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Management of Calcareous Soils in Arid Region

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Abstract: Calcareous soils are soils rich of calcium carbonate which occur mainly in the arid and semi-arid subtropics of both hemispheres. The diagnostic horizon in the calcareous soil is the calcic horizon which contains more than 15% $CaCO_3$ and has a depth of more than 15cm thick. Potential productivity of calcareous soils is relatively high where adequate water and nutrients can be supplied. Crusting of the surface may affect not only infiltration and soil aeration but also the emergence of seedlings. Cemented conditions of the subsoil layers may hamper root development and water movement characteristics.
Calcareous soils tend to be low in organic matter and available nitrogen. The high pH level results in unavailability of phosphate (formation of unavailable calcium phosphates as apatite) and usually reduced micronutrient availability, iron and zinc e.g. (lime induced chlorosis). There may be also problems of potassium and magnesium nutrition as a result of the nutritional imbalance between these elements and calcium.
Keywords: Calcium carbonate, calcareous soil

INTRODUCTION

As the Egyptian population continues to increase, it is necessary to increase land reclamation to close the gap between agriculture production and food demand. Since the early fifties, Egyptian population increased by more than 150% without a relevant increase of cultivated area in Egypt, which is till 7.5 million feddans. This implies necessity of vertical and horizontal development of agriculture production. The area of the old land is already used. There is need for expanding the cultivated area to surrounding desert having mainly calcareous soils. The range of $CaCO_3$ content in alluvial soils of the Nile Valley and Delta varies from 1 to 3%. The main soils with medium to high $CaCO_3$ content (3 to 30%) are those that border the fringe zone of Nile Valley. Beyond the fringe zone of the Nile Valley and Delta eastwards and westwards the $CaCO_3$ content in soils increase to range of 30 to 80%. Crop production in such soils is limited due to: firstly, the high $CaCO_3$ content and its effect on lowering soil fertility and nutrient availability, secondly, soil crusting formation and its effect on seedling emergent and crop stand and thirdly the low available moisture range. Therefore it was necessary to study factors that lead to increase water and nutrients holding of these soils such as, cultivating methods, fertilization, micronutrients application, organic manure and the farm residues application, types of machinery, method of irrigation, the suitable crops and other management practices were suggested to turn raising the productivity of these soils.

DEFINITION AND DISTRIBUTION OF CALCAREOUS SOILS

The terms calcareous, calcisols and/or calcids are expression to describe the soil rich in calcium carbonates or calcium and magnesium carbonated. A calcareous soil is a soil that has free calcium carbonate ($CaCO_3$) in the profile, i.e. contains enough $CaCO_3$ so that it effervesces when treated with hydrochloric acid. When free carbonates are present, the acid will produce bubbling due to the evolving of CO_2 gas as mention in reaction.

$$CaCO_3 + 2H^+ \rightarrow Ca^{2+} + CO_2\uparrow + H_2O$$

Hagin and Tucker [1] defined calcareous soil as a soil that its extractable Ca and Mg levels exceed the cation exchange capacity. In the context of agricultural problem soils, calcareous soils are soils in which a high amount of calcium carbonate dominates the problems related to agricultural land use. From plant nutrition point of view [2] found that an abrupt decrease in the uptake of iron and phosphorus has occurred at 8% $CaCO_3$, which they considered it as the margin at which the soil could be called calcareous.

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According to the Soil Taxonomy [3] calcareous soil are characterized by the presence of calcium carbonate in the parent material and/or by a calcic horizon. It is a horizon of accumulation of calcium carbonate or of calcium and magnesium carbonate. The accumulation may be in the C horizon, but it may also be in variety of other horizons. This form of calcic horizon includes secondary carbonate enrichment that are 15 cm or more thick, have a carbonate content equivalent to 15 percent or more $CaCO_3$, and have $CaCO_3$ equivalent at least 5 percent greater than the C horizon. The secondary carbonates occur as pendants on pebbles, as concretions, or as soft powdery forms. If this calcic horizon rests on limestone, marl, or other very highly calcareous materials (40 percent or more $CaCO_3$ equivalent), the percentage of carbonates need not decrease with depth.

