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Evaluation of Soil Limitations Effects on Sugar Beet Production under Centre Pivot Irrigation System, (Case Study in Menya governorate)

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ABSTRACT

Egypt suffers a negative gap between sugar production and demand consumption. Therefore to minimize the gap, it is necessary to expand the area planted with sugar beet in the newly reclaimed soils, especially those cultivated under modern irrigation technology in Menya governorate. Soil limitation factors such as topography (t), wetness (w), physical soil characteristics (s), soil fertility characteristics (f), salinity, and alkalinity (n) are the main factors effective on sugar beet productivity. The present study was conducted to determine the effect of soil limitations degree on sugar beet yield. According to obtained results of beet yield production, it's summarized to three groups related to soil limitation degree as follows: the first group soils has highest yield production with an average of 115.9 MT/ha, related to best quality parameters, the second has medium crop with an average of 89.3 MT/ha, associated to medium suitability of soil limitations such as topography and soil salinity, then the third group contains the lowest an average of 66.9 MT/ha, related to medium and severe limitations, like shallow profiles and sandstone rock. The current study aimed to identify and effect of specific site properties on beet yield productivity according to intensity of soil limitation, in west Menya governorate.

Keywords: sugar beet, production, pivot and soil limitations

1. Introduction

Sugar beet can grow successfully in a wide range of environmental conditions, tolerance to salinity, and may be adapted to water stress (Keller and Bliesner 1990; Monreal *et al.,* 2007; Abbasi, *et al.,* 2018). Land suitability refers to the soils ability to tolerate the production of crops in a sustainable way (Nuarsa *et al.* 2018). Bunning *et al.* (2016) mentioned that seven visual indicators of soil quality are: soil depth, texture, structure, surface crust, colour, soil life and roots. A decline in soil quality has an obvious impact on plant growth, yield, and production costs (Shepherd *et al.* 2008). Sprinkler irrigation especially "centre pivot" is one of the most common irrigation systems used worldwide, often irrigates every day, and has high water application efficiency compared to other irrigation systems.

Topography is a significant constraint to the proper use of modern irrigated systems, leading to surface runoff problems (Silva, 2017). The slope is an important element of landform, and plays a vital role wherever mechanization is concerned. Catchments exhibit topography changes that turn affect hydrodynamics, hydrology, and in particular runoff (Ghomash *et al.,* 2019). Fields with concave surfaces will concentrate water flow, increasing infiltration and reducing surface runoff, on the contrary convex areas, decrease soil surface storage capacity (Timlin *et al.,* 1998).

Surface water ponding means to free-standing water above the soil surface (Hunt and Gilkes (1992). When the soil infiltration rate is lower than the water application rate, the water does not infiltrate into the soil and ponds on the soil surface (Hillel, 2012). It impedes soils ability to provide an optimum medium for plant growth, Ferronato *et al.,* (2019), blocking the uptake of oxygen and nutrient (Karoly *et al.,* 2013). The remaining ponding water on the soil surface may form soil crusts such as lime, algae, and salts (Cattlin, 2006). Soil crusts and thickness affect negatively through reduced water

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infiltration and reduced seedling germination (FAO, 2008). Soil management and plant tolerance can reduce surface runoff problems and improve water availability and nutrients to plants (Masunaga and Fong 2018; Manik *et al.,* 2019). Surface runoff can also cause erosion problems by transporting sediments and fertilizers away from the cultivated fields. Amami *et al.* (2021) reveal that plowing enhanced soil infiltration capacity relative as compared to no-tillage treatment. Using of a subsoiler or chisel shank in tillage practices can increase soil infiltration capacity (Silva, 2017).

Texture influences soil behaviour in several ways: such as water retention and availability, soil structure, drainage; soil workability, traffic ability, and retention of nutrients. Soil texture class and potential rooting depths are considered the major factors of crop production (Shepherd *et al.,* 2008).

Soil salinization is a major factor contributing to the loss of productivity of cultivated soils (Machado *et al.,* 2017). Water ponding and increasing salinity are responsible for a long-term reduction in soil fertility (Bahceci *et al.,* 2008).

Crop management can contribute to higher yields (Amare *et al.,* 2013). Maximizing sugar beet yields and fertilizers management is very essential (Mahapatra *et al.,* 2020). Applications of amendments improve soil health, crop productivity, and reduce potentially toxic metals (Antonangelo *et al.,* 2021). Deep tillage with amendment applications significantly improved characteristics of soil physical and chemical as compared to control treatment (Ding *et al.,* 2021).

The present study was conducted to identify the soil limitation degree effect on sugar beet yield production, in west Menya governorate.

2. Materials and Methods

The area under investigation is in middle Egypt, west Menya governorate with studied total area STA reached to 1000 ha, represented with 24 centre pivot; each one pivot has an area of 42 ha, contains one groundwater well and includes 4 profiles, named a,b,c and d, with 96 of total profiles. Moreover, group A represented 291 h, whereas 500 h for group B and 209 h of group C. The group A includes 8 pivots i.e., (1-7 and 9) with 32 soil profiles, the second group is B contains 12 pivots beginning from no. 8 and pivots from10 to 20, with 48 soil profiles, while the third group C represented with 4 pivots, from 21 to 24 with 20 soil profiles. Numbers of soil profiles from (1 to 28 and 33 to 36) for group A, nos. 29 – 32 and from 37 to 76 for group B, while the third group C has profile nos. from 77 to 96. The study area has latitudes ranging from 27° 42' 51.1" to 27° 47' 27.3", and longitudes ranging 30° 14' 32.6" to 30° 24' 34.1". The area has various elevations ranging from 119 m to 152 m above sea level (ASL), Fig.(1).

