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# Significance of Protected Structures on Growth and Yield of Gherkins (*Cucumis anguria* L.) as Influenced by Magnetized Water in Semi-Arid Region

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The experiment was aimed to assess the effects of magnetized water on growth, yield, water use efficiency, and cost economics of gherkins (*Cucumis anguria* L.) using drip irrigation, both under shade net and open field conditions. The field experiments were conducted at the Department of Soil and Water Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, during the period from 2020-21 and 2021-22. An electronic and magnetic water conditioner (EMC) device was installed on the mainline of the drip system to convert non magnetized water into magnetized water. In the study, an asymmetric factorial experiment design were laid out which includes sixteen treatments and with four irrigation levels (60 %, 80 %, 100 %, and 120 % crop ET). Gherkin cultivation in the shade net with magnetized water at 80 % ET ($S_1M_1T_2$) showed the highest crop growth, yield (28.64 t $ha^{-1}$), and quality parameters, with superior physiological loss in weight, benefit-cost ratio (1.88), and a lower payback period (0.54 years), followed by 100 % ET and lowest in 60 % ET. In case of open field conditions also, the highest crop growth, yield (18.91 t $ha^{-1}$), and quality parameters were observed in magnetized water at 80 % ET ($S_2M_1T_2$), with a benefit-cost ratio of 1.76 and a lower payback period of 0.57 years, followed by 100 % ET and lowest in 60 % ET. Application efficiency was higher in shade net with magnetized water at 60 % ET (93.75 %) and lowest in open field with non magnetized water at 120 % ET (90.94 %). The maximum water use efficiency was recorded in the shade net with magnetized water at 60 % ET (199.49 kg $ha^{-1}$ $mm^{-1}$) ($S_1M_1T_1$) lowest in open field with non magnetized water at 120 % ET (28.59 kg $ha^{-1}$ $mm^{-1}$) ($S_2M_2T_4$). Overall, the study recommends shade net cultivation with magnetized water at 80 % ET for gherkins, providing statistical evidence supporting its efficacy. Among the factors, shade net cultivation yielded the best results compared to open field, despite its higher initial investment. Magnetized water consistently outperformed non-magnetized water, and 80 % ET in drip irrigation showed optimal results, followed by 100 % ET, with the least favorable outcomes at 60 % ET. Based on different parameters tested, the shade net with magnetized water at 80 % ET could be recommended for growing of gherkin crop.

*Keywords: Magnetized water; gherkins; shade net; Irrigation; application efficiency and water use efficiency.*

## 1. INTRODUCTION

Gherkin (*Cucumis anguria* L) is also called bur gherkin or West Indian gherkin, an annual trailing vine of the gourd family, grown for its edible fruit. The Gherkin plant is likely native to southern Africa and is grown in warm climates around the world. Gherkin fruits are served raw, cooked, or pickled, though the “gherkins” sold in commercial pickle mixtures are generally small, immature fruits of the common cucumber. The gherkin fruits are similar in form and nutritional value to a cucumber. Gherkins and cucumbers belong to the same species that is *Cucumis sativus* but are different cultivar groups. While there is a growing worldwide demand for pickled gherkins, more and more food companies have started to explore opportunities for producing gherkins. This is mainly true of India given the favorable growing conditions in that country [1].

Gherkin plants can be grown throughout the year in all seasons. It provides mainly employment opportunities to the family members of both the landholders and landless laborers in rural areas. This plant has palmately lobed leaves with toothed edges and can reach 2.5 meters (8 feet) in length. It bears small flowers and produces furrowed prickly fruits about 5 cm (2 inches) long. The Gherkin plant is intolerant of frost and is fairly resistant to most pests and diseases. Gherkin is a term normally used to refer to a savory pickled cucumber. They are generally picked when 4 to 8 cm (1 to 3 in) in length and pickled in jars or cans with vinegar (often flavored with herbs, particularly dill; hence, “dill pickle”) or brine. India has today emerged as the origin of the main Gherkin cultivation, processing, and exporters to the every-growing world requirement. Well-drained sandy loam with a pH range of 6.0 to 6.8 is optimum for Gherkin farming. Heat-absorbing, humus-rich soil with good water holding capacity and good structure is normally suited for cultivating gherkins. These contain humic loamy sand and sandy loam as well as black soil. The pH-optimum level lies in the range of pH 5.8 to 7. Generally, the Gherkin seed rate will be 800 g per hectare. The Gherkin plant is frost-sensitive and its thermophily is, among others, demonstrated by the fact that it develops physiological disorders (e.g. stunting) at a night temperature of below 5°C. The Gherkin plant germinates and grows at a minimum temperature of approximately 12°C and opens its flowers from 15°C.

