Effect of plant spacing and nitrogen fertilizer rates on yield and quality of flax plant

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The present study aims to evaluate the land suitability of some physiographic units in North Sinai for irrigated agriculture. The studied area is located south of El-Bardawil Lake between longitudes 32° 38 and 33° 40-east and latitudes 30° 50- and 31° 15- north, and covers an area of about 504657 feddans. Climatic data indicated a torric or aridic soil moisture regime and thermic soil temperature regime. Also, interpretation and analysis of thematic mapper (TM) landsat images covering the studied area led to identify four physiographic units, as follows:a)High dunes occupy the upper and southernmost part, with undulating to rolling topography and few to common natural vegetation.b)Low dunes occupy a considerable portion between the high dunes in the south and El-Bardawil Lake in the north, with gently undulating to undulating topography and dense cover of natural vegetation.c)Sabkhas occupy discontinuous patches in the lowermost parts of the low dunes, with almost flat topography, thin salt crust and lack any natural vegetation.d)Coastal sand beach occupies a narrow strip of land parallel to shore line of the Mediterranean Sea, withalmost flat topography, few to common shell fragments and none natural vegetation.Eighteen soil profiles were dug to a depth of 150cm, to represent soils developed on the different physiographic units, and morphologically described. Forty one soil samples, representing the different layers and horizons of all soil profiles, as well as samples of both ground water and irrigation water were collected for the different laboratory analyses.Field studies and laboratory analyses led to the following results:a) High dunes: Their soils are characterized by very pale brown or pale brown colours, single grains of loose sand, slightly to strongly alkaline (pH 7.67-8.54), none or very slightly saline (EC 0.48-3.37 dS/m), soluble cations dominated by Ca++ followed by Mg++ and/or Na+ and the least dominant cation is K+, vs. soluble anions of SO4- and/or CF followed by HCO3- and SAR values were low. Soil contents of gypsum, organic matter and calcium carbonates were very low, where their values were 0.09-1.69%, 0.00-0.14% and 0.59-1.90%, respectively. Soil texture is sand, since the mechanical fractions were 95.49-99.04%, 0.00-0.48% and 0.78-4.36% for sand, silt and clay, respectively. CEC values ranged from 1.73 to 4.93 cmolckg-I soil, exchangeable Ca++ and/or Mg++ were the dominantcations, followed by Na+ and K. ESP values ranged from 3.5 to 11.35, which indicate no sodicity.b)Low dunes: Their soils are characterized by very pale brown or yellowish brown colours, single grains of loose fine sand, slightly or moderately alkaline (pH 7.52-8.32), none or very slightly saline (EC 0.58-3.64 dS/m). Ca++ was the dominant soluble cation, followed by Mg++ and/or Na+ and the least one was K+ vs. soluble anions dominated by Cl- and/or SO4- followed by HCO3-. SAR values were low. Contents of gypsum, organic matter and calcium carbonates were low, where their values were 0.11-4.78%, 0.00-0.18% and 0.4-4.0%, respectively. Soil texture is fine sand, where the soil mechanical fractions of sand, silt and clay were 95.85-98.64%, 0.01-1.75% and 0.98-3.52%, respectively. CEC values ranged from 1.76 to 4.94 cmolckg-I soil, dominated by Ca++ and/or Mg++, followed by Na+ and K. ESP values ranged from 5.68 to 13.22, which indicate no sodicity.c)Sabkhas: Their soils are characterized by light yellowish brown, yellowish brown or pale brown colours in topsoil and upper parts of subsoil, while lower parts and substratum had gray, black, light brownish gray or white colours due to the effects of shallow to moderately deep (35-100cm) saline water table (EC 46.7-100.6 dS/m). Soils were neutral to strongly alkaline (pH 7.14-8.58), very strongly orextremely saline (EC 36.0-103.9 dS/m). Na+ was the

dominant soluble cation followed by Mg++ and Ca++, while K+ was the least one. Cl- dominated the soluble anions followed by SO4-, while HCO3- and CO3- were the least ones. SAR values ranged from 40.79 to 202.14. Soil contents of gypsum, organic matter and CaCO3 were 2.32-53.07%, 0.07-1.54% and 0.36-9.20%, respectively. Soil texture is fine sand in the topsoil and subsoil overlain sandy clay loam, clay loam, coarse sandy loam, loamy sand or loamy fine sand. As for the sand texture, soil mechanical fractions were 91.90-98.95%, 0.05-2.83% and 1.00-5.27% for sand, silt and clay, respectively, while their values for the other textures were 59.65-82.10%, 7.95-17.00% and 8.88-23.35%, respectively. CEC values ranged from 2.42 to 14.21 cmolckg-1 soil. Mg++ dominated the exchangeable cations, followed by Ca++, Na+ and K+. ESP values ranged from 4.49 to 20.58, where the highest value was recorded in the soils of the southern west portion, which indicate sodicity.d) Coastal sand beach: Its