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Review of Saline Water Irrigation Logging and Salt Affected Soil on Maize (*Zea Mays* L.*)* Yield and Managements

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Abstract

Severe waterlogging and salinity problems have challenged agricultural production, which has resulted in substantially lower yields than the potential. A critical review of recent studies on irrigation systems in developments was conducted from the historical point of view up to the present and the future. Waterlogging is the main drainage problem in the small-scale irrigation schemes in the lowland area. Salinity and salinization is also a common phenomenon in the large and medium scale irrigation schemes located in the lowlands area, major river basins with predominantly salt affected soils. The lack of functional drainage system and poor water management practices especially in developing country have also significantly contributed to the frequent occurrence of waterlogging and salt build-up in irrigation fields. The objective is reviewing different literatures on effect of water logging, saline water irrigation, and salt affected soil on maize yield and its management practice. The maize has not ability to germinate in the complete absence of oxygen, in standing water and soil structure disturbed due to salt. These problems caused due to excess of poor water application during irrigation activity and raise of water table. Thus displacing the air, the land is said to be waterlogged. Waterlogging is full (i.e. above 100% saturated) when water table rises to the surface and through time it came to affect soil structure. Management of water logging through biological drainage is not sensitive to water logging and soil salt affected. Surface and subsurface drainage reduce excess of water in soil particle. Saline soil and sodic soil can be managed through leaching by excess water, Tillage, deep ploughing, farm manure and chemical amendments that are used to provide soluble calcium include gypsum and calcium chloride respectively. To stop the loss of yield and soil structure due to salt accumulation, it is necessary to use appropriate soil, water management practices and land reclamation techniques practiced and also selection of crop type and proper irrigation methods should be designed for sustainability of soil productivity**.**

Keywords

Water logging, Application of saline water, Salt affected soil and Maize yield

Introduction

Waterlogging and salinization continue to cause economic losses in many areas of the world, though farmers and scientists have been aware of these problems and potential technical solutions for thousands of years. Waterlogging and salinity problems often require some form of drainage to allow sustainable agriculture production. This must be an integral part of irrigation system investments. However, poor irrigation and agronomic practices have led salinity and water logging, thus there are many researches in this branch such as Barrett *et al.* (2003*)* described a method for the establishment of controlled waterlogging events in the field. Wichelns (1999) examined farm-level and project-level models of crop production to identify policies that will encourage farmers to consider opportunity costs and the effects of irrigation and leaching on depth to regional water tables. Kotob *et al.* (2000) described counter-measures taken by the government on a national and regional scale and farmers on a local or field scale.

Water logging causes a condition of hypoxia (low oxygen concentrations) in soils, because of the low solubility of oxygen in water. Plants tolerant to water logging stress exhibit certain adaptation, such as, formation of aerenchymaand adventitious roots. Furthermore, due to the interaction of plant hormones, auxin and ethylene the formation of adventitious roots take place (Allahwardi, 1978). The maize has no ability to germinate in the complete absence of oxygen and grow in standing water (Walaa and El-Nashar, 2013; Medeiros *et al*., 2003; Cruz *et al*., 2003). However, in the case of drought some species grow deep root systems to tap deep water tables while some have large surface root systems to quickly absorb rainfall (Medeiros *et al.*, 2003; Cruz *et al.*, 2003). Some maize plants verities avoid drought by quickly re growing new leaves when environmental conditions and by improve dropping their leaves during droughts.

When soil is completely saturated with water is in general referred to the water logging. In this situation, ground water is too high that it does not allow convenient agricultural activities (Ammara and Shumaila, 2012).Water logging conditions drastically alter the soil properties, these changes in soil adversely affect the capability of a plant to survive in such situations (FAO, 1985). Permanent flooding offers a positive water and nutrient availability under anaerobic circumstances. However, the conservative system consumes a huge quantity of water. Plants growing under waterlogged conditions affected by numerous stresses for example restrictions to gas insufficiency of mineral nutrients and microelements poisoning. When maize plants are grown in water logging conditions or in anaerobic situations, their shoot and root systems counter differently. A multiple of anatomical and morphological modifications build up in the root system. Lessening in the root respiration rate had been reported in both species i.e. tolerant or intolerant to water logging. Roots in anoxic conditions are also depressed suppliers of mineral nutrients for the shoot systems and for themselves as well. Closing of stomata and non-stomata metabolic changes are liable for the decrease in leaf CO2 integration. In regulation of maintenance of physiological adaptations, mostly plant hormones are involved. Roots of any plant, because of water logging, undergo hypoxia or anoxia. In flood-tolerant plants, the development of arenchyma and adventitious roots in the surrounding area of cotyledonary nodes is a marker of the existence of adaptive characteristics. Permanent flooding offers a positive water and nutrient availability under anaerobic circumstances. However, the conservative system consumes a huge quantity of water (Mondal and Sharma, 1979). Temporary; transitory water logging can also have significant influences on growth and production of dry land maize. The harshness of the upshots of water logging depends upon the developmental stage of the plant.

