Towards a new approach for assessing the hazardous effects of soil salinity and sodicity

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1135. SUMMARYThis study deals mainly with the assessment of salt-affected soils and therole of the clay fraction in such assessment. Two natural soils, extremelydiffering in their texture, were selected from two locations in the:south of Delta,Tukh district i.e. Moshtohor (:,:58% clay) and Meet Kinana (:: 96% sand) todevelop the soil models needed for the study. Soil samples of both locationswere treated with NaCl + CaCh to obtain salinity grades corresponding to BCvalues of 2.75, 4, 8,12,16,20 and 24 d8m-l. Following to SOJil salinization, asodication process was performed using NaOH solution to obtain seven levelsof sodicity corresponding to E8P values of 10, IS, 20, 25, 30,40 and 50,through each of the abovementioned grades of soil salinity. Therefore the threecategories of salt-affected soils i.e, sodic and saline-sodic soils wererepresented through the prepared soil models.The role of the clay fraction on the hazardous effects due to salinityand/or sodicity was evaluated in soil models derived from the aforementionedsoils; by mixing each model derived from one soil, in increasing ratios, with thecorresponding model of the other soil i.e, of the same salinity and sodicitylevels. Accordingly, eight different grades of soil texture having clay contentvalues of 2.32% (81), 7.77% (82), 16.12% (83),24.46% (84),32.82% (85),41.47% (86), 49.52% (87) and 57.98% (88) were obtained through each gradeof salinity (7) or sodicity (7).Moreover, seventy samples representing the naturally saht-affected soils111 E&'Yptwere collected from different locations, adjacent to the bitter lakes inthe east to the Delta and lakes of Manzala, Burullus, Edku and Mariut at Deltanorthern coasts.Both prepared soil models and naturally salt-affected soils were subjectedto the routine analyses; EC, exchangeable cations and CEC as well as ESP andhydraulic conductivity (K).114A greenhouse trial was carried out using both prepared and natural saltaffectedsoil samples as growth media, where barley plants (Giza 123) weregrown for 45 days, thereafter. dry matter yield, as well as plant content anduptake of N, P, K, Na, Ca and Mg were estimated.The obtained data were subjected to statistical analyses and the differentinterrelationships describing the prepared soil models were estaliblished.The validity of soil parameters and equations developed for theassessment of salt-affected soils was evaluated by computing the values ofD.M. yield of barley plants predicted for the naturally salt-affected soils.Significancy of differences were estimated between the values of predicted yield(calculated) and those of actual yield of naturally salt affected soils wereestimated by means of "ANOVA" test.The obtained results can be summarized in the following:1- Soil salinity in relation to soil characteristics and producrivlty:A. Hydraulic conductivity (K):Results of (K) in tested soil models as affected by salinity and clayo~reveal that:1. Values of the relative hydraulic conductivity increased at a rate of about1.70% per each unit of increase in soil salinity above EC 4 dSmwl•2. K values is negatively and significantly (r=-0.913***) affected withincreasing the clay content of soils.3. The combined effect of soil salinity and clay content on K is described bythe equation;K = 9.67 + 0.0559 EC - 6.61 log clay (R = 0.921***)B. Soil pH (in 1:2.5 soil:water suspension):pH values of tested models in relation to soil salinity and clay% revealthe following:1151. Soil pH was significantly (r = -0.706***) reduced as the soil salinityincreased (at a rate of about 0.03 pH unit for each Eee unit above of 4dSm-l.2. Soil pH was significantly (r = -0.587⋯) decreased with increasing the clayfraction%. Each increase of 1.%in the clay content of the soil, above 2.32%,reduced soil pH by:: 0.01 unit.3. The combined effect of the soil salinity and the the clay content on soil pHis represented

