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Suitability of Specific Crops Using Micro LEIS Program in Sahal Baraka, Farafra Oasis, Egypt

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Abstract: One of the promising areas for the horizontal expansion in Egypt is Farafra oasis in the New-Valley Governorate. The current study deals with agricultural soil suitability evaluation of this oasis. Therefore, their crops suitability calculated on the basis of the proposed computer program "MicroLEIS" and presented as planning agricultural soil suitability maps. Twenty eight soil profiles have been selected to represent the variation in the soils of the studied area. According to the morphological description, climatic conditions, physical & chemical properties and USDA Soil Taxonomy, the soil can be classified as the following: *Typic Calcigypsids*, *Calcic Aquisalids, Gypsic* and *Calcic Aquisalida*, *Typic Torripsaments* and *Typic Quartzipsamments.* The obtained results reveal that the evaluated crops could be determined and arranged according to their soil suitability classes as follows: olives < peach < sunflower, melon and corn. This arrangement reflects the priority for agricultural utilization. Following a semiquantitative procedure and according to the generalization level set up for each soil diagnostic criteria, the area under investigation has been divided into five relative suitability classes. In this research, the main recognized soil factor limitations were soil texture, drainage condition and sodium saturation.

Keywords: Agricultural soil suitability, Farafra oasis, MicroLEIS program.

INTRODUCTION

In this study, the MicroLEIS program was used as a Decision Support System (DSS) to stand on the main factor(s) that affecting the soil suitability and productivity. Consequently, the modified computer program was developed to calculate indices of agricultural soil evaluation system. It is based on crop suitability affected by potentiality of the environment (i.e. the dominant soil characteristics).

Land evaluation is a tool for strategic land use planning. There are many models for simulation and many computer packages for application of land evaluation in land-use planning[7,9]. Since the early 1990s and following this trend, MicroLEIS (Mediterranean Land Evaluation Information System) has evolved towards an agro-ecological decision support system (DSS). Today, MicroLEIS is a set of useful tools for decision-making which in a wide range of agro-ecological schemes. The MicroLEIS system was developed to assist specific types of decision makers faced with specific agro-ecological problems. Yehia[14] used the MicroLEIS software to evaluate the soil of Banagr EL-Sokkar area (Egypt). He found that the dominant capability subclasses are S2I, S2TI and S3I with soil properties and topographic conditions as main limiting factors. Bahnassy *et al.*[2] applied land suitability using MicroLEIS program in integration with SALTMOD to predict the effect of water table and salinity on the productivity of wheat in sugar beet area, West Nubaria, Egypt. They found that the productivity of wheat crop will decrease due to increasing salinity and water table depth, as a result of mismanagement practices. On the other hand, Hamed[8] in his study on Libyan soils around Benghazi city using MicroLEIS software, found that the soils under investigation were belong to capability classes S2 and S3, with erosion risk and soil factor as the limiting conditions.

In this research, a simple map subsystem (ArcView GIS) was used and being all that is required to show basic data and model results on a map. It helps to extract information from the evaluation models (MicroLEIS) to be used and displayed as thematic geo-referenced maps. Fig. 1 shows the general scheme and the methodology followed of the ArcView procedure analysis, where the evaluation results are estimated by grid cell and aggregated to regional level[4].

A land evaluation can be made with the FAO Framework automatically with the useful computer program ALES[11,12], which enable an easy construction of an expert system for land evaluation. This is not an expert system in itself, as it provides no information, but rather is an empty system that enables evaluators to introduce their own evaluation characteristics [choose their own Land Utilization Type (LUTs), Land Qualities (LQs) and Land Characteristics (LCs)], according to

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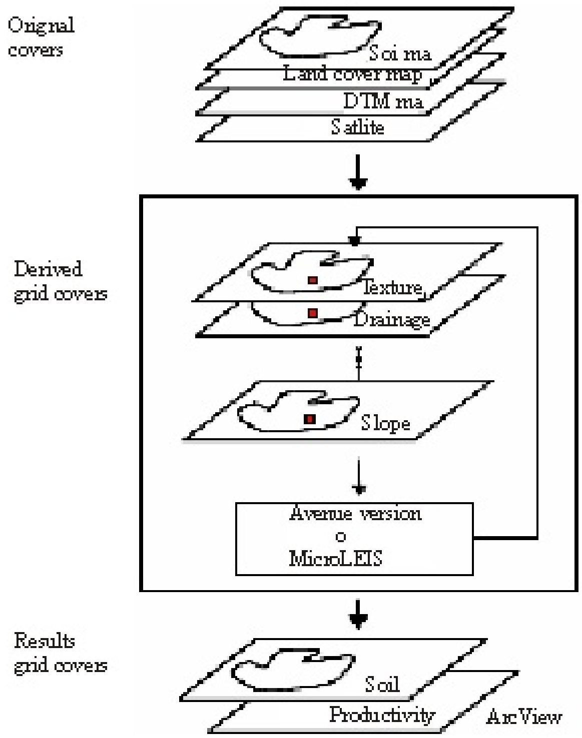


