EFFECT OF MAGNETISED WATER ON CHLORIDE IONS IN TRICKLE IRRIGATION

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PROJECT REPORT

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CERTIFICATE

Certificate that this project report, entitled, "**Effect of Magnetised Water on Chloride Ions in Trickle Irrigation**" is a record of project work done jointly by Raseena Salim, Rohit Murali and Vipin, P.R. under my guidance and supervision and hat it has not been previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

Tavanur,
03 -02-2012.

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DECLARATION

We hereby declare that this project report entitled, " **Effect of Magnetised Water on Chloride Ions in Trickle Irrigation**" is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award to us in any degree, diploma, associate ship, fellowship or other similar title of any other university or society.

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Raseena Salim

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Dedicated to

Our Loving Parents

and

Profession

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SYMBOLS AND ABBREVIATIONS

ºC	degree celcius
µm	micrometer
cc	cubic centimetre
cm	centimeter
Dept.	department
DF	degree of freedom
et al.	and other people
etc	etcetera
F-cal	F-value calculated
F-tab	F-value from ANOVA table
h	hour
EC	Electrical Conductivity
MTD.	Magnetic Treatment Device
KCAET	Kelappaji College of Agricultural Engineering and Technology
kg	kilogram
km	kilometer
ln	natural logarithm
log	logarithm

LWRCE	Land and Water Resources and Conservation Engineering
mg	milligram
min	minutes
mm	millimeter
MS	mean sum of square
N	cumulative percentage finer
no.	number
ns	non significant
sec	second
SS	sum of square
N	Nitrogen
P	Phosphurus
K	Potassium
mT	milliTesla
Hz	Hertz
T	Tonnes
Ha	Hectare
dS	deciSiemens

S1	sandy soil
S2	sandy loam soil
R1	Replication 1
R2	Replication 2
R3	Replication 3
T1	Treatment 1
T2	Treatment 2
T3	Treatment 3
T4	Treatment 4
M	Magnetised
N	Non-magnetised

INTRODUCTION

CHAPTER I

INTRODUCTION

Expanding problems of soil salinity and waterlogging have become serious issues of concern as they affect productivity and threaten the very sustainability of agriculture. Salt- affected soils are an important ecological entity in the landscape of arid and semi-arid region. In India nearly 9.38 million ha area is occupied by salt-affected soils out of which 5.5 million ha are saline soils (including coastal) and 3.88 million ha alkali soils. These occur from Jammu & Kashmir (Ladakh region) in north to Kanyakumari in south and Andaman & Nicobar Islands in the east to Gujarat in the west. These represent a serious threat to increase food production to meet the expanding needs. Indiscriminate use of poor quality water in the absence of proper soil water-crop management practices poses grave risks to soil health and environment. Development of salinity, sodicity, acidity, water logging and toxicity problems in soils not only deteriorates the quality and quantity of produce but also limits the choice of cultivable crops, many a times the effects become so severe that lands eventually go out of cultivation.

Continuous use of saline water for crop production enhances soil salinization. High contents of soluble salts accumulated in the soil can significantly decrease the value and productivity of agricultural lands. Using poor quality irrigation water with high salinity is one of the main problems in agriculture of many countries in the world. To reclaim soil and water and to reduce soil salinity, magnetised water can be used. Magnetised water is obtained by passing of water through the permanent magnets or through the electro magnets installed in/on a feed pipeline. The permanent magnets or electro magnets are installed around the incoming water pipe.

The changes caused by the magnetic influence depend on many factors, such as strength of the magnetic field, direction of applied magnetised field, duration of magnetic exposure, flow rate of the solution, additives present in the system and the pH. All the plants irrigated with magnetic water exhibited a remarkable increase in vegetative growth and biochemical constitutions. In controlled large-scale field experiments it was found that magnetic treatment affects the quality of irrigation water and the treated water contributes to an increase in farm yields in crop farming, yield being expressed in quantity and quality of the produce and in the specific economic contribution.

It is known that plants need mineral salts and microelements from the soil to function and photosynthesize properly. However, plants do not use majority of the nutrients that are present 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. The deficit of microelements/nutrients in the soil is the main reason for a decreased growth rate and low crop. That is the reason to why magnetic water is effective for irrigation. Magnetised water can easily take in mineral salts from the soil and no sediment is formed on the soil surface. Also if mineral and organic fertilizers are used, they dissolve better, which results in the decrease of their need by 50% and at the same time, plants still continue to develop without any extra effort. This results in an increased crop production and quality of agricultural products.

Installing a magnetic system within the pipes enables the interactions with dissolved solids in water that hold and attract hardening minerals like Magnesium and Calcium. Setting up a magnetic field and magnetically treating irrigation water can actually help with productivity in boosting plant growth and productivity.

Magnetised treatment of irrigation water has not yet been tried in Kerala. So an attempt is made to raise Amaranthus in a protected structure. Replicated pot experiments are done using magnetised and non-magnetised water at different salt concentrations. The objectives of the study are:

1. To compare the effect of magnetised and non-magnetised water treatment at different salt concentrations on the growth parameters of Amaranthus.
2. To compare the effect of magnetisation of saline water with the non-magnetised water.
3. To study the effect of magnetised and non-magnetised water in different soils at different salt concentrations.

REVIEW OF LITERATURE

CHAPTER II
REVIEW OF LITERATURE

The water treated by magnetic field or passed through a magnet is called magnetised water. Magnetic water conditioning sets can help the drip irrigation system by changing the molecular structure of water as it passes through a magnetic field. When water is magnetically charged, it electrically takes on a greater ionic charge than the minerals, which creates a natural magnetic attraction between the two. The magnetization then attracts and locks the dissolved minerals into the water creating healthy and cost-free desalination.

It is a scientific fact that use of magnetic water devices for treatment of irrigation water will improve water productivity and will lead to significant water savings for the irrigation sector, minimize soil salinity and sustain the health of the environment. The implementation of magnetic water treatment technology by the irrigation sector will be a significant benefit to the global environment.

2.1 History of magnetised water

In the Eastern Bloc Countries, particularly Russia, increased research and applications of MTDs began after the Second World War. This was largely due to the fact that the U.S.S.R did not have the chemical expertise or funding to treat their water chemically like that in the U.S.A. (Lobley, 1990).

Today, there are numerous varieties of MTDs for sale, ranging from $100 up to $10000. The controversial debate over the effectiveness of magnetised water is still undecided. There have been many successful industrial applications of MTDs in the west, including systems for NASA, yet the treatment has not been released mainstream or accepted by the Water Quality Association (Federal Technology Alert, 1996). Research works are improving all over the world to create more varieties of magnetizers. The implementation of magnetic water treatment technology by the irrigation sector will be a significant benefit to the global environment.

Marshutz (1996) reports that in 1954 the Federal Trade Commission filed a complaint against the Evis Manufacturing Company, which manufactured an early magnetic water conditioner. They charged the company with unfair competition and false advertising by its competitors. Following extensive hearings, the complaint was dismissed two years later. Experiments and studies in the west increased after numerous successful applications of MTDs came out of the U.S.S.R. By the 1990’s, many credible institutions were researching the topic with mixed results.

"If you look at the publications and split them down the middle, you would find that anything written outside of the U.S. generally favors magnetic water treatment, while anything you read on the subject written inside the U.S. tends to be questionable," explains Donald McClellan of MC$_2$ Resource Management, a distributor for the Descal-A-Matic Corp as cited in (Marshutz, 1996).

According to the Marshutz *et al.* (1996) Michael Faraday was the first researcher who seriously dug into magneto chemistry beginning in 1863. From 1890 and onwards, the subject of magnetically treating water had become extremely controversial, and was labelled “gadgetry” and “not sustainable under scientific scrutiny”. A company called Solavite, based in France, began to market a MTD in 1936.

According to Brower (2005), case histories of the success of magnetically treated water date back to 1803. The magnetic effect was first recorded when there was a notable difference in the texture of the mineral accumulation inside of soup and laundry kettles. These kettles were placed over fires and large stones were placed in the bottom to keep them from swinging in the windy weather. Reportedly, two of the five kettles, which were all made from the same cast iron metal, did not have hard scale formation. Instead, they had a soft, powdery substance which was brushed off easily. It was later found that the two of the five rocks used to stabilize the kettles in the wind were lodestones which are natural magnetic rocks.

2.2 Property changes due to magnetic water treatment

2.2.1 Electrical conductivity

Electrical conductivity is a measure of how well a material accommodates the movement of an electric charge. It is the ratio of the current density to the electric field strength. Its SI derived unit is the Siemens per meter. Electrical conductivity information can be used for measuring the purity of water, sorting materials, checking for proper heat treatment of metals, and inspecting for heat damage in some materials.

Malkin (2002) reported that the ions in the water are affected by exposure to magnetic fields. A further benefit of the alteration in the ion states of both calcium carbonate and magnesium carbonate is that, the change in structure of these compounds (which are the cause of the scale buildup in water pipes, kettles etc) resulting in much decrease in the buildup of scale, due to the loose nature of the ions which may cause the reduction in EC for sample. The element variations in response to magnetic intensity appeared to be variable.

Ibrahim (2006) examined the effect of static magnetic field on the biophysical properties of distilled water is investigated in this work. Magnetic field was applied in a direction perpendicular to distilled water drops coming from a burette (drop by drop), using a variable gap magnet, producing a magnetic field of strength varying from 0.2 up to 5 kG. Variations in the rate of flow of water, electric conductivity and dielectric constant were observed. Increasing the strength of magnetic field decreases the rate of flow, increasing both the electric conductivity and the dielectric constant of water.

Basant *et al.* (2008) examined whether there are any beneficial effects of magnetic treatment of different irrigation water types on water productivity and yield of snow pea, celery and pea plants. Replicated pot experiments involving magnetically treated and non-magnetically treated potable water (tap water), recycled water and saline water (500 ppm and 1000 ppm NaCl for snow peas; 1500 ppm and 3000 ppm for celery and peas) were conducted in glasshouse under controlled environmental conditions.

A magnetic treatment device with its magnetic field in the range of 3.5–136 mT was used for the magnetic treatment of irrigation water. They found that the use of magnetically treated irrigation water reduced soil pH but increased soil EC and available P in celery and snow pea.

Molouk *et al*. (2010) conducted a study aimed at solving the problem of stagnant water due to receiving of sewage water in a lake at Eastern Jeddah, using state of the art safe techniques. Samples were collected from the lake, and then treated using magnetic fields with different intensities in two states, static and shaking, for 30 days. Hence, the physical and chemical properties for samples were measured, in addition to their bacterial content. In both cases of static and shaking, increasing the magnetic flux density caused water clearness, in addition to a relative increase in the pH value and a remarkable decrease in its odor and electric conductivity (EC).

2.2.2 Yield

Lin and Yotvat (1989) experimented on the effects of magnetised water in agriculture with tests done on 14 experimentally established agricultural sites. When using magnetic water for irrigating crops, they recorded the following observations

- Increased cumulative yield per unit plot Extended crop season (growth, ripening, fruit-bearing); improved vegetative deployment.
- Improved fruit quality; size, shape, texture, sugar level, greener leaves.
- Larger fruit
- Improved growth uniformity; vitality
- Cleaner piping, reduced scale deposition in piping and drip heads

Moran *et al*. (1993) recorded an increase in the yield of various agronomic crops in response to magnetic field treatments.