Table 1. Distribution of different types of soils in the world. (Extent 10^3 ha)

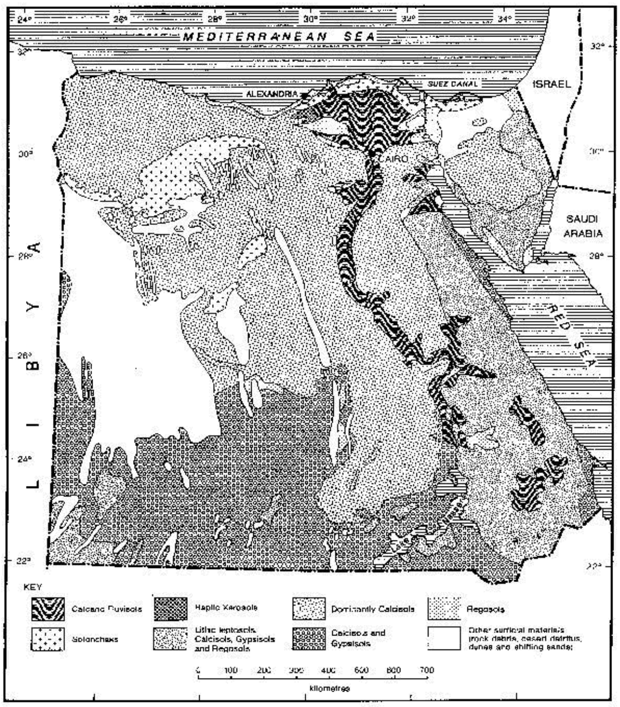
Soil Types	Africa	Australia	Europe	North America	North Asia	South America	South and Asia	Total
Acrisols	92728	32482	4170	114813	148241	341161	263005	996600
Arenosols	462401	193233	3806	25512	3436	118967	94530	901885
Calcisols	171237	113905	56657	114720	95264	24318	220068	796169
Ferralsols	319247	0	0	0	0	423353	0	742600
Histosols	12270	1167	32824	93462	99451	9245	24829	273248
Leptosols	381531	48789	64836	83303	710863	246588	48789	1655318
Podzols	11331	8459	213624	220770	21825	5522	5982	487513
Solonchaks	48574	16565	2308	127	46895	24344	48512	187325
Solonetz	13800	38099	7906	10748	30062	34652	0	135267
Vertisols	106126	90019	5856	9120	11797	38076	76328	337322

Regarding the distribution of calcareous soils [4] mentioned that they cover more than 30% of the earth surface, and their $CaCO_3$ content varies from a few percent to 95%, mainly concentrated in arid and semi arid condition such as in the Mediterranean region (Table1). However, the total area of calcareous soils is difficult to estimate because many calcisols occurs together with solonchaks that are actually stalinized calcisols and/or with other soils of carbonate enrichment that do not key out as calcisols. In Egypt, [5] stated that the calcareous soils occupy about 0.65 million acres as they formed along the Mediterranean littoral of the northern part of the Western Desert. Other areas are covered with calcareous soils as in Eastern Desert and Sinai, (Map1 and Table2).

Table 2. The areas of calcareous soils in Egypt.

Major soil associations	Area	
	km^2	% land area
Calcaric fluvisols	5771	6.03
Calcic	32 335	33.76
Haplic	1321	1.38
Calcaric	628	0.66
Lithic leptosols	720	0.75

Map 1. Distribution of calcareous soils in Egypt



OCCURRENCE OF CALCAREOUS SOILS

Brady and Weil [6] demonstrated that calcareous soils occur naturally in arid and semi-arid regions because of relatively little leaching. They also occur in humid and semiarid zones if their parent material is rich in $CaCO_3$, such as limestone, shells or calcareous glacial tills, and the parent material is relatively young and has undergone little weathering. Some soils that develop from calcareous parent materials can be calcareous throughout their profile. This will generally occur in the arid regions where precipitation is scarce. In other soils, $CaCO_3$ has been leached from the upper horizons, and accumulated in B or C horizons. These lower $CaCO_3$ layers can be brought to the surface after deep soil cultivation. In some soils, the $CaCO_3$ deposits are concentrated into layers that may be very hard and impermeable to water. These caliche layers are formed by rainfall leaching the salts to a particular depth in the soil at which water content is so low that carbonates precipitate. They also added that soils can also become calcareous through long period of irrigation with water containing dissolved $CaCO_3$. A major characteristic of calcareous soils is that they develop in regions of low rainfall and must be irrigated to be productive. Marginal desert soils, with low content of organic matter and high concentration of $CaCO_3$, can be of high agricultural value by supplying the nutrients in the soil solution through drip irrigation.