Fig1: General scheme of the process followed to integrate MicroLEIS DSS with GIS system.

their own knowledge and data availability. The MicroLEIS of De la Rosa *et al.*[6] is a complete computer program to evaluate according to the FAO Framework adapted to the Mediterranean environment. The main aim of this work is to evaluate the soils of Sahl Baraka area, Farafra oasis for agriculture development by using MicroLEIS program (ALMAGRA model) and presented as agricultural soil suitability maps.

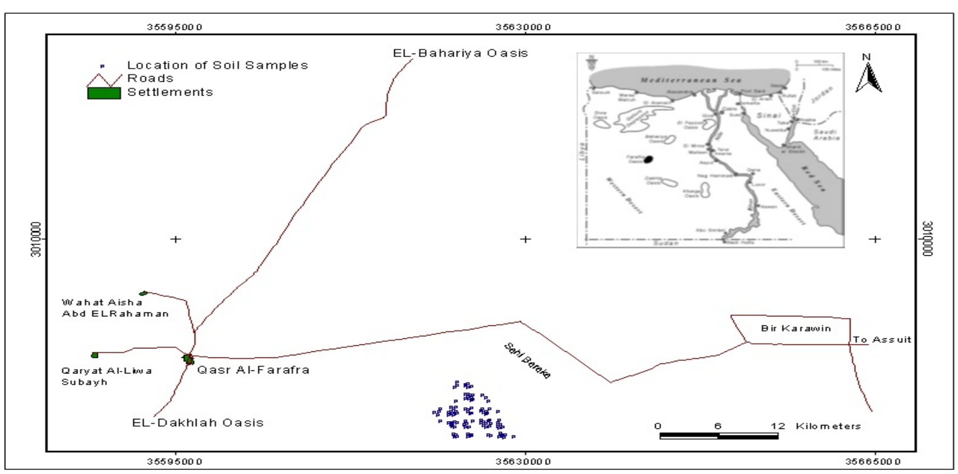
MATERIALS AND METHODS

Farafra oasis covers about 4.5 million feddan (fedden ≈ 4200 m^2); only 876,442 fed are considered suitable area for agriculture activities[1]. The investigated area is called "Sahl Baraka" and it is located to the south-west of Bir Karawin in Farafra oasis, New-Valley Governorate, with total area about 10000 fed. with coordinates 27° 01 40" N and 28° 15 32" E, which lies 35 km east of Farafra city, along the well constructed (Farafra-Asyut) main road, (Map 1).

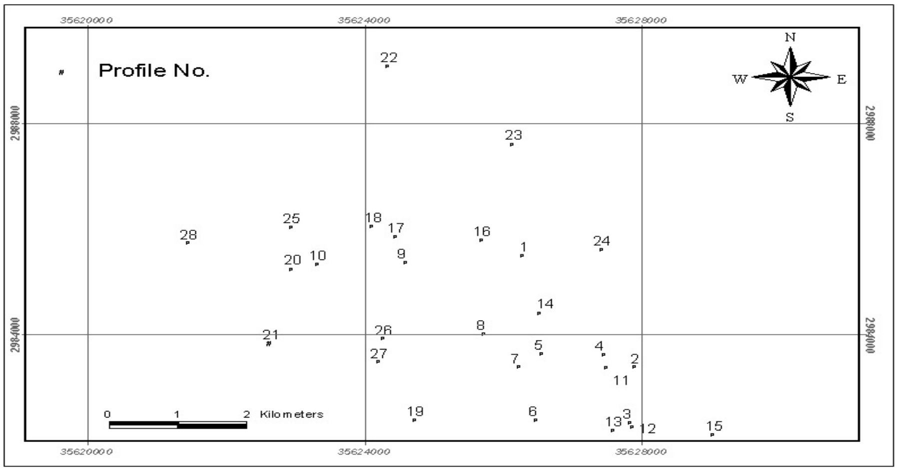
The field work was carried out starting with a general reconnaissance survey through the whole study area to be familiar with the different aspects available of the area, i.e., geomorphology, lithology, different land forms, soils, land use, vegetation cover and accessibility. Based on the pre-field interpretation and the information obtained during the reconnaissance field survey, the sample area was chosen. Twenty eight profiles have been selected (out of 100 profiles that have been examined in the field) to represent the variation in the soils of the study area. The exact locations of the soil profiles and auger observation points were defined in the field by using the GPS utility and plotted preciously on Map. 2.