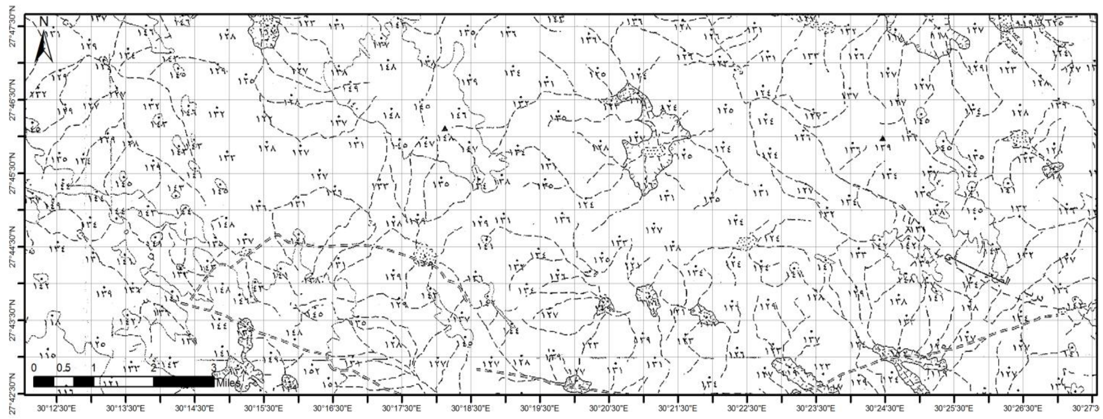

Fig. 1: Topographic map of the studied area

Alluvial terraces and wadi plain are the main geomorphic units of the study area based on visual interpretation of a satellite image and field observations, Fig. (2).

A **B**

Fig. 2: Alluvial Terraces A and Wadi plain B of the studied area

The geographical position of all sample points is referenced by a global positioning system (GPS) in the field, Fig. (3).

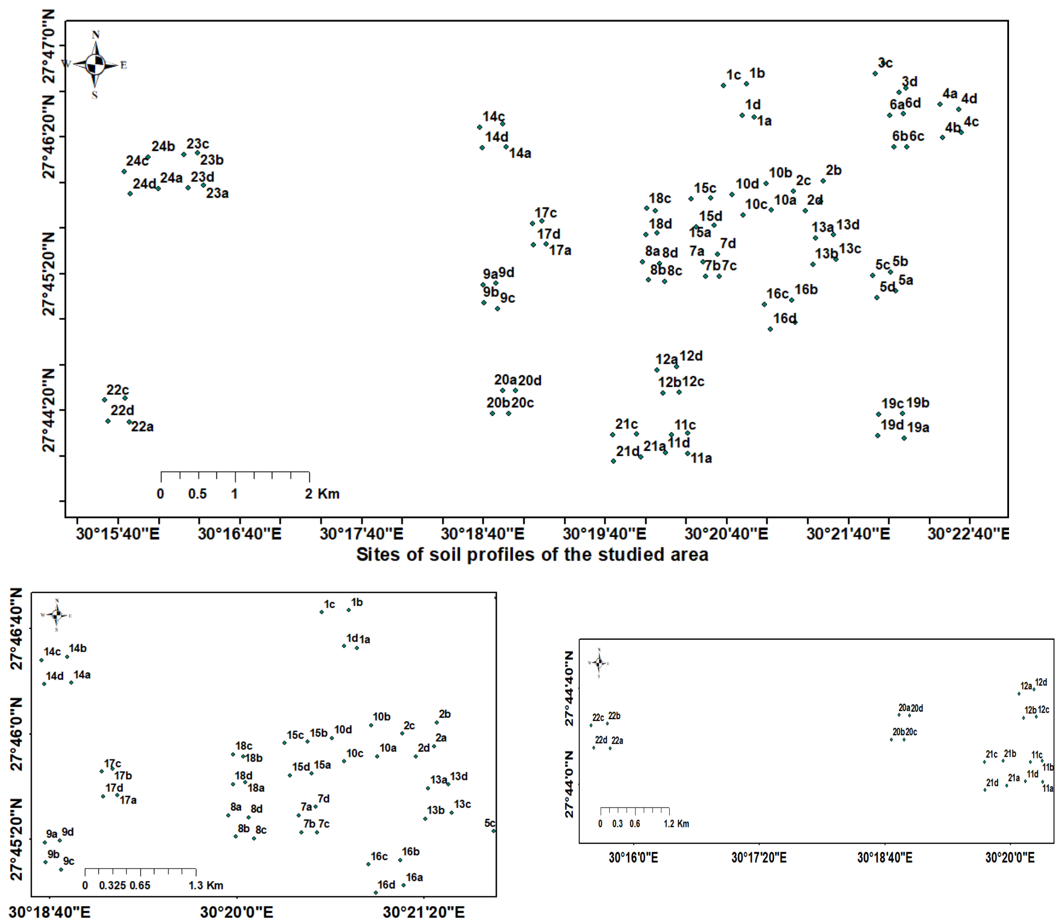

Fig. 3: Locations of soil profiles in the studied area

Based on, Soil Survey Staff (2014), the soil moisture and temperature regimes of the area are thermic and hyperthermic, respectively. Required climatic parameters of the period extending from planting up to the harvest of sugar beet were obtained from Asuit Meteorological Station and presented in Table (1).

Table 1: Climate parameters of the studied area for 2017 and 2018

	Months								
Parameter	**9/2017**	**10/17**	**11/17**	**12/17**	**1/2018**	**2/18**	**3/18**	**4/18**	**5/18**
T	28	24	18	18	12	16	20	21	25
RD	48	48	56	54	57	53	41	38	33
W	4.3	3.7	3.1	3.4	2.9	2.4	3.3	3.6	3.6
RF	0	0	0	0.2	0	1.7	0	0	0
SD	12	11	11	11	11	11	12	13	25

T: temperature °C, RD: relative humidity, W: wind m/sec, RF: rain fall mm/y and SD: sunshine duration

Sugar beet seeds were sown in the second half of September 2017 under centre pivot irrigation system and harvested in May 2018. Roots yield for each pivot was weighed and calculated as a metric ton (MT) per hectare (ha). 24 centre pivots with 96 soil profiles were selected to evaluate the effect of soil limitations on sugar beet production as well as identify pivot surface features. 24 groundwater wells are used in the study, since one well is for one pivot. Organic matter was added before sowing with 25 m^3/ha as compost. Doses of macronutrient fertilizers (N, P, k, and Mg) were added as foliar application fertigation, Table (2).

Table 2: Fertilizers amounts and applied times for sugar beet crop with kg/ha except phosphoric acid (L/ha).