Danilov *et al.* (1994) have shown that there is an increase in number of flowers, earliness and total fruit yield of strawberry and tomatoes by the application of magnetic fields.

Alexander and Doijode (1995) noted that aged onion (Allium cepa) and rice (Oryza sativa) seeds exposed to a weak electromagnetic field for 12 h increased the germination shoot and root length of seedlings.

Mahmoud *et al*. (2005) showed that magnetic fields are known to induce biochemical changes and could be used as a stimulator for growth related reactions. Chickpea seeds were irrigated with water passed through magnetic device (U050 mg, 0.5 inch, output 4-6 m3/hr, production by Magnetic Technologies L.C.C., Russia, branch United Arab Emirates). Results indicated that irrigation with magnetised water induced positive significant effect on all studied parameters. The percent of increase in seed, straw and biological yields per plant were 39.64, 41.03 and 39.85%, respectively compared with tap water (average over both seasons). Magnetic water treatment could be used to enhance growth, chemical constituents and productivity of chickpea under green house condition.

Basant and Harsharn (2008) examined whether there are any beneficial effects of magnetic treatment of different irrigation water types on water productivity and yield of snow pea, celery and pea plants. Replicated pot experiments involving magnetically treated and non-magnetically treated potable water (tap water), recycled water and saline water (500 ppm and 1000 ppm NaCl for snow peas; 1500 ppm and 3000 ppm for celery and peas) were conducted in glasshouse under controlled environmental conditions). A magnetic treatment device with its magnetic field in the range of 3.5–136 mT was used for the magnetic treatment of irrigation water. The analysis of the data collected during the study suggests that the effects of magnetic treatment varied with plant type and the type of irrigation water used, and there were statistically significant increases in plant yield and water productivity (kg of fresh or dry produce per kL of water used). In particular, the magnetic treatment of recycled water and 3000 ppm saline water respectively increased celery yield by 12% and 23% and water productivity by 12% and

24%. For snow peas, there were 7.8%, 5.9% and 6.0% increases in pod yield with magnetically treated potable water, recycled water and 1000 ppm saline water, respectively. The water productivity of snow peas increased by 12%,7.5% and 13% respectively for magnetically treated potable water, recycled water and 1000 ppm saline water. On the other hand, there was no beneficial effect of magnetically treated irrigation water on the yield and water productivity of peas. There was also non-significant effect of magnetic treatment of water on the total water used by any of the three types of vegetable plants tested in this study.

Faten *et al*. (2009) conducted a study on Static Magnetic Field Influence on Elements Composition in Date Palm *(Phoenix dactylifera* L.). Seedlings of date palm *(Phoenix dactylifera* L.) were treated with varying doses of static magnetic field (SMF) in order to evaluate the effect on elements uptake. The SMF source is a magnetic circuit set to produce three levels of magnetic field intensities (10, 50 and 100 mT). Seedlings were exposed to these magnetic fields for different periods: 0, 30, 60, 180, 240 and 360 min. Leaf samples were subjected to chemical analysis for elements (Mg, Ca, Na, P, K, Fe, Mn and Zn) using inductive couple plasma (ICP) spectroscopy. The results revealed that concentrations of Ca, Mg, Mn, Fe, Na, K, and Zn increased, while P concentration decreased with raising SMF intensities and durations of exposure. Static magnetic field has a potential to enhance growth due to the positive effect on the plant major elements such as Ca and Mg.

Poinapen *et al*. (2010) reported the effects of magnetic fields on the growth and yield of Butterhead lettuces (Lactuca sativa Var. Salina) whose seeds have been initially exposed to static magnetic fields of average intensity ranging from 40 to 8 mT. The seeds were exposed either 24 hours or 72 hours to north and south magnetic fields. The developed lettuces were cultivated under hydroponics conditions. Major increase in the growth of lettuces was observed from seeds that were treated with a south magnetic field for an exposure period of 24 hours. Under south field exposures, a significant increase [$p < 0.05$] in yield of 18.8 % and 12.9 % in fresh mass of lettuces was noted for the 24 hours and 72 hours exposed seeds respectively compared to control. The dry mass to fresh mass ratio was significantly increased by 9.5 % (24 hours) and 7.4 % (72 hours). For north field treatment, significant increases of 8.2 % in fresh mass of lettuces and 7.4 % in the dry mass to fresh mass ratio were observed (24 hours seeds exposure). However, no significant increase [$p > 0.05$] was obtained for the 72 hours exposure. In light of the data obtained, the effect of magnetic fields on growth and yield could be potentially exploited in economic plants.

Australian Strawberry Distributors are one of the biggest growers and distributors of strawberries, supplying such chain stores as Woolworths and Coles Myer. They claim, after treating their water magnetically, their production had increased; the quality had improved and they were saving at least 20% water if not more.

2.2.3 pH change

Changes in the pH of distilled water of up to 0.4 pH units have been reported by Joshi and Kamat (1966).

Busche et al, (1985) showed an initial decrease in pH of 0.5pH units from 7.0 to 6.5, followed by a gradual increase throughout the time of the experiment to pH 7.5 – 8.0

Parsons et al (1996) also recorded a decrease of 0.5 pH units after passing water through a MTD as can be seen in the Fig.2.1.

Bogatin *et al*. (1999) showed that the important components for effective magnetic treatment are flow rate through the apparatus and certain chemical parameters of water, namely, carbonate water hardness of more than 50 mg/L and concentration of hydrogenous ions in water at $pH>7.2$.

Quickenden (2002) found no pH change in double distilled water subjected to a very strong magnetic field of 24 000 Gauss.

Chibowski *et al.* (2003) showed that the changes caused by the magnetic influence depend on many factors, such as strength of the magnetic field, direction of applied magnetised field, duration of magnetic exposure, flow rate of the solution, additives present in the system, and the pH.

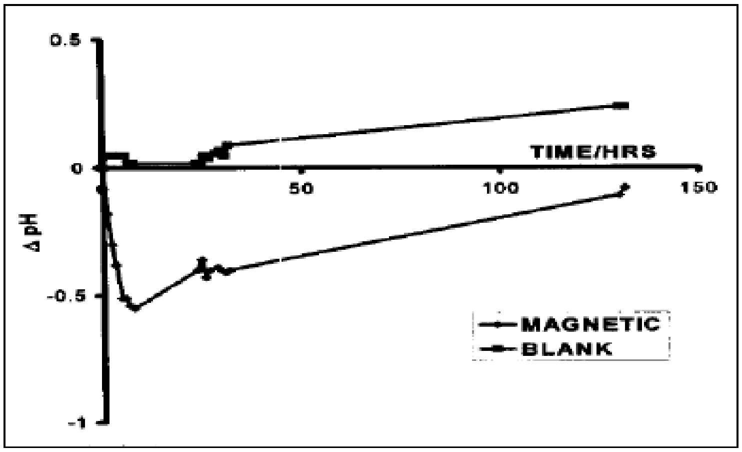

Fig.2.1. Effect of magnetically treated water.

Yamashita *et al.* (2003) witnessed, what he considered, slow and large pH fluctuations (0.05 - 0.1) during the first several hours of magnetically treating distilled water. His results indicated that to accurately evaluate the effects of magnetic fields on water, subtle experimental conditions such as field conditions produced by common lab devices and procedures cannot be ignored. He also states that extending measurements beyond several hours may be essential to observe accurately the effects of magnetizing water. From these experiments, it appears the fluctuations in pH change from experiment to experiment suggest that unforeseen interactions are contributing to pH change. While pH change may be an indicator for magnetically treated water in some situations, it cannot be solely relied upon.

Tai *et al.* (2008) cited that Ellingsen and Kristiansen showed that their water sample's pH decreased from pH 9.2 to 8.5 after magnetic treatment.

Molouk *et al.* (2010) conducted a study aimed at solving the problem of stagnant water due to receiving of sewage water in a lake at Eastern Jeddah, using state of the art safe techniques. Samples were collected from the lake, and then treated using magnetic fields with different intensities in two states, static and shaking, for 30 days. Hence, the physical and chemical properties for samples were measured, in addition to their bacterial content. In both cases of static and shaking, increasing the magnetic flux density caused water clearness, in addition to a relative increase in the pH value and a remarkable decrease in its odor and electric conductivity (EC).

2.2.4 N, P and K.

Noran et al. (1995) conducted a study on the effect of irrigation with magnetically treated water on the translocation of minerals in the soil. The magnetic field interacts with the surface charges of particles in the fluid solutions affecting the crystallisation and precipitation of the solids in them. These processes are of significant effect on the translocation of minerals in irrigated soil. The concentrations of K, N, P, Na and Ca+Mg, as well as the total mineral content in the MTW-irrigated soil were compared with the same data in soil irrigated with ordinary water. The soil was sampled at three different locations at three different distances from the dripper line, representing three different leaching states of the soil. Differences in concentrations were found in at least one of the three locations with respect to each mineral and including the total mineral content. Most of the differences appeared in the less leached parts of the soil, in the bed margin. It appears that there is a general tendency of minerals to precipitate out of the solution faster in MTW conditions. Great difference in the concentrations of phosphorus in the MTW-irrigated and control plots was evident. The data pointed to a particularly high solubility of phosphate under the influence of the magnetic treatment, conforming to the findings of work carried out in connection with zinc phosphate at the Brunel University. Experiments run in the laboratory, and data supplied by industry, showed clear influence of the magnetic treatment on the increase in solubility (or in the level of concentration in super saturation) of zinc phosphate. As regards calcium phosphate, they shown an increase of 50 per cent in the dissolution capacity after 24 hours of magnetic treatment, and five-fold increase after 120 hours.

Noran *et al*. (1996) observed (under drip irrigation system) differences in the concentrations of N, P and K in soils irrigated with magnetically treated water when compared those with nor mal water. They argued that magnetic treatment of water slows down the movement of minerals, probably due to the effect of acceleration of the crystallisations and precipitation processes of the solute minerals.

Bogatin (1999) concludes from their findings that MWT induces an increased yield by 10-15%, a more intensive root formation, the transfer of phosphorus fertilizers into more soluble form and a decrease in the risk of secondary salinification of soil. The magnetic treatment improves conditions of root layers due to (a) leaching of superfluous salts (b) better permeability of irrigated water and (c) better dissociation of mineral fertilizers.

A marked increase in P content of citrus leaves by magnetically treated water was also reported by Hilal *et al.* (2002).

Faten *et al.* (2009) conducted a study on Static Magnetic Field Influence on Elements Composition in Date Palm *(Phoenix dactylifera* L.). Seedlings of date palm *(Phoenix dactylifera* L.) were treated with varying doses of static magnetic field (SMF) in order to evaluate the effect on elements uptake. The SMF source is a magnetic circuit set to produce three levels of magnetic field intensities (10, 50 and 100 mT). Seedlings were exposed to these magnetic fields for different periods: 0, 30, 60, 180, 240 and 360 min. Leaf samples were subjected to chemical analysis for elements (Mg, Ca, Na, P, K, Fe, Mn and Zn) using inductive couple plasma (ICP) spectroscopy. The results revealed that concentrations of Ca, Mg, Mn, Fe, Na, K, and Zn increased, while P concentration decreased with raising SMF intensities and durations of exposure. Static magnetic field has a potential to enhance growth due to the positive effect on the plant major elements such as Ca and Mg, but negative electrical charges on the plants inhibited the uptake of anions such as P.