by the equation;pH = 8.62 M0.034 EC - 0.0104 clay (R = 0.920***)C. Results of the elemental content of barley plants grown on tested salinemodels showed the following:1. NMcontent of plants decreased with increasing soil salinity at all levels ofsoil salinity except those of ECe 16 and 20 dSm-l, as compared by thecontrol treatment.2. N-content of plants slightly but gradually increased with increasing the soilcontent of clay.3. Pvcontent of plants decreased with increasing soil salinity.4. Clay presence at any level tested, failed to affect clearly the PO..!o of plantsunder the different levels of soil salinity.5. K-content of plants was adversely and gradually affected with increasingsoil salinity. Values of K-content were reduced, on average, from 4.4% to2.5% for the highest level of salinity (EC 24 dSm-I).6. K-content of plants tended to increase steadily, with increasing the claycontent of soil models.7. Na-content of plants was positively affected by increasing soil salinity, butwas progressi vely reduced by increasing the clay content.8. Ca-content of plants consistently increased with increasing soil salinity aswell as with increasing the clay content.9. Mg-content of plants was positively affected by increasing soil salinity tomore than Eee 8 and up to 24 dSm-l, but did not show clear trend due to theincrease in the clay fraction.116D- Results of the elemental uptake by barley plants grown on tested salinemodels reveal the following:1. The total ,uptake of all the -tested elements was high significantly decreasedwith increasing soil salinity due to its adverse effect on dry matter yield.2. The total elemental uptake ,was positively affected by increasing the claycontent according to the following equations:N-uptake = 34.60 + 1.120 clay·P-uptake = 6,11 + 0.216 clayK-uptake = 37.30 + 1.210 clayNa-uptake = 13.90 + 0.185 clayCa-uptake = 14.90 + 0.484 clayMg-uptake = 9.26 + 0.243 clay3. The combined effect of soil salinity and clayuptake can be described by the equations:N-uptake = 83.20 - 3.45 EC + 1.120 clayP-uptake = 21.40 - 1.09 EC + 0.215 clayK-uptake = 116.00 - 5.59 EC + 1.200 clayNa-uptake = 22.20 - 0.596 EC + 0.185 clayCa-uptake = 23.20 - 0.591 EC + 0.484 clayMg-uptake - 11.40 - 0.155 EC + 0.243 clay(r = 0..636***)(r = 0.445**)(r = 0.491***)(r = 0.549***)(r = 0.811 ***)(r = 0.786***)content on total elemental(R = 0.960***)(R = 0.937***)(R = 0.968***)(R = 0.849***)(R == 0.888***)(R = 0.807·**)E- Dry matter yield (D.M.) of barley plants grown on the tested soil modelsshowed the following trends:I. D.M. yield gradually and significantly decreased (by about: 0.13 g/pot) foreach unit of increase in EC more than 4 and up to 24 dSm-1 according to theequation.D.M. yield =4.16 ’- 0.141 EC (r = -0.813 •••)2. The clay fraction soundly decreased the adverse effect due to soil salinity onthe n.M. yield which increased regularly under all the salinity levels, withincreasing soil content of clay as described by the equations:n.M. yield = 1.20 + 0.0338 clay (r = 0530"’)n.M. yield = 3.18 - 0.141 EC + 0.0338 clay (R = 0.970* ••)11- Soil sodicity in relation to soil characteristics and productivity:A. Hyd raulic conductivity (K):Results of the hydraulic conductivity (K) in the tested soil models asaffected by sodicity and clay% reveal that:1. The relative hydraulic conductivity was progressively reduced either as thesoil sodicity or the clay content increased according to the equation;K = 4.45 - 2.54 log clay - 0.0184,ESP (R = 0.862***)B. Soil pH (in 1:2.5 soil:water suspension):pH values