MAIN PRODUCTION CONSTRAINTS OF CALCAREOUS SOIL

Pearce *et al.* [7] mentioned that calcareous soils develop in regions of low rainfall and must be irrigated to be productive. Therefore one of the main production constraints is the availability of water for irrigation. The quality of the irrigation water is of crucial importance for sustainable agricultural production on calcareous soils. Frequently, the irrigation water is the cause of many management problems. Almost all waters used for irrigation contain inorganic salts in solution. These salts may accumulate within the soil profile to such concentrations that they modify the soil structure, decrease the soil permeability to water, and seriously injure plant growth. Another basic problem was that of surface crusting. It is known that the organic matter content of these soils is not more than 0.4% and it is usually much less than this. Before putting these soils under irrigation for the first time they possess apparent good physical conditions, but as soon as they are irrigated chemical changes occur. Solution of carbonates to bicarbonates and the precipitation of the latter upon drying assist in the formation of a hard surface crust which is also affected by the texture and the dominance of other salts beside the CaCO3. In the presence of Na salts the formation of the crust is not so obvious and it breaks off easily. It is thickness may very from a few centimeters to more than 20 cm in some cases. Since crusting of the surface may affect not only infiltration and soil aeration but also the emergence of seedlings. Cemented conditions of the subsoil layers may hamper root development and water movement characteristics. Calcareous soils tend to be low in organic matter and available nitrogen. The high pH level results in unavailability of phosphate (formation of unavailable calcium phosphates as apatite) and sometimes reduced micronutrient availability, e.g. zinc and iron (lime induced chlorosis). There may be also problems of potassium and magnesium nutrition as a result of the nutritional imbalance between these elements and calcium. Reported symptoms of improper nutrition in calcareous soils are chlorosis and stunted growth. This is attributed to the high pH and reduced nutrient availability. Marschner [4] found that improved nutritional management is required to grow crops successfully on calcareous soils. Fertilizer management on calcareous soils differs from that on non-calcareous soils because of the effect of soil pH on soil nutrient availability and chemical reactions that affect the loss or fixation of some nutrients. The presence of $CaCO_3$ directly or indirectly affects the chemistry and availability of nitrogen, phosphorus, magnesium, potassium, manganese, zinc, copper and iron. Brady and Weil [6] reported that nitrogen fertilizers should be incorporated into calcareous soils to prevent ammonium-N volatilization. The high levels of calcium and magnesium that are associated with carbonates reduce the availability of phosphorus and molybdenum. In addition, iron, boron, zinc, and manganese deficiencies are common in soils that have a high $CaCO_3$ due to reduced solubility at alkaline pH values.

MANAGEMENT OF CALCAREOUS SOILS

Macronutrients

Nutrient management in calcareous soils differs from that in non-calcareous soils because of the effect of soil pH on soil nutrient availability and chemical reactions that loss or fixation of almost all nutrients.

Nitrogen

The alkaline pH values found in calcareous soils affect the rates of N transformations, which in turn can influence the efficiency of N use by plants. Ammonia volatilization is the loss of N to the atmosphere through conversion of NH_4^+ to ammonia gas (NH_3). Proper management of N fertilizer in calcareous soils involves practices that minimize its loss through ammonia volatilization.

