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Soil Properties and Performance Measures

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Abstract – India is an agriculture-based economy and in agriculture soil properties plays the major role in deciding the yield quality and yield quantity. The major properties of soil are soil pH, conductivity of soil and soil Volumetric Moisture Content (VMC) content. Soil pH, conductivity and its VMC are the important soil parameters as they affects the physical and chemical properties of the soil, availability of water to plants and availability of nutrients in soil that can be absorbed by plants. This paper discusses the soil pH, soil conductivity and soil VMC and the effect of pH, conductivity and VMC on soil properties and plant growth. The various factors affecting the soil pH, conductivity and available moisture content for plant absorption are also presented. The different methods used for altering these major properties in order to make the soil suitable for agriculture provides are also presented in the paper.

Keywords: Soil, pH, Conductivity, VMC, Agriculture, Plant Nutrients

1. INTRODUCTION

The growth of plants/crops is based on quality of the soil which is playing most important role to provide better life to plants/crops. The plants/crops growth is mostly depending on water and nutrients contents present in soli which will helps to growth of the plants/crops. The contents of the soil (Water and nutrients) observed by roots and passed to all parts of the plants. The environmental condition is required by plants/crops is vary from plants to plants and contents of the soil also vary. Some of plants/crops are required acidic content in soil and some of required alkaline soil and etc.The attributes of the soil are also depending on soil texture, particular area and so on. The soil conductivity may vary from low value to high value with respect to rainfall of the particular region which leads to penetrate the root of plants/crops.

Plant/crops require about seventeen nutrients. Some plants nutrients are required more as compared to others and some nutrients are required in very small quantity. On that basis plant nutrients are classified as primary, secondary and micro nutrients. Some of them are listed in Table 1.

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Table 1 Classification of plant nutrients as primary nutrients, secondary nutrients and micro nutrients.

Primary nutrients	**Secondary nutrients**	**Micro nutrients**	
Nitrogen (N) Phosphorus (P) Potassium (K)	Sulfur (S) Calcium (Ca) Magnesium (Mg)	Zinc (Zn) Iron (Fe) Copper (Cu) Manganese (Mn)	Boron (B) Molybdenum (Mo) Chlorine (Cl)

Among seventeen nutrients required by the plants, fourteen nutrients are available in the soil and plant absorbs them in the form of soluble salts. Therefore, itis important to quantity the belongings of soil occasionally, which will help in maintaining the quality of soil and making it suitable for plants/crops growth by providing the proper treatment to soil in the form of fertilizers, liming etc.The properties of the soil which affects the availability of plant nutrients in the soil, soil life, tension/energy on plants in absorbing water from soil, quality of irrigation water to be used, irrigation scheduling are:

1. Soil pH.
2. Salinity/Conductivity of soil
3. Moisture content of soil

The information about the soil pH, Conductivity and Volumetric Moisture Content (VMC) helps in the effective use of soil or deciding the treatment which should be treated so that the soil is suitable of plants growths.

2. MOTIVATION

The agricultural reforms employ the soil properties, without the knowledge of factors of fertilizers and irrigation water that affects the soil properties and life of soil. This significantly disturbs the efficiency of soil and the quality of farming products. Understanding the soil properties and its effects on plant/crop growth is required for better agriculture yield in terms of quality and quantity both.

3. RELATED WORK

In [1], K.F. Golson presented the longitude and latitude variability of soil properties beneath the several land. There is no statistical differences on soil pH and organic content irrespective of slop, row position and etc,. There are no changes in soil texture while giving treatment to the plots. Somehow the differences are identified in percentage of clay, sand, soil depth, plot location, silt by slop and position of the row.

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In [3], [4],[5] discussed the result of soil pH on the handiness of nutrients in both organic and mineral soils. pH of soil is defined as the degree of alkalinity or acidity of soil. pH is calculated as the negative logarithm of H^+ ion activity. The most optimum range of soil pH is 6 to 7. In [3] it is discussed that highly acidic soil results in the toxicity because the elements like Aluminum, Manganese, Copper and Iron are highly soluble in acidic environment and the important nutrients like phosphorus, nitrogen become less available for plants. [3] Also discussed that strongly alkaline soil deficient in micronutrients likes Aluminum, Manganese, Copper and Iron. Addition of lime increases the soil pH and also provides the calcium and magnesium to soil. [4] Presented the classification of soil on the basis if its pH value. In [3], it is proposed to measure soil pH once in three year or twice during a rotation for optimum crop management. The influence of soil pH on different types of herbicides is also discussed in [5]. In [4] the effects of soil pH o the availability is discussed

In [6] discussed the reasons for building up of high soil salinity and its effect on plant growth. Soil salinity mainly builds up due the lower rainfall, poor drainage system and high salt concentration in irrigation water. High salt concentration in the soil puts water stress on plants due to osmotic effect. In [6], response of plants to soil saltinessalso exists. On the basis of plants response to soil salinity, plants are characterized as sensitive, moderately sensitive, moderately tolerant and tolerant to soil salinity.

