A PILOT STUDY ON SILT MAGNETIZED AND NON-MAGNETIZED WATER IN THE ON-FARM WATER USE EFFICIENCY MANAGEMENT

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ABSTRACT

Magnetized water is obtained by passing water through permanent magnet installed on a feed pipeline. The water that is passed through a magnetic field is termed as magnetized water. The magnetic field is created by permanent magnets that are placed diametrically opposite in the feed pipeline that causes water to magnetize. There is no energy requirement for magnetization of and can be used for long run without any maintenance requirements. Preliminary experiments were conducted to examine the properties of the magnetized water and non-magnetized water. The clustering structure of water molecules changes after magnetization. The macroscopic changes occurring in the water after magnetization is found by surface tension and viscosity. The surface tension and viscosity is found to be decreased for magnetized water compared to non-magnetized water. The decrease in percentage variation of surface tension, dynamic and kinematic viscosity is found to be 1.1 to 1.07, 1.2 to 1.05 and 1.08 to 1.04 with respect to discharge varying from 0.9 to 1.92 when compared to non-magnetized water. This decrease shows increase the fluidity of the water and water could easily pass through the cell membranes of the plant. One accurate method of measuring surface tension is through capillary action and the capillary rise of magnetized water is also found to decrease which indicates an increase in wettability. This helps in the improved crop growth and save water for irrigation. The treatment of irrigation water with magnetic fields improve the germination of seeds, growth of plants and also increase the soil moisture in the root zone of the plant compared to non magnetized water.

1. INTRODUCTION

Water is the most familiar matter in nature, our life and work require and use it from time to time, the growth and development of human beings, animals and plants need plenty of water. The world's fresh water resources are under pressure. Growth in population, increased economic activity and improved standards of living lead to increased competition for and conflicts over the limited freshwater resource.

Recently the critical problems face the world is depleted water resources and increasing in food demands to cover the human needs and therefore water scarcity is being increasingly accepted as a major limitation for increased agricultural production and food security in the 21st century. The water supply in India is going to be a serious challenge due to various reasons. The most serious concern is the growing population which is likely to increase to 1.66 billion by 2050. With the increasing population, the annual food requirement in the country will exceed 250 million tons. This will increase the demand for food production. Thus the demand for irrigation water has been steadily rising due to population growth and food requirement. The irrigation potential remains constant and the expansion of the agricultural area is indeed a difficult process, so within the available agricultural land the on-farm efficiency should be increased to meet the demand of the food. Hence greater productivity has to be obtained with less water.

The real water saving that can be achieved through micro irrigation system would be high under semi-arid and arid climatic conditions. With drip irrigation, water could be directly applied to plants, preventing this loss. Drip irrigation refers to application of water in small quantity at the rate of mostly less than 12lph as drops to the zone of the plants through a network of plastic pipes fitted with emitters. Drip Irrigation involves technology for irrigating plants at the root zone through emitters fitted on a network of pipes (mains, sub-mains and laterals). The emitting devices are designed to discharge water at prescribed rates. Water requirement, age of plant spacing, soil type, water quality and availability are some of the factors which would decide the choice of the emitting system. All types of surface and subsurface irrigation systems are covered under micro irrigation technology.

Magnetic water is obtained by passing water through permanent magnets or through the electromagnets installed in or on a feed pipeline. The water magnetizer installed in the pipe line to magnetize water in drip irrigation system showed a 7.5% increase in soil moisture distribution compared with non-magnetized water in the root zone depth is compared [6]. Irrigation with magnetized water caused higher soil moisture for different irrigation water salinity. The use of magnetized water for irrigation is recommended to improve irrigation efficiency [16]. The uniformity coefficient (U_c), emission uniformity coefficient (E_u)

The plants and trees need mineral salts and microelements from the soil to function and photosynthesize properly. However, plants do not use the majority of nutrients that are in soil. While watering plants with normal water, only a small amount of nutritional elements dissolves in the soil and becomes available to the plants. Further consumption of these nutrients from the soil is very rare when plants start to grow and a larger amount of nutrients is required, the deficit of microelements results in low numbers of crop. The deficit of microelements/nutrients in the soil is the main reason for a decreased growth rate and low crop. That is the reason why magnetic water should be used for irrigation. Hence the yield of the crop is increased when water is magnetized [2, 3]. The economic advantage of using magnetic water for irrigating the crops decreases vegetation period and crop production increases.