Crop age (day)	**Phosphoric acid (L/ha)**	**Potassium sulphat kg/ha**	**Ammonium sulphate kg/ha**	**Ammonium nitrate kg/ha**	**Urea kg/ha**	**Magnesium sulphate kg/ha**
9	2.4	0.0	12.0	0.0	0.0	0.0
12	3.6	0.0	18.0	0.0	0.0	0.0
15	4.8	0.0	0.0	16.6	0.0	12
20	6.0	0.0	0.0	21.6	0.0	12
25	6.0	7.2	0.0	25.0	0.0	12
30	7.2	9.6	0.0	19.2	9.6	12
35	7.2	10.8	0.0	43.2	0.0	12
40	7.2	12.0	0.0	36	12.0	12
45	7.2	13.2	0.0	74.4	0.0	12
50	7.2	14.4	0.0	79.2	0.0	12
55	7.2	15.6	0.0	0.0	58.8	12
60	7.2	16.8	0.0	76.8	0.0	12
65	7.2	19.2	0.0	0.0	0.0	0.0
70	7.2	21.6	0.0	72	0.0	0.0
75	7.2	22.8	0.0	0.0	0.0	0.0
80	4.8	24.0	0.0	67.2	0.0	0.0
85	4.8	24.0	0.0	0.0	0.0	0.0
90	4.8	24.0	0.0	62.4	0.0	0.0
95	4.8	24.0	0.0	0.0	0.0	0.0
100	4.8	12.0	0.0	55.2	0.0	0.0
110	0.0	0.0	0.0	24.0	0.0	0.0
120	0.0	0.0	0.0	24.0	0.0	0.0
130	0.0	0.0	0.0	36.0	0.0	0.0
Total	118.8	271.2	30	732.7	80.4	120

The micronutrient sprayed consisted of (0.8% B, 1.5% Cu, %5 Fe, %3Mn, 0.2%Mo, %4 Zn) as 0.5 kg /ha. Humic acid was added three times at a rate of (2.5 L/ha) after 30, 40, and 50 days from sowing. According to Hegazi *et al*. (2018), the irrigation water used in the study area was pumped from a well. Amounts of irrigation water were applied according to actual evapotranspiration (ETa) for sugar beet of Menya governorate, middle Egypt based on reference evapotranspiration (ETo) and crop coefficient (Kc). Soil survey of semi-detailed was used in the study area, where four soil profiles were dug up for each pivot; these profiles were morphologically described to identify the intensity of soil parameters. Soil samples were air-dried overnight and then passed through a 2 mm sieve and subsequently analysed to determine the main soils physical and chemical properties according to the methods described by Black (1965) and Soil Survey Staff (2014). Soil limitation parameters used are topography (t), wetness (w), soil texture (s1), soil depth (s2), lime content (s3), gypsum (s4) as well as salinity and alkalinity (n). These parameters could be achieved in relative limitation scales, where five levels are used in the following Table (3):

Table 3: Rate of suitability index and intensity limitation

Symbol	Intensity of limitation	Rating
0	No	95-100
1	Slight	85-95
2	Moderate	60-85
3	Severe	45-60
4	Very severe	<45

Soil suitability index Ci is calculated according to rate of each parameter in the following equation:

$$Ci = t * \frac{w}{100} * \frac{s1}{100} * \frac{s2}{100} * \frac{s3}{100} * \frac{s4}{100} * \frac{n}{100}$$

Where Ci: suitability index, t: topography, w: wetness, s1: texture, s2: soil depth, s3: lime, s4: gypsum and n: salinity.

Rate of suitability index for parameters is classified as follow: Ci more than 75 is considered high suitable (S1), Ci from 75 to 50 is moderately suitable (S2), , Ci between 50 and 25 is marginally suitable (S3), and Ci less than 25 is not suitable (N), Sys and verheye (1978). Therefore the study area is classified into three soil groups according to soil suitability classes: soils of group A, soils of group B, and soils of group C.

3. Results and Discussion

3.1. Characteristics of soil limitations

Soil properties assessment, based on inherent soil factors and focusing on dynamic sides of the soil system, is an effective method for evaluating the environmental sustainability of land use and management activities, Nortcliff (2002). Some physical and chemical properties of three group soils are shown in Table (4). In general, Soils of group A are considered highly suitable for sugar beet production as compared to B and C soils, whereas groups B and C have severe and very severe limitations, i.e., moderate and marginal suitable.

Table 4: Some physical and chemical properties of the studied soils and groundwater

Characteristics	Studied Total Area STA			Soils of group A			Soils of group B			Soils of group C		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
pH	7.7	8.3	8.0	7.7	8.4	8.0	7.9	8.5	8.1	7.8	8.3	8.1
ECe dS/m	3.1	32.0	7.3	3.4	15.0	4.1	3.2	32.0	11.6	3.1	23.8	6.7
OM %	0.1	1.0	0.5	0.3	1.0	0.6	0.1	1.0	0.3	0.1	1.0	0.4
Clay %	4.0	38.0	15.5	8.0	32.0	18.9	7.0	38.0	21.0	4.0	10.0	6.6
Silt %	2.0	40.0	13.4	4.0	35.0	15.8	7.0	40.0	19.0	2.0	8.0	5.3
Gravel %	1.0	60.0	10.4	1.0	25.0	8.7	3.0	60.0	19.8	1.0	5.0	2.7
lime %	1.0	35.0	7.6	1.0	8.0	4.6	2.0	35.0	11.2	2.0	29.0	8.3
Gypsum %	2.0	30.0	4.7	2.0	5.0	2.6	2.0	30.0	8.1	2.0	5.0	3.3
ECiw dS/m	1.0	4.8	2.3	0.95	1.21	1.1	1.08	2.5	1.4	1.27	5.8	2.38
IR cm/h	3.0	50.0	27.4	18.0	50.0	28.0	3.0	35.0	23.0	26.8	43.0	31.2
N mg/kg	28.0	297.0	114.0	28.0	179.0	120.6	49.0	297.0	131.4	45.0	274.0	89.9
P mg/kg	0.1	5.5	0.53	0.10	0.50	0.43	0.01	5.50	0.39	0.02	2.00	0.24
K mg/kg	66.0	482.0	229.0	66.0	181.0	206.6	115.0	592.0	265.1	94.0	482.0	215.6
Fe mg/kg	0.75	8.9	1.95	0.90	2.70	2.20	0.07	8.90	2.00	0.75	4.00	1.64
Zn mg/kg	0.02	1.6	0.17	0.02	0.29	0.22	0.02	1.60	0.13	0.02	1.05	0.15
Mn mg/kg	0.05	2.7	0.25	0.07	0.35	0.39	0.05	0.69	0.17	0.09	2.73	0.18
Cu mg/kg	0.01	1.99	0.08	0.01	0.21	0.16	0.01	0.39	0.05	0.01	1.99	0.03