Helal (2011) examined the response of some growth characteristics; yield and some chemical constitute of common bean for irrigation with magnetised and tap water. Irrigation of common bean plants with magnetic water increased significantly the growth characteristics, potassium, GA_3, kinetin, nucleic acids (RNA and DNA), photosynthetic pigments (chlorophyll *a*, chlorophyll *b*, and carotenoid), photosynthetic activity ($^{14}CO_2$–fixation), and translocation efficiency of photoassimilates ($^{14}CO_2$–assimilation) as compared with control plants. Treatment with magnetised water had no significant effect on water content, malondialdehyde, and H_2O_2 contents as compared with the control. Also, there is a stimulation effect in the activities of the antioxidant enzymes (catalase, peroxidase, and superoxide dismutase) in the magnetised plants over the control. It appears that utilization of magnetised water (30 mT) can led to improve quantity and quality of common bean crop. It suggests that magnetic water could stimulate defense system, photosynthetic activity, and translocation efficiency of photoassimilates in common bean plants. So, using magnetic water treatment could be a promising technique for agricultural improvements but extensive research is required on different crops.

2.2.5 Root growth

Muraji *et al*. (1991), did their experiment to find the effect of alternating magnetic field on the growth of the primary root of corn. Corn seeds each with a primary root were exposed to alternating magnetic fields. Locations of the root before and after exposure were accurately measured, and the growth during the exposure was calculated. These values were compared with those of the control group. Results indicate that the relatively low frequencies used in the experiments hastened the growth of the primary root while relatively high frequencies slowed root development

Muraji *et al*. (1992) demonstrated an enhancement in root growth of maize (Zea mays) by exposing the maize seedling to 5 mT magnetic fields at alternating frequencies of 40- 160 Hz. However, there was a reduction in primary root growth of maize plants

Muraji *et al*. (1997) did their experiment on primary root growth rate of *Zea mays* seedlings grown in an alternating magnetic field of different frequencies and studied the effect of an alternating magnetic field on the growth rate of primary roots in *Zea mays*. Corn seedlings were grown in the dark, under constant conditions of temperature (25°C) and humidity (100%). They were also subjected to a 5 mT magnetic field, alternating at frequencies of 5, 10, 20 or 40 Hz. The rate of primary root growth, in plants grown at each frequency, was measured and compared to a control group. Control plants were grown under similar conditions, in the absence of the magnetic field. The growth rate of primary roots in seedlings grown at each of the magnetic field frequencies used, was increased compared to the control group. The highest growth rate was seen in seedlings exposed to a magnetic field alternating at 10 Hz.

Bogatin (1999) concludes from their findings that MWT induces an increased yield by 10-15%, a more intensive root formation, the transfer of phosphorus fertilizers into more soluble form and a decrease in the risk of secondary salinification of soil. The magnetic treatment improves conditions of root layers due to (a) leaching of superfluous salts (b) better permeability of irrigated water and (c) better dissociation of mineral fertilizers.

Pietruszewski *et al*. (2000) examined the effect of alternating magnetic field on the yield and chemical composition of sugar beet roots. The investigations were undertaken on four varieties of sugar beet viz. Colibri, Evita, Kawetina and Maria and four magnetic exposure doses in the field. The results of the research showed that the effect of the pre-sowing magnetic biostimulation is positive. In all the combinations except Evita variety the yields of roots (5.0-9.4 t/ha) and leaves (5.0-9.4 t/ha) were higher than the yield of control. Also, the biological yield of sugar increased in all the combinations. The alkality coefficient was higher than 1.8, which from the technological point of view is very advantageous.

In general, there are possibly some beneficial effects of magnetic field or treatment on plant growth and other related parameters. However, there is no clarity as to the extent of these effects and mechanisms operating behind these effects. Furthermore, there is not much research carried out on the effects of magnetic treatment of irrigation water on plant growth and crop and water productivity.

2.3 Magnetised water

Lin and Yotvat (1989) noted that, the use of MTW is common in various branches of industry as a precaution against accumulation of scale in the water supply system, cooling tower, thermal and solar heating installation. They also reported an increase in water productivity in both crop and livestock production with magnetically treated water.

Higashitani *et al*. (1993) showed that magnetised water is obtained by passing of water through the permanent magnets or through the electro magnets installed in/on a feed pipeline. When a fluid passes through the magnetised field, its structure and some physical characteristic such as density, salt solution capacity, and deposition ratio of solid particles will be changed.

Amaya *et al.* (1996) showed that an optimal external electromagnetic field accelerates the plant growth, especially seed germination percentage and speed of emergence.

Higashitani and Oshitani (1996) investigated the effect of magnetic fields on the stability of nonmagnetic colloid particles, and suggested that colloidal stability is influenced by magnetic fields through alteration of the structure of water molecules and ions either adsorbed on the particle surface, or in the medium.

Diaz *et al*. (1997) showed that the magnetic treatment of irrigation water can improve water productivity. An increase in nutrient uptake by magnetic treatment was also observed in tomatoes.

Kieber *et al*. (1999) concluded that magnetic field stimulates protein synthesis via increase cytokinins and they can promote the maturation of chloroplast.

Celestino *et al.* (2000) reported enhanced germination and growth of Cork oak (Quercus suber) seedlings when exposed to chronic magnetic field.

Aladjadjiyan (2002) observed that the magnetic field stimulated the shoot development of maize and led to an increase in germinating energy, fresh weight and shoot length.

Harichand *et al*. (2002) reported that exposure of magnetic field (10 mT; 40 h) increased plant height, seed weight per spike and yield of wheat.

Ruzic and Jerman (2002) showed that the impact of heat stress at 40°, 42° and 45° C for 40 minutes in cress seedlings (Lepidium sativum) was reduced by exposing plants to extremely-low-frequency magnetic field (50 Hz, 100 μT)

Atak *et al.* (2003) found that an increase in chlorophyll content specifically after exposure to a magnetic field for a short time.

Belyavskaya (2004) showed that the proliferative activity and cell reproduction in meristem in plant roots are reduced in weak magnetic field. Cell reproductive cycle slows down due to the expansion of G1 phase in many plant species and G2 phase in flax and lentil roots. There was a decrease in the functional activity of genome at early pre-replicate period in plant cells exposed to weak magnetic field. In general, these studies conclude that weak magnetic field caused intensification of protein synthesis and disintegration in plant roots.

Esitken and Turan (2004) have shown that there is an increase in number of flowers, earliness and total fruit yield of strawberry and tomatoes by the application of magnetic fields.

Podleoeny *et al.* (2004) studied the effects of magnetic treatment by exposing the broad bean seeds to variable magnetic strengths before sowing and observed marked beneficial effects on seed germination, emergence rate and seed yield. It also showed that an optimal external electromagnetic field accelerates the plant growth, especially seed germination percentage and speed of emergence

Podlesny *et al.* (2005) observed that,in broad bean (Phaseolus lunatus) and pea (Pisum sativum*)* cultivars the magnetic stimulation of seeds improved the sprouting and emergence of seed and resulted in higher pod number and seed yield.

Rajendra *et al*. (2005) observed that the growth of the germinated Vicia faba seedlings was enhanced by the application of power frequency magnetic fields (100 mT) that were supported by increased mitotic index and 3H-thymidine uptake.

Ghauri and Ansari (2006) conducted an experimental study which showed that a relatively weak magnetic influence (field) increased the viscosity of water, which was interpreted by the stronger hydrogen bonds under the magnetic field.

Kney and Parsons (2006) showed that to reclaim soil and water, and to reduce soil salinity, magnetised water can be used.

Elmaloglou and Diamantopoulos (2007) showed that distribution pattern of soil water and salts resulting from trickle irrigation is quite different from those resulting from the conventional irrigation methods

Turker *et al*. (2007) reported an inhibitory effect of static magnetic field on root dry weight of maize plants, but there was a beneficial effect of magnetic field on root dry weight of sunflower plants.

Celik *et al*. (2008) reported that the positive effect of magnetic field on regeneration percentage, shoot numbers and chlorophyll content of the explants exposed to a magnetic field for a 2.2s period were higher than controls.

Basant *et al*. (2009) evaluated the effect of magnetised irrigation water on vegetable crop yield and water productivity. The analysis of the result suggests that the effect of magnetic treatment varied with plant type and the type of irrigation water used and there were significant increases in plant yield and water productivity.

Shabrangi and Majid (2009) reported that, the greatest shoot growth and biomass were seen in lentil plants exposed to magnetic field.

Amira *et al.* (2010) conducted experiments to study the response of growth, yield components and some chemical constituents of flax for irrigation with magnetised water and tap water. The flax plants which irrigated with magnetic water exhibited marked increases in the most of vegetative growth and chemical constitutes. Moreover the magnetised water treatment increases yield.

Nawroz *et al.* (2010) conducted experiments on the impact of magnetic application on the parameters related to growth of chickpea. The results showed that magnetised seeds irrigated with magnetised water have enhanced seed performance in terms of plant height, number of branches, number of leaves, root and shoot fresh weight and dry weight.

Behrouz *et al.* (2011) studied the effects of magnetised water on soil sulphate ions in trickle irrigation. The results showed that at all soil depths below the emitter, the mean soil sulphate ions for the magnetised irrigation water treatment are less than the non-magnetised irrigation water treatment.

Mojtaba *et al*. (2011) studied the effects of magnetised water and irrigation water salinity on soil moisture distribution in trickle irrigation. The results showed that the mean soil moisture contents below the emitter for the magnetised irrigation water treatment were more than the non magnetised irrigation water treatment. The irrigation with magnetic water as compared with the nonmagnetic water increased soil moisture.

Mostafazadeh *et al*. (2011) investigated effects of magnetised water and irrigation water salinity on soil moisture distribution in trickle irrigation. They showed that the mean soil moisture contents at different soil depths below the emitter for the magnetised irrigation water treatment were more than the non-magnetised irrigation water treatment and the differences were significant at 5% level.

MATERIALS AND METHOD

CHAPTER III

MATERIALS AND METHOD

A field study was conducted to evaluate the growth parameters of Amaranthus with magnetised and non-magnetised water at different soils. This chapter presents the materials used and methodology employed for experimentation, data collection and analysis of data.

3.1 Experimental site

The experiment was conducted inside a rain shelter made in the Instructional Farm of KCAET, Tavanur in Malappuram District, Kerala. The study area is situated at $10^0 52'30''$ North Latitude and 76^0 East longitudes.

3.2 Climatic conditions

Agro climatically, the area falls within the border line of northern zone, central zone and kole zone of Kerala. The area receives rainfall from the South-West monsoon and to a certain extent from North-East monsoon. The average annual rainfall of the region varies from 2500 to 2900 mm.

The climatological data of the experimental site is shown below.