Accumulation of excess salts in the root zone resulting in a partial or complete loss of soil productivity is a worldwide phenomenon (Dregne, 1976). The problems of soil salinity are most widespread in the arid and semi-arid regions but salt affected soils also occur extensively in sub-humid and humid climates, particularly in the coastal regions where the ingress of seawater through estuaries and rivers and through groundwater causes large-scale salinization (Dregne, 1976).

Waterlogging and salinity problems often require some form of drainage to allow sustainable agriculture production. This must be an integral part of irrigation system investments. However, poor irrigation and agronomic practices have led salinity and water logging, thus there are many researches in this branch such as Barrett *et al. (*1986) described a method for the establishment of controlled waterlogging events in the field. Kotob *et al.* (2000) examined farm-level and project-level models of crop production to identify policies that will encourage farmers to consider opportunity costs and the effects of irrigation and leaching on depth to regional water tables. Kotob *et al.* (2000) described counter-measures taken by the government on a national and regional scale and farmers on a local or field scale. Hatton *et al*. (2002) studied waterlogging and groundwater recharge characterized by sloping duplex soils. Barrett *et al*, (1986) studied the occurrence of seasonal water logging across a small catchment in the south-west of Western Australia. Barrett (2003) reviewed a range of studies under controlled conditions focusing on the effects of the interaction between water logging and salinity on the ion relations, growth, and survival of higher plants. Turner (2004) made an analysis of the yield increases of maize in Mediterranean– climatic regions, which showed that there had generally been an increase in the yields over the past decades, albeit at a lower rate than in more temperate regions.

Salt affected soils and the associated poor soil drainage conditions results from poor management of soils and irrigation systems application (Tessema, 2011). The Middle and Lower Awash River Basins in Ethiopia appear to be the most recent examples of such a situation (Tadesse and Bekele, 1996). In addition to these, salt affected soils are not only the result of the saline soils but also attributed to application of low quality irrigation water. All waters used for irrigation caries varying amounts of dissolved salts and other constituents. Some dissolved constituents can improve crop growth if present in small to moderate amounts, otherwise can harm soils, and restrict plant growth if they are present in excessive amount.
The first effect of salts is reducing the ability of plants to absorb water (osmotic effect), which leads to slower growth; second, salts may enter the transpiration stream and injure leaf cells, further reducing growth (Munns, 2005). The high concentration of Na^+ and Cl^- in soil solution is generally the main cause of the saline stress (Hasegawa *et al.*, 2000) and the consequent slower growth is an adaptive feature for plant survival because it allows plants to rely on multiple resources to combat stress.

Water Logging, Application of saline water, Salt Affected Soil and Its Management

Nature of water logging

Water logging is a great problem worldwide in the 21st century (ILRI, 1972). Actually, it can be considered as a bad outcome of technological and economic development in the present age. It has become an increasing problem in recent years for a variety of reasons: natural changes in river flow, increased sediment in riverbeds due to reduced sediment depositions on flood plains protected by embankments, and a lack of operation and maintenance of sluice gates of the polders (Awal, 2014). The problem affects the agricultural rural people as well as the urban residents heavily. In the past years, mainly farmers would experience the hazards; but presently the dwellings of the big urban areas are badly affected hereby. Water logging causes serious humanitarian crisis creating challenges in living condition, livelihood, health, food, security, employment, education and communication for a several months (Rai *et al.*, 1970). The main reasons of water logging in maize fields are due to block or filled up the drainage canals by greedy farmers to increase their croplands (Rhoades *et al.*, 1973).
On the other hand, different development structures such as embankments, polders, bridge, culverts, and roads that causes the demise of water drainage. Moreover, unplanned and liberal urbanization process makes the water congestion a death trap to the city residents. As most of the agricultural lands goes under water, the people have to be forced unemployed. The coastal polders, shrimp farming, climate change make this a one kind of handicapped region. Because, new canals are not excavated more and the existing ones are being narrow down or grabbed by the influential villagers. Embankment area is the worst suffered zone that happens every year causing dangerous losses and damages in the living conditions and the whole ecosystem. The people, as if, have been habituated with the disaster as a normal phenomenon. A good number of roads, kitchen markets, business centres, houses and schools went under ankle-to-knee deep water during the current spell of rain for the last few days. Locals blamed unplanned buildings in wetlands, illegal encroachment of low-lying areas, and a lack of regular cleaning of the drains for the situation.

