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EVALUATION OF SOIL SUITABILITY FOR WHEAT USING KRIGING AND REMOTE SENSING DATA

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Abstract

This study was carried out in the middle of Babylon Governorate on a farm of the Col. of Agriculture/ Al-Qasim Green University. in the northern-west part of Babylon University, between the latitudes 32°23'48.7741"N & 32°23'57.3867"N and the longitudes 44°23'43.9113"E & 44°23'54.7926"E, on an area of 4.57/hectare. The main aim of the study is to specify the most suitable spatial arbitrary function to evaluate the soil suitability for wheat plant, and then to estimate the soil chains for wheat plant suitability with an abstract of L.S.D. The study reached the fact that the exponent-model was the optimal one in realizing the highest spatial prediction accuracy, by classifying the wheat soil suitability with a high-abstract-coefficient reached to **0.9922. Moreover, it was found that DW55 chain abstractly outmatched, in suitability for wheat plant, the chains TW454, DM95, DP94, and TP954, because it achieved abstracts of 513.60, 530.60, 67.00, and 57.80 successively. Hence, the study recommended the necessity of carrying-out a future-test for the prediction-accuracy-model when the soil and water management type is changed on the farm towards the best, and it also recommended the reclamation of the deteriorated part of the farm ground providing a covered or vertical-drainage system, with an artesian-well with supply of good-quality-water for irrigation, because the farm location and capacity is promising to be a good agricultural site in favor of the University and the country's sustainable development plans.

Key words: Soil suitability, distant perception, geographical information systems, Kriging.

Introduction

The soil's chemical, physical, and fertile data-base represents the quantitative degree indications of the soil unit's suitability plan of the farm-crops according to a numeral measurements designed by Sys *et al.* (1993). The soil plan unit design, within its geographical and topographical borders, has been demanding the assistance of distant perception when a precise distinction between the soil unit types is needed, for this would be used to estimate the soil's accurate suitability for the economical plants (Gitelson *et al*., 2004). The diverse formulas within the geographical information systems provide the land-surveyors with the possibility of gaining the most precise soil suitability for the farm-corps plan. In this respect, Albaji *et al*. (2009) was able to design suitability plans for the well-known farm crops in the Iranian western-south plain-land, which was produced within the geographical information programing systems, in addition to diagnosing the limitation factor of crops productivity for each soil unit. The pedo-genetic data complementarity with the measured differing formulas outlets, besides the distant-perception data, enabled Ali & Shalaby, (2012) to design suitability plans for many farm-crops in the western-desert of the Nile delta, the north of Egypt, which included the study of the crops water demands factor, its quality, and its role in productivity increase/ decrease. This complementarity is necessary also in identifying the productivity barriers of each soil unit. Using the complementarity approach, Albaji *et al*. (2012) diagnosed the weak points of the agricultural lands management in the Iranian Khuzestan County. Therefore, by using the complementarity approach Taha *et al*. (2018) was able to evaluate the effect of the spatial relation between the soil's organic material and the instant nitrogen on the wheat's soil suitability increase. The interwoven-systematic engineering style provides the opportunity to gain samples of soil survey in a regional environment allows a proportionate separating of the farm soil units, which eventually leads to a fair impartial test of any predictable design resulting from the pedo-genetic data complementarity with the measured differing outcomes to evaluate the soil suitability for the farm-crops, which to be planted in future by the Crops Department at our college on the farm of the College of Agriculture, Al-Qasim Green University.

Hence, this study tempted to attain the following goals:

- Specifying the most suitable arbitrary spatial function for evaluating the wheat plant soil suitability, and
- Estimating the soil chains abstract in respect of its suitability for wheat planting with L.S.D.