Min: minimum, Max: maximum, Ave: average, Ees: electric conductivity of soil extract, OM: organic matter, ECiw: electric conductivity of irrigation water and IR: infiltration rate

3.1.1. Topography (t)

The field observation, contours map, points of global positional system (GPS), and satellite image show the elevations of the study area range from 119 m to 152 m above sea level (ASL) and involved two physiographic units; alluvial terraces and wadi plain. Slopes are classified according to the high mechanized farming system as follows: about 56.7% of the studied total area (STA) has a slope of 1-2 % (no limitation), 43.3% has a slope with 2% reached to 3 %, and located in slight limitation class (2-8 %), which are highly suitable for sugar beet crop according to sys (1980), Fig. (4). Moreover little areas from the previous class are suffering from surface water ponding and water runoff phenomena, identified by visual observation, Landsat image analysis, and low crop production. Surface water runoff can be decreased by simple levelling to prevent many hazards such as; the removal of fine fractions from the surface, insufficient water for crops, and nutrients loss. Moreover about 56.9 of the soil surface in group A is flat and almost flat compared to 35.4 and 45 % for groups B and C, respectively (Table 5). Soil management can contribute to decreasing surface runoff and improving water availability, consequently higher yields (Soomro et al., 2009; Masunaga and Fong, 2018).

Fig. 4: Slopes in the study area

3.1.2. Wetness (w)

Sys and Verheye (1978) suggested that both irrigation and drainage are limitations found as subtitle characteristics under the wetness parameter.

3.1.3. Irrigation water

Groundwater wells are the only source of irrigation water in the investigated area. The average values of ECiw for the soil groups A, B and C were 1.1, 1.4 and 2.4 dS/m which have IWQI 80 , 78 and 75, characteristics with no restriction for A, low restriction for b and C respectively, according to Hegazi *et al.,* (2018).

3.1.4. Drainage

The best expression of drainage is the infiltration rate of the soil, Sys *et al.,* (1991). The infiltration rate of the studied soils ranged between 50 cm/h for sandy soils and 3 cm/h for fine texture soil. Poor drainage is found in the soils that have compacted layers of fine textured soils. Impermeable layer results of using heavy equipment in fine-texture soils led to forming of water ponding that changes crop intensity, Rhebergen (1989 and Macena *et al.,* (2021). Soil limitation intensity of drainage status in the current area are high suitable represent 65.7 % of STA, 29.1 % consider moderate suitable and Sys (1980), Table (5). About 3.2% of group B soils suffer from water ponding, while A and C groups have lower values of 1.6 and 3 % respectively, Fig. (5). The lime crust is formed after dried ponding which reduces water infiltration and seedling germination, Bahceci *et al.,* (2008), Shepherd *et al.,* (2008). Surface water ponding and salinity can decrease the crop yield by 30–80% and soil fertility, Dinnes (2002). Improve of heavy textured soils, compacted layers, and hard crusts in the study area with tillage operations are very important to prevent formation of surface water pondings. In other words, plowing with subsoilers and using organic matter are more much useful in these cases.

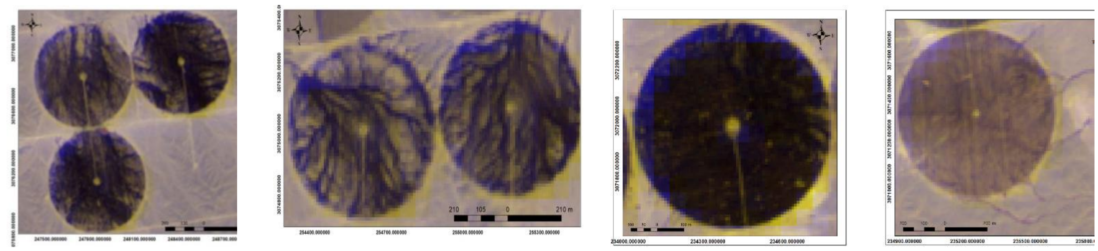

Fig. 5: Water ponding's and Runoff (blue color) of some pivots in the studied area

3.1.5. Soil texture

The soil texture of the investigated area varies from sandy to clayey. The coarse texture soils (sandy, loamy sand, and sandy loam) represented 68.6 % of STA (Fig 6). Data also revealed that the intensity of texture limitation values were 5.2, 14.6, 42.7, 31.2, and 6.2 % , representing no, slight, moderate, severe, and very severe limitations, respectively, Table (5). Based on Sys (1980), the data obtained indicate that about 37.4% of group A soils consider unsuitable because it includes the high intensity of soil texture, Fig. 6. In addition, 65% of the textural properties of Group C soils have severe and very severe limitations, compared to 27.1 % for Groups B. In the case of fully mechanized agricultural soils with coarse textures, consider better practicality and good drainage (Huang *et al.,* 2011; Singh *et al*., 2020). In contrast, clay and clay loam layers have fine-textured suffering of compaction and become impermeable resulting in standing surface water (Rhebergen, 1989; Macena et al., 2021). Dissociation of compacted layers (low and poor drainage), and hard crusts in the study area with tillage and gypsum application operations are very useful to avoid surface water ponding phenomena.