Causes of Water logging

The twin problems of water logging and salinization in world are broadly attributed to the depression location of the area coupled with the lack of proper drainage system, poor percolation because of impervious clay strata and constant seepage from irrigation field Canal diversion. Moreover, intensity of irrigation and land-levelling leading to a major obliteration of the natural topography and drainage coupled with major shifts in cropping patterns and practices, all of which seem to have contributed and compounded the dual problem of water logging and salinity (Rasmussen and Neal, 1973).
Much of the unsaturated zone (vadose zone) in large parts of world raises with the groundwater levels. The capillary fringe now operates more actively in the soil-zone than in the sediment below, clearly giving rise to salinization and decreased hydraulic drainage of soils (Leffelaar and Sharma, 1977; FAO. 1985). Many studies have documented the negative effects of waterlogged soils on soil structure and crop growth. Williamson and Kriz (1970) presented a comprehensive review of the literature relating static (constant) non-saline water table depths to crop yield and included additional results from their own studies.
The rate of the occurrence of problematic soil in the Rift Valley areas of Ethiopian becomes particularly higher where water tables are near the soil surface with having high dissolved salts and irrigating without giving attention due to consideration (Mesfin, 1998).

Figure 1. Schematic picture of adverse effects of waterlogged on soil structure. Photo was taken from irrigated lands in the Wabi Shebele River basin, Ethiopia, indicating the presence of high poor irrigation.

Problem of Water Logging

Water logging is happened when the soil is so filled or soaked with water. When the water table rises to such heights that the soil pores become saturated, thus displacing the air, the land is said to be waterlogged (Figure. 2). Water logging is full (i.e., 100% saturated) when water table rises to the surface (Abrol *et al.*, 1980; Pla and Dappo, 1976). However, the process of water logging starts even when the water table is quite below the surface. An area may be regarded as waterlogged in this study when the water level above the ground is too high that does not permit an anticipated activity, like agriculture. It occurs when the rate of accumulation of water through rainfall or some other means exceeds the combined rates of drainage, percolation and evapotranspiration of a catchment or when floodwater submerges an area. Water logging may differ from flood situation in such a way that the flow of water is almost nil in former case as the water body is arrested by a boundary (like polder).

Soil water logging has long been identified as a major a biotic stress and the constraints it imposes on maize roots have marked effects on plant growth and development (Figure. 2). When such events take place in the mechanism, they can greatly reduce seed germination and seedling establishment. Thus, soil water logging is an important factor affecting the growth, development and survival of numerous plant species, not only in natural ecosystems but also in agricultural and horticultural systems (Dat *et al.,* 2006).

Rapid change in soil properties takes place the following soil water logging. As water saturates the soil pores, gases are displaced, reduction in gas diffusion occurs and phyto toxic compounds accumulate as anaerobic condition prevails. All these change greatly affect capacity of maize growth to survive such condition. In the responses the stomata resistance increase photosynthesis and root hydraulic conductivity decline, and the translocation of photo assimilates is reduced.

Effect of Water logging on the Crop Yield

The effect of water logging on plant growth depends on the duration of saturated conditions, the proportion of the potential root zone affected, the limitation on root elongation, the rate at which oxygen is depleted, the effect on availability and uptake of nutrients, and the accumulation of toxins (Murthy and Janardhan, 1971). The rate of oxygen depletion, and degree of harm caused by water logging, depends upon a number of factors temperature, availability of organic matter, salinity, acidity and the stage of growth of the plant. According to Abrol *et al*. (1980), there are three basic requirements for water logging to occur in the root zone of plants:

(1) Supply of water sufficient to produce saturation of the soil within the root zone

(2) Mechanisms and physical characteristics by which water is supplied and retained within the root zone

(3) Adequate time for saturation of the plant roots to produce anaerobic conditions and associated changes in biological and chemical activity, which is detrimental to plant health

Figure 2. Schematic picture of adverse effects of over irrigation on soil structure and Maize crop production. Photo was taken from irrigated lands in the Wabi Shebele River basin, Ethiopia, indicating the presence of high salinity irrigation.