Several experiments and practices have been carried out to overcome the problem of nitrogen deficiency in the calcareous soils, [8] concluded that in calcareous soils inoculation by Azotobacter or Bradyrhizobium markedly enhanced all the measured yield components for maize and cowpea compared to uninoculated crops as well as nitrogen uptake by plants was increased. Estefanous *et al.* [9] added that microbial counts, phosphate-dissolving bacterial (PDF) activity in the soil, as well as N, P and K availability, were enhanced by sawdust compost and (PDF). He *et al.* [10] applied another way in India to overcome the leaching of nitrate NO_3^- below the root zone and gaseous losses of nitrogen N such as ammonia NH_3 volatilization, are major mechanism of N loss from agricultural soil. They interfused new techniques to minimize production costs and the risk of potential N contamination of ground and surface water. They found that amendment of zeolite or plus organic materials such as cellulose has great potential in reducing fertilizer N loss in calcareous soils. Reda [11] revealed that inoculation with Azotobacter and Mycorrhizal accompanied by organic manure could save 50% of N and 25% of P-mineral fertilizers.

An experiment was conducted in Burg El-Arab by [12] on olive trees to study the combined effect of sewage sludge and ammonium sulfate fertilizer application on yield and fruit quality of olive trees grown on calcareous soil. All sewage sludge levels resulted in increased fruit weight and volume. Progressive increase on fruit yield and quality parallel to nitrate applied up to 600g N/tree were recorded.

Phosphorus

Phosphorus availability in calcareous soils is usually restricted. Maximum availability to plants of both native and applied P is in the pH range of 6.0 to 7.5. At higher pH values, phosphate anions react with Ca and Mg to form phosphate compounds of limited solubility [13].

Recently, many investigators have used Rizobium, Mycorrhizal inoculation, lately, foliar application of phosphate fertilization with farmyard manure (FYM). To increase plant growth in calcareous soil, [14] stated that applied foliar spraying of 200-liter/fed super-phosphate supernatant with

Rhizobium inoculation increased soybean yield in calcareous soils. In this respect, [15] concluded that inoculation by Mycorrhizal or phosphate-dissolving bacteria increased P-supply, which led to improve P uptake by maize or cowpea plants for calcareous and sandy soils. Also [16] evaluated the effects of farmyard manure and super phosphate on sesame in calcareous soils in Assiut Government. The combined application of both fertilizers enhanced the growth and yield of sesame more effectively than when these fertilizers were applied individually. As reported by [17] the inoculation with phosphate-solubilizing bacteria, organic manure and phosphate fertilization on peanuts grown on sandy calcareous soil, revealed that shoot and pod yields, and N, P and K contents in shoots were highest in inoculated plants with 50 or 100 Kg P and farmyard manure. Koreish [18] concluded that a highly response of faba bean or wheat plants to mixed inoculation (Mycorrhizal, phosphate dissolving bacteria and Rhizobium or Azotobacter) was observed to be higher than that for single inoculation for two tested types (sandy and calcareous soils).

On the other hand, [19] the researchers found that compost (M) and chemical fertilizers (F) confirmed calcareous soil treatments in P accumulation in deep soil, but total P in the surface layer with compost was much lower than fertilizer treatment. It was concluded that the reduction of pH due to application of compost mainly contributed to P transformation and release in calcareous soil.

Wahba et al. [20] have conducted a recent investigation on the availability of phosphorus in calcareous soils. Their experimental results show that adding 5 to 10% of the compost for 96 to 120 days was very favorable in enhancing the availability of phosphorus in the soil. Also, mixing the calcareous soil with 2% elemental sulfur was very beneficial. Enter the new round of ammonium zeolite to be combined with the calcareous samples at a rate of 20 g / kg of soil collected in a high proportion of phosphorus available for 60, 96 and 120 days of treatments.

Potassium

Potassium is an essential nutrient for enzyme activation, affecting most of the biochemical and physiological processes that influence plant growth and crop productivity and also performs several functions that affect the quality, of agricultural products. Plants require quite large amounts of K and therefore, providing crops with sufficient K are essential to obtain higher yields and better quality especially in calcareous soil. Field and greenhouse experiments were conducted by [21] to measure the crop response to K of apple trees and lettuce. In the field experiment fertilizers and zeolites were added through irrigation water (fertigation), while in the greenhouse experiment, they were added directly to the soil before planting. Overall, K had a positive effect on plant growth, yield, water use efficiency and quality. On the other hand, [22] pointed out that the calcareous soil which received aerobic compost (sugar beet residues) contained organic matter higher than those received anaerobic. The uptake of nitrogen, phosphorus and potassium by plants was improved by increasing the dose of application and the best rate was found to be 4% of compost.