Table 5: Soil limitations % of the studied total area

Variable	Intensity	Rate	(t) %	(w) %	(s1) %	(s2) %	(s3) %	(s4) %	(n) %
Studied total area	NL	100-95	56.7	45.8	5.2	28.1	40.6	63.5	43.7
	SL	95-85	43.3	29.1	14.6	29.2	53.1	25.0	25.0
	ML	85-60	0.0	15.6	42.7	22.9	6.3	7.3	9.4
	S.L	60-45	0.0	6.2	31.2	12.5	0.0	4.2	12.6
	V S.L	<45	0.0	3.2	6.2	7.3	0.0	0.0	9.4

t: topography, w: wetness, s1: texture, s2: depth, s3: lime, s4: gypsum, n: salinity, NL; no limitation, SL: slight limitation, ML: moderate, S.L: severe limitation, VS.L: very severe limitation.

3.1.6. Gravel percent

As for gravel content in cross-section of profiles, values of gravel samples varied between 1.0% and 60 %, Table 4. The maximum values of gravels were found in the subsurface and deepest layers and sometimes were noticed in the surface layer as a result of gravel transfer from alluvial terraces through leveling operations. According to Sys *et al.,* (1980), the study area has nearly 51.8 % has gravel (0-3%) is considered no limitations (NL), 10.9 % of samples are of slight limitation (SL) having gravel of 3-15% and 22.7 % of gravel samples are in the range of (15-40%), considered moderate (ML). Moreover 14.6 % of gravel (40-75%) is a severe limitation, and consider not suitable, Figs. (6 & 8) As a result of terraces leveling operations, sometimes different gravel sizes reached to more than 6 cm are transported over surface soil and usually coated with salts, that effect on seeds and productivity. Qin *et al.,* (2015) suggested that the existence of gravel in the soil profile is not beneficial to soil nutrition impounding and vegetation growth.

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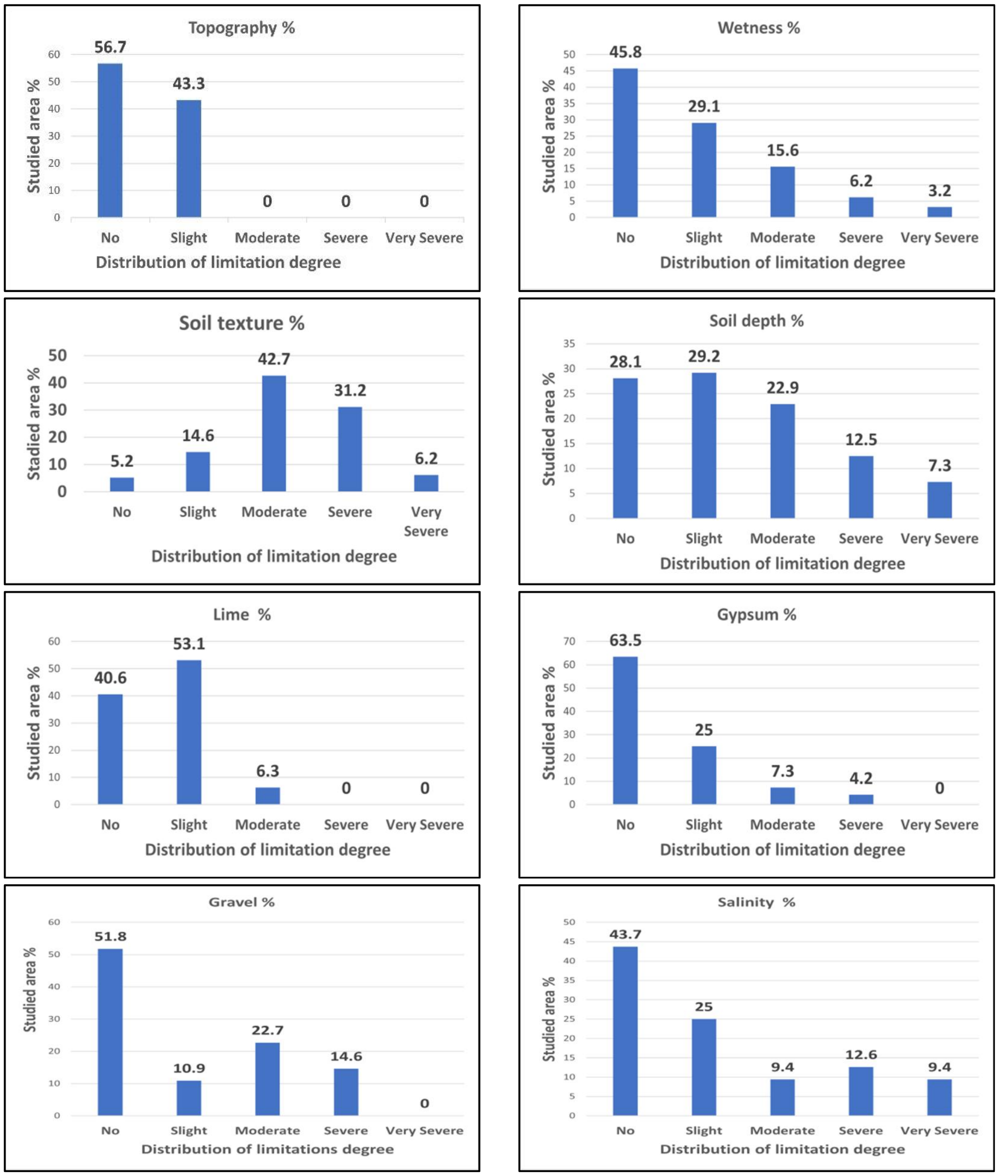

Fig. 6: Distribution of soil parameters according to soil limitation of the studied area

3.1.7. Soil depth

One of the important functions of soil, it provides suitable media for plant roots through the effective soil depth. Soil profile depths vary from shallow to very deep soils. According to Sys classification (1980), about 28.1 % of the total soil samples are considered no limitation for sugar beet crop, 29.2 % slight and 22.9 % is moderate limitation, Fig. (6). Moreover 19.8 % of soil depth is considered severe and very severe limitations, consequently not suitable for beet production. Soils of group C have 55% of soil depth severe and very severe limitations as compared to 17.7 and 3.6 % for B and A groups, respectively. The obtained data indicate that low sugar beet yield was shown in shallow soils located over sandstone rock and some scattered areas consider rockout crop, Fig. (7). Fischer *et al.* (2008) mentioned that soil depth limitations affect root penetration and may constrain the yield formation of roots and tubers. On the other hand, high production will be provided by the soils have deep soil. These findings indicated that soil depth and associated moisture determine productivity, Christopher et al. (2008). Saturation of surface soil and subsurface layers with water led to dissociation of compacted layers and sandstone and consequently increase root zone area.