Materials and Methods

1. The Study-area Site:

The study site is located in the middle of Babylon Governorate represented by a farm at the Col. of Agriculture/Al-Qasim Green University, situated in the western-north part of the university between the altitudes 32°23'48.7741"N & 32°23'57.3867"N and longitudes 44°23'43.9113"E & 44°23'54.7926"E, on an area of 4.57/hectare. A handled G.P.S. was used to specify the farm borders' coordinates according to the UTM projection, in order to isolate the soil units pedo-genetically. The samples were reached by the OCR for 24 sites mediated among 6 Pedons, by using the interweaved-engineering system demanded for the spatial analysis measurement suggested by Lark (2009) which is explained in Figure 1 below:

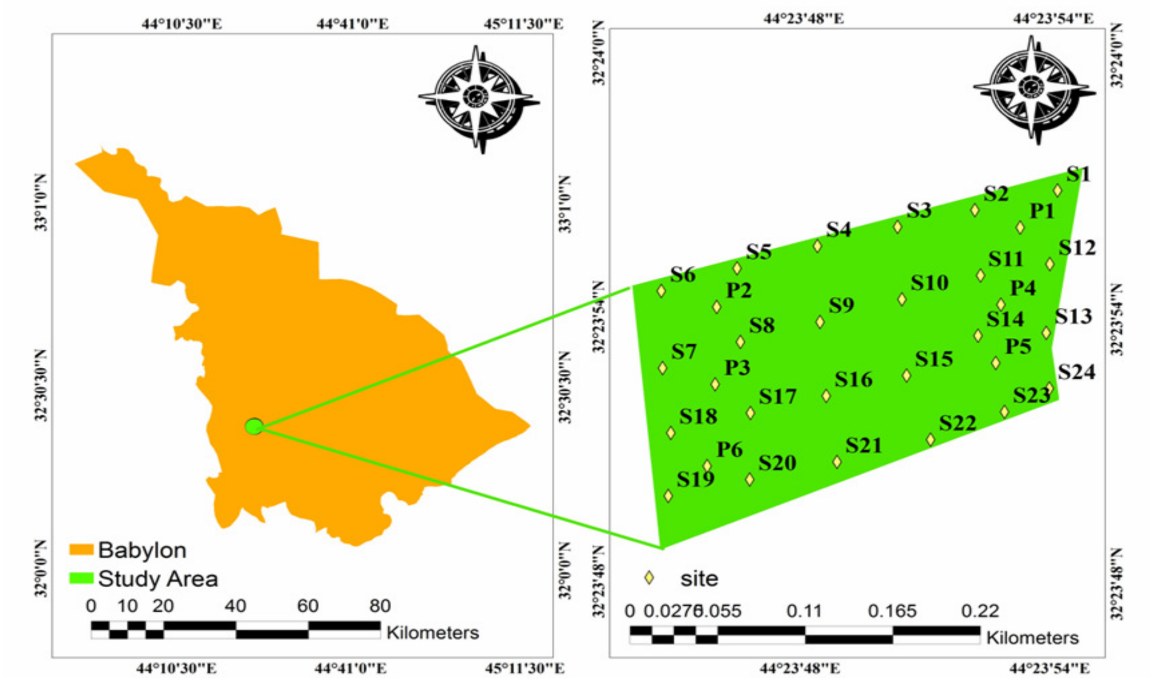

Fig. 1: Study area location in Babylon Governorate with the samples' sites

2. Field Work

OCRs were used to diagnose the soil units, and the six Pedons were described morphologically according to the basics of the pedological approach adopted in the soil survey guide Soil Survey Division Staff (1999). In this guide the classification system depends on the family-level, whereas on the serials level the mechanism suggested by Al-Agidi (1976) was used because it is devoted to the soil chains classification in the middle and south of Iraq.

