	4.20	450.00
	Subsurface	13	10.20	4.80	5.75	600.00
10	Surface	9	12.20	5.30	3.63	500.00
Min		8	8.60	4.80	2.09	350.00
Max		28	31.50	16.28	10.87	800.00
Average		18	15.02	9.02	5.78	529.48

For the bare soil profiles (Table 9), the available soil nitrogen content (N) ranged from 6.73 to 14.74 mg/kg with an average of 8.96 mg/kg, while the available phosphorus content ranged between 1.08 and 13.13 mg/kg with an average of 7.43 mg/kg, and the available potassium content (K) ranged from 150 to 950 mg/kg with an average of 417.82 mg/kg. The CEC for bare soils were ranged between 5.29 and 16.46 meq/100 g soil with an average of 8.89 meq/100 g soil.

Table (9). Soil fertility status of bare soil profiles

Profile. No	Soil layers	Thickness (cm)	CEC (meq/100g soil)	N(mg/kg)	P(mg/kg)	K(mg/kg)
1	Surface	7	16.46	14.74	2.13	150.00
	Subsurface	31	12.08	7.95	1.21	325.86
2	Surface	20	9.02	9.02	1.08	950.00
	Subsurface	18	8.23	8.71	9.50	350.00
3	Surface	19	8.82	7.39	4.83	350.00
	Subsurface	12	5.29	7.70	4.80	550.00
4	Surface	11	7.25	12.36	9.80	400.00
	Subsurface	15	7.15	11.04	7.16	779.71
5	Surface	10	6.66	9.81	6.75	400.00
	Subsurface	7	6.47	8.98	12.00	350.00
6	Surface	17	14.90	8.89	10.13	350.00
	Subsurface	12	13.92	8.36	3.13	300.00
7	Surface	17	6.66	8.27	1.75	450.00
	Subsurface	4	8.04	6.73	10.00	350.00
8	Surface	20	7.45	8.05	8.00	300.00
	Subsurface	28	7.34	8.38	10.99	251.84
9	Surface	11	7.25	7.70	8.13	450.00
	Subsurface	25	6.17	8.18	12.12	348.97
10	Surface	10	9.21	8.32	11.88	600.00
	Subsurface	8	9.41	8.71	13.13	350.00
Min		4	5.29	6.73	1.08	150.00
Max		31	16.46	14.74	13.13	950.00
Average		18	8.89	8.96	7.43	417.82

Both cultivated and bare soil profiles have poor N and P contents, the low N and P content of cultivated soils could be due to the more extraction that might take place by the trees cultivated in. Both soils have a high level of available K, which may be due to the soil composition. The management practices that have been applied on the cultivated soils, and the effect of decomposition of dead leaves from trees could have contributed to the relative increase of some nutrients in the soil. Under cultivation, the significant improvement in the CEC parameter in those semi-arid slopes could confirm the positive consequences of applying suitable and sustainable land practices.

The multiple linear regression between soil fertility status (N, P, and K) and some chemical properties (ECe, OM, $CaCO_3$, and CE) is illustrated in Table (11).The equation in the form of:

$$Y=a_1\times ECe + a_2\times OM + a_3\times CaCO_3 + a_4\times CEC$$

Where:

Y is the required property (N, P, and K)

a1, a2, a3, and a4 are the regression parameters

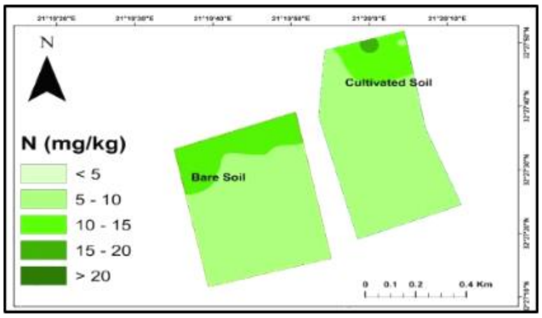
Table (10). Multiple linear regression between soil fertility status and some chemical properties