Salt affected Soil

Soil salinity is caused by an excessive application of saline water, accumulation of salt and is typically pronounced at the soil surface (Abrol *et al.*, 1980; Szabolcs, 1974). Salt can be transported to soil surface by capillary action from salt laden water table, where they accumulate a result of evaporation. They can also be concentrated in the soil because of human practices, such as the excessive and no efficient use of agrochemicals, and by the addition of salts via the irrigation water. As soil salinity increases, the salt effects can result in a degradation of the soil's ability to support growth and consequently, reduction for maize vegetation. Because of mineral weathering, salts are also deposited via dust and precipitation. In dry regions, salts may accumulate and cause naturally saline soils. Proper irrigation management can avoid salt accumulation by providing adequate drainage to leach added salts from the affected soil root zone layers (Cerdia *et al*., 1975).

Disrupting drainage patterns that provide leaching can also result in salt accumulation. An example of this occurred in Egypt in 1970 when the Aswan High Dam was built. The resulting change in the level of the groundwater resulted in soil erosion, which led to high concentrations of salts in the water table (Di Baldassarre and Uhlenbrook, 2011). After construction, the continuing high level of the water table led to the salinization of arable land (Brown and miller, 1978; Bharagava *et al.*, 1980).

Salinity can occur in dry lands place when the depth of the water table is between 2 and 3 m. The salts from the groundwater are raised by capillary action to the surface of the soil. It can also occur when groundwater is saline (a common condition) and land use practices allow more water to enter the aquifer than it can accommodate. For example, the clearing of trees for agriculture can induce dry land salinity in some areas since the deep root systems of trees are replaced by the shallow root systems of annual crops, resulting in reduced water extraction and a rise in the saline water table (Bazilevick, 1965).

Salinity is an important and growing source of land degradation all over the world. It can be reduced in leaching soluble salts out of the soil with excess irrigation water. Soil salinity control involves water table control and flushing in combination with tile drainage or another form of subsurface drainage. High levels of soil salinity can be tolerated if salt tolerant plants are grown. Sensitive crops lose their vigor even in slightly saline soils. Most crops are negatively affected by (moderately) saline soils and only a few food crops can thrive in, or even tolerate, severely saline soils. Rain or irrigation, in the absence of leaching, can bring salts to the surface by capillary action (Wichelns, 1999; Narayana, 1977).

Salinity from irrigation can occur over time wherever irrigation occurs since almost all water (even natural rainfall) contains some dissolved salts. Since soil salinity makes it more difficult for plants to absorb soil moisture, resulting in detrimental effects on maize growth and yield, these salts must be leached out of the plant root zone by applying additional water. This water in excess of plant needs is called the leaching fraction (LF). Additionally, salinization, because of using irrigation water, is greatly increased by poor drainage and the use of saline water for irrigating agricultural crops (Pearson *et al.*, 1966; Pal and Mondal, 1980).

Classification of salt affected soils

Two main groups of salt affected soils, related to plant nature, characteristics and growth relationships, can be distinguished (Narayana, 1977).

Saline soils: These are soils containing sufficient neutral, soluble salts to adversely affect the growth of maize crop plants. The soluble salts are mainly sodium chloride and sodium sulphate, but saline soils also contain appreciable quantities of the chlorides and sulphates of calcium and magnesium

Sodic soils: Soils containing sodium salts capable of alkaline hydrolysis, mainly sodium carbonate (Na2CO3); have also been termed ‘alkali’ in older literature (Bharagava *et al.*, 1980).

These two main groups of affected soils differ in their chemical characteristics, their geographic and geochemical distribution, and their physical and biological properties. The two categories also require different approaches for their reclamation and agricultural use. In nature, the various sodium salts do not occur separate, but in most cases, either the neutral salts or the ones capable of alkaline hydrolysis exercise a dominant role on the soil forming processes and, therefore, in determine soil properties.

Modes of formation of saline soils

Saline seeps are the result of excessive leaching caused by reduced evapotranspiration after a change in land use from natural forest vegetation to cereal grain crop farms. Alternatively, it may also occur after a shift in the cropping pattern, such as the introduction of a fallow season in a grain farming system. Salinity problems are also caused by the ingress of seawater through tidal waves, underground aquifers, or through the wind transport of salt spray (salt drift).