Detailed morphological description were recorded for each of the studied soil profile by[10], and classified according to USDA Soil Taxonomy[13]. The number of observations was determined mainly by the inherent variability of the mapping units in the area under investigation.

The MicroLEIS software is an automatized application of this soil suitability method, which matches soil characteristics of the soil-units with growth requirements of each particular crop; and results in the crop growth limitations being provided by the computer. Following a semi-quantitative procedure and according to the generalization level set up for each soil diagnostic



Map 1: Location of the studied area in Sahal Baraka, Farafra oasis, New-Valley.



Map 2: Location of the selected soil profiles in the studied area.

criteria, five relative suitability classes are determined: Class S1 Optimum, Class S2 High, Class S3 Moderate, Class S4 Marginal and Class N Nile. The Subclasses are indicated by the letters corresponding to the maximum limiting soil factors.

In this study, five traditional crops are considered as follow: corn (M), melon (Me) and sunflower (G) as annual crops as well as peach (Mc) as fruits and olive (O) as perennials. The selected crops were evaluated according to the available soil conditions of the study area. Depending on the gradations considered for each of the criteria selected (gradation matrices) and on the different agricultural uses, five suitability classes are established. Following the criterion of maximum limitation, each factor has a definite action, and the verification of the degree of a single variable is sufficient to classify the soil in the corresponding category[3].

The modeling phase involves the following main stages:

- selection of land attributes: land characteristics and associated land qualities;
- defining of relevant land use requirements or limitations: land use response or degradation level;
- matching of land attributes with land use requirements; and
- validation of the developed algorithms in other representative areas.

RESULTS AND DISCUSSIONS

The results of the suggested computer program "MicroLEIS" for agricultural soil suitability evaluation were obtained as data outputs presented in Tables (1 & 2). These results including land suitability indices (S_1) of each selected crop and their suitability classes i.e. for the highest value of (S_1). The results show the agricultural soil suitability subclasses at five suitability classes namely; 1, 2, 3, 4 and 5 of each soil profile for each crop type. Suitability subclasses show type(s) of limitation by subclass suffixes codes. The land characteristics for the suitability classes are shown in Table 1.

The agricultural soil suitability results of [Corn (M), melon (Me) and sunflower (G)] are shown in Table 2. By using the MicroLISE microcomputer evaluation program, all the examined 28 soil profiles were evaluated for their agricultural soil suitability. Obviously, the obtained results below indicate that the overall soil suitability of the soil profiles does not have much significant difference between each other.

Out of the twenty eight soil investigated points; only one site is highly suitable (S_2), four sites are moderately suitable (S_3), one soil site is completely not suitable (S_5), while the rest show low suitability (S_4) for the three provided crops. The suitability classes are based on maximum limitations factors that cannot be corrected.

Soil profile P21, which belongs to *Typic Calcigypsids* presents high suitability (S_2) for sunflower. However, it expresses moderated suitability (S_3) for corn and melon as land use types.

On the other hand, soil unit P_{22} indicates moderate suitability for the three mentioned evaluated crops. The majority of this soil subgroup shows dominate low suitability (S_4), except for soil unit P_{22} that have completely no suitability for the suggested land use types. The main limitations are soil texture and sodium saturation.

It is worthy to mention that according to the ALMAGRA model explanation part, the annual crops are considered more appropriate for the fine-textured soils [6]. However, as long as the coarse sand-textured soils are dominant in the study area, the suitability classes are going to be lower. Taken into consideration

Table1: Qualitative land suitability classes for a particular land use.