2. LITERATURE REVIEW

According to Craig Andrew McMahon (2009) the unusual properties of water can be attributed to extensive hydrogen bonding between its molecules. It has been suggested that the molecules could form clusters and these associations and dissociations of water molecules are in thermodynamic equilibrium. In general, each cluster contains about 100 water molecules at room temperature. In a magnetic field, magnetic force can break apart water clusters into single molecules or smaller ones. Therefore, the activity of water is been improved.

Every water molecule can be H-bonded with up to 4 adjacent water molecules (two through lone pairs and two through its two H-atoms) as shown in figure 2.4. When water is subjected to pass through a strong magnetic field, water molecules arrange in one direction. This mode of arrangement causes a decrease in the covalent bond angle from 104^0 leading to a decrease in consolidation degree between water molecules and increase in size of molecule. Thus, surface tension of water alters while passing through a magnetic field, and reduces more than that of normal water (Dhara. S et al., 2011).

Water is diamagnetic; however, its biophysical properties can be affected by magnetic field. The application of magnetic field resists the motion of water drops, as they pass perpendicular to the direction of the applied magnetic field and may decrease the intermolecular distances between water molecules. This conclusion may explain the observed decrease in the rate of flow of water under the effect of the applied magnetic field. Application of magnetic field on water may make also alignment of water clusters and that alignment may be increased by increasing the magnetic field strength. The alignment of water clusters may increase its conductivity to electric current. This increase is essentially permanent and is different from original. Also it may be concluded that, the applied magnetic field may affect the formation of hydrogen bonds of water molecules and that may lead to conformational changes. These changes may be the reason for the observed variations in conductivity. This work concluded some changes in biophysical properties of water due to the effect of magnetic field and these changes were varied in accordance with the filed strength (I. H. Ibrahim 2006).

The effects of magnetic treatment of water on soil moisture distribution in trickle irrigation were examined with magnetized water and different irrigation water salinity. (Behrouz Mostafazadeh et al., 2011) Two main treatments of MW and NMW and three sub treatments of irrigation water salts were conducted with well water as a control, 200-ppm and 400-ppm calcium carbonate. The MWT induces an overall 7.5% increase of soil moisture content in the three month irrigation period. There was a significant difference in the effect of irrigation water salinity on soil moisture and the highest was from the 400-ppm calcium carbonate. The effects of magnetized water on the distribution pattern of soil water with respect to time in trickle irrigation showed that the differences in soil moisture for days 1, 2 and 3 were lesser for magnetized irrigation water than non magnetized irrigation water treatment (Khoshravesh.M et al., 2011).

The emergence rate of seeds (wheat, barley and tritical) using saline water for irrigation of sandy soil with MW and NMW were evaluated. The result showed an increase in the biological and grain yield by 11.8 and 9.5% for magnetized irrigation water and the rate of seed germination of wheat, barley and tritical were 83, 86 and 86% (Selim.M.M., 2008).

The experiments on wheat crop during two successive winter season were conducted in a screen glass house to study the response of growth, yield and some biochemical constituents of wheat plant for irrigation with tap and magnetized water. The result exhibited marked increase in the vegetative growth, chemical constitute i.e. photosynthetic pigment (chlorophyll a, b and Carotenoids) and yield on irrigated with magnetized water. There was an increase of 31.33, 24.56 and 28.24% for grain, straw and biological yield per tiller (Mahmoud Hozayn and Amira., 2010)

There is no study related to application of magnetized water in agriculture in India. The objective of the study is to compare the soil moisture under the root zone for magnetized and non-magnetized water. The effect on the crop growth and yield on irrigation with magnetized water is compared with normal water.