Salinity problems are most extensive in the irrigated arid and semi ‑ arid regions (Pal and Mondal, 1980; Flávio *et al.*, 2008). In every river basin prior to the introduction of irrigation there existed a water balance between rainfalls on the one hand and stream flow, groundwater level and evaporation and transpiration on the other. This balance is disturbed when large additional quantities are artificially spread on the land for agriculture. Moreover, evaporation of groundwater through the soil surface will raise the salinity of the soil surface and root zone. Such salinization problems can be more severe when the salinity of the groundwater is high, as is usually the case in arid regions. Once the water table is within 1 to 2 m of the soil surface, saline groundwater can contribute significantly to evaporation from the soil surface and, thereby, to root zone salinization (El-Gabaly, 1971). Localized redistribution of salts can often cause salinity problems of a significant magnitude. Soluble salts move from areas of higher to lower elevations, from relatively wet to dry areas, and from irrigated fields to the adjacent non ‑ irrigated fields, etc.

Figure 3. Schematic picture of adverse effects Soil salinity on soil structure. Photo was taken from irrigated lands in the Wabi Shebelle River basin, Ethiopia, indicating the presence of high soil salinity.

Salinity and Maize Growth

Excess soil salinity causes poor and spotty stands of crops, uneven and stunted growth and poor yield. The extent of these effects depends on the degree of salinity. The primary effect of excess salinity is that it renders less water available to maize plant, even though there is still water present in the root zone. This is because the osmotic pressure of the soil solution increases as the salt concentration increases. Apart from the osmotic effect of salts in the soil solution, excessive concentration and absorption of individual ions may also prove toxic to the plants and/or may retard the absorption of other essential plant nutrients. There is no critical salinity point beyond which maize cease to grow (Hussain *et al.*, 2010). There is no critical salinity point beyond which maize cease to grow. As salinity increases, growth of plant decreases, until the plants become chlorotic and die. However, plants differ widely among and even within, species in their ability to tolerate salts in the soil. Salt tolerance ratings of plants are based on the yield reduction when grown in affected soil, as to the yield in similar, but non - saline soils (Rasmussen and Neal, 1973).

Irrigation with saline water reduced total biomass of maize and total yield by approximately 31% and 21%, respectively (Hussain *et al*., 2010). This is due to high salts concentration results in high osmotic potential of the soil solution; consequently, the maize has to use more energy to absorb water. Moreover, under extreme salinity conditions, maize cannot absorb water even when the surrounding soil is saturated. (Al-Omran *et al.*, 2009) reported similar results. They mentioned that, irrigation with saline water having EC 4.7 dS m-1 significantly reduced the total yield by 24.3%. Maggio *et al*. (2007) reported that there was an approximately 6% reduction in plant dry mass per one dS m-1 increase until approximately 9 dS m-1, whereas, only 1.4% decrease in yield per dS m-1 after 9 dS m-1. Al-Omran et *al.* (2012) concluded that the adverse effect of irrigation with saline water on total dry biomass and total maize yield were the reduction in WUE and TYWUE.

Management of water logging, irrigation water application and salt soil Biological Drainage

It involves deep-rooted crops and trees that modify water flux through evapotranspiration. Good drainage enables plant to send root deeper in to soil so that they can extract moisture and nutrient from larger volume of soil. Plant with deep root is better able to with stand with drought. Biological drainage is less costly than conventional drainage and can provide fuel wood, timber, windbreak, shed, shelter, and organic matter (Henperman and Dencke, 2002). Biological drainage also can remove ponds that from along canal embankments. The sustainability of bio drainage is not guaranteed in all setting. Gradual accumulation of salinity might eventually harm deep-rooted crops and trees reducing their effectiveness. In addition, the decline or harvesting of drainage plants will enable salts that have accumulated below root zone to move upward through capillary raise action. The combination of bio drainage and conventional drainage system might minimize the impact of salt accumulation. Biological drainage is one of these alternative options. The absence of effluent makes the system attractive. However, for biological drainage systems to be long-term sustainable, careful consideration is required of the salt-balance under the biological drainage crops.

Morris *et al.* (1998) found that Eucalyptus camaldulensis and E. Grand is grown on a shallow saline water table both used approximately 300 mm per year. They also stated that the plantation's ability to transpire groundwater is reduced where the groundwater table is drawn down in soils of low hydraulic conductivity. Potential water use differences between species are also a topic of discussion. Hatton *et al.* (1998) recognized the need to generalize water use behaviour of Eucalypts to facilitate landscape management processes in a wide range of environments. They concluded that the leaf efficiency of sympatric Eucalypt species in soil water-limited systems is similar, i.e. there was a strong linear relationship between tree leaf area and mean daily water use for a wide range of Eucalypt species grown under similar climatic conditions.