Mean maximum temperature: 42.1^{0}C

Mean minimum temperature: 22^{0}C

Average relative humidity : 42%

Average annual rainfall : 2000mm

3.3 Experimental setup

The seedlings of Amaranthus are grown inside a shade house with dimensions of 5×10m^2. They are used to protect plants from hot sun, mind or excessively bright light. A shade house can protect plants from extreme heat in the middle of the day or extreme cold in the middle of the night. Proper land preparation was done before the installation of the system in the field. A temporary shade house was constructed for carrying out the trial. It was made using bamboo and areca nut. The top of the shade house was covered with polythene sheets and the sides were covered with transparent or translucent material and ventilations were provided on all sides. The experimental setup is shown in Plate 1 and the layout is shown in Fig.3.1

Plate 1.Experimental setup

Installation of irrigation system consisted of:

- Fitting of mains and sub-mains
- Fitting of filter unit and fertilizer unit.
- Laying of laterals and emitters

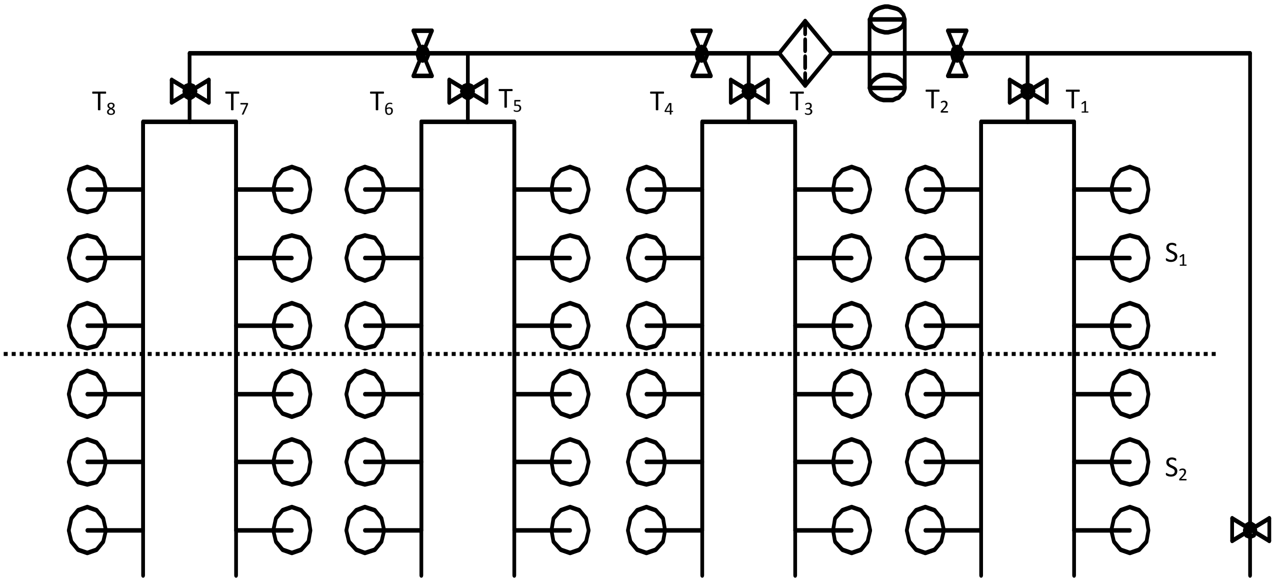

Fig.3.1 Layout of the experiment

S_1 - Sandy soil

S_2 -Sandy loam soil

T_1 -Magnetised potable water

T_2 -Non-magnetised potable water

T_3 -Magnetised water with EC= 1mmhos/cm

T_4 -Non-magnetised water with EC= 1mmhos/cm

T_5 -Magnetised water with EC= 2mmhos/cm

T_6 -Non-magnetised water with EC= 2mmhos/cm

T_7 -Magnetised water with EC= 3mmhos/cm

T_8 -Non-magnetised water with EC= 1mmhos/cm.

The methodology employed and equipments used for the experiment are given below.

3.3.1 Planting material

The planting material comprised of seeds of Amaranthus seedlings which was initially sown in seeding mixture on Oct 23, 2011, and normal potable water was used for establishing the seedlings. Once seedlings achieved required growth, healthy seedlings were selected for the study, which were transplanted into polythene bags on Nov 13, 2011.

3.3.2 Shade house experiment

A Trickle Irrigation setup with complete randomized block design was used for the installation. The trickle irrigation system had four sub-units of 0.75 inch PVC pipe and each sub-unit had two lines, which had six laterals, spaced 0.6m apart, with diameter of 12mm.The system received water from a sub-main of 1.5 inch PVC pipe. Each lateral was provided with emitters of 4lph. Control valves were installed at the beginning of each sub-unit and the sub-units were spaced at 1m apart. An electrical pump supplied water to laterals from water source at desired pressure of 1atmosphere.

In the experiment, out of the four sub-mains, one sub-main was provided with normal portable water, and the three sub-mains were provided with saline water at different concentrations. A fertilizer tank of 30 liters capacity was used for the mixing up of salt in water. A filter with nominal size of 30 mm nominal pressure of $2kg/cm^2$ and strainer element SS mesh 200 was used to avoid clogging of emitters. The attachment of fertilizer tank to the screen filter is shown in Plate 2.

3.3.3 Salinity levels

The saline water used in the study was prepared by adding measured amounts of NaCl salt to potable water to achieve required salinity levels. To understand the impact of salinity levels on magnetically treated water, three salinity levels were used for three sub-units. The salinity levels of irrigation water were selected based on the sensitivity of Amaranthus (2 mmhos/cm) to saline water. Therefore the salinity levels were EC=1mmhos/cm, EC=2 mmhos/cm and EC=3 mmhos/cm, thus providing six irrigation water types, in which three were magnetically treated and three were non-treated.

The concentration of salt solution varies with the electrical conductivity and capacity of fertilizer tank. The measured amount of NaCl to be added to achieve the required salinity levels were done in the Soil and Water Testing lab of KVK. For the determination of EC, an EC-meter is used ,which is calibrated using 0.01N KCl solution. After calibration, the portable water was poured into a 1l beaker and the rods of EC-meter were immersed in it. The salt is then added to the water and stirred thoroughly. The quantities of salt added inorder to attain the three EC values were then recorded.

Plate 2. Fertilizer tank attached to screen filter

For achieving statistically valid and unbiased estimates of treatments means, treatments differences and experimental error, we used statistical principles, for replication and randomization in these experiments. Completely randomized design was used in the study and each treatment had three replications.

3.3.4 Magnetic treatment

The irrigation water of different types was treated with a magnetic device before applying to the plants. The mean values of pH, EC, N, P and K values of different irrigation water types before and after magnetic treatment are presented in Fig.1. and values are given in Appendix. Magnetic treatment of water tends to reduce slightly the water pH, while there is no apparent trend for EC values. The values of N, P and K content of different water types were not affected by magnetic treatment of water.

Magnetic Fluid Conditioner, PERMAG N406 with its magnetic field 0.9360T, made with very powerful Neo-dymium magnets was used for the magnetic treatment of irrigation water. The device had a length of 3.5 inches which accommodates a 0.5-0.75 inch pipe. For the magnetic treatment of irrigation water, it was passed though the magnetic treatment device. The magnetic fluid conditioner attached to the pipe is shown in Plate 3 and to the control line is shown in Plate 4.

3.3.5 Treatments

3.3.5.1 Treatment with non-saline water

In this treatment, portable water is pumped to irrigate in which salt is not added. In this setup, one line was non-magnetised and the other was magnetised, using the Magnetic Fluid Conditioner. Each line had three replications of two types of soil, which made a total of six plants. The plants were watered for 30 minutes, as the water requirement of Amaranthus is 2lph. During the treatment, the valve to all other sub-units is closed.

3.3.5.3 Treatment with saline water of EC-2 mmhos/cm

In this treatment, the valve of the first, second and fourth sub-units are closed and then the weighed salt for EC-2 is added into the fertilizer tank, which passes through the filter, and reaches the third sub-unit. This sub-unit also has two lines in which one is magnetised and the other is non-magnetised. This is also continued for time of 30 minutes and then stopped.

3.3.5.4 Treatment with saline water of EC-3 mmhos/cm

In this treatment, the weighed salt for EC-3 is added into the fertilizer tank, which passes through the filter, and reaches the fourth sub-unit. The valves for all other treatments are closed during this time. This sub-unit also has two lines in which one is magnetised and the other is non-magnetised. This is also continued for time of 30 minutes and then stopped.

Plate 3. Permag N046 Magnetic fluid conditioner

Plate 4. Magnetic fluid conditioner attached to control line

3.3.6 Soil texture

The particle size analysis, for finding out the percentage of various sizes of particles in a dry soil can be performed using sieve analysis for coarse grained fraction. The soil was collected from the experimental field at a depth of 40cm from the soil surface. The soil sample was oven-dried and passed through a set of IS sieves of size 2mm, 1mm, 600 micron, 425 micron, 300 micron, 212 micron, 150 micron and 75 micron for sieve analysis. The percentage finer was calculated on the basis of percentage of soil retained in each sieve. The values for sandy soil is shown in Appendix VI and for sandy loam soil is shown in Appendix VII.

3.4 Observations taken

1) Temperature and relative humidity under the shade house.

2) Shoot length and root length

3) Number of branches per plant.

4) Number of leaves.

5) Yield

3.4.1 Temperature

The temperature inside the shade house was taken using a thermo-hygroclock. The temperature during the day time and night time was recorded using the thermo-hygroclock.

3.4.2 Relative humidity

Relative humidity was recorded by using the instrument thermo-hygroclock.

3.4.3 Shoot and root length

The plants were pulled out from each treatment at 30 days after transplanting. The root length and shoot length were measured using a scale.

3.4.4 Electrical conductivity

The EC of magnetised and non-magnetised water of controlled and saline water is measured using the EC-meter. It is done by inserting the rods of EC-meter into the water samples. In soil, 10g soil sample is taken and 25ml distilled water is added and stirred well. Allow it to settle for half an hour. Using this solution EC is measured.

3.4.5 pH

The pH of magnetised and non-magnetised water of controlled and saline water is measured using the pH-meter. It is done by inserting the rod of pH-meter into the water samples. In soil,10g soil sample is taken and 25ml distilled water is added, and stirred well. Allow it to settle for half an hour. Using this solution EC is measured.

3.4.6 Nitrogen

A known weighed 5g of soil is mixed with excess of alkaline $KMnO_4$ solution. Fit the tube in distillation unit. Add 25ml of 2.5% NaOH solution through dosing pump. Pipette out 20 ml of 2.5% boric acid in a conical flask and dip receiving end in it. Distil NH_3 gas from tube and collect the receiver acid. Add 5 drops of mixed indicator and titrate with 0.02 NH_2SO_4.

Calculations:

Available N = (14×Titrating value×0.02 N×2.24×10^6) ÷ (5×1000).kg/ha of soil

3.4.7 Potassium

To 5 gram soil sample add 25 ml neutral CH_3COONH_4 and then shake it for 5 minutes. Then filter the solution. Reading was taken using flame photometer.