3. MATERIALS AND METHODS

The experiments were conducted in Field Laboratory of the Centre for Water Resources, Anna University-Chennai. The experimental field is situated at $13^{o}0'$ N latitude, and $80^{o}14'$ E Longitude and this has sandy loam soil of a shallow depth. The soil samples were drawn and analyzed in laboratory for various parameters and the results of soil physical and chemical characteristics of the experimental field are indicated as shown in the Table 1 and 3. Bore well situated in field was used for irrigation and the quality is represented in the Table 2. The methodology of the study is represented in the Figure 1 and the representation of the drip irrigation layout implemented in the field is shown in Figure 2.

Table 1 Soil physical and chemical characteristics of experimental field

Soil Type	pH	EC (µS/ppm)	Temperature (^{o}C)	Infiltration Rate cm/hr
Sandy Loam	7.938	49.7	35.7	2.082

Table 2 Chemical characteristics of the irrigating water

EC (ds/m)	pH	TDS (mg/L)	Salt (g/L)	SAR
0.66	6.5	465	0.294	0.143

Table 3 Physical Characteristics of the soil for the experimental field

Soil Depth (cm)	Clay (%)	Silt (%)	Sand (%)	Soil Texture	Field Capacity (%)	Permanent Wilting Point (%)	Water Holding Capacity (%)	Bulk Density (g/cm3)	Soil Porosity (%)
0- 15	2.94	32.46	64.6	Sandy Loam	14.6	4.1	46.4	1.73	35
15- 30	2.66	28.80	68.55	Sandy Loam	13.6	4.1	46.4	1.74	34
30- 60	0.15	35.02	64.83	Sandy Loam	14.1	3.5	46.6	2.13	20

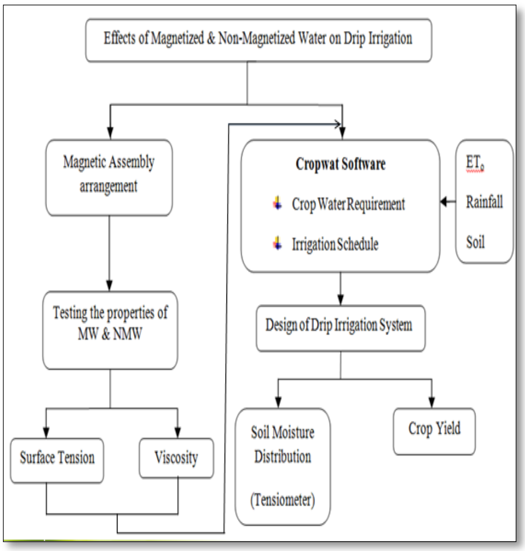


Figure1. Methodology for computing soil moisture distribution in root zone and crop yield