Physical structure Drainage system

Surface drainage system

The reclamation practice, known as surface drainage, can be defined as the diversion or orderly removal of excess water from the land through ditches or by shaping of the ground surface (van Lier, 1999). Sometimes, a subsurface system of drainpipes is needed in conjunction with the surface drainage measures. Design discharges generally are based on rainfall intensity because this is usually the most critical source of excess water. Rainfall–runoff relationships are a classical problem in hydrology, for which several approaches have been proposed. These range from simple formulas that give only the peak discharge value, such as the rational formula method, to complex physically based models that allow the simulation of distributed hydrological processes van (Lier, 1999; FAO, 1980).

Subsurface drainage system

Subsurface drainage systems are often used in irrigated, waterlogged, agricultural lands in arid and semi-arid regions to reduce or prevent soil salinity. The salt balance of these lands depends largely on the water balance, in which the amount of irrigation water is a dominant term. When sufficient irrigation water is applied, the effect of drainage on the salt balance stems from the discharge of salts along with the drainage water. Hence, drainage for salinity control is primarily based on the discharge effect rather than on a lowering of the water table. Criteria for salinity control should therefore be sought for water needed to provide sufficient leaching, rather than in the depth of the water table (Safwat Abdel-Dayem;Ritzema, 1990).

With a well-designed and properly operated irrigation system, the water table need not be kept at extra deep levels to control soil salinity. If, on the other hand, the irrigation system is poorly designed and operated, even maintaining very deep water tables will not alleviate soil salinity. For example, Safwat Abdel-Dayem and Ritzema (1990) and Oosterbaan and Abu Senna (1990) have shown that, for Egypt's Nile Delta, average seasonal depths of the water table in the range of 1.0 to 1.2 m are amply sufficient for effective salinity control, whereas maintaining deeper water tables may even negatively affect the irrigation efficiency. Also Rao *et al.* (1990) have shown that the time-averaged depth of the water table during the critical drainage season (i.e. the monsoon season) need not be much more than 0.8 m below the soil surface to allow the adequate reclamation of saline soils.

Management of salt‐affected soils

Since there is usually no single way to control salinity and sodicity, several practices should be combined into systems in oder to function satisfactorily. This means that development of a technologicalpackage, which consists of individual prac tices, should be implemented as a package. This packagefield tested under farmers' conditions. The management practice s and human aspects related tothe reclamation and sustainable use of saltaffected soils can be summarized as follows (Abdel, 2011):

- Leaching by applying excess water and allowing it to leach the salts from the root zone
- Leaching methods Continuous: maintain water at a depth of 10 cm by frequent additions of water to replace the amounts lost by evaporation and drainage
- Physical methods several mechanical methods have been used to improve infiltration and permeability in the surface and root zone, and thus control saline and sodic condition
- Tillage is another mechanical operation that is usually carried out for seedbed preparation since it breaks up surface crusts and improves soil permeability. However, if this method is improperly executed it might form a plow layer or bring a saline layer closer to the surface.
- Deep ploughing is most beneficial on stratified soils with an impermeable layer. It loosens the soil, improves the physical condition of this layer, and increases the air space and K values.
- Amendments that are used to provide soluble calcium include gypsum and calcium chloride. Gypsum is the most commonly used amendment for reclaiming sodium soil and reducing the harmful effects of high sodium irrigation waters because of its solubility, low cost, and availability
- Farm manure acts as a source of nutrients and improves soil structure and other properties. However, it does encourage the upward movement of salts.

Fertilizers for salt‐affected soils

Salt accumulation in the soil may affect nutrient content and its availability for plants in one or more of the following ways (Murthy and Janardhan, 1971):

Changing the form in which nutrients are present in the soil

- Cation and anion interaction effects
- Effects of non‐nutrient (complementary) ions on nutrient uptake
- Adverse interactions between salts already present and the added fertilizers, thereby decreasing the fertilizer use efficiency.

The benefits expected from the reclamation of saltaffected soils will not be obtained unless adequate plant nutrients are s upplied as fertilizer (but not in excess) or by other means.

The type of fertilizer used in saltaffected soils should, preferably, be of acid reaction and contain calcium rather than sodi um. It may also be necessary to take account of the complementary anions present.