In [7] [8] discussed the information available about the soil from its Electrical Conductivity (EC) measurement. Measurement of soil EC provides the information about the water holding capacity, porosity salinity, and cation exchange capability of soil. EC is proportional to concentration of salts. Higher salt concentration in soil results in high soil EC and higher soil salinity. [7] discussed the different methods of measuring the soil's conductivity. Both contact and non-contact methods are available for soil EC measurement. [8] presented the various factors affecting the soil EC. [9]discussed how irrigation water salinity or Total Dissolved Salts (TDC) in irrigation water effects physical properties of soil. Excess salt concentration in root zone hinder the plants from absorbing water from soil and put plants under the water stress.

In [10], A. Robert Patterson discussed the classification of soil in different salinity classes and sources of soluble salts in soil. Soil have salinity problem when there is loss in plant productivity, salt formation on the surface of soil, loss of soil permeability. In [10], soils are categorized soils as saline, slightly saline, moderately saline, very saline and highly saline soils on the basis of its conductivity. Water supply, human diet, detergents, soaps and cleaning agents are the different sources of soluble salts in soil and adds up to the salt concentration of soil. [17] and [18] provides study about the effect of saline irrigation water on soil properties, plant and vegetation growth and management practices.

The various components and concepts of soil water have been discussed in [11], [19].Soil distributes the water to plants through the small pores with help of gravity force. Plants damages

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can be avoided by providing intensity water level are to be followed in soil. The availability of soil water for plants/crops is among Field Capacity (FC) and Permanent Wilting Point (PWP) of soil.

4. SOIL PROPERTIES

The soil pH, soil conductivity and VMC content of soil are very important parameters and have predominant effect on the growth of the plant and various other characteristics of soil. These parameters affect the soil properties, soil capacity to hold water, porosity, salinity, and water stress on plant, soil fertility, and availability of nutrients to soil in soluble form thereby to plants. This section deals with insight discussion on these properties with their effect and how these soil properties can be modified to suit the agriculture production.

4.1 **SOIL pH**

[2] discussed the basics of pH.The nature of aqueous solutions will be defined by pH values which will decide the soil as acidic, alkaline, in the range of 0 to 14. The pH is derived from “p” and “H” chemical symbol of Hydrogen. The acids and bases values are shown in figure 1.

$$pH = -\log[H+] \qquad (1)$$

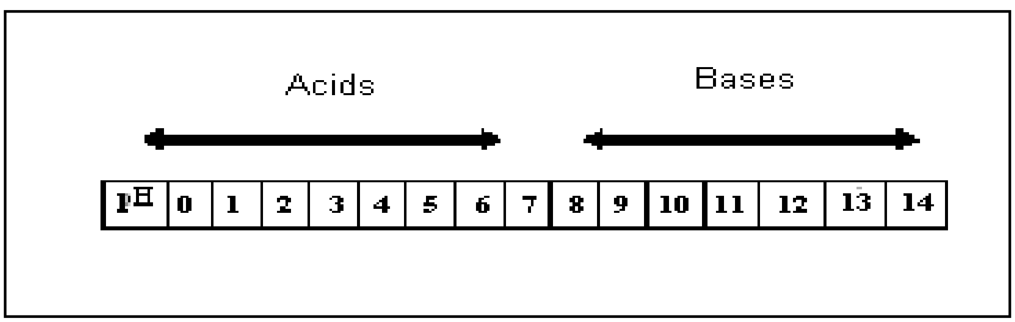

Figure 1: pH values for acids and bases

Plants absorb most of the nutrients from soil. Knowledge of soil pH gives the information about easily available nutrients for plant absorption and elemental toxicity. Figure 2.2 exemplifies the connection between pH of the soil and the presence of various nutrients in the soil.