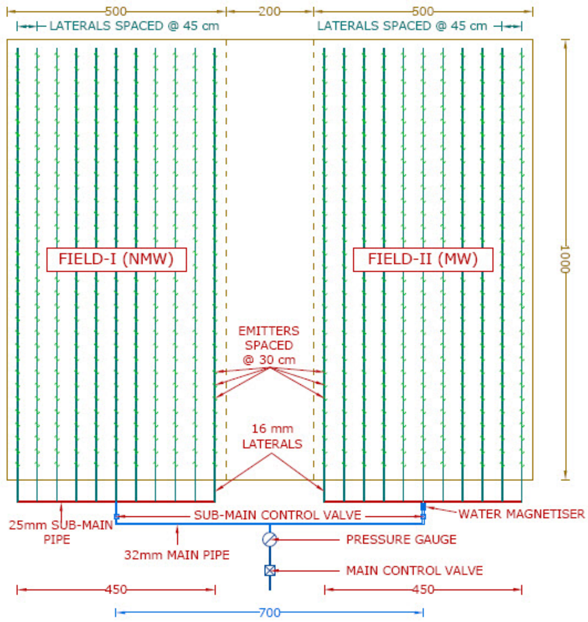


Figure2.Schematic diagram of drip irrigation system

A field plot measuring 12m x 10m was selected in the field lab as shown in Figure 2. The field was irrigated for the first time with no crop cover. It was ploughed thoroughly with power tiller and leveled partially. It was divided into two equal parts, each plot meant for using magnetized water and non-magnetized water for irrigation.cm/hr. After preparation of the land or seedbed, drip irrigation system was installed. The components of surface drip irrigation systems includes the pump, control head includes pressure regulators and control valves. Also includes the main lines, sub-mains and laterals.

For water pumping to the system through the main, an electric pump of 1 H.P. was used in the system. The main line in the system installed was made up of PVC having 32mm (I.D) diameter and pressure regulator were installed. The sub-main was also PVC made having 25mm I.D. The length of the sub-main on each plot was 4.5m. The main line was connected with a reduced T 32/25 mm. The lateral lines used were also PVC made and flexible, having 16mm I.D. On each plot, eleven laterals each 10m long were used. The distance between two lateral kept was 45cm (recommended distance for okra between two rows).

The crop selected is okra and the spacing adopted is 30cm within the lateral and 45cm between the laterals. 33 emitters of discharge 2.1 l/h are on each lateral keeping a distance of 30cm from c/c (based on the distance between two plants of okra). Thus, on eleven lateral lines, the total numbers of inline emitters were, 33 x 11 = 363 in each plot. The pressure regulator was fitted on the main line for regulating the water pressure as per requirement and the volume of water is calculated using the pressure given and the emitter specification of the lateral. The control valve was used for control of water pressure and to ensure water delivery uniform up to last emitter.

Okra was grown under drip system of irrigation during the period Feb. to April 2013. Before crop sowing, drip irrigation system was installed to assess for its performance through uniformity Co-efficient to indicate the system is working satisfactorily. The Cropwat software is used to estimate the crop water requirement and the crop irrigation schedule is estimated as indicated in Figure

4 PRELIMINARY EXPERIMENTS CONDUCTED

The experiment is conducted in the CWR field laboratory of CEG campus. The magnetic arrangement (permanent magnet placed diametrically opposite i.e. above and below in the wooden box inserted in the pipeline of 40mm diameter) is connected to a 5m long lateral of 16mm diameter and the emitters are placed at 0.3m apart within the lateral to study the influence of magnetic field on macroscopic properties of water.

The samples were collected at each 0.3m and the discharges are controlled using control valve fixed before the magnetic arrangement. The samples were collected for varying discharges of 0.9, 0.93, 0.96, 1.68, 1.8 and 1.92lph. The properties of the magnetized water and non-magnetized water are compared by conducting experiments. The macroscopic changes occurring in the water after magnetization could be found by surface tension and viscosity. This is compared with the non magnetized water to find the changes occurred in the water.

The surface tension is dependent on temperature. The surface tension (ST) is found out using Eotvos Rule as shown in equation (1),For water the above equation is valid between 0^oC and 100^oC. Where, T is the température in kelvin. This equation shows with the increase of temperature, the ST decreases.

$$ST = 0.07275\ (1-0.002(T - 291\ K)) \qquad (1)$$

One accurate method of measuring surface tension is through capillary action. There is a direct relation of surface tension and capillarity as shown in equation (2). The capillary rise of magnetized water is observed to be less compared to non-magnetized water. This also confirms the reduction in surface tension.