3. Soil Description Analysis:

The proportional distribution of soil particles sizes was estimated by the suction method after removing the relating materials according to Black (1965). Meanwhile, the apparent density of the face horizon was estimated by the Core Method according to Black (1965). Then, the extracting of the soil solution from the aggregated paste by a dragging system, in addition to measuring the electrical access by EC-meter according to Page *et al*. (1982). Furthermore, the reciprocal calcium, magnesium, sodium, and Potassium ions were estimated after extracting them from ammonium acetate (*N*)1, where the reciprocal calcium and magnesium were estimated by a test of EDTA program, while the reciprocal potassium and sodium were estimated by the system of flame-photometer according to Page *et al*. (1982). As for the positive ions reciprocal capacity, it was estimated according to Papanicolaou (1976), which is related to the gypsum and lime soils, and the reciprocal sodium percentage was measured by the equation 1 below:

$$ESP\% = \frac{\text{exchangable}\left(Na^{+}\right)}{CEC} \times 100 \qquad ...(1)$$

As for the apparent reciprocal cationic capacity, it was estimated according to the following equation:

$$\text{Apprent } CEC = \frac{CEC}{\text{Clay}\left(kg\right)} \qquad ...(2)$$

As for the holistic carbonic metals, they were estimated by the weightiness method according to Richard (1954), while the gypsum content in soil was estimated by acetone precipitation and electrical access measurement according to Richard (1954). Meanwhile, the organic material was estimated by wet oxidation with dual potassium dichromate by adding concentrated sulfuric acid as a resource of heat, then flowing with the ammoniac $FeSO_4$ according to Walkly and Black mentioned by Black (1965).

4. Suitability measurement:

It was calculated according to Storie equation mentioned in Sys *et al*. (1993) as in the following equation:

$$I = A * \frac{B}{100} * \frac{C}{100} * \frac{D}{100} * \frac{E}{100} * \frac{F}{100} * \frac{G}{100} * \frac{H}{100} * \frac{J}{100} * \frac{K}{100} * \frac{L}{100} * \frac{M}{100} ...(3)$$

Here, A stands for soil depth, B for stony, C for soil constituent, D for calcium carbonates, E for apparent cationic reciprocal capacity, F for soil interaction degree, G for soil organic carbon, H for soil salinity, J for soil reciprocal sodium percentage, K for soil slant inclination, L for natural drain status, and M for gypsum.

DEM ASTER data-base was used on 18/3/2018 after being downloaded from www.usgs.com the site of the American Geological Association site, followed by processes to transform it into maps having to do with the topographical feature (level and land slope), followed by transforming them into Triangulated Irregular Network (TIN) by the ArcGIS10.5 program as it is illustrated in the following figure:

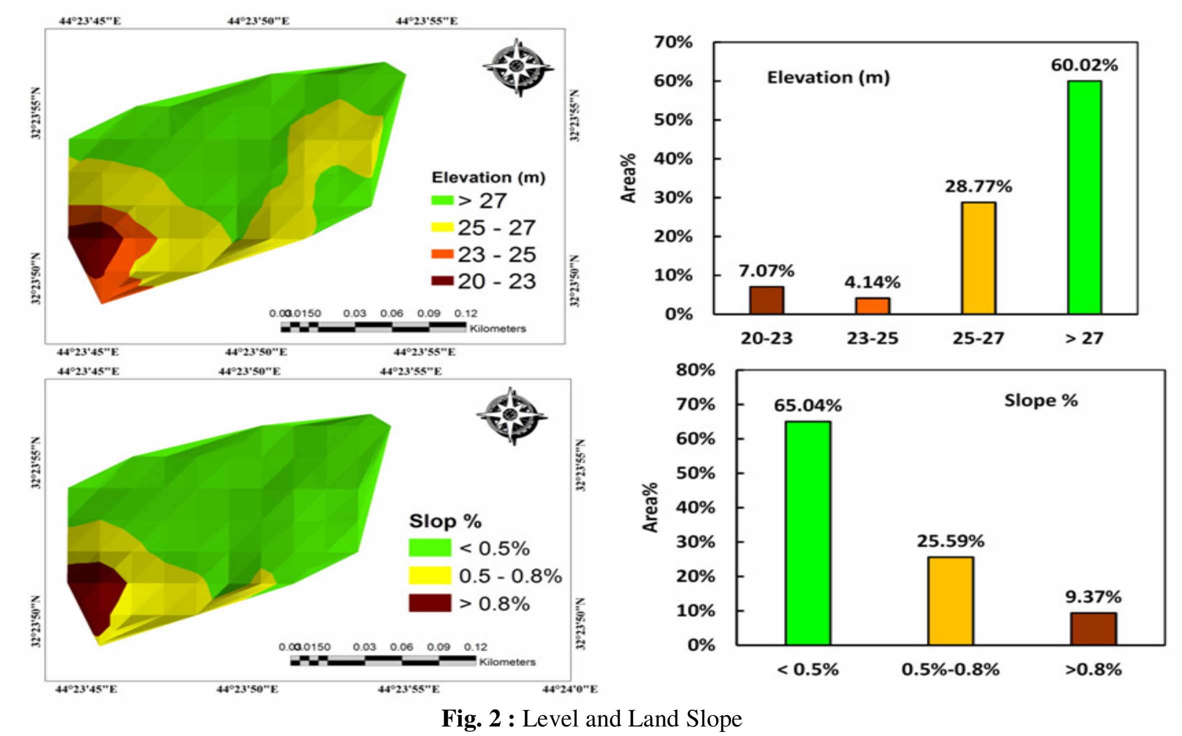

Fig. 2 : Level and Land Slope

5. Spatial Analysis by the Kriging Function

In analyzing the space factor, functions within the ArcGIS 10.5 program were used, according to Ordinary Kriging with linear, exponent, globular, and goblet models. This is for evaluating the optimal model that insure the spatial prediction stability with minimum nugget effects, because the less it is valuable the more it is valid and stable in respect of predicting the variables' spatial distribution at issue (Taha *et al*., 2018).

According to F.A.O. (2012), the classification of the crops suitability for the study area soils was as follows:

Table 1: Types of soil units' suitability for the farm crops

Index	Definition	Symbol
80-100	Highly Suitable	S1
60-80	Moderately Suitable	S2
40-60	Marginally Suitable	S3
25-40	Currently not Suitable	N1
0-25	Permanently not Suitable	N2

In order to examine the effect of the soil quality in respect of suitability for farm-corps, a test was carried out to find out the less abstract difference on the basis of unequal replications with the aid of GenSTAT12 program, while the illustrative means were drawn with the aid of Microsoft Excel 2015 program.

Outcomes and Discussion

1. Results of the Soil's Quality Laboratory Analysis

Table 2 shows the possibility of diagnosing five soil chains at the study area, while Table 3 shows that %66.54 of the study area size falls under the major group Typic Torrifluvents, for it was built-up by the Euphrates precipitation. It is worth mentioning that all the spots and complexities in the studied soil horizon are mostly attributed to calcium carbonates compounds, which can hardly be melted in the area's dry environment, which became to be an ideal morphological evidence for the pidones interior discharge, for it is in origin a calcareous alluvium material. The soil's building-up could be enhanced by the sudden precipitation cut-off in the Pedons, from a horizon to the next depending on the precipitation's intensity facing the soil in the course of time, which is technically called stratification.

Table 2: Laboratory analysis values' mean of the soil & suitability classification data