Fig. 7: Sandstone rock over surface soil and subsurface layer

3.1.8. Lime content

Classification of soil limitation degree for lime content as sugar beet requirements was reported by Sys (1980). Lime values in the study area varied from 1.0 to 35 % with an average of 7.58 %, Table 4. About 40.6 % of the total samples have no limitation, 53.1 % have slight limitation and 6.3 % were of moderate limitation which means 93.7 % of gravel content is considered highly suitable, (Fig. 6). On the other side degrees of severe and very severe limitations are not found in the study area. Lime plays an important role in affecting nutrient availability to the plants, Naik *et al.,* (2007). Fine fractions of calcium carbonate can transport by water runoff to depressed soils, forming lime crust, which impedes seed emergence and causes low infiltration. More than 80%, 85.6% and 100% for A, B and C groups soils have no and slight limitations for lime content, respectively. Some hazard effects of water runoff like lime crust forming, impedes seed emergence and causes low infiltration. Silva (2017) mentioned that fields with concave areas have a surface runoff, whereas the convex areas occur water ponding.

3.1.9. Gypsum percent

Classification of gypsum content according to soil limitation degrees for sugar beet crop by Sys (1980) are: (0-3%) is no limitation (3-5%) slight, (5-10%) moderate, (10-20%) and (>20%) severe and very severe limitation. Values of gypsum content varied from 2.0 to 30 % with an average of 7.58 %, Table (4). Minimum values were found in the surface layers, while the maximum percentage is found in the subsurface layers of cross-section profile. About 80.5 % of the soil samples have gypsum content less than 5 % which is considered highly suitable for sugar beet crop and 7.4 % of the studied samples contain gypsum in the range from 5 to less than 10% i.e., belongs to moderate suitable class. Moreover 4.2 % of the samples contain gypsum in the range from 10 to less than 20% are considered marginally suitable. Some areas of groups B (6.2%) and C (5%) are suffering from severe and very severe limitations of gypsum content, (Table 5 and Fig. 8). Fine gypsum is converted to cemented layers or pans (petrogypsids horizon) which would limit penetration of plant roots and restrict drainage, thus leading to weak production. Soils that have significant amounts of gypsum particularly occur in the driest areas and restrict plant growth, FAO (1990).

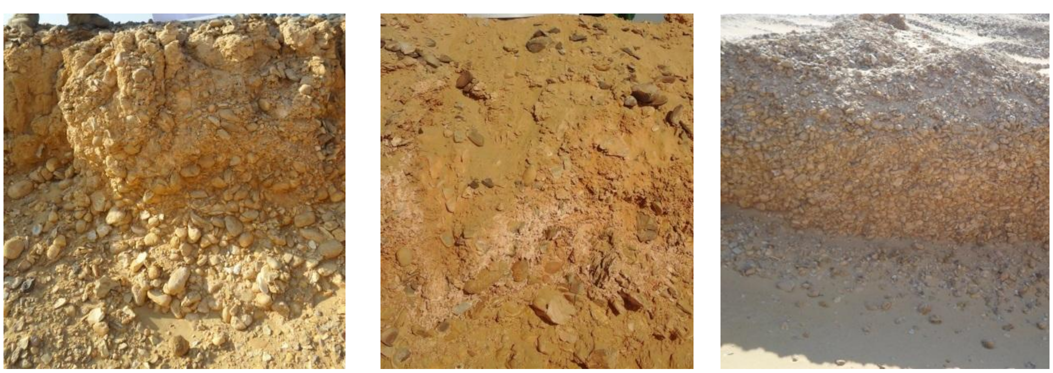

Fig. 8: Distribution of gravel content of some soil profiles

3.1.10. Soil salinity

Salinity may be observed on the soil surface as whitish or brown patches. Data in (Table 4 and Fig. 6) reveal that values of the soil salinity varied from 3.1 to 32 dS/m with an average of 8.9 dS/m. The minimum values were shown in subsurface layers of soil profiles, while the highest ones were noticed in the surface layer of profiles. High values of EC are the main limiting factor of sugar beet production in the studied area especially when the soil is a fine texture. Sys (1980) suggested that soil salinity values for sugar beet crop are no limitation range from 0-8 dS/m, representing 43.7 % of the total studied samples, 14-18 dS/m are considered of severe limitation, representing 12.6% of samples and >18 dS/m are considered of very severe limitations representing 9.4 % of the soil samples, Table (5). The high percentage of severe limitation for soil salinity was found in group C soils, Fig. (9). Soil salinity refers to the occurrence of soluble salts in soil that adversely affects plant growth, Hardie *et al.,* (2012). Intensive soil leaching operations before planting are very important to reduce the harmful effects of salts, especially when removed from the upper layers of terraces to depressed soils.

Table 6: Soil limitations percentage of the studied groups (G) and studied total area (STA)