Micronutrients

In general, newly reclaimed soils of Egypt contain low available micronutrients and scarcity of organic matter, where most of these soils are calcareous and sandy texture. Since micronutrients deficiency, especially Fe and Zn is commonly known, beside lowering organic matter below the critical level, leaching of nutrients and exhaustion of nutrients through removal by crops influence the availability of these elements of plants. The availability of Fe and Zn in calcareous soil was increased as a result of town refuse addition to the newly reclaimed soils [23]. On the other hand calcareous soils may contain high levels of total Fe, but in unavailable forms to plant. Visible Fe deficiency, or Fe chlorosis, is common in many crops. In this respect, [24] suggested that foliar sprays with Fe could help to avoid fruit quality losses caused by Fe chlorosis in citrus orchards. Liu et al. [25] applied two explosive-producing bacteria: Peauibacillus illinoisensis (YZ29) and Bacillus sp. (DZ13). On the other hand, Also, mention [26] that siderophors bacteria producing bacteria and iron sulfate with bio-charcoal, can be an effective way to improve plant growth. Ramzani et al. [27] concluded that the combination of iron and biocar use could be an effective approach to improving the growth of grains and the biological fertilization of wheat. Ipek et al. [28]. Their studies concluded that bacterial strains have important potential to be used as biomass to replace the use of iron fertilizers.

on the absorption of iron and plant growth of nuts peas in the calcareous soil. They found that these applications enhanced root activity, chlorophyll and active iron content in the leaves, total N, P and K and the accumulation of plants and the quality of walnut beads increased and plant biomass to control.

Singer et al. [29] studied the response of snap bean to Delta mix-TM (micronutrient mixture) on growth and productivity under calcareous soil conditions in Egypt. They concluded that using Delta mix produced more vigorous plants and pads with higher N, P, K, and protein and carbohydrate contents. Dahdoh et al. [30] found that the nitrate and EDDHA forms of N and Fe respectively, produced higher grains yields of wheat when compared with the other sources. Also, [31] concluded that in calcareous soils where Zn is deficient, the use of biochemical treatments (citric, salicylic acids and/or arbuscular mycorrhizal fungi) could help in improving Zn and Fe forms to be more available for maize and reduce the inhibition effect of Zn on Fe uptake by plants. In the calcareous soil in India [32] studied the effect of zinc sulfate and boric acid, singly or in combination on sugarcane. They found that the application of 20 kg zinc sulfate plus 5kg boric acid per ha with the recommended NPK may be beneficial in improving sugarcane yield and juice quality. Natta et al. [33] indicate that high pH, high calcite content and organic matter as well as a high concentration of Na, Ca, Mg, Bicarbonate and phosphate are the main factors affecting the availability of zinc in soil solution.

Mostafa *et al.* [34] concluded that in calcareous and sandy soils the application of organic manures was more effective in decreasing pH values compared to the application of either Fe or Zn alone. Also application of organic manures consistently increased available Fe and Zn as well as organic matter content in both two soils. In addition farmyard manure (FYM) was superior followed by chicken manure and the residual effect of (FYM) was more effective than chicken manure on the availability of Fe and Zn in both soils. To overcome zinc deficiency problems, many applications were followed, zinc fertilizer to soil, paper spraying and seed processing [35, 36].

On the other hand potassium has ameliorative effect on iron utilization by plants grown in arid and semi arid regions. Thus, fertilizers must be added in adequate amounts to potassium deficient soils particularly calcareous ones. In this respect, [37] studied the role of potassium in ameliorating iron nutrition of maize plants in calcareous soil in a greenhouse experiment. Maize plant growth was optimum with the application of 100 mg K/kg soil in combination with 20 mg Fe. The same authors investigators stressed on a the role of potassium in ameliorating iron nutrition of corn plants in calcareous soil, corn plants were able to overcome iron deficiency chlorosis resulting from adverse calcareous soils conditions in the presence adequate K fertilization. Also the use of K fertilizers exhibited marked improvement or increasing the efficient use of $FeSO_4$, which has been shown to be ineffective when added to calcareous soil. With respect element born, [38] confirmed the effect of soil structure on transport B, which may cause shallow groundwater contamination and economic loss. A recent investigation by [39] concluded that it would be possible to produce alfalfa in large quantities and with appropriate feed quality using boron nano fertilizer under calcareous soil.