Combined Effects of Both Water-Logging and Soil Salinity

The selection of Maize variety for cultivation during the reclamation of salt affected soils involves more than studying the tolerance lists and choosing the most tolerant variety maize crop. Sometimes crops are chosen which are, from the viewpoint of reclamation, not ideal. The selection should be based on tolerance to salt and waterlogged conditions and the economic value of the crop. In Egypt, it has been found that after six years of crop succession, complete desalinization of the root zone and normal use of the soil (Baldassarre and Uhlenbrook, 2011; Abdel, 2011). Interactions between salinity and water logging can have a major impact on maize growth and survival because there is a synergetic effect (Walaa and El-Nashar, 2013). Water logging may be a serious inhibitor for maize growth even at low levels of salt. This can be significant for rehabilitation because it is often easier to reduce water logging intensity (with shallow drainage) than manage salinization. Maize growths that are waterlogged are very susceptible to salinity, especially in their early growth stages. Under saline conditions, this inhibits the ability of roots to screen out salt during water uptake, which allows lethal concentrations of salt to occur in the plant shoots. It is not unexpected, therefore, that the lowest uptake of salt occurs for plants with a tolerance to water logging. The effects of soil salinity on maize production are increased when waterlogging conditions are present. In these cases, the data sets were combined and the same regression techniques were used. This can be seen for maize in Figure 4, which uses the data from three separate studies.

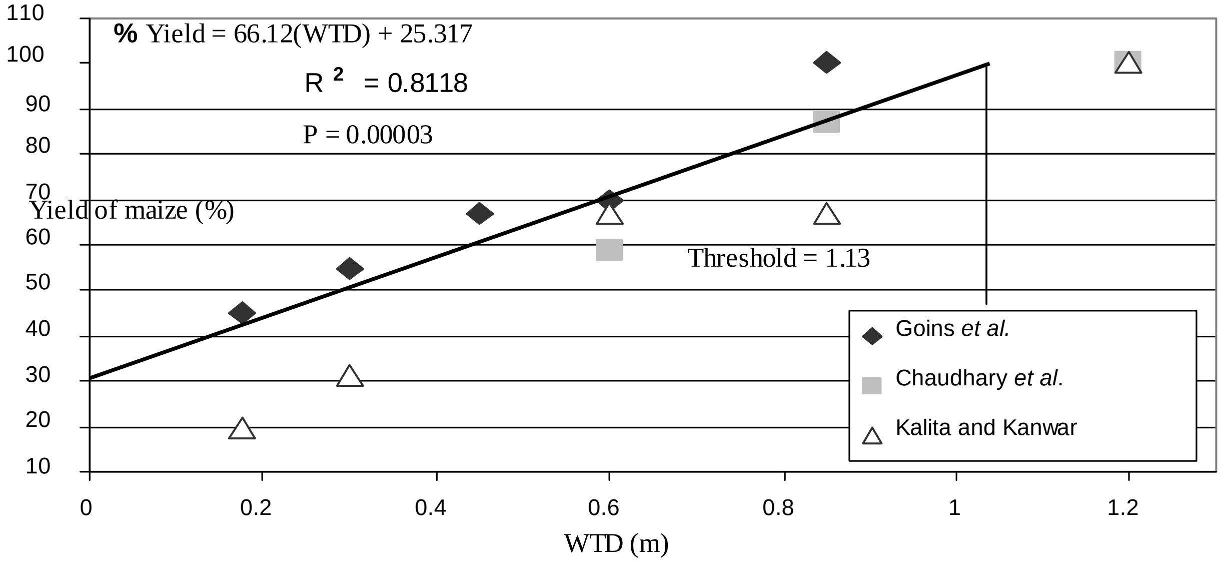


Figure 4. Schematic diagram of relationship between relative maize yield and depth of water. Diagram revised from Marshall Frasier and Eric Schuck. 2004. The regional effects of waterlogging and soil salinization on a rural county in the Arkansas River basin of Colorado, Western Agricultural Economics Association Annual Meeting, Honolulu, June 30 July 2, 2004