$$ST = hr\rho g/2 \qquad (2)$$

Viscosity indicates the resistant of the fluids to flow. The viscosity is obtained by the equation, Kinematic Viscosity, $\mu = \mu_0\ (1/\ 1+\ \alpha t+\beta t^2)$, Dynamatic Viscosity = μ/ρ. Where, μ = Viscosity of liquid at t^oC in poise, μ_0 = Viscosity of liquid at 0^oC in poise, (α, β) = are constants for the liquid, α = 0.03368, β = 0.000221 .This equation also shows with the increase of temperature, the viscosity decreases. The poiseuille's method is also used to determine viscosity. The coefficient of viscosity of the water, $\eta = (\Pi\rho g r^4 Ht)/8lv$

5. EFFECT OF SOIL MOISTURE DISTRIBUTION

The sampling of soil sample is done at various depths below the emitter and 25cm from the emitter. The root zone depth at 15cm, 30cm, 45cm and 60cm below the is compared with magnetized water and non-magnetized water.

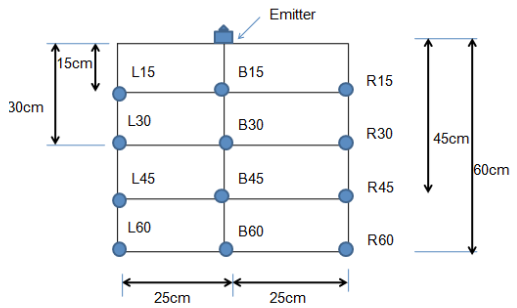


Figure 3 Schematic diagram of drip irrigation system

6 RESULTS AND DISCUSSION

6.1 Properties of Magnetized Water

The surface tension of magnetized water shows a decrease in trend compared to non-magnetized water. As the discharges increases the contact time of the magnet reduces and the more contact time the magnetization is more. The % variation is minute but still more in case of less discharge when compared to the higher discharge as represented in the Table 4.

The surface tension or wetting angle is an important indicator of the rheology or flow characteristics of water through a living system and across cell membranes. Lower surface tension indicates lower wetting angle and the wetter the water. Lower surface tension is critical to healthy cellular function and absorption of nutrients. The higher surface tension causes the surface to act like a stretched elastic membrane inhibiting absorption while increasing molecular resistance.

The dynamic viscosity and kinematic viscosity of the magnetized water is less compared to the non-magnetized water. The rate of discharge increases the percentage variation is observed to be decreasing. The magnetization of water is more during less rate of discharge and the viscosity is observed to be less when compared to higher discharges. The percentage variation of dynamic viscosity on magnetized water compared to non-magnetized is 1.20 to 1.05 with respect to discharge varying from 0.9 to 1.92lph as represented in the Table 4. Similar trend is evaluated in the case of kinematic viscosity, where the percentage variation of magnetized water compared to non-magnetized is 1.08 to 1.04 with respect to discharge varying from 0.9 to 1.92lph as represented in the Table 4.