Suitability classes	Land characteristics			
	Soil depth (cm)	Texture	Salinity (dS/cm)	Slope (%)
S_1 (Very high)	> 120	Loam, silt loam, silt	0 to 2	0 to 3
S_2 (High)	60 to 120	Silt loam to clay	2 to 4	3 to 8
S_3 (Moderate)	30 to 60	Silt loam to sand	4 to 8	8 to 15
S_4 (Low)	15 to 30	Sand	8 to 10	15 to 30
S_5 (Not suitable)	< 15	Clay	> 10	> 30

Table2: Code of soil unit and suitability classes for (M), (Me) and (G) crops.

Soil	ID	Corn	Melon	Sunflower	Soil	ID	Corn	Melon	Sunflower
					Typic Caligypsids	14	S4t	S4t	S4t
Typic Torripsamments	1	S4t	S4t	S4t		15	S4ta	S4t	S4t
	2	S4t	S4t	S4t		16	S4t	S4t	S4t
	3	S4t	S4t	S4t		17	S4t	S4t	S4t
	4	S4t	S4t	S4t		18	S4ta	S4t	S4t
	5	S4t	S4t	S4t		19	S4t	S4t	S4t
	6	S4t	S4t	S4t		20	S3tcsa	S3cs	S3ts
	7	S5a	S5a	S5a		21	S3a	S3s	S2
	8	S4t	S4t	S4t		22	S5t	S5t	S5t
	9	S3t	S3t	S3t		23	S4t	S4t	S4t
	10	5Sa	S4ta	S4ta		24	S4t	S4t	S4t
Typic Quartzipsamments	11	S4t	S4t	S4t	Calic Aqulsalids	25	S5sa	S5sa	S5sa
	12	S4t	S4t	S4t	Gypsic Aquisalids & Cacic Aquisalids	26	S4t	S4t	S4t
	13	S4t	S4t	S4t		27	S5s	S5s	S5s
						28	S3t	S3t	S3t

p=useful depth, t=texture, d=drainage, c=carbonate, s=salinity and a=sodium saturation.

the stoniness percentage, which is considerably higher in some soil units and selected as a condition factor of the soil texture.

On the other side, sodium saturation is referred to the percentage of sodium cation from the total mount of exchangeable cations that can be held by the soil. This factor is analyzed with regard to their influence on the plant growth by direct toxic effects[6]. In regard to the ground truth data obtained, some soil units (e.g. profiles 7, 10 and 25) are considerably affected by sodium percentage which clearly reflected on the suitability classes.

Fig. 2 shows the degree of solubility for the three investigated crops with these groups of soils. When the value is more than 10% the degree of solubility is decreased.

On the other side, soil unit of P_{28}, which is classified as *Gypsic Aquisalids & Calcic Aquisalids* indicates moderate suitability (S3) with soil texture as a main limiting factor for corn, melon and sunflower cultivations. The other two remaining soil units show low to almost not suitable for the three applied annual crops.The soil type of *Typic Torripsamments* expresses low suitability (S4) up to completely not suitable (S5) classes. The dominant unsuitability criteria in this type of soil are refereed to soil texture (t) and sodium saturation (a) as the main soil limiting factors. As a matter of fact, corn is considered the most affected crop to high levels of exchangeable sodium, while the annual crops in general are considered most appropriate for the fine-textured soils.