of the tested soil models in relation to soil sodicity and clay%showed the following:I. Soil pH significantly (r = 0.877***) increased with increasing soil sodicity(by 0.03 pH unit for each ESP unit), according to the equation;pH = 8.22 + 0.0307 ESP (r = 0.877***)2. The clay fraction significantly (r = -0.427**), but negatively, correlated withsoil pH, at a rate of about 0.011 unit versus each increase of 1% in clay(above 2.32%). This compo sited relation is represented the equation;pH = 8.52 + 0.0307 ESP - 0.0105 clay (R = 0.975···)c. Plant contents of elements showed the following trends:I. The N, P, K, Ca and Mg in barley plants significantly and graduallydecreased, but Na increased with increasing soil sodicity.2. Plant content of N, K, Ca and Mg increased with increasing soil content ofclay, while PO.lo and Na% slightly decreased.3. The combined effect of soil sodicity and clay% on elemental content ofplants can be described by the equations:N% = 2.540 + 0.0106 clay% - 0.0020 ESPPO.lo :: 0.799 - 0.0006 clay% - 0.0046 ESPK% = 3.970 + 0.0090 clay% - 0.0540 ESPNa% = 0.372 - 0.0044 clay% + 0.0439 ESPCa% = 0.786 + 0.0064 clay% - 0.0088 ESPMgOfc) = 0.555 + 0.0010 clay% - 0.0056 ESP(R = 0.621···)(R = 0.663···)(R = 0.973···)(R = 0.995···)(R = 0.946···)(R = 0.826···)IISD- Results of total elemental uptake by barley plants grown on the testedsodic soil models reveal the following:1. Plant Uptake ofN, P, K, Ca and Mg sharply decreased with increasing soilsodicity, while Na-uptake significantly increased as the soil sodicityincreased.2. Elemental uptake of barley plant was positively affected with increasing theclay content.3. The combined effect due to the soil sodicity (ESP) and clay content (0/0) onelemental uptake is repesented by these equations;Nsuptake = 78.70 - 1.040 ESP + 1.290 clayP-uptake = 21.60 - 0.296 ESP + 0.231 clayK-uptake = 111.00 - 2.230 ESP + 1.300 clayNa-uptake = 5.29 + 0.896 ESP + 0.395 clayCa-uptake - 22.20 - 0.441 ESP + 0.466 clayMg-uptake - 15.70 - 0.275 ESP + 0.187 clay(R = 0.989***)(R = 0.926·**)(R = 0.983***)(R = 0.846***)(R = 0.973***)(R = 0.933-*-)E. Dry matter yield (D.M.):Results of D.M.' yield of barley plants grown on sadie soil modelsshowed the following trends:1. D.M. yield was significantly (r = -0.478**) reduced with increasing soilsodicity, at rate of about 0.03 g/pot for each ESP unit. The relationshipbetween D.M. yield and soil sodicity is described by this equation:D.M. yield = 3.77 - 0.0262 ESP .(r = -0.478**)2. The clay fraction presence diluted the adverse effect of soil sodicity onn.M. yield of barley plants and consequently increased regularly this yield.at a significantly (r = 0.858·_·) increased with increasing the clay content,at a rate of about 37 mg/pot for each 1% of the clay content.3. The relationship between D.M. yield and the clay content is.described bythe equation:D.M. yield = 1.96 + 0.0374 clay (r = 0.858*·*)4. The composited relation ofD.M. yield with ESP and clay% lisrepresentedby the equation:D.M. yield = 2.68 - 0.0262 ESP + 0.0374 clay (R = 0.983***)119III- Combined effect of soil salinity and sodicity of soils on theircharacteristics and productivity;A. Hydraulic conductivity (K):The obtained trends for hydraulic conductivity under saline-sodicconditions are swnmarized in the following:1. Values of the relative hydraulic conductivity were increased at a rate ofabout 1.03% per each unit of increase in soil salinity above EC 4 dSm"l.2. Relative hydraulic conductivity values decreased with increasing soilsodicity, but increased with increasing soil salinity.3. Relative hydraulic conductivity values gradually decreased with increasingthe soil content of clay and the levels of soil sodicity as well, but tended toincrease with increasing soil salinity under the tested