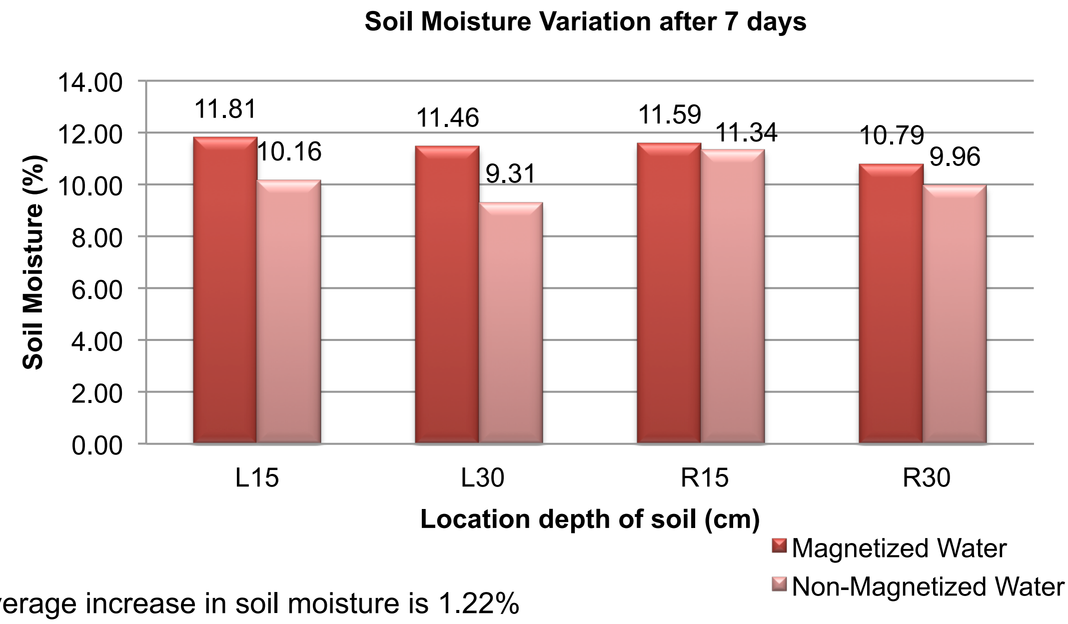
The percentage of total dissolved solids and salinity in magnetized water is observed to be low on comparison with non-magnetized water. The percentage variation of magnetized water with respect to the non-magnetized water varies between 1.03 and 1.01 as the discharge varies between 0.9 to 1.92lph. The TDS and salinity is found to be lower in case of water with more contact time. The variation of TDS and salinity with respect to discharge is in Table 4.

Table 4 Variation of properties of magnetized water from non-magnetized water

% Variation / Properties	Discharge (l/hr)					
	0.9	**0.93**	**0.95**	**1.68**	**1.8**	**1.92**
Surface Tension (N/m)	1.1	1.09	1.09	1.09	1.08	1.07
Dynamic Viscosity (Ns/m^2)	1.2	1.09	1.08	1.08	1.06	1.06
Kinematic Viscosity (Ns/m^2)	1.08	1.09	1.08	1.07	1.06	1.04
TDS	1.03	1.02	1.02	1.01	1.02	1.01
Salinity	-	1.03	1.02	1.04	1.02	1.01

6.2 Effect of soil moisture on Magnetized Water

The effects of soil moisture on magnetized plot were found to be higher by 1.22%, 1.55%, 1.43% and 3.13% after 7days and 14days as shown in Figure 4 and 5. The weed growth in the magnetized plot is found to be higher than non-magnetized plot which is an indicator of increased moisture.