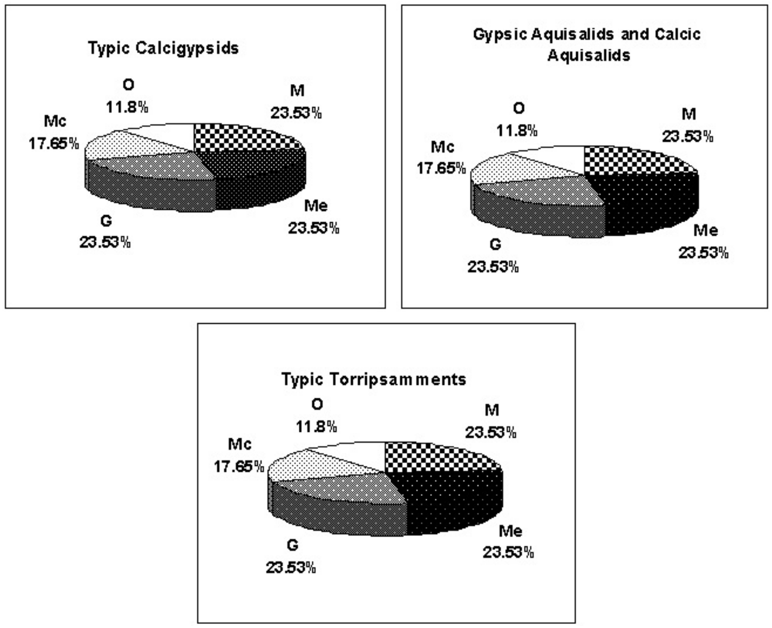


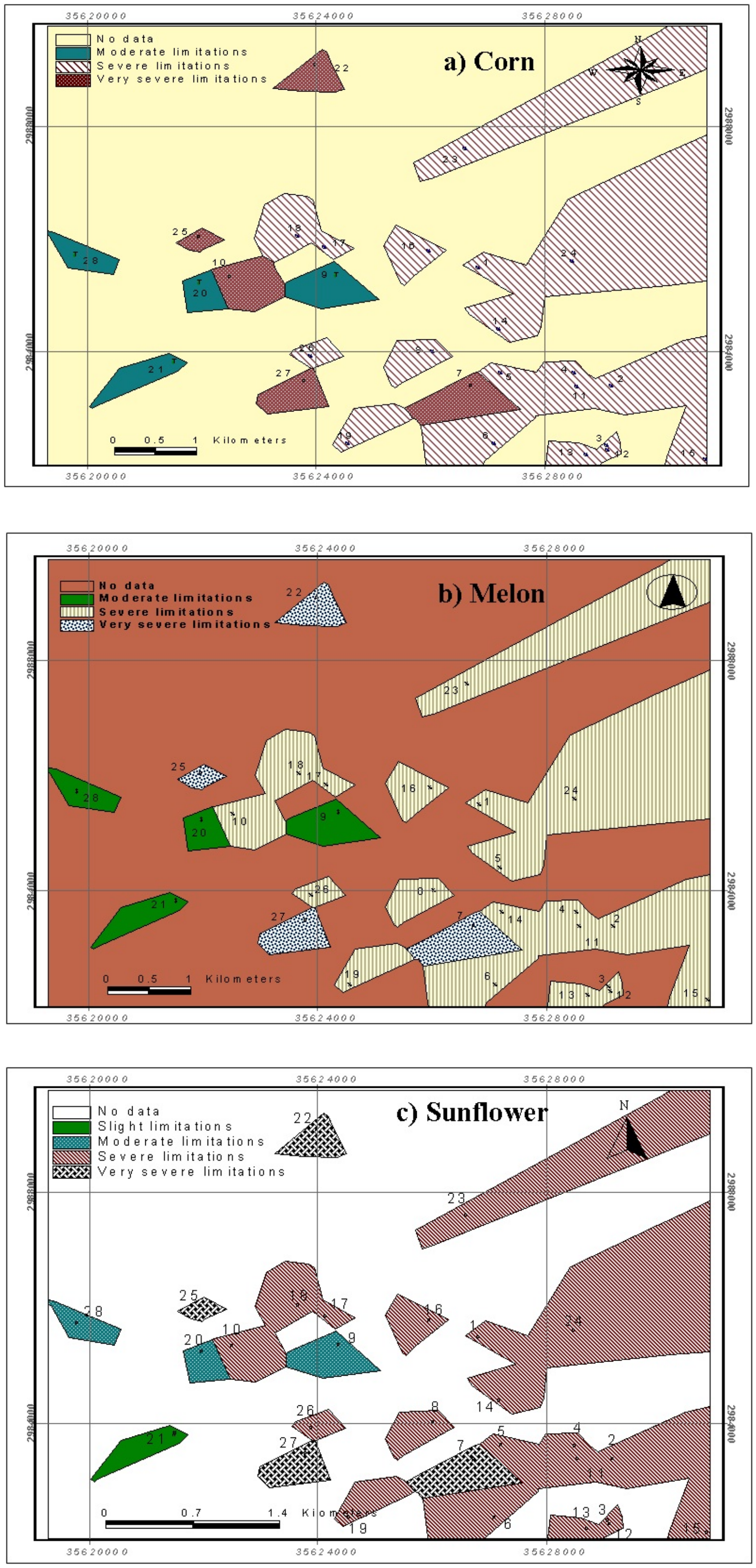
Fig. 2: Soil suitability classes of Typic *Calcigypsids, Gypsic Aquisalids* and *Calcic Aquisalids* and *Typic Torripsamments*.