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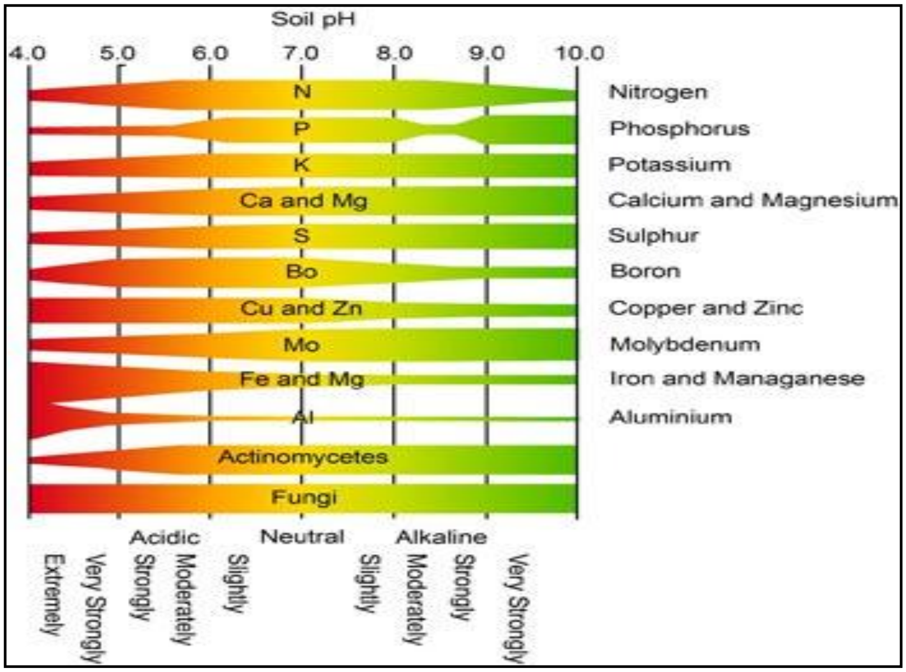

Figure 2:Relation between nutrients and pH value

Nutrients like Zinc, Aluminum, Manganese, Copper and iron are soluble in acidic soils and are accessible for plants/crops commitment. But at pH below 5, the concentration of these elements becomes very high and is toxic for some plants. Nutrients like Potassium, Calcium and Magnesium are also available for plant absorption in slightly acidic soils. Highly alkaline soils have higher concentration of bicarbonate ions which affects finest progress in plant by intrusive with normal intake of supplementary ions. The availability of micronutrients like Manganese, Copper, and Zinc decreases in highly alkaline soil. Soil pH also affects the soil lifetime. Soil lifetime denotes to the active organisms that living in soil and disruption organic material into meeker forms. Soil microorganisms accountable for decay of organic substantial into meeker nutrient form that develop food for plants/crops flourishes at 6.3–6.8 pH. On the other hand, fungi, molds and anaerobic bacteria prefer acidic environment. This make the soil prone to souring and purification rather than undergoing sweet decay process associated with organic matter.

4.1.1 FACTORS AFFECTING SOIL pH

[3] [4] presents the various factors affecting the pH of the soil like parent material from which soil is made, rainfall, pollution level. The parent material of soil decides whether the soil is acidic or alkaline. Soils developed from basic rocks are alkaline and have higher pH values than soil developed from acidic rocks.

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Rainfall also has prominent affect soil pH. Higher rainfall increases the acidic nature of soil because as soon as water permits through the soil, it trickles away the elementary nutrients like calcium and magnesium from soil. Due to the leaching away of basic nutrients, soil formed under high rainfall condition are more acidic than formed under low rainfall conditions. Carbon dioxide released from the decomposition of organic matter form organic acids when dissolved in soil water. This becomes a factor for decreasing the soil pH. Pollution caused by vehicles also alters the soil pH.

4.1.2 METHODS TO ALTER SOIL pH

[3] [4] discussed the various methods of altering the soil pH. Due to the application of fertilizers, high rainfall, decomposition of organic matter and pollution soil tends to become acidic with time. So, it becomes necessary to alter soil pH to bring its value within limits. The pH value of the acidic soils is increased by the addition of lime in the soil. The amount of lime required to adjust soil pH is termed as lime requirement and depends on many factors like soil pH, soil texture, amount of the organic matter. Higher the amount of clay in soil, higher the buffering capacity of soil and thus more lime is required. Similarly, quantity of organic substance in soil determines the quantity of organic acids in soil. Thus, soil with higher concentration of organic matter requires more time to adjust soil pH. Addition of lime removes all the major problems associated with acidic soil and also provides two nutrients: Calcium and Magnesium. Addition of lime fastens the decomposition of organic matter in soil and this increases the availability of nitrogen.