G	Inte.	t % from		w % from		s1 % from		s2 % from		s3 % from		s4 % from		n % from	
		G	STA	G	STA	G	STA	G	STA	G	STA	G	STA	G	STA
A	NL	56.9	7.3	50.0	14.6	10.7	3.1	53.6	15.6	60.7	17.7	75.0	21.9	60.7	17.7
	SL	37.1	9.4	32.1	9.4	17.9	5.2	28.6	8.3	39.3	11.5	25.0	7.3	21.4	6.3
	ML	0.0	11.5	14.3	4.2	53.6	15.6	14.3	4.2	0.0	0.0	0.0	0.0	14.3	4.2
	S.L	0.0	1.0	3.6	1.0	35.7	10.4	3.6	1.0	0.0	0.0	0.0	0.0	3.6	1.0
	VS.L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B	NL	35.4	5.2	52.1	26.0	4.2	2.1	25.0	12.5	25.0	12.5	58.3	29.2	43.7	21.9
	SL	64.6	21.9	27.1	13.5	18.7	9.4	41.7	20.8	70.8	35.4	22.9	11.5	27.1	13.5
	ML	0.0	18.8	10.4	5.2	50.0	25.0	18.7	9.4	4.2	2.1	12.5	6.3	6.2	3.1
	S.L	0.0	3.1	4.2	2.1	25.0	12.5	12.5	6.3	0.0	0.0	6.2	3.1	10.4	5.2
	VS.L	0.0	1.0	6.2	3.1	2.1	1.0	2.1	1.0	0.0	0.0	0.0	0.0	12.5	6.3
C	NL	45.0	4.2	25.0	5.2	0.0	0.0	0.0	0.0	50.0	10.4	60.0	12.5	20.0	4.2
	SL	55.0	9.4	30.0	6.3	0.0	0.0	0.0	0.0	30.0	6.3	30.0	6.3	25.0	5.2
	ML	0.0	6.3	40.0	7.3	35.0	7.3	45.0	9.4	20.0	4.2	5.0	1.0	10.0	2.1
	S.L	0.0	1.0	5.0	2.1	40.0	8.3	25.0	5.2	0.0	0.0	5.0	1.0	30.0	6.3
	VS.L	0.0	0.0	0.0	0.0	25.0	5.2	30.0	6.3	0.0	0.0	0.0	0.0	15.0	3.1

3.1.11. Organic matter and nutritive elements

Soils of the studied area characteristics of low content of organic matter (O.M) and nutritive elements, the averages values of O.M is 0.5 %, 114 mg /kg for N , 0.53 mg /kg for P, 229 mg /kg for K, 1.95 mg /kg for F, 0.08 mg /kg for Cu, 0.25 mg /kg for Mn, and 0.17 mg /kg for Zn, Table (3). So these soils are needed applications of organic matter and fertilizers.

Fig. 9: High salinity of some studied soil profiles

3.2. Sugar beet Production related to soil suitability

Distribution of sugar beet production is shown in Fig. (10). Sugar beets were cultivated in 1000 ha as the studied total area STA, including 291 h for group A, 500 h group B and 209 h of group C. The results reveal that sugar beet crop in the studied soils can be classified into three groups according to productivity related to soil properties. The root yield averages of the three groups are 115.9 MT/ha, 89.3

MT/ha and 66.9 MT/ha for A, B and C groups respectively, Table (7). Deterioration of soil quality has clear impact on plant growth, yield and production costs, Shepherd *et al.,* (2008).

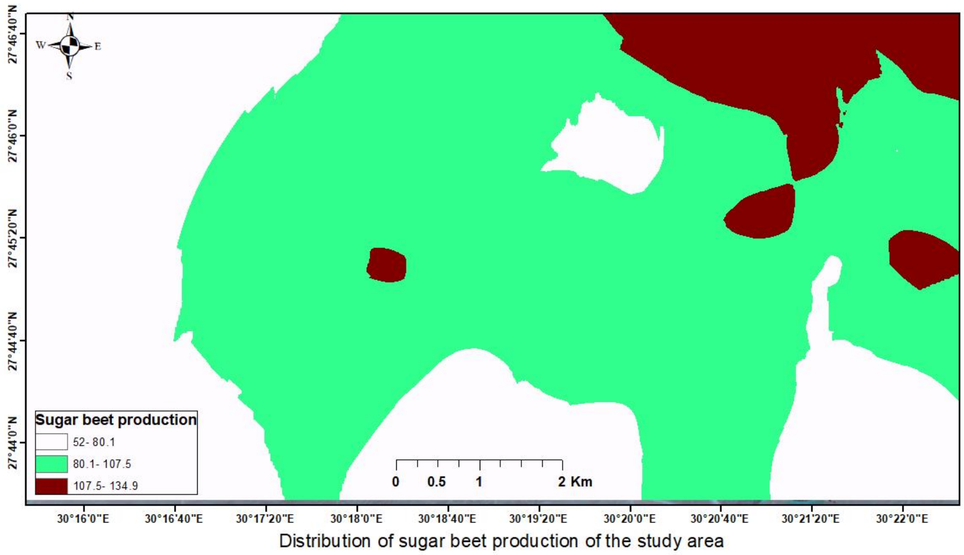

Fig. 10: Sugar beet production in the studied area

Group A

Sugar beet yield of group (A) varied from 107 to 134.8 MT/ha with the highest average of 115.9 MT/ha relative to B and C groups. The results in Table (7) indicate that soil suitability classes of (A) group include three sub orders i.e., S1, S2 and S3, whereas the sub order N is not found. The dominant suitability classes are classified according to descending order as follows S2 > S3 > S1.This group characteristic has a large area of S1 (high suitable), representing 66.1 % of total S1.

Class S1: high suitable for sugar beet representing about 14.2 % of A group soils and 4.1 % of total studied areas and have the highest values of soil suitability index (Ci) ranged from 76.2 to 79.7. Class S2 is moderately suitable, covering about 61.6 % of group A area and 17.9 % of the STA, the average of suitability index (Ci) is 61.4. Whereas Class S3 is marginal suitable, representing about 24.2 % of A group area and 7.3 % of STA, suitability index (Ci) ranged between 30.4 and 46.2. The obtained results reveal that the dominant limitation of subclass for group A is (s-1) where about 89% of soil textures are considered moderate and severe intensity limitations, Table (6). On a spit of the irrigation water is considered good water quality, Hegazi (2018). High yield production of this group is related to good soil quality as compared to B and C groups, Warkentin (1995).

Group B

This group differs from A and C groups, it's contained two phenomena's i.e., surface water ponding and water runoff, causes reducing in sugar beet production. The root yield of group (B) varied from 76.5 to 98.5 MT/ha with an average of 89.3 MT/ha, yield is moderate production compared to groups A and C and attributed to: Large area 36.4 % of the studied group soils is considered not suitable (N1). One of the reasons for medium production is high salinity that is removed from salic horizons of terraces to surface depressed parts by levelling processes. The soils have four suitability classes i.e., S1, S2, S3 and N1. Dominant of suitability classes in group B is S3 (50.2%), followed S2 (36.7%), N1 (10%) then S1 (3.1%) which affected production, Table (7).