Calculations:

Available Potassium, K (mg/kg soil) = photometer value×5

Available Potassium, K (Kg/ha) = Available K × 2.24

3.4.8 Phosphorous

A 5 gm soil sample is weighed and 50ml Bray no: 1 is added. Shake it well for 5 minutes. Filter the solution through a filter paper and pipette out 5ml into 25 ml standard flask and 4ml Reagent-B. Make it up to 25ml read the intensity of colour after 10 minutes using Spectro photometer.

Calculations:

Available P (mg/Kg soil) = Absorbance for sample / slope of standard curve × 50

Available P (Kg/ha) = Available P (mg/Kg soil) × 2.24

3.5 Statistical analysis and interpretation of data

ANOVA was used for the analysis and interpretation of data obtained in these experiments. The statistical design used for the study is Randomized Complete Block Design with eight treatments and three replications of each soil type. The soil types used where sandy soil and sandy loam soil. Therefore, a total of sixteen treatments were used for the study. The layout of the experiment is given in Fig.3.1

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The results of the field study conducted to evaluate the effects of magnetisation on chloride ions in trickle irrigation system are discussed in this chapter.

The experiment was conducted in Amaranthus crop and total eight treatments, consisting of magnetised and non-magnetised water were given alternatively. Each treatment was given in two types of soils. These treatments had 3 replications each. The treatments are then compared on the basis of magnetisation effects.

4.1 Effects of magnetization in water

The magnetization effects caused changes in the EC, pH and N, P, K of normal and saline water given to plants.

4.1.1 Electrical conductivity

In case of EC of water, a slight reduction in the EC was observed, when it is magnetised. The variations in EC are shown in the Fig.4.1and values are shown in Appendix V. From the observations, It is clear that magnetization of saline water with EC= 3 mmhos/cm is comparable with the non-magnetised treatment of EC=2 mmhos/cm. Magnetic treatment gave less change to control for EC=3 mmhos/cm, which gave a higher change. Changes in EC=2 mmhos/cm and EC=3 mmhos/cm were comparable.

4.1.2 pH

In case of pH of water, there were changes in magnetised water than the non-magnetised one. The variations in the pH of water used for the treatment are shown in Fig.4.2 and values are shown in Appendix V. In all the treatments pH varied in the same range, except for EC= 1, which showed a difference of 0.08. In general, the treatment of irrigation water with magnetic field reduced their pH.

4.1.3 N, P and K

The magnetic treatment of irrigation water showed significant changes only in the P in water, whereas N and K did not show a noticeable difference in the concentration. The values are shown in Appendix V. The variations in N,P and K of water used for the treatment is shown in Fig.4.3, Fig.4.4 and Fig.4.5 respectively

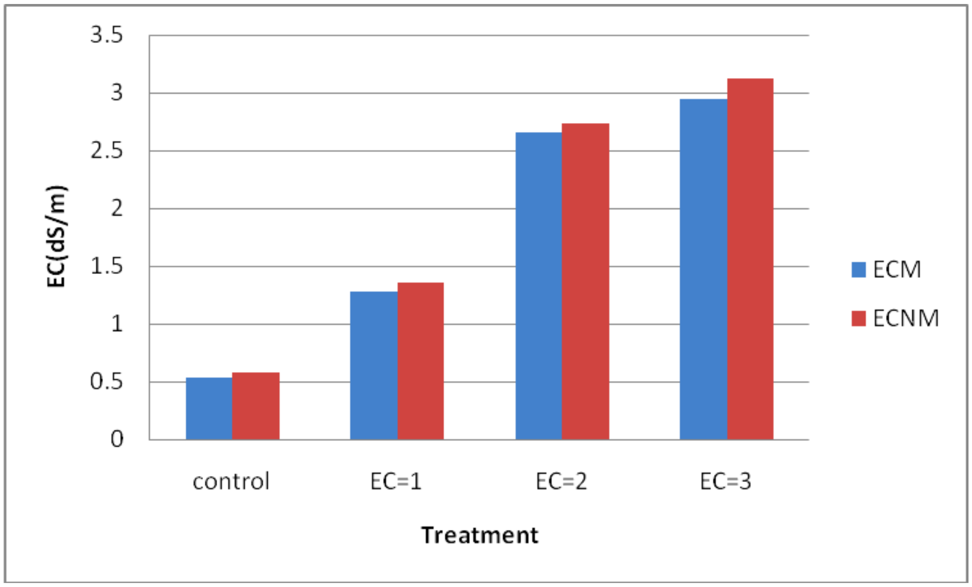

Fig.4.1 Variation of EC of water due to magnetization

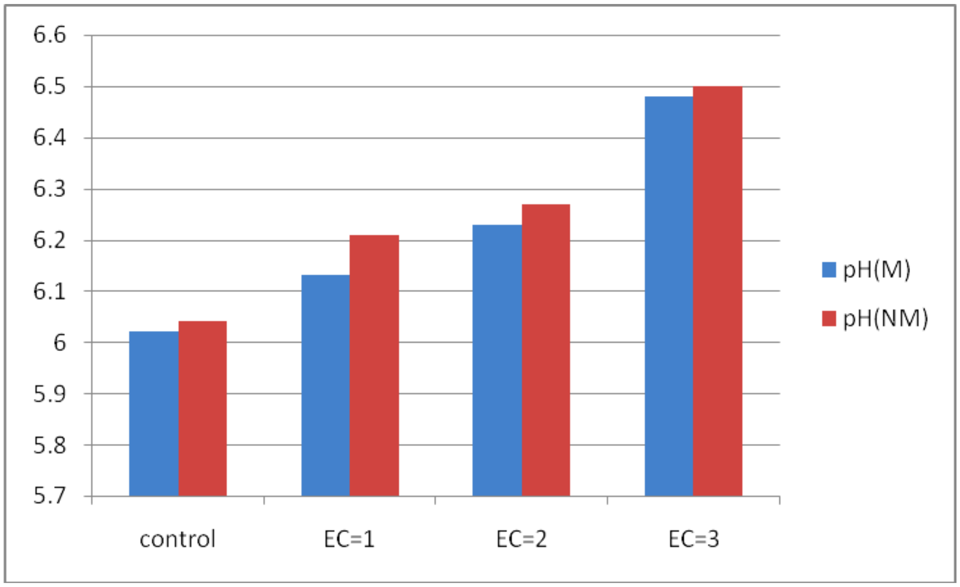

Fig.4.2 Variation of pH of water due to magnetisation

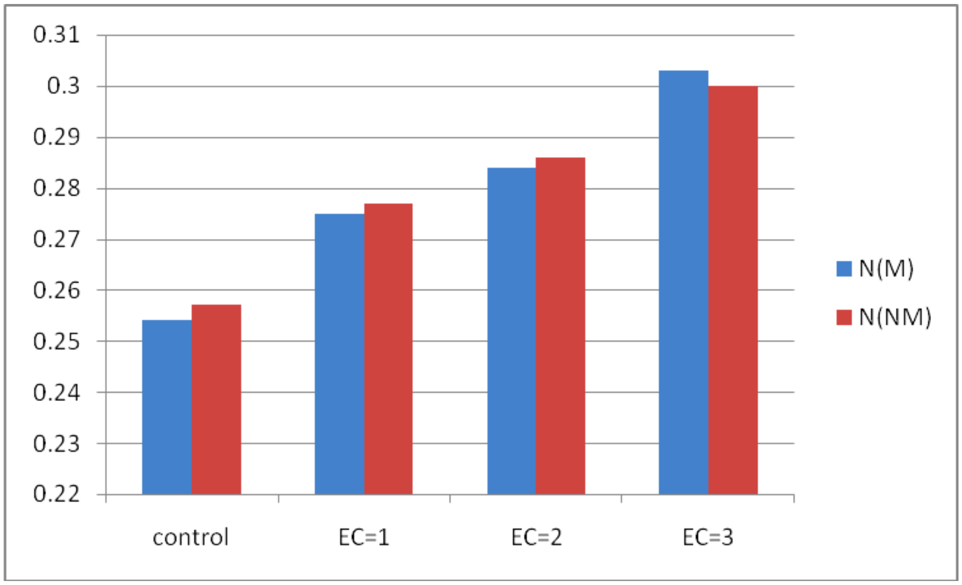

Fig.4.3 Variation of N of water due to magnetisation

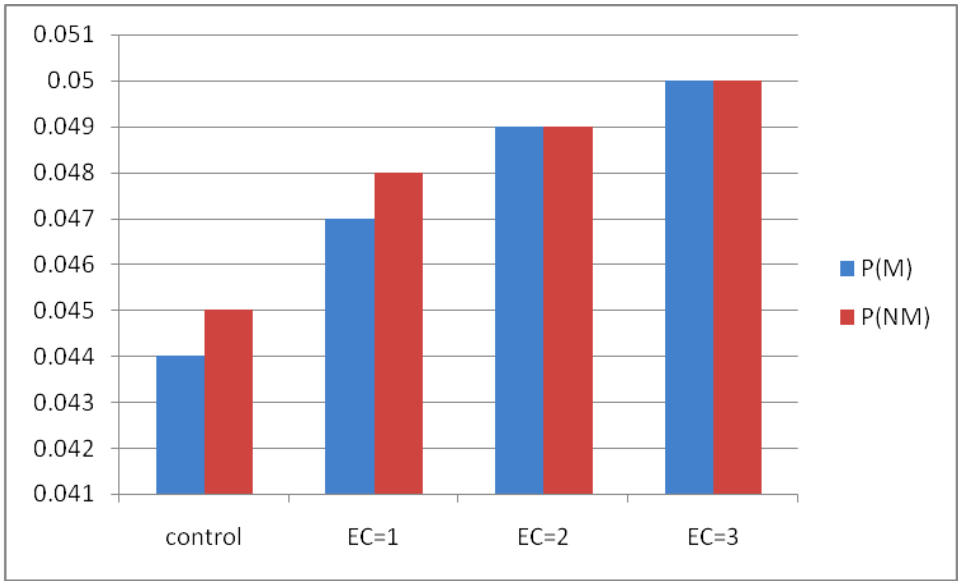

Fig.4.4 Variation of P of water due to magnetisation

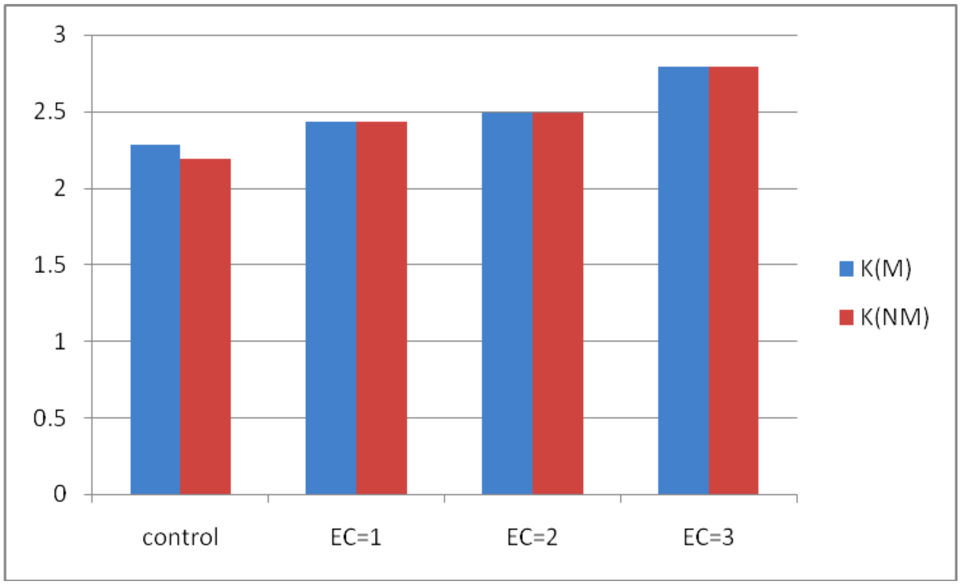

Fig.4.5 Variation of K of water due to magnetisation

4.2 Effects of magnetization in plant

4.2.1 Yield of plant

There were differential effects of magnetic treatments of different irrigation water types on yield on both the soils based on the fresh weight and dry weight of shoot. The interaction effects between magnetic treatment and non-magnetic treatment and different irrigation water types indicate significant increase in yield mainly in magnetised water treatment on EC=2 mmhos/cm and EC=3 mmhos/cm The yield of plants obtained from magnetised water was more than that obtained from the non-magnetised one, but varied with soil type. Plants grown in the sandy loam soil, gave much better yield than the sandy soil. The effects of magnetic water treatment of irrigation water on mean values of plant yield parameters are given in the Fig.4.6.The comparison of crop between magnetised and non-magnetised water in sandy soil and sandy loam soil is shown in Plate 5 and Plate 6 respectively.