Sulfur Products Used as Soil Acidifiers

Sulfur products used as soil acidifiers to improve calcareous soils, in addition to supplying sulfur as a nutrient, S compounds are also used as soil amendments. These compounds act as soil acidifiers neutralizing $CaCO_3$ with acid; this, in turn, may lead to a lowering of soil pH and improved nutrient availability. The rates of soil acidifiers required to cause a plant response depend on the amount of $CaCO_3$ in the soil. Negm *et al.* [40] mentioned that under field conditions, farmers also could maximize the compost efficiency through the rate of application and/or mixing with some other useful materials as sulfur or other amendments. They also used a commercial compost (Biotreasure) combined with different rates of sulfur. Obtained data revealed the importance of these additions in improving soil properties to productive trend. The Water holding capacity, Cation exchangeable capacity, organic mater total and fractions of nitrogen and availability of macro-and micro nutrients (P, K, Fe, Zn and Mn) were increased while soil pH decreased by additions especially in the surface layer. With respect to mix organic manure with sulfur, [41] recorded that in field experiment was carried out on calcareous soil, application of 40 m^3 organic manure interacted with 250 kg S/fed gave significant increase of fresh and dry yields of Acacia.

Hussein [42] conducted a pot experiment to study the effect of boron in relation to sulfur amendment in calcareous soil. Increasing S levels increased significantly the yield of sugar beet plant. Boron fertilization and increasing S level from 0.0 to 0.6% affected significant soil pH, soil extractable B, and leaf B concentrations. These data revealed the beneficial effect of both B and S on the growth and some quality characteristics of plant.

Irrigation

Under Egyptian conditions, shortage of fresh water resources for agricultural extension in the newly cultivated and reclaimed lands is an important problem. Thus, an urgent need for using low quality water for this purpose is of a vital importance. However, the use of saline waters for irrigation affects many soil properties such as those related to pH, ion exchange equilibrium and salt concentration. Therefore, some investigators tried using organic manure with saline water in sandy and calcareous soils. *Fatma et al.* [43] stated that the applications of chicken manure, at low level of water salinity (EC< 2 mmhos/cm), obviously increased the uptake of such nutrients indicating the beneficial effect of such manure. Generally, addition of organic amendments with saline water improved some chemical properties of calcareous soils. El Hady *et al.* [44] found that maize responded significantly to K up to 240 kg K_2O/ha with normal irrigation and up to 360 kg K_2O/ha with half-normal irrigation. Also, [45] studied the responding of some faba bean cultivars to skip on irrigation at different growth stages in a sandy calcareous soil. He concluded that total number of pods, plant, pod setting percentage and protein content were greatest with no irrigation at late seed filling, followed by full irrigation, and lowest with no irrigation at flowering or pod development. On the other hand, for more suitable cultivars of faba bean in sandy calcareous soil, Giza-2 and Giza-402 had higher seed yields, yield component values and protein content than Giza- 674. The results obtained by [46] revealed that the availability of N, P and K were increased at 20 m^3/fed of FYM, also available values were observed under irrigation intervals (every 14 days) compared to longer ones (every 21 days). Mansour [47] published detailed and valuable data related to design study of the closed circle of drip irrigation system. In this regard, [48] explains in detail the design, operation and maintenance of the drip irrigation system and its economy. With regard that another aspect mentioned by [49] about the properties of salt and re-distribution of cations soluble soil sodic saline impermeable reclaimed with drip irrigation improvement. Large increases in cationic cations (Ca^{++} and Mg^{++}) were observed between the dotting line but no significant changes were made in other areas of the soil.