Parameters	Bare soil			Cultivated soil		
	N	**P**	**K**	**N**	**P**	**K**
ECe	0.614	1.070	8.901	0.739	0.739	7.425
OM	-3.595	-0.328	-280.449	0.348	0.348	-3.492
$CaCO_3$	0.052	0.073	5.342	0.026	0.026	14.321
CEC	1.006	0.314	48.351	0.245	0.245	11.300
F value	74.28**	8.44**	14.18**	57.76**	41.03**	48.74**
R^2	0.9489	0.6785	0.7799	0.9429	0.9214	0.9330

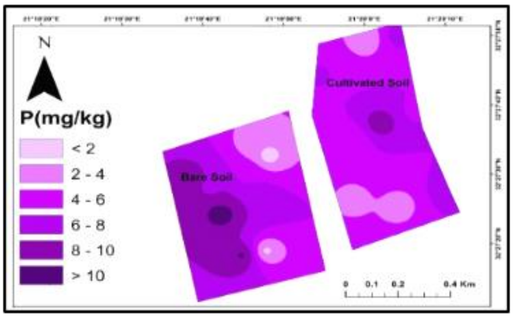
The soil content of N, P, and K showed a highly significant correlation with ECe, OM, $CaCO_3$, and CEC parameters, which means that soil fertility status is highly dependent on chemical properties with R^2 ranging from 0.6785 to 0.9489.

GIS map of soil characters

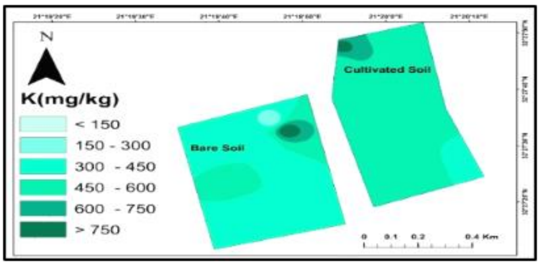
The GIS maps of soil fertility parameters and some related chemical characters are illustrated in Maps (3 – 9).



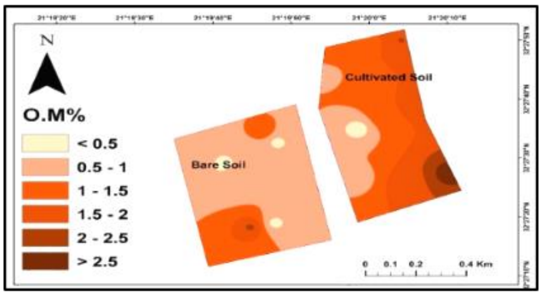
Map (3). The distribution of available N in the cultivated and bare soils of the study area



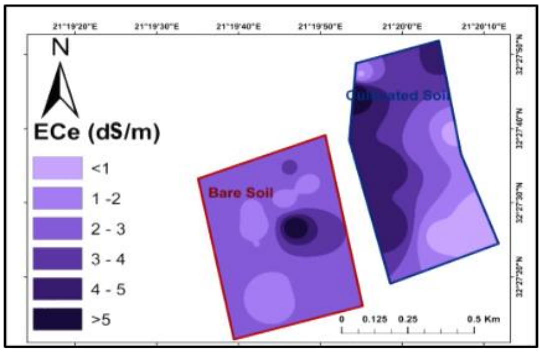
Map (4). The distribution of available P in the cultivated and bare soils of the study area



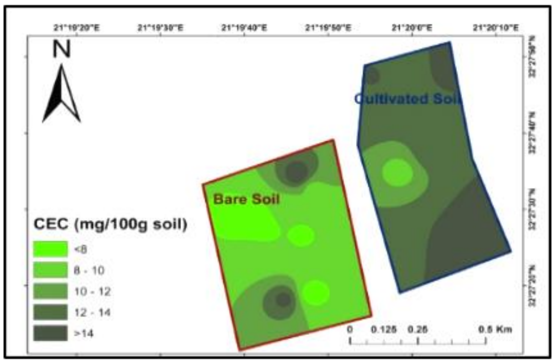
Map (5). The distribution of available K in the cultivated and bare soils of the study area