4.2 **SALINITY/CONDUCTIVITY OF SOIL**

In [6] discussed that various soluble salts are presented in soil. Ions are ecstatic to soil over rottenness of crystals existing in the soil, irrigation water, fertilizers or they may drift mounting in the soil from covert water. The rainfall is deficient to leach away the salts from soil or drainage system is deprived, the salts accrue in the soil. If this ailment triumphs over extended period, the outcome is extreme attentiveness of salts in soil and this extreme concentration/accumulation of salts in soil is named as soil salinity. High soil salinity has bad disturb on plant/crops progress. The foremost consequence of soil salinity is osmotic consequence. Osmotic consequence results in the energy increase with which soil holds the water. This decreases the quantity of water available in the soil for plants/crops captivation and henceforth plants/crops growth gets effected.

Soil salt absorption is a major factor contributing to the salt salinity. There are few varieties of crops that respond vastly to it while others respond soberly. Salt tolerant plant handles the osmotic effect better than the salt delicate plants. Plants/crops acceptance to salinity is also pretentious by weather circumstances, soil illness and plant’s growth stage. Salt injuries to plant

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growth due to soil salinity are less during cool weather as compared to hot, dry weather due to lower demand of transpiration. Soil water salinity also has consequence on the physical possessions of soil. Soil water salinity results in flocculation, which is the binding of small fine particles into aggregates. This is beneficial for root growth and soil aeration. Bad impact of soil salinity on plants/crops development is more than constructive impact on plants/crops development. In [20] discussed that the typical approaches of calculating the soil conductivity.Soil excerpt is the result comprising water and soil in 2:1 relation. Conductivity of soil water excerpt gives the info about the attentiveness of salts in the soil which in turn helps in depicting the level of soil salinity. In solutions, the conductivity is mainly due to the presence of ion. The conductivity of this extract is measured and the conductivity so obtained gives the information about the salinity of soil. The cataloguing of soil as salt or non-saline with admiration to the conductivity of soil excerpt is specified in Table 2

Table 2 Effects of soil salinity

S.No.	**Conductivity (mmho/cm or ds/m)**	**Effect**
	2:1 Water/Soil Sample	
1	<0.40	**Non-Saline:** Salinity effect on plants/cropsprogress is tiny.
2	0.40 – 0.80	**Very Slightly saline:** The development of identical salt subtle plants/crops is condensed by 25% - 50%.
3	0.81 – 1.20	**Moderately saline:** The development of salt subtle plants/crops is condensed by 25% - 50%.
4	1.21 – 1.60	**Saline soils:** The development of salt accepting plants/cropsimaginable.
5	1.61 – 3.20	**Strongly saline**: Suitable for salt accepting plants/crops.

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6	>3.2	**Very strongly saline:** only salt accepting plants/crops will raise.

4.2.1 FACTORS AFFECTING SOIL SALINITY

[10] Discussed that the main cause of building up of soil salinity is the poor irrigation water quality, poor irrigation management, excessive use of fertilizers and poor drainage system. Irrigation water contains naturally occurring salts. Plants absorb water to meet their evapotranspiration demand. But the salt in irrigation water remains in the soil. As a result, soil salt concentration increases. Poor drainage restricts the leaching of excessive salts of soil as a result soil concentration builds to high level.

4.2.2 METHODS TO ALTER SOIL SALINITY

In [9] discussed that productivity of soil is decreased due to high amount of salt present in soil. Hampers and plants/crops growth are maintained by control of the salt present in soil in order to increase the productivity of soil. The saltiness, drainage system, quality of water and sensitivity of plants are affecting the leach. The leaching is being done as much as possible if the quality of water, saltiness, sensitivity of plants/crops is poor or less.

4.3MOISTURE CONTENT OF SOIL

The nutrients are distributed to the different parts of plants/crops through the observed water from the soil. [12] [14] discussed that the obtain ability of soil water to plants/crops depends upon the salinity, soil texture and plant's effective rooting depth. The amount (moisture) of water is available in soil is more in clay type of soil as compare to sand type of soil. The extraction of water is good when the root is penetrating in to depth.

Transpiration is a process by which maximum water given to plants/crops is absorbed by their leaves from where it is evaporated in the atmosphere. Only 1% of water is taken up by the roots in the soil. Water is an important component for plants/crop growth without which a plant/ crop will not grow and hence die. Therefore, there is a need of proper water management to prevent damage to plant/crop.[15] Discussed the irrigation management technique for supplying the sufficient water to plant/ crop without any pressure on it. Irrigation management includes both under irrigation that can cause the stunted growth of plant/crop; or Over irrigation that leads to the leaching of essential nutrients of soil.