Tillage

Tillage is considered as a technique that plays an important role in soil and water conservation where the process of infiltration, runoff, and evaporation are involved. Wander and Bollero [50] defined the tillage as the mechanical manipulation of the soil aimed at improving soil conditions affecting crop production. The intensity of tillage and different tillage systems affect the physical properties of soil, such as water content, bulk density, penetration resistance, and soil porosity. Changes in soil physical properties might be expected to develop slowly after the initiation of conservation tillage. For studying the effect of tillage on properties of calcareous soils, [51] studied the effect of no till (zero tillage) and three plowing depth (20,40,60 cm) on soil hydro-physical properties under calcareous soil conditions at El- Nubaria. He concluded that increasing plowing depth significantly decreased soil bulk density values and penetration resistance values in surface, subsurface and deep layers. Total soil porosity was higher in the treated soils than no till and the highest values were observed with plowing to 60 cm. Increasing in air porosity values with plowing depth in comparison to no-till for all soil layers and highest values were observed with plowing to 60 cm depth in deep layers. Increasing in total drainable pores and quick drainable pores values with plowing depth in comparison to no-till and highest values were observed with plowing 60cm depth. Increasing of plowing depth up to 60cm has resulted in increasing of the cumulative infiltration rate. Lastly, the fine aggregates (less than 0.25 mm) decreased with plowing depth but the coarse aggregates (more than 0.25 mm) increased with plowing depth. On the other hand, [52] studied the effect of various tillage practices on the physical properties of soil under wheat in a semi-arid environment. They pointed out that the type of plowing has a significant impact on the bulk density (BD) and penetration resistance.

Recently, [53] on integrated nutrient management and tillage to improve physical properties, organic matter and micronutrients were made on alkaline calcareous soils grown with wheat. They concluded that the effect of tillage practices on micronutrients were minimal.

Soil Conditioners

In Egypt, some natural and synthetic soil conditioners have been used for reclaiming sandy and calcareous soils. For applying natural conditioners in calcareous soils, [54] applied two natural bentonite clay deposits to study their impact on water movement in sandy calcareous soil, at Riyadh, Saudi Arabia. Available water content (AWC) increased with increasing concentration of bentonite. In another experiment used two natural bentonite clay deposits were used as amendment for calcareous soil. They found that the addition of both deposits caused a considerable increase in relative swelling index (RSI). As the concentrations of natural deposits application were significantly effective in reducing the cumulative evaporation and have increased the percentage of water conserved in the soil columns.

El-Aggory and Abd El-Rasoul [55] stated that the synthetic soil conditioners can be included as a biotechnology and as a major mean of increasing productivity in the agriculture sector. Soil conditioners, if used according to the established procedures, may be increase water infiltration into soil containing clay and prevent soil crusting in calcareous soils. They applied the biopolymer agar, derived from red algae, as a gel soil conditioner. Their results revealed that the application of agar solution to a calcareous soil as anti-crusting agent at the rate equivalent to 0.025% of soil weight and slightly improved the yield of Sudan grass. Another way for using hydrogels as amendment in calcareous soil, [44] referred to the addition of10 ton organic manure mixed with 100 kg acrylamide hydrogel/fed seems to be suitable to get use of the benefits of both types of soil conditioners without adverse effects on growth, nutrient uptake, yield and water and fertilizers efficiency by growing plants.

SUMMARY

The management of water and nutrients is the main production challenge. Optimal amounts of water for plant growth have to be provided without wastage, and salts, which may affect plant growth, have to be controlled.

Improved fertilizer management is required to grow crops successfully on calcareous soils. To avoid ammonia volatilization, fertilizers containing ammonium-N or urea should be moved into the root zone with rainfall or irrigation, or be incorporated into the soil. For optimal availability of P inoculation with Rizobium or Mycorrhial and foliar application with phosphate fertilizers were used to increase plant growth. Crops planted on calcareous soils may require above normal levels of K and Mg fertilizer for satisfactory nutrition. Using chelated Fe, Zn and Mn deficiencies can be corrected through foliar application of chelates. Adequate K supply and organic matter application can improve the availability of micronutrients. Sulfur products that act as soil acidifiers can potentially improve nutrient availability in calcareous soils by decreasing soil pH. To increase the efficiency of irrigation on calcareous soils, addition of organic manure with saline water improved the soil properties besides the control of irrigation intervals. It is found that increasing of plowing depth up to 60 cm has beneficial effect on soil physical properties of calcareous soils. Application of natural or synthetic conditioners played as anti-crusting agent and improved the productivity of calcareous soils.

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