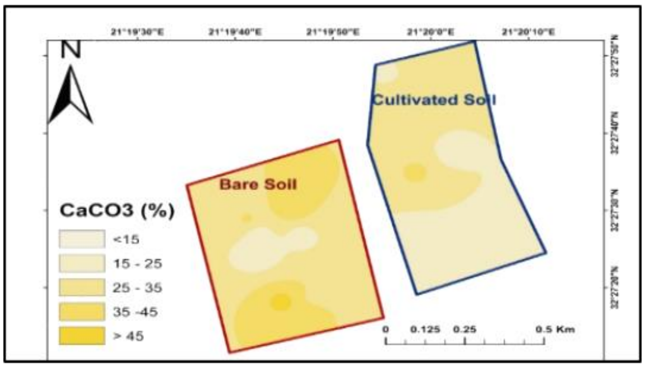
Map (6). The distribution of OM in the cultivated and bare soils of the study area



Map (7). The distribution of ECe in the cultivated and bare soils of the study area



Map (8). The distribution of CEC in the cultivated and bare soils of the study area.



Map (9). The distribution of $CaCO_3$ in the cultivated and bare soils of the study area

The area distribution of each soil character **is** illustrated in Tables (11 to 14) for bare and cultivated areas.

Both bare and cultivated soil profiles have a low content of available N, P, and K content. For bare soil, 83.89% of the total area has 4 to 12 mg/kg available N content, but for cultivated soil, 73.11% of the total area has 4 to 8 mg/kg available N content. The available K content has adequate values ranging between 350- 550 mg/kg representing 79.83 and 79.17% of the total area for bare and cultivated soil, respectively. The available P content represents 73.20 and 94.17% of the total area in the range of 2 to 8 mg/kg for bare and cultivated soil, respectively.

Table (11). Area distribution of soil fertility for the bare soil

N			P			K		
Scale mg/kg	**Area ha**	**%**	**Scale mg/kg**	**Area ha**	**%**	**Scale mg/kg**	**Area ha**	**%**
< 4	0.07	0.24	< 2	4.65	16.03	< 350	1.20	4.14
4 – 8	13.21	45.55	2 - 4	6.10	21.03	350 - 450	9.93	34.24
8 – 12	11.12	38.34	4 - 6	5.62	19.38	450 - 550	13.22	45.59
12 - 14	3.93	13.55	6 - 8	9.51	32.79	550 - 650	2.89	9.97
>14	0.67	2.31	> 8	3.12	10.76	650 - 750	1.26	4.34
						>750	0.50	1.72

Table (12). Area distribution of soil fertility for the cultivated soil

N			P			K		
Scale mg/kg	**Area ha**	**%**	**Scale mg/kg**	**Area ha**	**%**	**Scale mg/kg**	**Area ha**	**%**
< 4	2.33	8.03	< 2	0.93	3.21	< 350	1.85	6.38
4 – 8	13.11	45.21	2 - 4	11.23	38.72	350 - 450	15.98	55.10
8 – 12	8.09	27.90	4 - 6	13.28	45.79	450 - 550	6.98	24.07
12 - 14	3.56	12.28	6 - 8	2.80	9.66	550 - 650	2.94	10.14
>14	1.91	6.59	> 8	0.76	2.62	650 - 750	0.71	2.45
						>750	0.54	1.86

The organic matter content represents 69.8% in the range of 0.5 to 1.5 % OM content for bare soil, but for cultivated soil, it represents 80.62% in the range of 0.5 to 2.5 % OM. The total soluble salts (ECe) has a high value of about 70% of the total area in the range of 2 to 3 dS/m for bare soil, but it distributed overall the area in the range of 1 to 5 dS/m for cultivated soil. The management of bare soil by cultivation decreased the ECe in all cultivated areas. The cation exchange capacity (CEC) represents 85% of the bare soil in the range of 8 to 10 meq/100g soil for bare soil, but it represents 96.87% of the cultivated soil in the range of 10 to 14 meq/100g soil. The $CaCO_3$ content in the range of 30 to 40% represents about 71% of bare soil, but it represents about 17.72% of cultivated soil. The distribution of soil characters indicated that the bare soil improved through the cultivation and the soil become more suitable for use.