Table 3: Code of sample and suitability classes of each soil unit for Peach and Olive tress.

Soil	ID	Peach	Olive	Soil	ID	Peach	Olive
				Typic Caligypsids	14	S3t	S2
Topic Torripsamments	1	S3t	S2		15	S3ta	S3a
	2	S3t	S2		16	S3t	S2
	3	S3t	S2		17	S4d	S4d
	4	S3t	S2		18	S3ta	S3a
	5	S3t	S2		19	S3t	S2
	6	S3t	S2		20	S4ds	S4d
	7	S5a	S5a		21	S4td	S4td
	8	S3t	S2		22	S5t	S4td
	9	S2	S2		23	S3t	S2
	10	S4da	S4da		24	S3t	S2
Tupic Quartzipsamments	11	S3t	S2	Calic Aqulsalids	25	S5sa	S5sa
	12	S3t	S2	Gypsic Aquisalids & Cacic Aquisalids	26	S3t	S2
	13	S3t	S2		27	S5s	S5s
					28	S2	S2

p=Useful depth, t=Texture, d=Drainage, c=Carbonate, s=Salinity and a=Sodium saturation

On the other hand, the following Maps (3a, b and c) shows the evaluation results maps in coordinate geo-referenced form. According to the following maps, the model showed a dominant marginal suitability S4. That is may be due to, inappropriate soil texture type and the access of sodium cation in some soil units that eliminate the extension of corn, melon and sunflower annual crop cultivations. Mainly, the marginal suitability units are geographically distributed in the north-east and south-east of the area under investigation,



Map 3: Agricultural soil suitability maps of a) corn, b) melon (Me) and c) sunflower in the selected area.

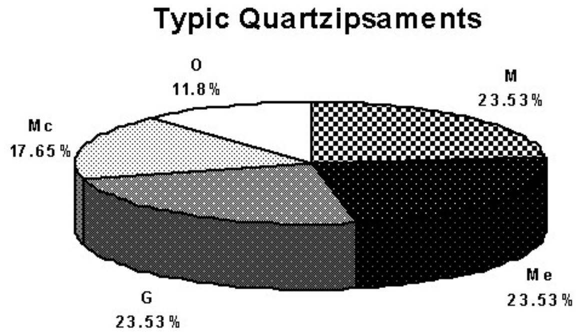
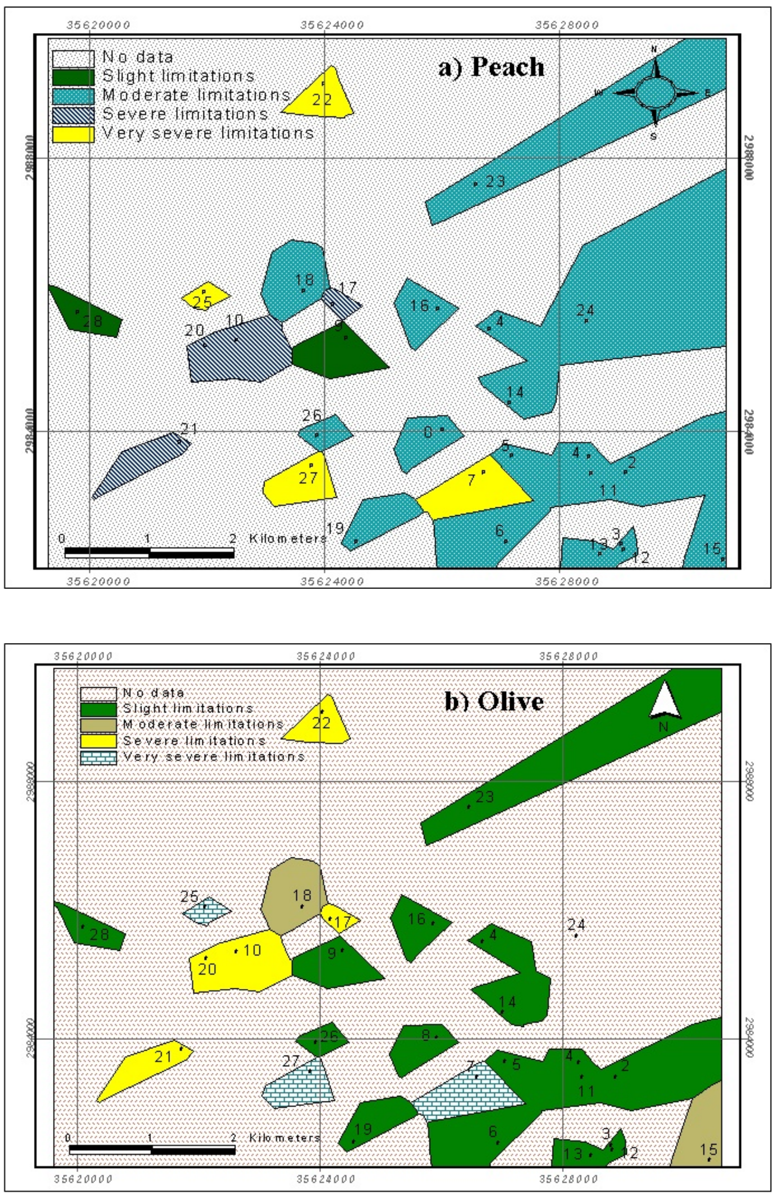