Series	cm	gm.kg^{-1}								Texture Class	Cm	d*S*.m^{-1}	gm.kg^{-1}	
		Sand			Silt				Clay		Mottling Depth	ECe	Lime	Gypsum
	Depth	Coarse	Fine	Total	Coarse	Medium	Fine	Total						
DW55	28	161.09	189.10	350.19	188.07	132.50	106.86	427.43	222.38	Loam	110	2.19	215.28	0.09
	34	146.49	25.85	172.34	213.84	116.08	281.05	610.97	216.69	Silt Loam		4.03	219.43	0.40
	41	136.74	28.01	164.75	144.47	94.22	389.42	628.11	207.14	Silt Loam		5.59	211.59	0.66
	47	230.21	173.67	403.88	60.04	92.07	248.18	400.29	195.83	Loam		6.51	218.73	0.45
TW454	32	192.11	26.20	218.31	112.70	355.91	124.57	593.18	188.51	Silt Loam	107	2.42	237.74	0.19
	35	200.09	184.70	384.79	46.36	139.07	236.00	421.43	193.78	Loam		3.32	238.65	0.32
	40	146.43	82.36	228.79	100.49	177.34	313.29	591.12	180.09	Silt Loam		4.18	238.76	0.43
	43	179.52	348.47	527.99	129.98	97.49	133.59	361.06	110.95	Sandy Loam		6.78	242.89	0.46
DM95	25	147.92	79.65	227.57	131.27	250.61	214.80	596.68	175.75	Silt Loam	68	3.15	258.35	0.27
	36	50.11	66.43	116.54	76.63	120.42	350.33	547.38	336.08	Silty Clay Loam		3.36	258.61	0.32
	48	71.46	53.90	125.36	59.55	324.83	157.01	541.39	333.25	Silty Clay Loam		4.58	260.09	0.48
	41	143.91	255.84	399.75	52.41	88.69	262.02	403.12	197.13	Loam		5.19	260.83	0.56
TW454	22	170.09	50.80	220.89	225.66	121.98	262.24	609.88	169.23	Silt Loam	97	4.31	259.76	0.38
	37	241.96	136.10	378.06	136.28	136.28	153.32	425.88	196.06	Loam		3.86	259.22	0.39
	45	124.01	114.47	238.48	209.39	95.72	293.16	598.27	163.25	Silt Loam		3.77	259.11	0.45
	46	178.73	331.92	510.65	154.00	94.11	179.66	427.77	61.58	Sandy Loam		7.14	263.2	0.48
DP94	25	64.11	48.37	112.48	122.14	244.28	188.77	555.19	332.33	Silty Clay Loam	11	24.66	284.46	0.74
	35	43.75	81.24	124.99	213.69	115.07	219.17	547.93	327.08	Silty Clay Loam		33.55	295.26	0.26
	46	59.30	75.47	134.77	133.98	96.46	305.47	535.91	329.32	Silty Clay Loam		33.91	295.69	0.26
	44	200.78	356.94	557.72	196.59	62.25	68.81	327.65	114.63	Sandy Loam		41.85	305.33	2.04
TP954	26	59.65	72.91	132.56	79.86	159.71	292.80	532.37	335.07	Silty Clay Loam	17	24.85	284.37	0.75
	32	25.67	116.96	142.63	109.67	203.67	208.88	522.22	335.15	Silty Clay Loam		24.86	284.71	0.81
	43	317.21	55.98	373.19	152.92	152.92	118.95	424.79	202.02	Loam		35.17	297.22	0.26
	49	163.16	399.45	562.61	94.17	141.26	192.63	428.06	9.33	Sandy Loam		38.29	301.01	1.16

On the other hand, the absence of an active drainage net, the ground-water increased because of using open dusty-channels in water-supply management, which caused the agricultural activities to be transformed from the major group Typic Torrifluvents into the major group Typic Haplosalids with a mean of 533.46.

Table 3 shows the measured mean of the soil's effective qualities in respect of suitability for wheat plant, for the salinity, sodium, and calcium carbonates increase caused the decrease of the organic material in the soil content, and thus its suitability for wheat plant was gradually and noticeably deteriorated.

On the other hand, a farm wise management means using covered-drainage channels accompanied with safe water- supplies, and this could not be achieved but by digging an artesian-well with good quality water-supply, which allows the sustainability of the salinity balance in the farm soils, besides adopting agricultural circles system which allows transforming the farm soils into an optimal environment for the postgraduate-students to carry-out their studies in a way that achieves as high control as possible on the environmental variables, and eventually leads to a better control on the field experimental procedures.