Table (13). Area distribution of some chemical characters for the bare soil

OM			ECe			CEC			$CaCO_3$		
Scale (%)	Area (ha)	(%)	Scale (dS/m)	Area (ha)	(%)	Scale (meq/100 g)	Area (ha)	(%)	Scale (%)	Area (ha)	(%)
<0.5	4.93	17.00	< 1	0.005	0.02	6 – 8	0.0004	0.00	<20	0.43	1.48
0.5 - 1	15.94	54.97	1 – 2	4.94	17.03	8 – 10	14.88	51.31	20 - 30	6.52	22.48
1 – 1.5	4.30	14.83	2 – 3	20.24	69.79	10 – 12	11.51	39.69	30 - 40	20.46	70.55
1.5 – 2.5	2.85	9.83	3 – 4	2.62	9.03	12 – 14	2.38	8.21	>40	1.59	5.48
>2.5	0.98	3.38	4 – 5	0.68	2.34	>14	0.22	0.76			
			>5	0.51	1.76						

Table (14). Area distribution of some chemical characters for the cultivated soil

OM			ECe			CEC			$CaCO_3$		
Scale (%)	Area (ha)	(%)	Scale (dS/m)	Area (ha)	%	Scale (meq/100 g)	Area (ha)	(%)	Scale (%)	Area (ha)	(%)
<0.5	3.96	13.66	< 1	4.01	13.83	6 - 8	0.0004	0.00	<20	0.00	0.00
0.5 - 1	6.61	22.79	1 - 2	4.35	15.00	8 - 10	0.81	2.79	20 - 30	23.70	81.72
1 – 1.5	10.40	35.86	2 – 3	5.46	18.83	10 - 12	3.15	10.86	30 - 40	4.94	17.03
1.5 – 2.5	6.37	21.97	3 - 4	6.97	24.03	12 - 14	17.20	59.31	>40	0.35	1.21
>2.5	1.66	5.72	4 - 5	7.6	26.21	>14	7.83	27.00			
			>5	0.58	2.00						

Table (15). Comparison between cultivated and bare soil for all studied soil properties

Soil properties	Cultivated Soil	Bare soil
Profile Thickness (cm)	23.60	30.20
Slop degree	4.35	3.00
Clay (%)	26.91	25.43
Silt (%)	28.17	28.19
Sand (%)	44.90	46.07
Soil bulk density (g/cm^3)	1.40	1.45
ECe (dS/m)	1.34	1.67
pH	8.11	8.28
O.M (%)	1.25	0.83
CEC (meq/100g soil)	15.02	8.89
$CaCO_3$ (%)	24.24	32.39
Available N (mg/kg)	9.02	8.96
Available P (mg/kg)	5.78	7.43
Available K (mg/kg)	529.48	417.82

According to the present study, it is obvious that changes in land-use patterns and natural vegetation clearance can lead to higher soil degradation. Investigating soil properties showed how soil degradation was accelerated by land use impact. Inappropriate land uses practices and management have contributed to soil degradation especially with the shallow soils, and irreversible soil degradation and loss of productivity can take place if these shallow soils have been subjected to severe erosion. Shallowness in red Mediterranean soils contributes to their low productivity (Liniger *et al*., 2011). Due to the destruction of the natural vegetation and low resistance to soil erosion, these soils are more likely to be subjected to desertification (Yassoglou *et al*, 1997). Variations in erosion-driven soil degradation between land use observed in the field were partly explained by soil properties. Soil properties and land use are interdependent. Indeed arguably land use is more important in affecting the soil properties that largely control erodibility and degradation than are differences in the intrinsic properties of major soil types (Stocking, 2003). The results indicate soil degradation driven by soil erosion as a result of the introduction of intensive land use, which highlights the potential hazards if no measures of soil conservation are taken.