Fig. 3: Soil suitability class of *Typic Quartzipsaments*.



Map 4: Agricultural soil suitability maps of a) peach and b) olive in the selected area.

in additional to some other scattered units around. It consumes about 28.5% of the entire evaluated area.

On the other hand, the dada in Table (3) shows the agricultural soil suitability for peach (Mc) considered as fruit and olive (O) as perennials trees following the MicroLISE program. Referring to the obtained evaluation results, there are many soil units express high suitability for olive tree plantation. Obviously, olive cultivation is considered appropriate with the current soil conditions and the available agricultural

- soil resources in the study area. Especially, in the *Typic Quartzipsamments*
- soil subgroup, which show unique high suitability for olive cultivation, Fig. 3.

According to the morphological description of the soil profiles, the soil depth is suitable for olive tree to grow under this condition. In addition, olive is considered as the most appropriate crop for coarse textured soils as present in the area under investigation. Furthermore, the drainage condition is matching with the olive requirements.

On the other hand, most soil units express moderate suitability (S_3) for peach plantation, taking into consideration the soil texture and drainage condition as limiting factors. However, almost half of the profiles in the *Typic Calcigypsids* soil type are fluctuating between low suitability to completely not suitable for peach cultivation. It is will known that peach is considered the most exigent crop according to the soil natural fertility[5,6].

In general, data revealed that soil under consideration were highly suitable for both olive and peach trees as land utilization. It is worth to mention that *Calcic Aquisalids* suborder show clearly no suitability for any suggested crops provided in this research. The following Maps (4a and b) show the evaluation results as grid geo-referenced maps. As mentioned, aspects of soil suitability for fruit trees (peach & olive) are determined based on soil variables. Combining physical land evaluation models through a GIS improves evaluation model and enables an analysis more relevant to policy-making than the original basic data. It is clear from the following maps that the dominant suitability class is moderately suitable S3 in case of peach trees and highly suitably S2 with slight limitation for olive trees. The area units north-east and south-east of the entire study area showed a high suitability for olive cultivations. Highly suitable areas have a sustainability of yield from year to year. Both suitability classes are occupying an about (29.5%) of the entire agricultural area.

Conclucion: This study is qualitative evaluation for the actual soil parameters to realize a precise and objective interpretation for the area under consideration and its suitability for a wide range of crops. It can be concluded that the most effective soil parameters that influence the suitability classification in the studied area are soil texture, drainage condition and sodium saturation. The methodology followed in this study helps to match soil characteristics of the soil units with growth requirements of each particular crop. It results in the crop growth limitation being provided by the computer. From such results, it could be concluded that the *Typic Haplogypsids* showed the highest agricultural soil suitability for the selected analyzed crops with soil texture limitation. On the other hand, area limited of Haplo-soil is suitable for cultivation, while only one soil unit in *Typic Haplogypsids* is highly suitable for wheat, potato, sunflower, alfalfa and citrus with soil texture as limiting factor and the rest of this order are low suitable. The largest part of the agricultural area were classified as low suitable to almost not suitable for studying crops due to physical and chemical soil parameters such as; soil texture, useful soil depth and drainage condition. The most limiting chemical factors being considered is soil salinity which can be removed by reclaiming these soils through leaching, especially as the good quality irrigation water is available and applied management programs, which can be decreased the salinity. On the other hand, the soil maps for agricultural suitability designed in this research can be helpful in this management.

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