The various components or levels of soil moisture in plants or crops are discussed in [11] [12] and shown in Figure 3. Soil has minute pores that retain the water against gravity. Field capacity is defined as the upper limit of the soil to retain maximum water while Permanent Wilting Point

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(PWP) is defined as the lower limit of water holding capacity of soil.. Available Water Holding capacity is defined as the difference between FC and PWP and is given by (2.2).

$$AWHC = FC - PWP \qquad (2)$$

AWHC = Available Water Holding Capacity

FC = Field Capacity

PWP = Permanent Wilting Point

The AWHC is for plants/crops absorption without any scuffles. It is about 50 percentage of the AWHC of soil. The pores of the soil are filled by water when the FC reaches to saturation point.

At this point, adequate quantity of water is obtainable for plant acceptance but this conditionprimes to deficiency of oxygen which is turn consequence the preoccupation of water by plants. Below PWP is over dry condition. At this point, no water is present in the soil.

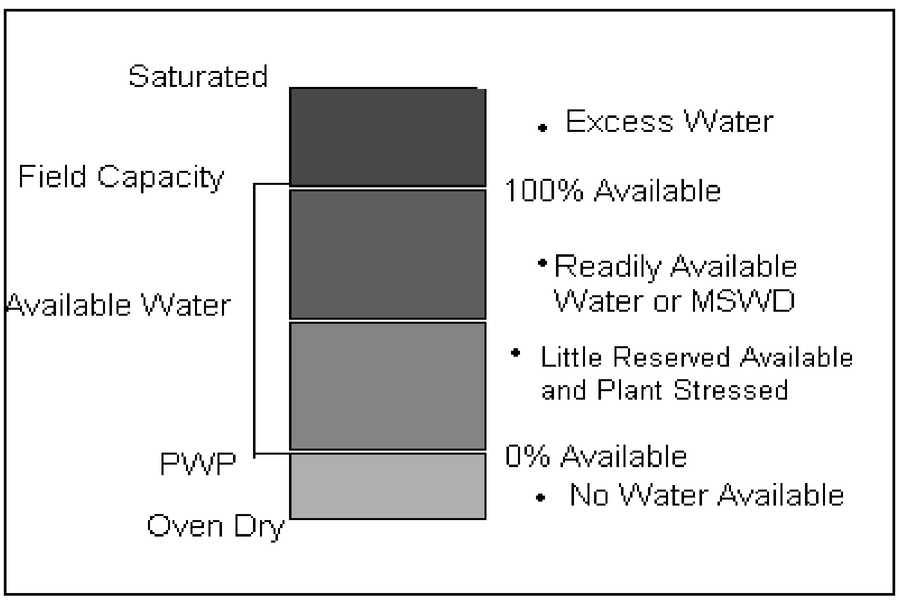

Figure 3: Different terms related to soil water

5. FACTORS AFFECTING AWHC OF SOIL AND IRRIGATION MANAGEMENT

[13] Discussed the various factors affecting the AWHC of soil and irrigation management. Soil water penetrates toward the underground water below the root zone under the force of gravity. Soil holds water for plant use against the force of gravity in the small pores present in soil. The

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soil with smaller pores store more water than soil with larger pores. The ability of soil to hold water against the force of gravity is called Water Holding Capacity (WHC) of soil. The ability of soil to store water depends upon its texture and structure.

Soil texture determines the size of solid particles from which soil is made up of. It determines the relative percentage of silt, clay and sand particles in the soil. Fine–textured soils have greater amount of silt and clay while coarse–textured soils have larger percentage of sand particles. Soil structure is the relative grouping of soil particles in various sizes and shapes. Soil structure defines the movement of water and air thorough soil. Good soil structure allows the rapid exchange of water with plants. Water holding capacity of soil depends on soil void spaces and its porosity. Larger soil voids lead to the movement of soil water below root zone due to gravity. Soil compaction is the destruction of soil porosity. This mainly results due to animal grazing and traffic.

Figure 4 gives the VMC for different soil texture class. VMC between two brown lines shows the moisture content that is readily available for plant absorption without causing any water stress to plants. The upper brown line gives the FC for different soil texture classes and lower brown line gives the PWP for different soil texture classes.