Gherkin cultivation in India is determined largely by contract farming. Gherkin is an export-oriented vegetable or cucurbit crop. Karnataka state accounts for about 90 percent of exports of preserved Gherkins. Gherkin cultivation and exports started in India during the early 1990s with a modest beginning in Karnataka State in South India and later extended to the neighboring states of Tamil Nadu and Andhra Pradesh. The export of processed gherkin is done by about 51 companies located mainly in Karnataka, Tamil Nadu and Andhra Pradesh. Gherkin industry in India is mainly concentrated in the three southern states of Karnataka, Andhra Pradesh (AP) and Tamil Nadu. Karnataka accounts for almost 60 percent of the Gherkin production. Also, Tamil Nadu and AP each account for 20%. Currently, there are more than 1,00,000 small and marginal farmers who are engaged in the Gherkin production. Gherkins are cultivated exclusively on a “contract farming” basis [1].

## 2. MATERIALS AND METHODS

The study was conducted in experimental research plots of Department of Soil and Water Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur. The experimental site located at 16° 12' 9'' N latitude and 77° 19' 48'' E longitude with an elevation of 394 m above mean sea level (MSL). Raichur belongs to North Eastern Dry Zone-II of Karnataka under state agro-climatological classification. The daily weather data such as temperature, relative humidity, evaporation and rainfall was collected from the Meteorological observatory, located at Main Agricultural Research Station, UAS, Raichur. The present study spreads across two years namely January 2020 to May 2020 (Season-I) and December 2020 to March 2021 (Season-II) for both open field and shade net structure (the weather parameters such as temperature, relative humidity and evaporation were also monitored inside the shade net), to investigate the influence of magnetized water on the growth, yield, and water use efficiency of gherkins using drip irrigation under a shade net structure.

### 2.1 Properties of Soil

The physical and chemical properties of the soil and water during study period were determined with a standard methods as listed in Table 1 and Table 2 respectively.

### 2.2 Experimental Setup

The experiment was conducted during two consecutive year 2020 and 2020-21 under protected structure (shade net) and in open field (control) for gherkins crop. The experiment was laid out in asymmetric factorial experiment design with sixteen treatments and three replications. Layout of the experimental plot was presented in Fig.1.

**Table 1. List of physical and chemical properties conducted during the study period**

| Sl. No. | Parameters | Methodology/ Instrument | References |
|---|---|---|---|
| 1 | Soil texture | International pipette method | Piper, [2] |
| 2 | Bulk density | Core cutter method | Piper, [2] |
| 3 | Field capacity | Pressure plate apparatus (0.33 bar) | Richards and Weaver, [3] |
| 4 | Permanent wilting point | Pressure plate apparatus (15 bar) | Richards and Weaver, [3] |
| 5 | Infiltration rate | Double ring infiltration test | Anonymous, [4] |
| 6 | Hydraulic conductivity | Inverse auger hole | Ritzemma, [5] |
| 7 | pH | pH meter | Jackson, [6] |
| 8 | Electrical conductivity | Conductivity bridge | Jackson, [6] |
| 9 | Organic carbon | Wet digestion and titration | Walkley and Black, [7] |
| 10 | Available nitrogen | Kjeldahl method | Kjeldahl, [8] |
| 11 | Available phosphorus | Olsen’s method | Olsen et al. [9] |
| 12 | Available potassium | Flame photometer | Hanway and Heidal, [10] |
| 13 | Soil moisture | TDR | Jackson, [6] |
| 14 | Soil temperature | TDR | Jackson, [6] |