Considering the output of the present research, it can put forward the following recommendations to be used to strengthen land management practice and to relieve the negative impact of land degradation and soil fertility deterioration, so that the sustainability of land management in the present study area can be guaranteed:

- The farmers should develop their agricultural technologies, which would increase soil organic matter to renew the lost plant nutrients and to manage their land fertility,
- The farmers also need to apply adequate quantities of organic manure to increase the soil nutrients content needed by the plant, microbial activity reinforcement, and soil physicochemical characteristics improvement.
- Sustainable land management practices are necessary, especially terraces and trenches, and to select improved seeds and species for agroforestry that can generate more organic material for such semi-arid poor soils.
- The farmers should use both organic and chemical fertilizers efficiently to increase the soil productivity of their land.
- Soil waste management must be considered to prevent toxic elements from polluting soils and damaging their fertility status. The acidic tolerant plants should be adopted to be grown in that area if there is no other possibility to improve soil basicity such as lime application,
- The government, agricultural institutions, and other institutions involved in land management activities should invest more in research to enable farmers to adopt adequate soil fertility management practices and soil quality improvement in general.

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الملخص العربي

إدارة الأراضي وأثرها على حالة الخصوبة في جنوب الجبل الأخضر، ليبيا

محمد صالح عيسى يوسف[1] – جمال عبد الناصر خليل[1] – عادل حسين احمد[1] – مراد ميلاد ابوراس[2] – هدى عبد الفتاح محمود[1]

[1]قسم الأراضي والكيمياء الزراعية – كلية الزراعة سابا باشا – جامعة الاسكندرية

[2]قسم التربة والمياه – كلية الزراعة – جامعة عمر المختار – ليبيا

تمثل الإدارة المستدامة للأراضي تحديًا كبيرًا لمستخدمي الأراضي وأصحاب المصلحة الآخرين في جميع أنحاء العالم. يمكن أن يؤدي اضطراب النظم الإيكولوجية للأراضي الجافة بسرعة إلى تدهور شديد للأراضي وبالتالي إلى التصحر. قيمت هذه الدراسة طرق إدارة المنحدرات شبه االجافة في جنوب الجبل الأخضر وتأثيراتها بقياس بعض المؤشرات الميدانية والمعملية وحالة خصوبة التربة وبعض الخواص الفيزيائية والكيميائية للمنحدرات غير المزروعة. والمناطق المزروعة. أشارت النتائج إلى وجود فروق نسبية في بعض المعايير المتعلقة بجودة التربة عند مقارنة الأراضي المزروعة والأراضي غير المزروعة. تم تسجيل قيم CEC أعلى ، بالإضافة إلى زيادة معنوية في محتوى التربة من المواد العضوية والنيتروجين الكلي داخل الأراضي المزروعة مقارنة بالأراضي غير المزروعة. أوضحت الدراسة أن ممارسات إدارة الأراضي المطبقة قد حسنت بعض خصائص التربة التي ترتبط مباشرة بوظيفة الإنتاج وجودته ، ونتيجة لذلك توفر المزيد من المساحات الخصبة والإنتاجية ضمن هذه الأراضي المزروعة شبه الجافة. بالنظر إلى ناتج الدراسة الحالي ، يمكن أن تقدم بعض التوصيات لاستخدامها في تعزيز ممارسة الإدارة المستدامة للأراضي والتخفيف من الأثر السلبي لتدهور الأراضي وتدهور خصوبة التربة. ويمكن أن تشمل هذه التوصيات تكييف التكنولوجيا الزراعية الحديثة ، وتطبيق ممارسات إدارة الأراضي المستدامة ، والاستخدام الفعال للأسمدة العضوية والكيميائية. بالإضافة إلى ذلك ، سيكون من المناسب إجراء المزيد من االدراسات حول ممارسات إدارة خصوبة التربة لنجاح خطط الحفاظ على التربة في المستقبل داخل هذه المناطق الضعيفة.