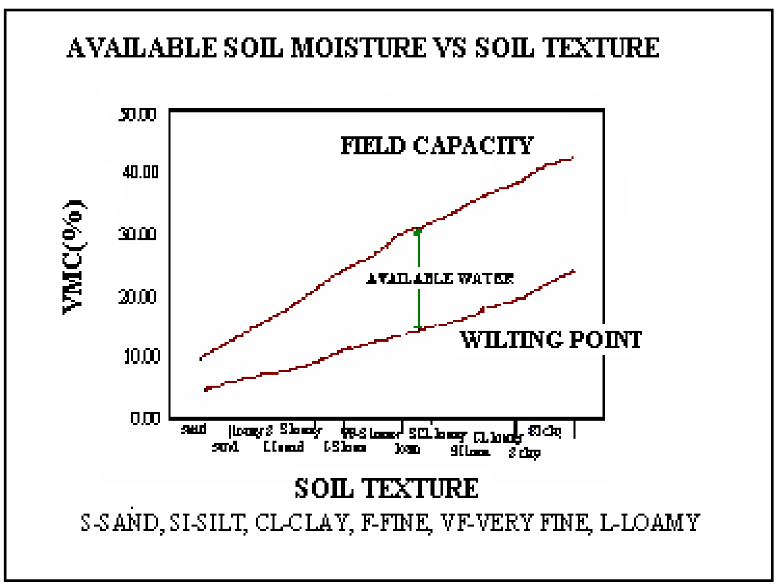

Figure 4: VMC of different soils

[14] discussed the effect of soil permeability and infiltration on soil's Water Holding Capacity (WHC). Soil penetrability is the capability of water or air to move finished soil and depends on size, form and steadiness of pore spaces. Infiltration is the downward flow of water from soil surface. Soil permeability is classified into various classes and infiltration rate is expressed in inch/ hour. Soil permeability classes and their corresponding infiltration rate are given in Table 3.

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Table 3 Penetrability classification and their infiltration rate

Classification	Infiltration rate (inches/hour)
Very Slow	Less than 0.06
Slow	0.06 – 0.2
Moderately Slow	0.2 – 0.6
Moderate	0.6 – 2.0
Moderately Rapid	2 .0– 6.0
Rapid	6.0 – 20
Very Rapid	Greater than 20.0

[15] discussed that soil depth and crop rooting depth are also the important parameters for irrigation management. Soil depth is the thickness of soil up to which it provides the nutrient and water for plants growth. Crop rooting depth is the depth of root zone and is dependent on crop species, type and stages of growth. Higher root depth means that more water is available for plant use as compared to plants having less rooting depth.

[14] [15] discussed the importance of testing the irrigation water. Irrigation water may have adverse effect on soil and crop. Irrigation water is to be properly tested or analyzed before being used for irrigation. Purpose of analysis of irrigation water quality is to determine the salt content of water. Quality of water is expressed in terms of total dissolved salts (TDS). TDS is the total amount of dissolved in water and is uttered in terms of electric conductivity.

6. CONCLUSION

Soil pH, soil conductivity and soil VM are the most important parameters in agriculture and are deciding factor for soil properties and plant growth. Soil pH effects the availability or deficiency of soil nutrients in soluble form so that they can be absorbed by the plants. The most optimum range of soil Ph is 6 – 7. The knowledge of soil pH makes it easier to decide the method odr soil treatment to be adopted so as to make the soil suitable for plant growth and micro organism activities. Major factors affecting the soil pH are rain, from which the soil is made, fertilizers usage and pollution level. High rain fall tends to make soil acidic by leaching away the basic nutrients which can be taken care by adding lime to the soil.

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Due to fertilization, improper irrigation and decomposition of material in soil, soil received salts. Major factor for high soil salinity are poor irrigation water, poor irrigation management, use of fertilizers in excess and poor drainage of water. High soil salinity effects the plant growth by increasing the osmotic effect. Due to it the dynamism with which the water is detained by soil increases and thus decreases the water availability to plants. Soil salinity is managed by leaching.

Soil water acts as a medium for transportation of soil nutrient to plants. Soil water available for plant is given by the AWM which is the difference of FC and PWM. Soil water available for plant absorption is contingent on the soil salinity and soil properties, and plants/crops root depth. High soil salinity increases the osmotic effect and thus reduces available soil water to plants. Soil texture affects the soil water holding capacity which is more for clay soil than sandy soil. Rooting depth defines the depth of extracting the water form soil and increases the volume of soil from which water can be absorbed by plants.

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