Table 3: Laboratory analysis measured values mean of the of the soil suitability for wheat plant

Site	pH	d*S*.m^{-1}	%			cmol$_c$. Kg^{-1}	%		cmol$_c$. Kg^{-1}clay
		ECe	Lime	Gypsum	S.O.C.	C.E.C.	ESP	B.S.	Apparent CEC
P1	7.43	4.89	21.63	0.04	0.67	23.13	8.93	0.94	110.88
P2	7.70	4.34	23.97	0.04	0.66	23.01	7.99	0.94	139.23
P3	7.5	4.23	25.97	0.04	0.66	23.19	8.86	0.94	85.74
P4	7.71	4.9	26.05	0.05	0.64	23.3	9.69	0.94	165.19
P5	6.98	34.62	29.65	0.09	0.3	26.12	29.47	0.95	98.08
P6	7.14	32.2	29.36	0.08	0.37	25.54	29.42	0.97	134.04
S1	7.65	3.78	20.88	0.04	0.69	22.02	6.17	0.94	120.91
S2	7.55	3.57	21.89	0.04	0.68	22.57	8.79	0.95	112.2
S3	7.51	3.37	25.86	0.03	0.69	22.57	8.17	0.93	112.03
S4	7.4	4.7	26.02	0.05	0.65	23.39	11.34	0.94	163.24
S5	7.83	5.59	26.13	0.05	0.62	23.7	13.02	0.94	133.94
S6	7.45	3.93	25.94	0.04	0.67	22.93	9.74	0.96	139.04
S7	7.73	4.89	26.05	0.05	0.64	23.55	11.79	0.97	140.08
S8	7.66	4.46	26.00	0.04	0.66	22.84	9.13	0.93	124.17
S9	7.63	5.67	25.90	0.05	0.48	23.74	10.53	0.96	91.56
S10	7.64	4.54	26.00	0.05	0.65	23.23	11.05	0.95	139.18
S11	7.46	4.32	25.98	0.04	0.66	22.93	7.86	0.93	126.92
S12	7.84	3.4	23.64	0.03	0.69	22.38	8.7	0.96	114.93
S13	7.16	33.52	29.53	0.05	0.36	26.79	28.42	0.97	95.89
S14	7.48	4.42	25.99	0.05	0.65	23.38	10.81	0.95	130.19
S15	7.02	37.18	29.97	0.11	0.35	26.84	29.26	0.97	97.5
S16	7.68	5.59	26.13	0.05	0.52	23.69	13.1	0.95	85.96
S17	7.75	6.96	26.06	0.05	0.39	24.05	15.22	0.93	88.5
S18	7.61	5.31	26.10	0.06	0.62	23.71	11.73	0.92	93.22
S19	7.14	33.34	27.39	0.06	0.36	26.12	29.13	0.95	119.94
S20	7.03	37.29	29.98	0.12	0.35	26.73	29.51	0.95	126.23
S21	7.05	37.95	30.06	0.08	0.34	26.99	29.16	0.95	112.42
S22	7.15	33.74	29.55	0.08	0.36	26.74	28.52	0.95	106.4
S23	7.11	34.61	29.66	0.06	0.36	26.45	29.17	0.95	94.28
S24	6.98	39.38	30.23	0.11	0.34	28.01	28.69	0.96	102.65