Average increase in soil moisture is 1.22%

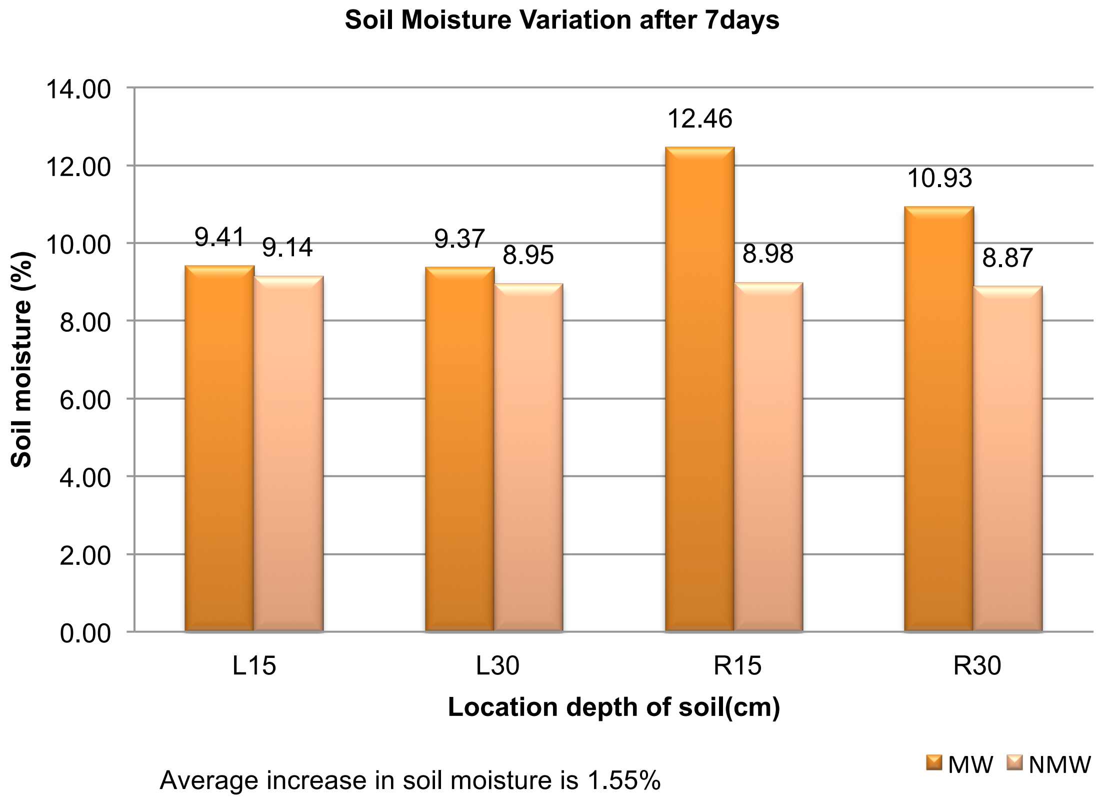
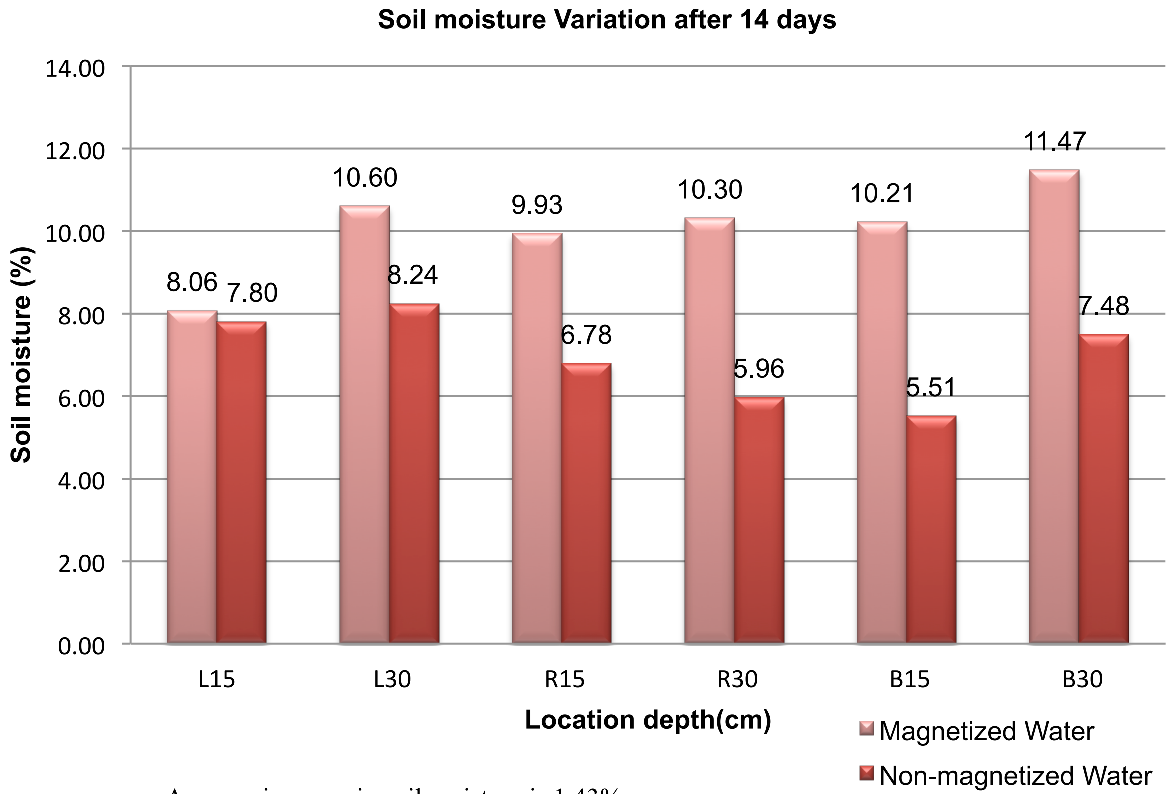
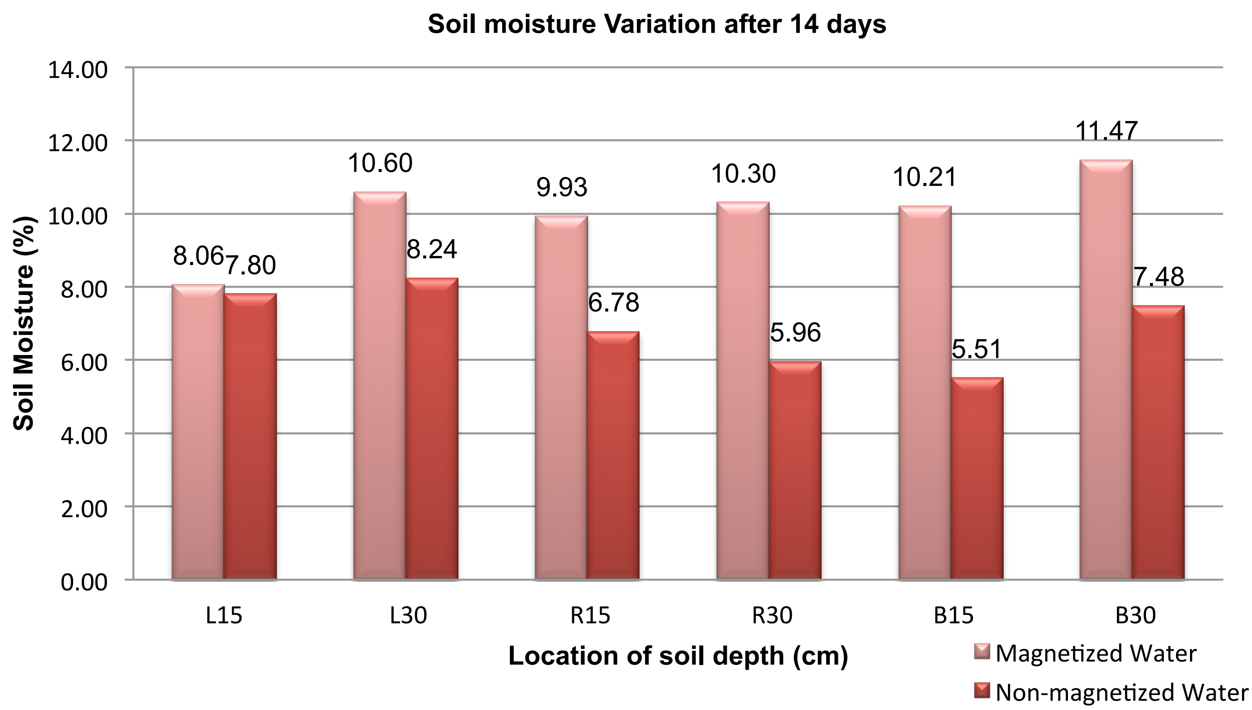


Figure 4 Soil moisture variations after 7 days



Average increase in soil moisture is 1.43%



Average increase in soil moisture is 3.13%

Figure 5 Soil moisture variations after 14 days

CONCLUSION

The water passing through 10 Tesla magnets fixed in the feed pipeline causes changes in the properties of water. This helps to increase the soil moisture distribution in the root zone depth of the soil. The growth of crop is to be analyzed.

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