The segmented linear relationship relative yield concept for soil salinity, because of water table depth (RY^{WTD}) and crop yield relative to soil salinity (RY^{S}) can be described mathematically as follows:

$$RY^{WTD} = 100 - d\,(c - WT) \quad \text{for } 0 \leq WT \leq c \tag{1}$$

$$RY^{S} = 100 - b\,(EC - a) \quad \text{for } EC \geq a \tag{2}$$

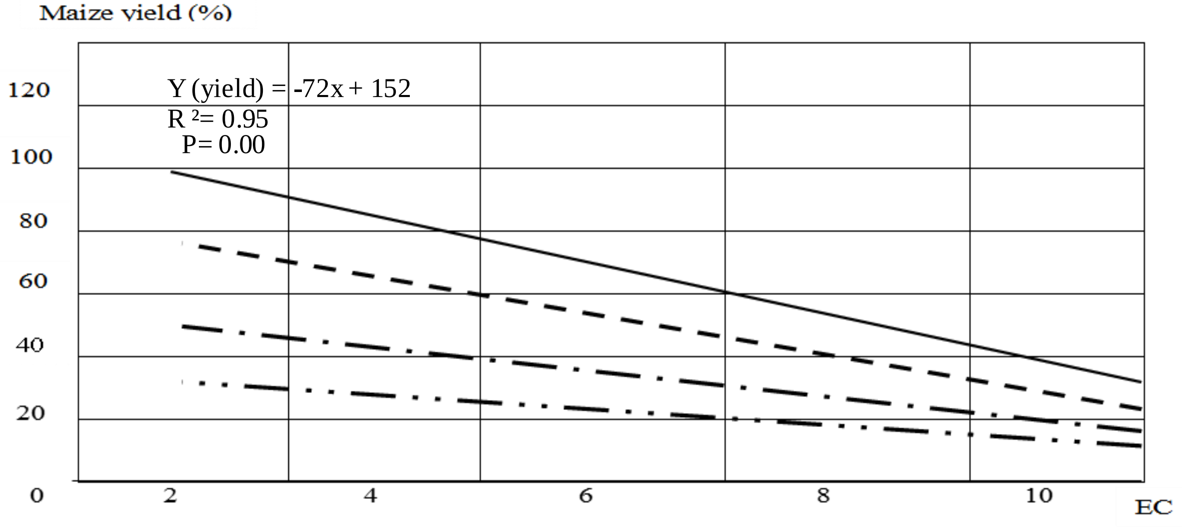
Where, d is the slope of the waterlogging response curve.WT is the depth to water table and c is the water table depth threshold level at which crop yields begin to be affected and where, b is the slope of the yield response to salinity and *a* is the salinity threshold level at which crop yields begin to be affected.

Combined Effect of Water-logging and Salinity on the Crop Yield

By using equation 1&2, the effect salinity and water logging on each crop is calculated for each decreasing growth and yield of crop. Kahlown and Azam (2002) also observed the combined effect of waterlogging and soil salinity to be more harmful to crop yields than the individual effect of waterlogging. Due to the complexity associated with these interactions, only a few studies have tried to account for the relationship between these impacts, typically assuming the interaction to be additive (Grieve *et al.*, 1986) or multiplicative (Christopher and TeKrony 1982; Gates and Grismer 1989). This study will follow the method developed by Christopher and TeKrony (1982) and later applied by Gates and Grismer (1989). These studies related the total relative yield factor (*RY*) for each crop to be the product of the relative yield associated with soil salinity (RY^{S}) and the relative yield associated with waterlogging (RY^{WTD}) as follows:

$$RY = RY^{S} * RY^{WTD} \quad (3)$$

Combined effect of both waterlogging and soil salinity on maize yield is shown in Figure 5.



—WT=1.23, --WT=0.8m, — ·— WT=0.4m, — ··—WT=0m

Figure 5. Schematic diagram of adverse effects of both Water logging and Soil salinity on Crops Yield. Diagram revised from Walaa and El-Nashar (2013).

Summary and Conclusion

The article is to review the risk of water logging and salinity on the crop yields and the net profit. Soil salinity is caused by an excessive-application of saline water accumulation of salt and it is physically pronounced at soil surface. The Salt can be transported to the soil surface by capillary action from a salt laden water table, where it accumulates because of evaporation. The Management of water logging through biological drainage activity and selection of crop variety in relation to increasing salt levels is more profitable. Water logging and salinity is becoming a serious issue in developing country. Shallow groundwater tables and associated salinity problems have become dominant features in agricultural field areas around the world and when irrigation project plan is done environmental impact assessment should include. Especially in developing country, the research based recommendations on the effect of water logging, saline water on maize yield, and its management practice seriously needed. Developing specific strategies based on management water logging and application like gypsum or salt tolerant plant use for the reclamation of saline and sodic soils. To stop the loss of yield and soil affected due to salt accumulation is necessary to use appropriate soil and water management practices. Although water management practices for dealing with irrigation induced waterlogging and soil salinization have been well documented over time, it is critical to determine whether they are economically justified within this region. Future research will need to evaluate the alternatives available for improving the current conditions in the basin.

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