**Table 2. The chemical properties of irrigation water and the methodology adopted for the analysis**

| Sl. No. | Parameters | Methodology/ Instrument | Reference |
|---|---|---|---|
| 1 | pH | pH meter | Jackson, [6] |
| 2 | Electrical conductivity | Conductivity bridge | Jackson, [6] |
| 3 | Chloride | Argentometric method | Richards, [11] |
| 4 | Carbonate | Argentometric method | Richards, [11] |
| 5 | Bicarbonate | Argentometric method | Richards, [11] |
| 6 | Cations | Complexometry | Anonymous, [12] |
| 7 | Anions | Complexometry | Anonymous, [12] |
| 8 | Residual sodium carbonate | Argentometric method | Richards, [11] |

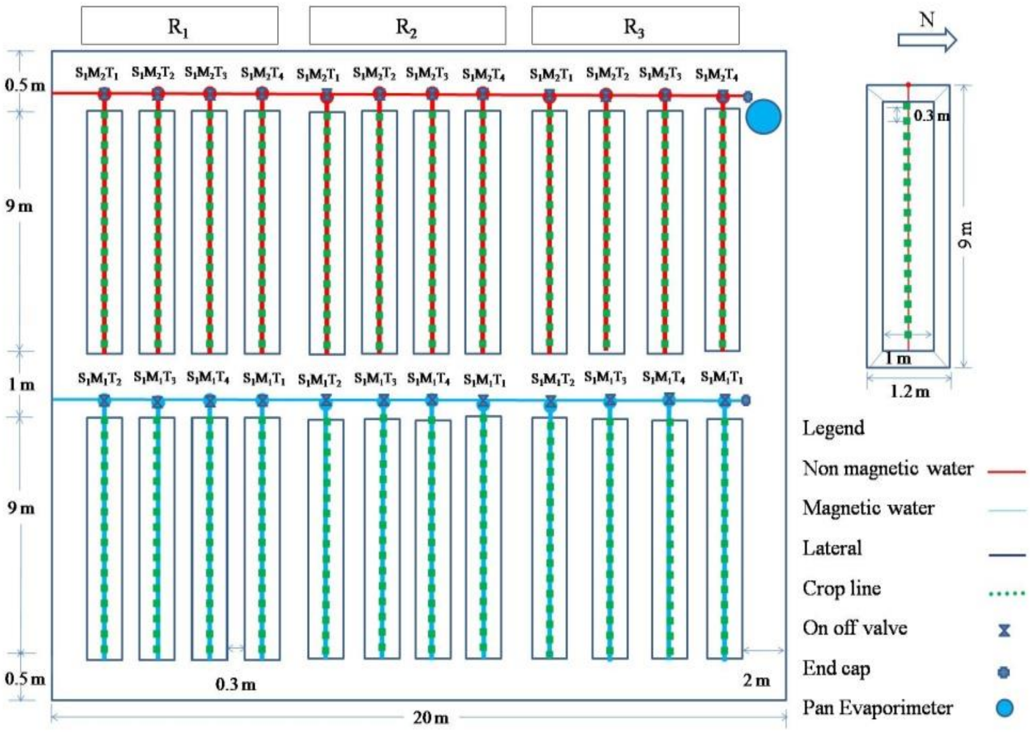


**Fig. 1. Layout of the experimental plot**

Factor –I (S) as fields$S_1$ - Shade net condition, $S_2$ - Open field condition; Factor –II (M) as water types $M_1$ - Magnetized water, $M_2$- Non magnetized water; Factor –III (T):$T_1$- Water application at 60 per cent of ET, $T_2$- Water application at 80 per cent of ET, $T_3$- Water application at 100 per cent of ET and $T_4$- Water application at 120 per cent of E

## 2.3 Laying of Surface Drip Irrigation

Surface drip irrigation was used for the experiment. Drippers of 4 lph capacity were laid manually at 30cm apart on each of the raised bed of 9 m length with on and off valves which was used for regulating different levels of irrigation in each lateral.