Class S1: represent about 3.1and 2.1 % of group B and STA, respectively, which lower than group A and cover about 21 ha of STA. It has a rate of suitability index that ranges from 76 to 78.5 with an average of 76. Class S2: represents about 36.7 and 18.8% of group B and STA, respectively; and covers about 21 ha of the studied total area. It has a rate of suitability index ranging between 51 and 73.5 with an average of 62.3. Class S3: covers about 50.2 and 23.9 % of group A and STA, respectively; and covers about 239 ha from STA. It has a rate of suitability index ranged from 25.1 to 48.1 with an average of 37.1. Class N1: this class is not suitable, representing about 10 and 5.2 % of group B and STA, respectively. It has low rate of suitability index ranging from 17.3 to 23.1 with an average of 18.

Major soil limitations of this class are topography, wetness, soil texture, depth and salinity, which contributed of decreasing production. Moreover, some soil profiles are considered skeletal that contain > 35 % gravel that reached about 60 % in cross section of profiles. Water ponding and increasing salinity can decrease the crop yield by 30–80%, McFarlane and Williamson (2002). Irrigation water salinity values range from 1.08 to 2.49 with an average value of 1.38 dS/m and IWQI ranging between 73.9 and 83; these values are considered low restrictions for most plants.

Table 7: Distribution of suitability degrees, areas and production of sugar beet for three groups soils

Suitability	Variable	Group A	Group B	Group C
S1	Area (h)	41.4	15.5	0
	% of group	14.2	3.1	0
	% of STA	4.1	2.1	0
	Ci	76.2 - 79.7	76 - 78.5	0
	ACi	77.4	76	0
S2	Area (h)	179.2	183.5	37.6
	% of group	61.6	36.7	18
	% of STA	17.9	18.8	4.1
	Ci	51.7-73.7	51.6 - 73.2	51.7 - 57.8
	ACi	61.4	58.7	53.8
S3	Area (h)	70.4	251	96.1
	Group	24.2	50.2	46
	% of STA	7.3	23.9	9.6
	Ci	30.4 - 48.2	25.1- 48.1	29 - 47
	ACi	40.6	37.1	33.4
N1	Area (h)	0	50.0	75.3
	Group	0	10	36
	% of STA	0	5.2	7.3
	Ci	0	21.3 - 23.1	16.5 - 20.3
	ACi	0	22.3	18.8
IWQI	Rate	76.9-85.7	73.9-86	74-81.8
	Av	79.8	78	75.3
Dominant suitability	Class	S2>S3>S1	S3>S2>N>S1	S3>N1>S1
	Subclass	s-1	s-1>n>s-2>w	s-1>s-2>n
Production MT/ha	Range	107 - 134.8	76.5 - 98.5	55 - 73.8
	Aver	115.9	89.3	66.9

S1: High suitable, S2: Moderate suitable, S3: Marginal suitable, CI: Suitability index, ACi: Average Ci, STA: Studied Total Area, MT: metric ton, h: hectare, s-1: texture, s-2 soil depth, n: soil salinity, w: wetness, Av: Average

Group C

The root yield of group (C) varied from 55 to 73.8 MT/ha with an average of 66.9 MT/ha, Table (7). Sugar beet production of this group is the lowest among the studied groups. The marked decrease of sugar beet yield may be attributed to the following reasons: dominant suitability classes in group C is S3 followed N then S2, sub order S1 is not found in group C, suitability index of group C soils is low, ranged from 28.9 to 60. Unsuitable conditions of soil properties for group C such as soil salinity, soil depth and texture are influenced on sugar beet production. Singh *et al.,* (2015) reveals physical restriction for roots resulting in formed by compacted subsoil layer can also decrease plant growth irrespective of water and nutrient supplies. Moreover, Fischer et al., (2008) mentioned that soil depth limitations affect root penetration and may constrain the yield formation of roots and tubers. Textural class and potential rooting depth are primary assessments of water holding capacity which is considered one of the effective of crop production, Shepherd et al., (2008) and Confalonieri et al., (2014). The results in Table (7), indicate that soil suitability classes of group (C) include three sub orders i.e., S2, S3 and N1, as well as its percentages for specific area as follows:

Class S2: represents about 18.2 and 2.3% of group A and (STA), respectively; and covers about 2.3 ha from studied STA. It has a rate of suitability index ranged from 53 to 65, whereas S3 represents about 45.5 and 5.8% of group C and STA, respectively; and covers about 4.1 ha from STA. It has a rate of suitability index ranged from 26 to 38. Class N1: soils are not suitable, represent about 36.4 and 4.4 % of group A and (STA), respectively and cover about 3.3 ha from the studied total area. It has a rate of suitability index ranging from 15 to 22.

Successful practices of soil management such as drainage, tillage, salt leaching, application of organic matter and levelling processes increase plant production, Pagliai *et al.,* (2004) and Unger *et al.,* (2018). Moreover, improving soil management can increase infiltration, decrease surface runoff, and improve water and nutrients availability for plants, Schmidt and Zemadim (2015) and Masunaga and Fong (2018).

4. Conclusion

Large agricultural projects in the new lands are characterized by their huge investment, using canter pivots for irrigation and full agricultural machinery. The sugar beet crop may give the highest productivity with good management of soil properties. Decreasing runoff by simple levelling is essential process to increasing crops and preventing such hazards; as removal fine fraction from the surface, insufficient water for crops, losses of nutrients and surface lime crust that hinder seed germination and poor productivity. During soil preparation for agriculture, it must be taken improve heavy textured areas, compacted soil layers and hard crusts with tillage operations. In other words, plowing with subsoiler and using organic matter are much useful in these cases. Soil leaching operations before planting are very important to reduce the harmful effects of salts, gypsum and carbonates, especially those transferred from the upper layers of terraces to low soils. Adding organic and mineral conditioners such as compost and sulfur to improve the soil drainage system and prevent the formation of water ponds is the desired process. The current research is needed to study effect of management system on runoff, water ponding and topography.

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