levels of ESP andclay%.4. The net combined effect due to soil salinity (EC), soil sodicity and claycontent on hydraulic conductivity (K) is expressed by the equation;K = 7.12 + 0.0749 EC ~0.0165 ESP ~4.90 log clay (R = 0.874***)B. Soil pH (in 1:2.5 soil:water suspension):The following trends for soil pH under saline-sodic conditions wereobvious:1. The soil pH negatively correlated with soil salinity, at a rate of about 0.04pH unit reduction per each unit of increase in EC above 4 dSm". The soilsodicity increased the soil pH at a rate of about 0.03 pH unit versus eachESP unit above 15.2. Soil pH decreased, on average, (from 8.81 to 8.17) with increasing the claycontent of the soil from 2.32 up to 57.98%.3. The combined effect of soil salinity, soil sodicity and clay content on soilpH is described by the equation:pH = 9.23 ~0.0462 EC + 0.0054 ESP - 0.0109 clay (R = 0.638***)c. Elemental content of barley plant:The following trends of elemental content of barley plants. under salinesodic1. N, P and K contents decreased with increasing soil salinity under all theESP levels, while N-content at EC 16 and 20 dSm- increased. Na, Ca andMg contents increased as the soil salinity increased, but the rate of increasein Ca and Mg was slight, under all the ESP levels.2. Plant content ofN, P, K, Ca and Mg was adversely affected with increasingsoil sodicity, while Na-content was progressively increased under all thelevels of soil salinity.3. N, K, Ca and Mg contents of plants were positively affected" while Na+%was negatively affected as the soil content of clay increased. P~Vc>showed noclear trend due to increasing the clay fraction content in soil.D. Total elemental uptake by barley plants:Results of total elemental uptake by barley plants grown on saline-sodicsoils reveal the following:1. Uptake of N, P, K, Na, Ca and Mg by plants was significantly reduced asthe soil salinity increased at different levels of ESP.2. Uptake of N, P, Kj Ca and Mg soundly decreased with increasing soilsodicity, while Na-uptake was incraesed.3. Uptake of N, P, K, Na, Ca and Mg significantly increased as the claycontent increased.4. The combined effect of soil salinity, soil sodicity and the clay content of thetested soil models on plant uptake ofN, P, K, Na, Ca and Mg is describedby the equations:N-uptake = 64.40 - 4.30 EC + 0.1590 ESP + ~.02 clayP-uptake = 18.00 - 1.10 EC + 0.0703 ESP + 0.186 clayK-uptake = 69.70 - 4.29 EC + 0.2570 ESP + 1.06 clayNa-uptake = 46.30 - 2.58 EC + 0.3040 ESP + 0.427 clayCa-uptake = 13.20 - 0.758 EC + 0.0908 ESP + 0.309 clayMg-uptake = 9.38 - 0.427 Ee + 0.0344 ESP + 0.200 clayE- Dry matter yield (D.M.):Results of the D.M. yield of barley plants grown on saline-sodic soilmodels showed the following trends:1. D.M. yield of tested soil models was decreased by about 0.12 g/pot for eachunit (Ee) of increase in soil salinity 2. D.M. yield decreased with increasing soil sodicity at different levels of soilsalinity, at a rate of 0.016 g/pot for each unit of increase in ESP above 20.3. D.M. yield significantly increased with increasing the clay content, the rateof the increase was about 0.03 glpot per each 1% of clay.4. The net effect of soil salinity, soil sodicity and the clay content of the testedsoil models on D.M. yield is expressed by this equation:D.M. yield = 2.45 - 0.144 Ee + 0.0137 ESP + 0.0295 clay (R:::; 0.952***)Finally, it should be referreing that this investigation represent apreliminary study only restricted to the conditions prevailing in soils of ”Delta”in Egypt and barley (var. Giza 123) as an indicator plant. However, it could beprofitable for assessment the salt affected soils under other conditions and othercrops by developing specific new equations, in the same way that could be moresutiable for such conditions.