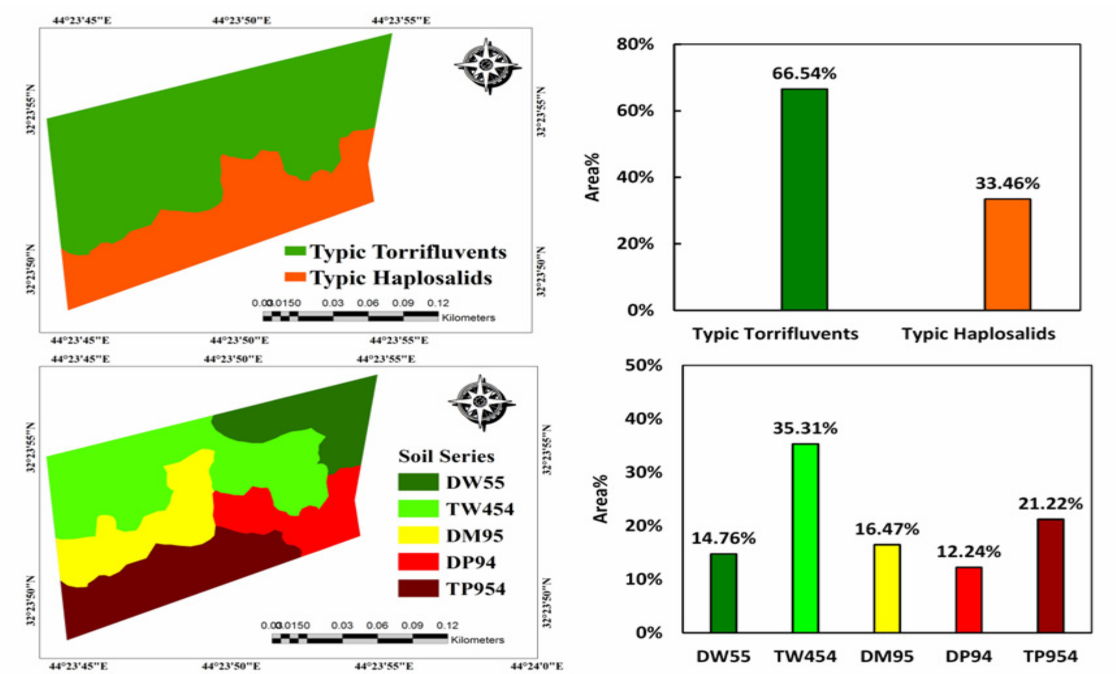

Fig. 3: Soil types' distribution within the study area

2. Spatial Prediction Distribution of Soil Suitability for Wheat Plant

Figure 4 indicates that the ***exponent-model*** was the best in achieving the higher spatial prediction precision about the soil suitability for wheat plant, with a high abstract coefficient reached to ****0.9922**.