soils are characterized by very pale brown layers stratified with black or gray ones, single grains of loose fine sand with few shell fragments throughout the soil profile. Soils were moderately alkaline (pH 8.19-8.24) and slightly to strongly saline (EC 5.97-17.10 dS/m). Na+ dominated the soluble cations followed by Mg++ and Ca++, while K+ was the least dominant one. Cl- dominated thesoluble anions followed by SO4, while HCO3” was the least dominant one. SAR values ranged from 18.14-41.68. Soil contents of gypsum, organic matter and calcium carbonates were 0.10-0.15%, 0.01-0.02% and 0.80-1.04%, respectively. Soil texture is fine sand, where soil mechanical fractions constitute 99.55-99.80%, 0.10-0.15% and 0.10-0.35% for sand, silt and clay, respectively. CEC values ranged from 1.17 to 2.16 cmolckg-1 soil, with a dominant CC, followed by Mg++ and Na+, while K+ was the least exchangeable cation. ESP values ranged from 10.77 to 14.53, which indicate no sodicity.e) Sand mineralogy:The microscopic investigation using polarized light indicated that quartz was dominant, with amount ranged from 81.28 to 96.94% of the light minerals. Feldspars constituted the rest, where orthoclase and plagioclase were the principal members, while microcline represented the least content. The higher amount of quartz indicates its resistance to weathering, whereas presence of a considerable amount of feldspars reveals that the studied soils are still young. Heavy minerals constituted 0.44 to 22.71% of the light minerals (as expressed by the index figure) for soils of the high dunes, low dunes and sabkhas, whereas those of the coastal sand beach constituted 220.81-3672.49% of the light minerals. The obtained results indicatedthat opaques were the most abundant heavy minerals. Non-opaque minerals were dominated by pyroxenes and amphiboles (pyroboles) that are extremely unstable minerals, followed by slightly stable minerals of garnet and epidote and very stable minerals of zircon, rutile and tourmaline. Other minerals such as kyanite, staurolite, andalusite, sillimanite, biotite,monazite, glauconite, apatite and ziosite were presented in less pronounced amounts or absent entirely.f)Soil uniformity and development:Regarding soil profile uniformity and development, data reveal that the studied soils are heterogeneous, may be due to that they are formed under multi-origin and/or multi-depositional regimes. Values ofweathering ratios indicate that soils under consideration are still young from the pedological point of view. It is worthy to mention that data of sand mineralogy are used to classify the soils at the family level, whether it is siliceous or mixed.g)Factors and processes of soil formation:The obtained data of soil properties indicate that climate, parent material and relief, as main soil forming factors, have an effective role on formation of the studied soils, whereas living organisms and time have less effect. In addition, formation of salic and gypsichorizons in soils of the sabkhas is a result of forming processes of saline soils. Upper movement of saline water table by capillary rise and evaporation has caused salt accumulation, and then formation of salic and gypsic horizons. Gleization is another process observed in soils of the sabkhas as a result of ground water table fluctuation, and the susceptibility of soils to oxidation—reduction (redox) processes. Under such conditions of oxygen lack, microorganisms use the oxygen of oxidized components for their metabolism, then reduction processes of both iron and manganese oxides give the soil its grey, green, blue or white colours.h) Soil classification:According to Soil Taxonomy System undertaken by Soil Survey Staff (1975 and 1999), soils of the studied area could be classified into two orders (Aridisols and Entisols), three suborders (Salids, Gypsids and Psamments), three great groups (Aquisalids, Haplogypsids and Torripsamments), three subgroups (Gypsic Aquisalids, Leptic Haplogypsids and Typic Torripsamments) and six soil families. Four of which, in soils of the sabkhas, belong to Aridisols, as follows:1)Gypsic Aquisalids, sandy, mixed, thermic,2)Gypsic Aquisalids, sandy, gypsic, thermic, 3)Gypsic Aquisalids, sandy over fine loamy, mixed, thermic,4)Leptic Haplogypsids, sandy, mixed, thermic, and Two soil families belong to Entisols, as follows:1)Typic Torripsamments, siliceous, thermic, for all soils of the high and low dunes, and2)Typic Torripsamments, mixed, thermic, for soils of the coastal sand beach.i) Land evaluation:Current and potential suitability of the studied soils for irrigated agriculture were assessed according to the system of Sys and Verheye (1978), modified by Sys et al. (1991) on the basis of FAO (1976). Soils could be classified currently into two orders [suitable (S) and not suitable (N)], two classes [marginally suitable (S3) and currently not suitable (N1)] and four subclasses asfollows:1)S3ts: Marginally suitable with a very severe