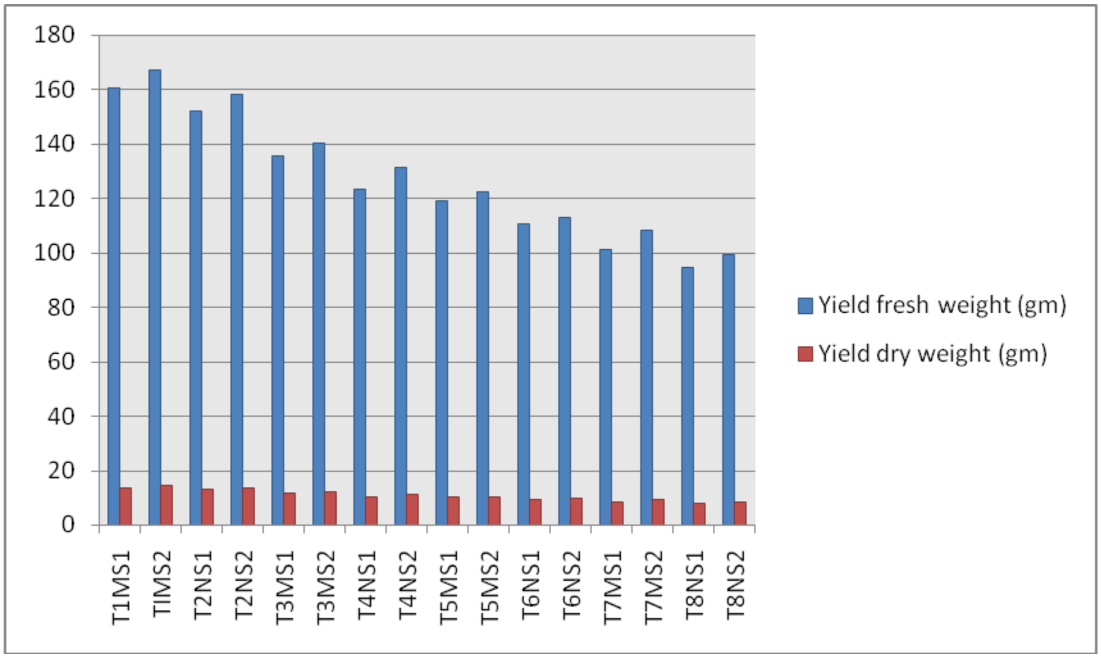

Fig.4.6 Yield variation due to magnetization

Plate 5 Comparison of crop between magnetised and non-magnetised water in sandy soil

Plate 6 Comparison of crop between magnetised and non-magnetised water in sandy loam soil

4.2.2 Root length

There was a drastic increase in the root length of plants irrigated with magnetised water, compared with the non-magnetised water under all treatments, but it varied with the type of soil. Plants grown in the soil sandy loam soil, were much better in root growth than the sandy soil.The variations on the root length of plants irrigated by magnetised and non-magnetised water is shown in Fig.4.7. for sandy soil and in Fig.4.8. for sandy loam soil and values are given in Appendix II.The average values are given in Table 1. The comparison of root length using magnetised and non- magnetised water for different treatments and soil is shown in Plate 7.

4.2.3 Shoot length

The shoot length of plants obtained from magnetised water was more than that obtained from the non-magnetised one, but varied with soil type. Plants grown in the soil sandy loam soil, were much better in shoot growth than in the sandy soil. The variations on the shoot length of plants treated with magnetised and non-magnetised water is shown in Fig.4.9. for sandy soil and in Fig.4.10. for sandy loam soil and their values are given in Appendix III and average values are shown in Table 3. The comparison of shoot length using magnetised and non- magnetised water for different treatments and soil is shown in Plate 7.

Plate 7 Comparison of root length and shoot length using magnetised and non- magnetised water for different treatments and soil

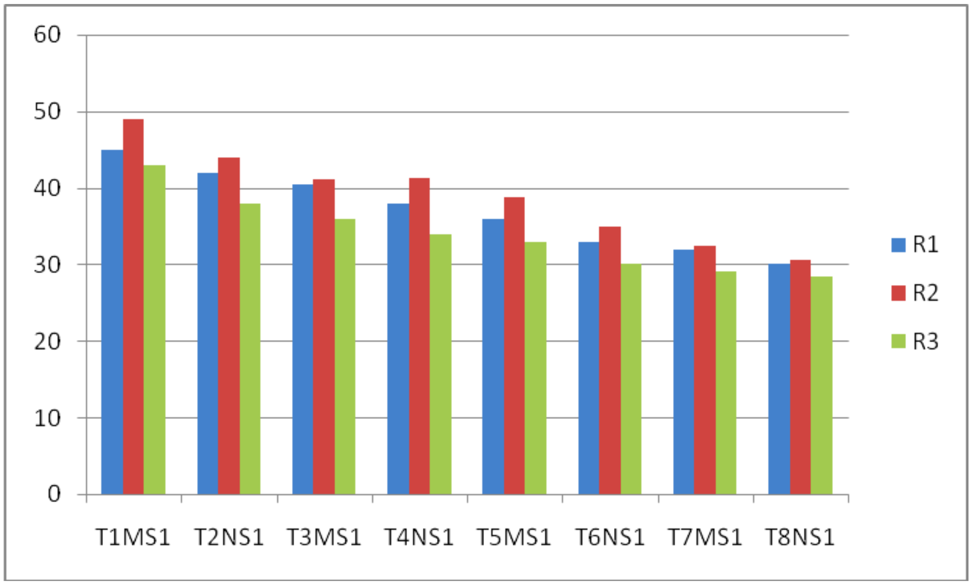

Fig.4.7 Variation of root length due to magnetization in sandy soil

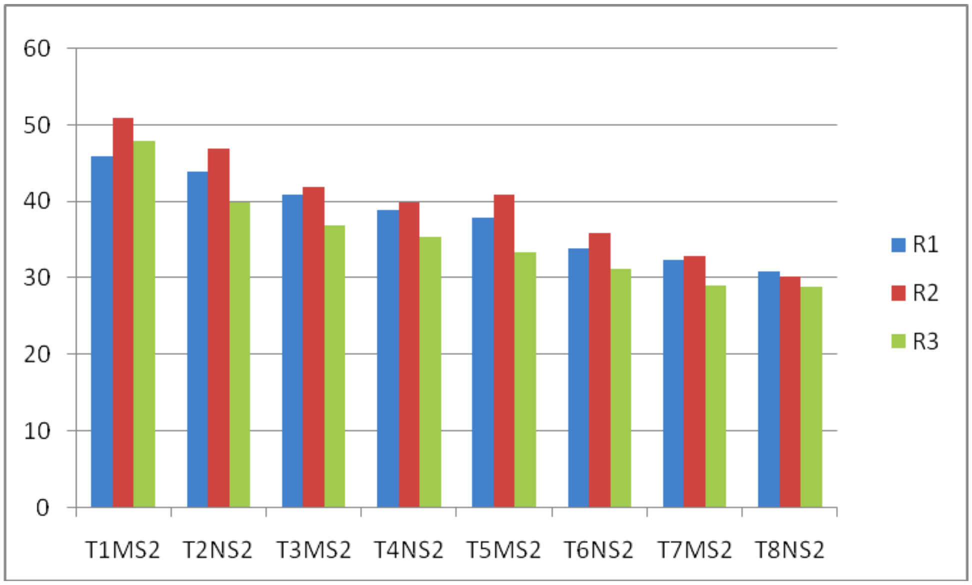

Fig.4.8 Variation of root length due to magnetization in sandy loam soil

Table 1. Average root length of plants under different treatments

Treatment	**Average root length(cm)**
T_1MS_1	45.66
T_1MS2	48.33
T_2NS_1	41.33
T_2NS_2	43.66
T_3MS_1	39.2
T_3MS_2	40
T_4NS_1	37.73
T_4NS_2	38.16
T_5MS_1	35.9
T_5MS_2	37.5
T_6NS_1	32.6
T_6NS_2	33.73
T_7MS_1	31.16
T_7MS_2	31.5
T_8NS_1	29.67
T_8NS_2	30.06

Table 2. ANOVA table for root length of plants

Source	Degree of freedom	Sum of squares	Mean value	F value	Table value	Remarks
Blocks	2	193.59	96.79	74.07	3.32	‘‘
Treatment	15	1435.98	95.73	73.26	2.04	‘‘
Error	30	39.20	1.31			
Total	47	1668.77				