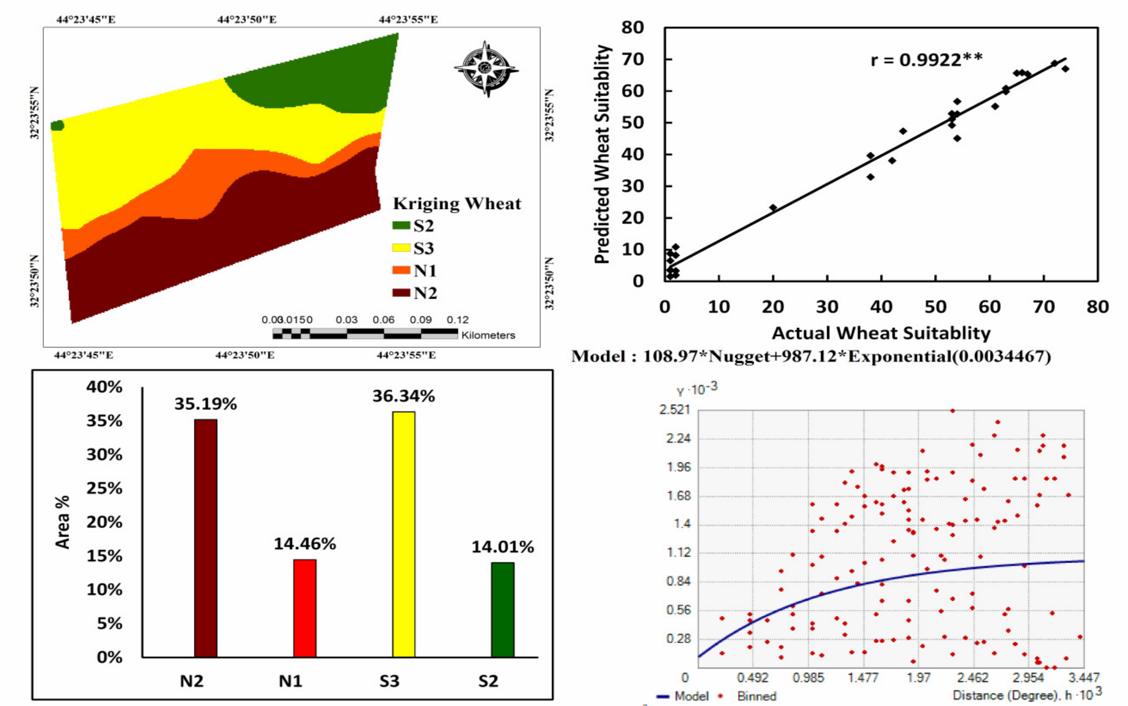

Fig. 4: Spatial distribution of soil types' suitability for wheat plant

The prediction function precision test of soil quality, within the geographical information system programing, is very important for founding a set of solution for the decision-maker to choose the most suitable one, in a procedure of development which is, in terms of geographical information systems application, called Suitability Models, by recommending one of the models to develop plans for one of the environmental qualities (Taha *et al*., 2018).

Furthermore, the exponent spatial prediction function applied in this study, enabled the researchers to evaluate the distribution stereotype of the soil types suitability for wheat plant in the study area, where the increase of saltinity caused soil's organic content detirioration, which eventually caused the absence of S1 type, while S2 type noticably shrinked at the front part of the farm where 41.01% of the land is exploited for cultivation, and 36.34% of the suitablly limited area type S3, with an obvious spatial graduation in ground sloping towards the low land area, where the type N1 reached to 14.46% of the area size, followed by type N2 with 35.19%, extending to the south of the studied area, where the ground is covered with canes, esparto, and halofyte plants.

3. Evaluation of the Abstract Differences between the Soil Serials Suitability for Wheat Plant

Figure 5 below indicates that in respect of wheat plant suitability, chain DW55 outmatched the chains TW454, DM95, DP94, and TP954, where an abstract increase reached to 13.60%, 30.60%, 67.00% and 67.80% successivelly.

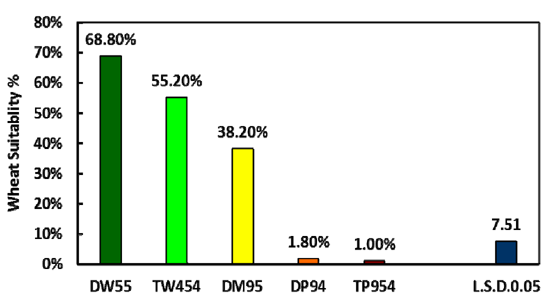

Fig. 5: Evaluation of the abstract differences between the soil serials suitability for wheat plant

Furthermore, in respect of suitability for wheat plant, the chain TW454 outmatched the chains DM95, DP94, and TP954, where an abstract increase reached to 17.00%, 53.40% and 54.20% successively. Meanwhile, chain DM95 outmatched the chains DP94 and TP954, where the abstract-increase was achieved to reach 36.40% and 37.20% successively.

However, such dissimilarity in results would be attributed to the soil chains' interweaving successiveness, which appeared to be the best in chains DW55 and TW454, in addition to the mentioned 2 chains location within the exploited land area, which has had a good interior covered drainage system with less salinity and more organic material content by virtue of the continual cultivation of land, which has a great role in the increasing of soil quality for wheat production. In fact, this agrees with outcomes of Albaji *et al*., (2012), who argued that adopting perfect soil management system would take part in improving the soil's qualities, which can be transferred to other highly suitable types and more acceptable in the agricultural work systems.

Conclusions and Recommendations

To conclude:

- Exponent model adaptation is very important to state the distribution of soil types' suitability for wheat plant in the study area.
- Soil management has positive effect which increases the soil suitability for wheat plant, while its absence may cause the soil-quality deterioration, in particular for the important crop cultivation.

To recommend:

- Carrying-out future test of the prediction model precision when change happens in the farm's soil and water management toward the best.
- Reclaiming the deteriorated parts of the farm land, by supplying a covered or vertical drainage system, with artesian-well of good quality water for irrigation.
- The farm's location and capacities provide the possibility of a promising agricultural station foundation, which would be in favor of the university to take part in the country's sustainable development.

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