intensity of texture, a moderate intensity of topography and slight intensity of calcium carbonate and gypsum limitations. This subclass comprises soils of the high dunes, with an area of about 345019 feddans.2)S3s: Marginally suitable with a severe intensity of texture and slight intensity of topography andgypsum limitations. It represents soils of the low dunes, with an area of about 105750 feddans.3)Nlwsn: Not suitable with severe intensity of wetness and texture and moderate intensity of gypsum, salinity and alkalinity limitations. It represents soils of the sabkhas, with an area of about 46098 feddans.4)Nlws: not suitable with a very severe intensity of texture, a moderate intensity of wetness and slight intensity of gypsum, salinity and alkalinity limitations. It represents soils of the coastal sand beach, with an area of about 7790 feddans.Potential suitability was identified after required land improvements have to be completed, i.e. leveling of undulating surfaces of the high and low dunes, removing salinity and alkalinity in soils of the sabkhas and coastal sand beach under an efficient drainage system to drain or to lower the saline ground water table and the required leaching water. In addition, application of chemical and organic fertilizers, green manures and soil conditioners to increase the soil fertility and to improve the physical and chemical soil properties, as well as modern irrigation systems, to save irrigation water and to prevent the formation or rise of ground water table. Construction of natural and/or artificial windbreaks is necessary to avoid or to reduce the effects of wind erosion and deposition.Therefore, potential suitability of the studied soils could be distinguished into two orders (S and N), two classes (S3 and N1), two subclasses (S3s and N1 ws) and four units (S3s-1, S3s-2, Nlws-1 and N1ws-2). These units could be summarized as follows:1)S3s-1: It is represented by soils of the high dunes with a very severe intensity of texture and slight intensity of topography, calcium carbonate and gypsum limitations.2)S3s-2: It is represented by soils of the low dunes with a severe intensity of texture and a slight intensity of gypsum limitations.3)Nlws-1: It is represented by soils of the sabkhas with a severe intensity of texture, moderate intensity of wetness and gypsum and slight intensity of salinity and alkalinity limitations.4)Nlws-2: It is represented by soils of the coastal sand beach with a very severe intensity of texture, a moderate intensity of wetness and slight intensity of gypsum, salinity and alkalinity limitations.j) Irrigation water quality:Water of El-Salam canal was evaluated for irrigation according to Ayers and Westcot (1976), who classified water quality into 3 classes (class 1, class 2 and class 3), as follows:1)EC of irrigation water ranged from 1.188 to 1.610 dS/m, which indicate increasing problem of salinity (class 2).2)Adj. SAR (8.7-14.4) indicates class 2 or 3, but it can't affect soil permeability due to sand texture of the studied soils.3)Boron content (0.09-0.11 mg1-1) indicates class 1 (no toxicity).4)Sodium content (6.66-12.40 mmolc1-1) indicates class 2.5)Chloride content (6.56-8.96 mmolc1-1) indicates class 26)Bicarbonate content (3.24-3.60 mmolc1-1) indicates class 2.7)Values of pH (7.97-8.14) indicate class 1, since they fall within the normal range.k) Land suitability for specific crops:Potential suitability of the studied soils for 24 crops could be evaluated according to Sys et al. (1993), after achieving aforementioned land improvements. Crops are arranged in a descending order according to their corrected land indexes as follows:LLL1) Low dunes:*Highly suitable (Si) for citrus, mango, olives, cabbage, carrots, green pepper, onion and watermelon.•Moderately suitable (S2) for maize, groundnuts, sesame, sunflower, alfalfa, cowpea, pea, potato, sweet potato, tomato, sorghum, beans, guava and soya.•Marginally suitable (S3) for barley and wheat.2) High dunes:*Moderately suitable (S2) for citrus, carrots, green pepper, watermelon, olives, mango, cabbage, onion, guava, maize, groundnuts, sesame, sunflower, alfalfa, cowpea, pea, sweet potato, tomato, sorghum and beans.* Marginally suitable (S3) for soya, potato, barley and wheat.3) Sabkhas:*Moderately suitable (S2) for olives.*Marginally suitable (S3) for watermelon and potato.•Not suitable (Ni) for barley, sunflower, alfalfa,sorghum, cabbage, sweet potato, maize, groundnuts, sesame, tomato, guava, wheat, pea, cowpea, greenpepper, soya, onion, carrots, mango, citrus and beans.4) Coastal sand beach:* Marginally suitable (S3) for sorghum, sesame, soya, alfalfa, tomato, watermelon and sunflower.* Not suitable (Ni) for green pepper, maize, barley, pea, cowpea, potato, sweet potato, olives, cabbage, wheat, mango, carrots, beans, guava, groundnuts, citrus and onion.from the economic point of view, highly suitable (Si) and moderately suitable (S2) crops are only recommended to be cultivated.