CD=1.91

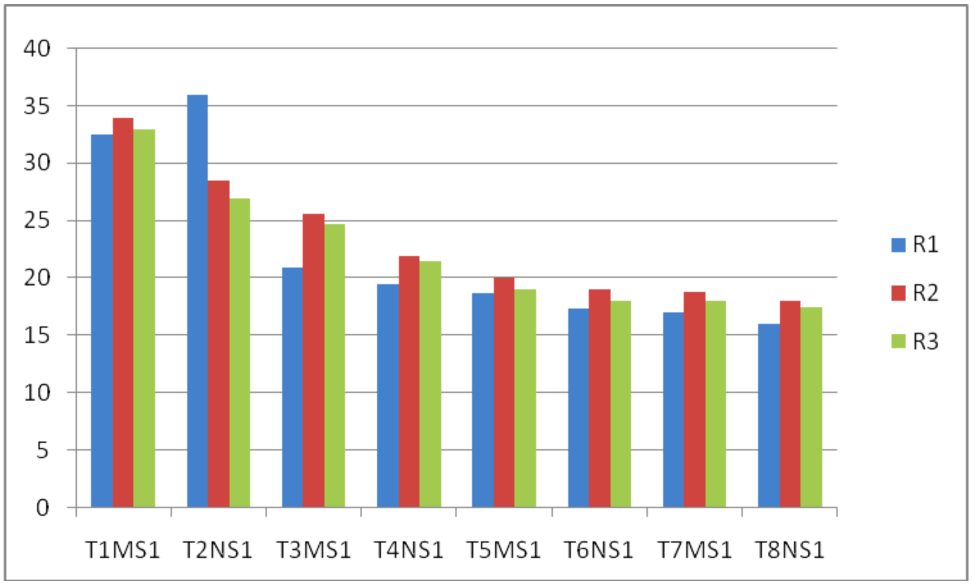

Fig.4.9 Variation of shoot length due to magnetization in sandy soil

Table 3.Average shoot length of plants under different treatments

Treatment	Average Shoot length(cm)
T_1MS_1	33.16
T_1MS2	41.16
T_2NS_1	27.16
T_2NS_2	31.26
T_3MS_1	23.76
T_3MS_2	24.8
T_4NS_1	21
T_4NS_2	22.23
T_5MS_1	19.23
T_5MS_2	20.16
T_6NS_1	18.16
T_6NS_2	18.83
T_7MS_1	17.93
T_7MS_2	18.56
T_8NS_1	17.16
T_8NS_2	17.7

Table 4. ANOVA table for shoot length of plants

Source	**Degrees of freedom**	**Sum of squares**	**Mean square**	**F value**	**Table value**	**Remarks**
Blocks	2	43.99	21.99	56.76	3.32	*
Treatment	15	2090.44	139.36	359.65	2.04	*
Error	30	11.63	0.39			
Total	47	2146.05				

CD=1.04

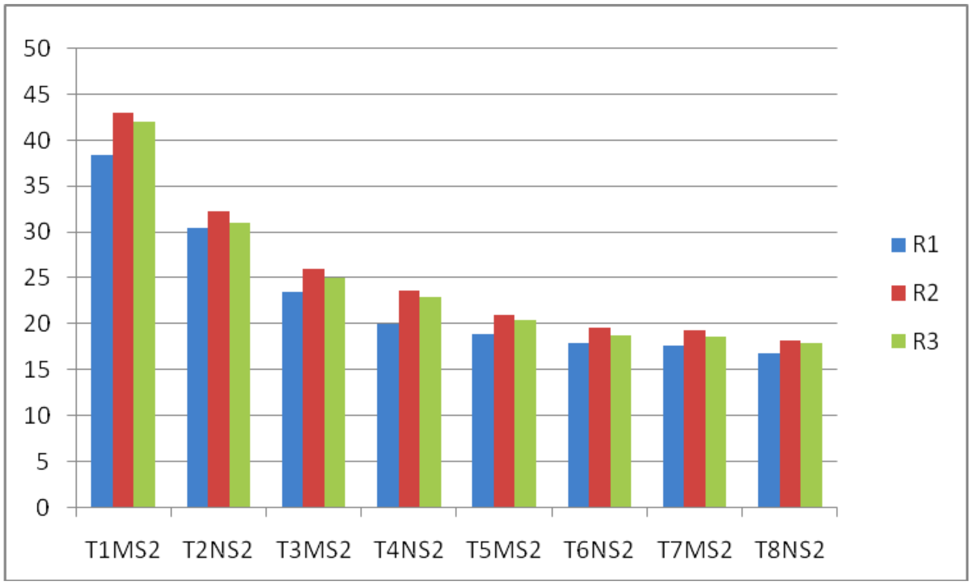

Fig4.10 Variation of shoot length due to magnetization in sandy loam soil

4.3 Effects of magnetization in soil physical properties

4.3.1 Soil Texture

The results of the soil textural analysis are shown in Appendices VI and VII. The results of the mechanical analysis (sieve) were plotted to get particle size distribution curve. In this curve percentage finer 'N' was taken as ordinate and particle diameter (mm) as abscissa on logarithmic scale. The sandy soil showed a C_u of 2.66 and C_c of 1.62, while the sandy loam soil showed a C_u of 2.91 and C_c of 1.48. As per the USDA classification chart, the textural classes of the soils are found to be well-graded soil.

4.3.2 Soil EC

The magnetic treatment resulted in significant effects on EC value after harvest of plants when compared with the control. In particular, the magnetically treated water resulted in significant increase in soil EC values.The variation of soil EC due to magnetization is shown in Fig.4.11. The values are shown in Appendix IV.

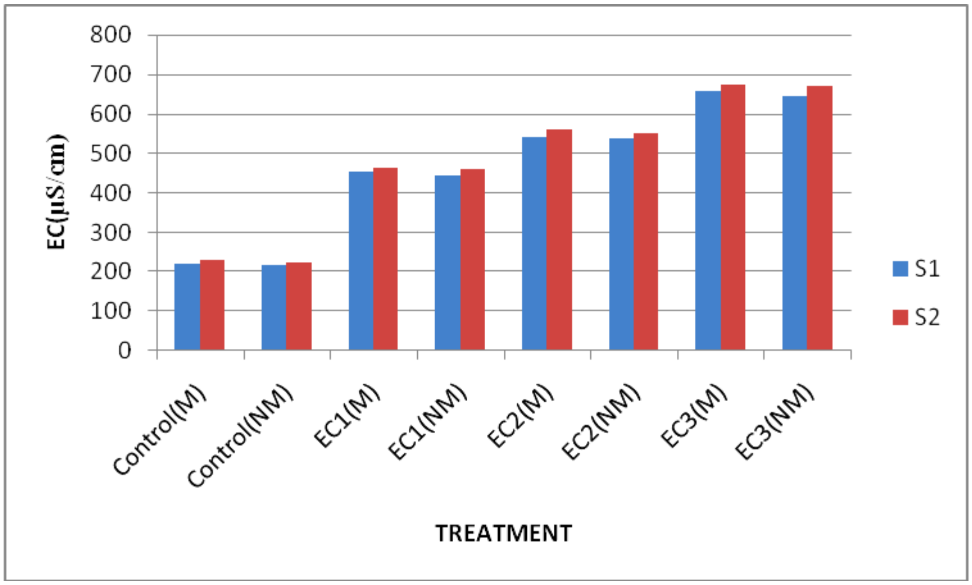

Fig.4.11 Variation of Soil EC due to magnetisation

4.3.3Soil pH

For both the soils, the magnetic treatment of irrigation water affected soil pH. Irrigating the two soil types with magnetically treated water significantly decreased the soil pH after the harvest when compared with the control. The variation of soil pH due to magnetization is shown in Fig.4.12. The values are shown in Appendix IV.

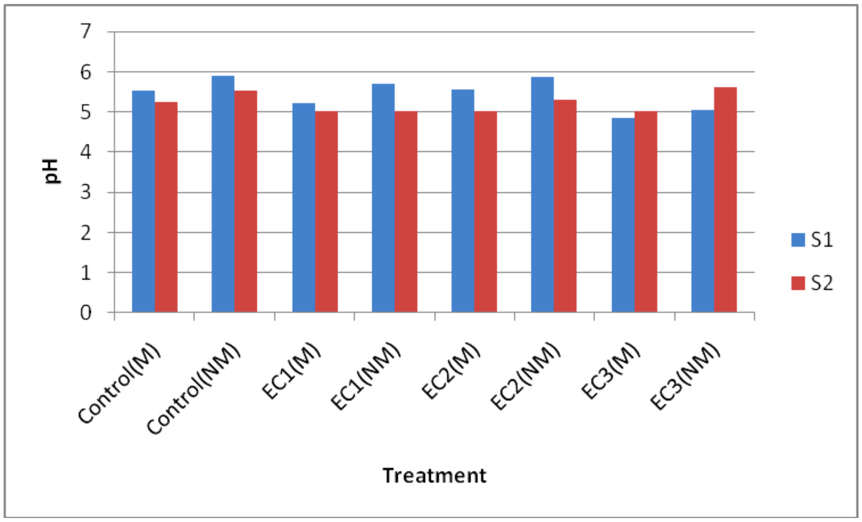

Fig.4.12 Variation of soil pH due to magnetisation

4.3.4 Soil N, P and K

In the present study, an increase in soil available P and K, particularly under magnetically treated water and saline water irrigation, appears to have played some role in improving yield. Magnetic treatment of water may be influencing desorption of P and K from soil, and thus increasing its availability to plants, and thus resulting in an improved plant growth. The variation of soil P, N and K is shown in Fig.4.13, Fig.4.14 and Fig 4.15 respectively. The values are shown in Appendix IV.

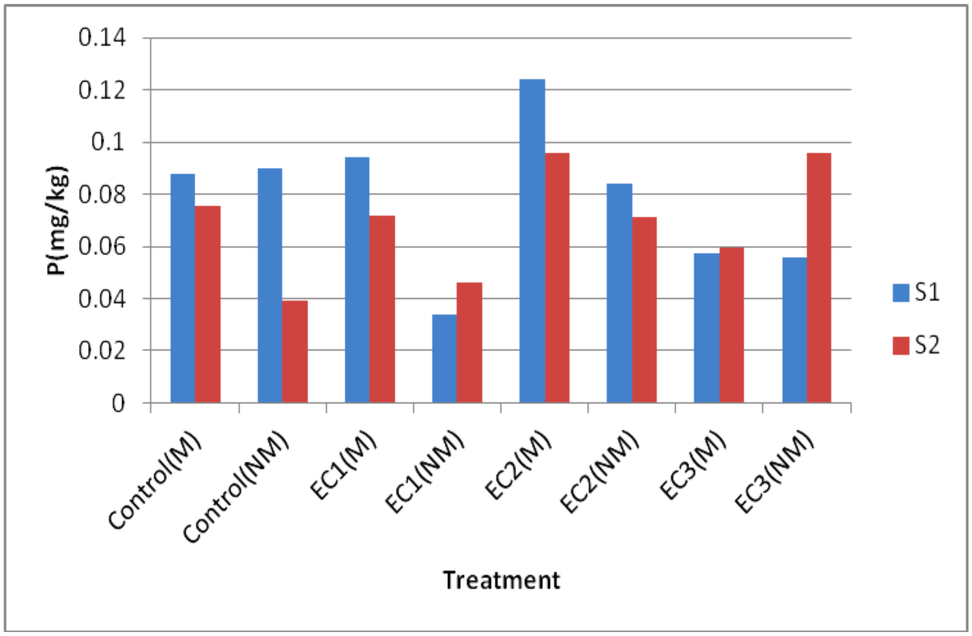

Fig.4.13 Variation of Soil P due to magnetisation

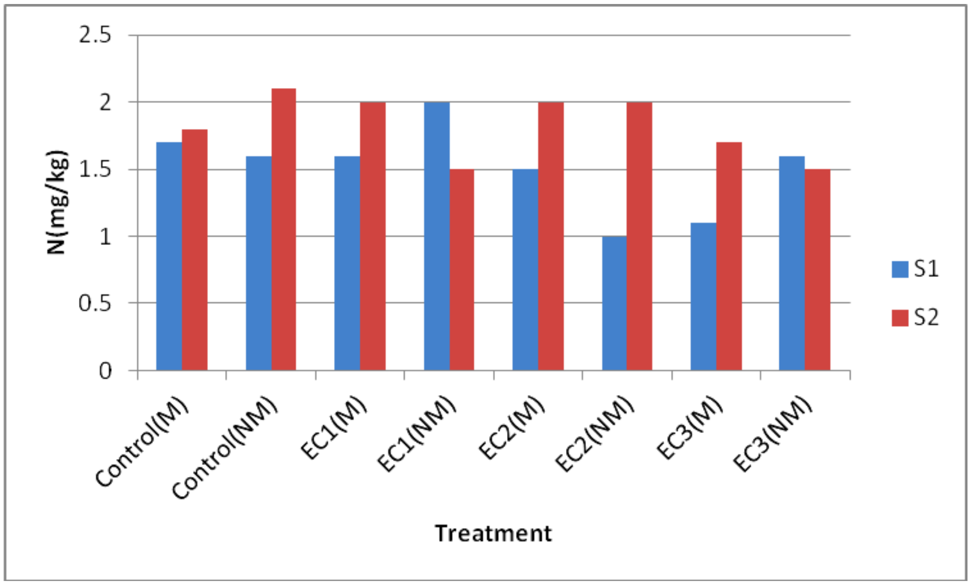

Fig.4.14 Variation of Soil N due to magnetisation

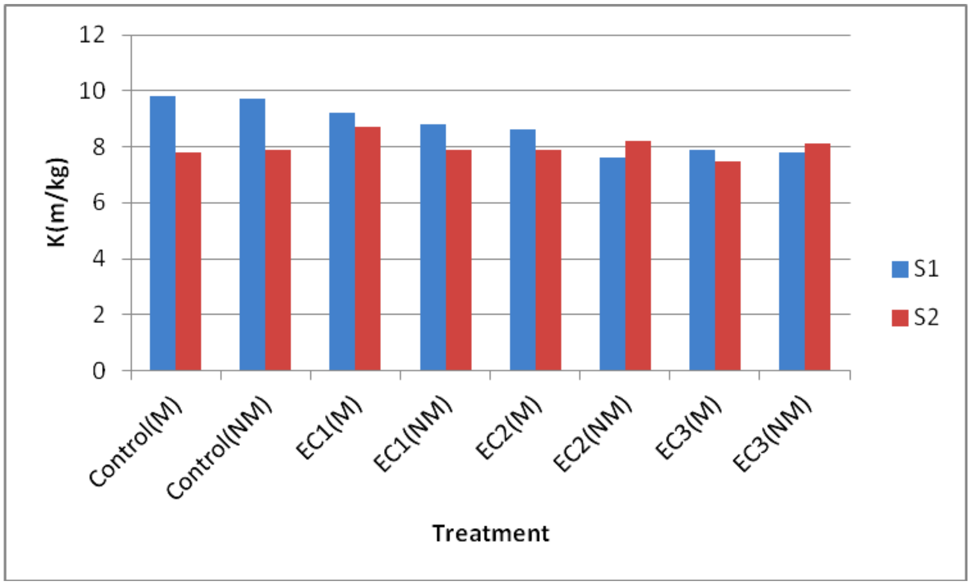

Fig.4.15 Variation of soil K due to magnetisation

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted to evaluate the effect of magnetised water treatments on chloride ions in trickle irrigation system and to compare it with the non- magnetised water treatment. The effect of magnetised water on plant, soil and water were taken into consideration. The treatments given consisted of normal water and water with different salt concentrations (EC=1 mmhos/cm, EC=2 mmhos/cm, EC=3 mmhos/cm) and each type of water was supplied as magnetised and non-magnetised. The comparison was evaluated in terms of shoot and root length of plants, and EC, pH and NPK of soil and water exposed to magnetic-field.

The results obtained from the present study can be summarised as follows.

The magnetic treatment of irrigation water resulted in statistically significant increase in the yield of plants in both soils, but it was greater in soil S_2 than in soil $S_{1.}$ The root length of the plants treated under magnetised water showed remarkable increase than the non-magnetised water.Similarly, shoot length also increased in case of magnetisation.

The magnetic treatment of irrigated water tends to decrease the EC of water, under all conditions and it was found that magnetised water treatment of EC=3 mmhos/cm was given to plants it developed a potential to grow than the non-magnetised water treatment. Amaranthus is salt tolerant upto an EC=2 mmhos/cm only .The pH of the water also increased after the exposure to magnetic field treatment in fresh water as well as in different salt concentrations of water. In case of nutrients in water, there was a noticeable increase in the concentration of P than the N and K.

The magnetic treatment resulted in significant effects on EC value after harvest of plants when compared with the control. In particular, the magnetically treated water resulted in significant increase in soil EC values.

For both soils, the magnetic treatment of irrigation water affected soil pH. Irrigation of two soils with magnetically treated water significantly decreased soil pH after the harvest when compared with the control.

In the presentt study, an increase in soil available P and K, particularly under magnetically treated water and saline water irrigation, appears to have played some role in improving yield. Magnetic treatment of water may be influencing desorption of P and K from soil, and thus increasing its availability to plants, and thus resulting in an improved plant growth.

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APPENDICES

APPENDIX I

Yield fresh weight and dry weight

Treatment	Yield fresh weight (gm)	Yield dry weight (gm)
T1MS1	160.6	13.8
TIMS2	167.25	14.4
T2NS1	152.3	13.1
T2NS2	158.5	13.6
T3MS1	135.7	11.7
T3MS2	140.35	12.1
T4NS1	123.25	10.6
T4NS2	131.5	11.3
T5MS1	119	10.2
T5MS2	122.6	10.5
T6NS1	110.5	9.5
T6NS2	112.9	9.7
T7MS1	101.1	8.7
T7MS2	108.4	9.3
T8NS1	94.8	8.2
T8NS2	99.3	8.5

APPENDIX II

Variation of root length with treatment

Treatment	Root length of Amaranthus(cm)		
T1MS1	45	49	43
T1MS2	46	51	48
T2NS1	42	44	38
T2NS2	44	47	40
T3MS1	40.5	41.1	36
T3MS2	41	42	37
T4NS1	38	41.2	34
T4NS2	39	40	35.5
T5MS1	36	38.7	33
T5MS2	38	41	33.5
T6NS1	33	35	30
T6NS2	34	36	31.2
T7MS1	32	32.5	29
T7MS2	32.5	33	29
T8NS1	30	30.6	28.4
T8NS2	31	30.3	28.9

APPENDIX III

Variation of shoot length with treatment

Treatment	Shoot length of Amaranthus(cm)		
T1MS1	32.5	34	33
T1MS2	38.5	43	42
T2NS1	26	28.5	27
T2NS2	30.5	32.3	31
T3MS1	21	25.6	24.7
T3MS2	23.5	26	25
T4NS1	19.5	22	21.5
T4NS2	20	23.7	23
T5MS1	18.7	20	19
T5MS2	19	21	20.5
T6NS1	17.4	19	18.1
T6NS2	18	19.7	18.8
T7MS1	17	18.8	18
T7MS2	17.7	19.4	18.6
T8NS1	16	18	17.5
T8NS2	16.9	18.3	17.9

APPENDIX IV

pH, EC, N, P, K for different soils

Treatments	pH	EC(µS/cm)	N(mg/kg soil)	P(mg/kg soil)	K(mg/kg soil)
T1MS1	5.54	219	1.7	0.088	9.8
T1MS2	5.24	229	1.8	0.075	7.8
T2NS1	5.89	216	1.6	0.09	9.7
T2NS2	5.53	222	2.1	0.039	7.9
T3MS1	5.21	455	1.6	0.094	9.2
T3MS2	5.01	463	2.0	0.072	8.7
T4NS1	5.70	445	2.0	0.034	8.8
T4NS2	5.03	459	1.5	0.046	7.9
T5MS1	5.56	542	1.5	0.124	8.6
T5MS2	4.02	559	2.6	0.096	7.9
T6NS1	5.88	539	1.0	0.084	7.6
T6NS2	5.31	551	2.0	0.071	8.2
T7MS1	4.86	656	1.1	0.057	7.9
T7MS2	5.03	673	1.7	0.059	7.5
T8NS1	5.05	645	1.6	0.055	7.8
T8NS2	5.60	669	1.5	0.957	8.1

APPENDIX V

Table for pH, EC and N,P,K of water that is magnetised and non-magnetised

Irrigation water type	pH		EC(dS/m@25^{0}C)		N(mg/l)		P(mg/l)		K(mg/l)	
	M	NM	M	NM	M	NM	M	NM	M	NM
Control	6.02	6.04	0.029	0.032	0.157	0.159	0.051	0.043	2.29	2.28
EC1	6.13	6.21	1.281	1.358	0.220	0.210	0.057	0.052	2.38	2.40
EC2	6.23	6.27	2.654	2.732	0.219	0.217	0.055	0.052	2.42	2.42
EC3	6.48	6.5	2.944	3.12	0.221	0.219	0.059	0.052	2.54	2.54

APPENDIX VI

Sieve analysis of sandy soil

Seive	Mass retained Grams	%retained	Cumulative % retained	% fineness
2mm	29	8.97	8.97	91.02
1mm	13	4.02	12.99	87.006
600µ	25	7.739	20.729	79.265
300µ	68	21.05	41.779	58.209
212µ	116	35.91	77.689	22.289
150µ	20.5	6.34	84.029	15.947
75µ	34.5	10.68	94.709	5.269
Receiver	17	5.263	99.972	

APPENDIX VII

Sieve analysis of sandy loam soil

Seive	Mass retained(grams)	% retained	Cumulative % retained	% fineness
2mm	28.5	8.72	8.72	91.27
1mm	26.5	8.11	16.83	83.16
600	31.5	9.64	26.47	73.52
300	56	17.15	43.62	56.36
212	113.5	3476	78.38	21.59
150	6.5	1.99	80.37	19.60
75	51	15.62	95.99	3.98
Receiver	13	3.98	99.97	

ABSTRACT

Magnetic fields are known to induce biochemical changes and could be used as a stimulator for growth related reactions, to enhance growth, chemical constituents and productivity of crops.The method of magneto-hydro dynamical activity of natural water is an essential part in the whole complex of using magnetic fields in agriculture. It includes physical- chemical changes of natural water parameters, resulting in improvement of filtration properties and in an increase of dissolving properties of water. These changes result in an increased ability of soil to get rid of salts and results in a better assimilation of nutrients and fertilizer in plants during the vegetation period.

Water treated by magnetic field or passed through a magnetic device is called magnetic water .The study examines the effect of magnetic treatment of different irrigation water types on growth and yield of Amaranthus. Replicated pot experiments using magnetically treated and normal tap water and saline water (EC=1mmhos/cm,2mmhos/cm and 3mmhos/cm) were conducted under controlled environmental conditions. A magnetic treatment device with magnetic field of intensity 0.9360T was used for the magnetic treatment of irrigation water. The analysis of data collected from the study revealed that the effect of magnetic treatment varied with the type of irrigation water used and there was a statistically significant increase in plant yield with magnetised irrigation water.