## 3. RESULTS

## 3.1 Properties of Soil

The soil at the experimental plot was found to be clay textured soil (Table 3). The bulk density of soil was found to be 1.50 g $cm^{-3}$ in open field and 1.58 g $cm^{-3}$ in shade net field. The basic infiltration rate of soil was measured by using Double-Ring infiltrometer and was found to be 1.50 cm $h^{-1}$ in both open field and shade net. Hydraulic conductivity of soil was estimated using Inverse Auger Hole method Ritzemma, [5] and was found to be 0.92 m $day^{-1}$ in both open field and shade net field. The field capacity was found to be 23.15 and 22.80 per cent and permanent wilting point of soil were found to be 20.22 and 20.11 per cent in both open field and shade net field respectively. The Electrical conductivity (EC) of the soil were determined using standard procedure and were found to be 1.24 dS $m^{-1}$ in 2020 and 1.45 dS $m^{-1}$ in 2020-21 in open field and 0.86 dS $m^{-1}$ in 2020 and 1.08 dS $m^{-1}$ in 2020-21 at shade net field respectively. The pH of the soil was determined using standard procedure and were found to be 7.89 during 2020 and 7.86 during 2020-21 in open field, and 7.80 during 2020 and 7.77 during 2020-21 in shade net field, respectively.

### 3.2 Properties of Irrigation Water

Physico-chemical properties of irrigation water before and after magnetic treatment in gherkin crop study during season-I (2020) and season-II (2020-21) was measured and were analyzed. The water samples were collected randomly during the experiment thought the study period and values were averaged and results are presented in Table 4. The pH during 2020 before and after magnetization was 7.51 and 8.11 (7.99 per cent increase) and during 2020-21 before and after magnetization was 7.86 and 8.05 (2.42 per cent increase) respectively. Similarly, EC (dS $m^{-1}$) during 2020 before and after magnetization was 0.94 and 0.83 (11.70 per cent decrease) and during 2020-21 before and after magnetization was 0.85 and 0.83 (2.35 per cent decrease) respectively. TDS during 2020 before and after magnetization was 462 and 457 (1.08 per cent decrease) and during 2020-21 before and after magnetization was 458 and 451 (1.53 per cent decrease) respectively. From the results it was noticed that pH, was increased and EC and TDS were decreased during both the season 2020 and 2020-21 after magnetization.

The cations such as $Ca^{2+}$, $Mg^{2+}$ and $Na^{+}$ available in irrigation water are measured. From Table 4 calcium ($Ca^{2+}$) ions during 2020 before and after magnetization was 3 meq $l^{-1}$ and 2.50 meq $l^{-1}$ (16.67 per cent decreases) and during 2020-21 before and after magnetization was 2.80 meq $l^{-1}$ in both cases respectively. Similarly, magnesium ($Mg^{2+}$) ions during 2020 before and after magnetization was 2.20 meq $l^{-1}$ and 2.10 meq $l^{-1}$ (4.55 per cent decreases) and during 2020-21 before and after magnetization was 2.10 meq $l^{-1}$ and 2 meq $l^{-1}$ (4.76 per cent decreases) respectively. Sodium ($Na^{+}$) ions during 2020 before and after magnetization was 5.91 meq $l^{-1}$ and 5.25 meq $l^{-1}$ (11.17 per cent decreases) and during 2020-21 before and after magnetization was 5.85 meq $l^{-1}$ and 5.48 meq $l^{-1}$ (6.32 per cent decreases) respectively.

**Table 3. Physical and chemical properties of soil**

| Soil physical properties | Open field | | Shade net | |
|---|---|---|---|---|
| Sand, (%) | 14.68 | | 15.42 | |
| Silt, (%) | 40.10 | | 40.80 | |
| Clay, (%) | 45.22 | | 45.28 | |
| Soil texture | Clay | | Clay | |
| Bulk density, (g $cm^{-3}$) | 1.50 | | 1.58 | |
| Infiltration rate, (cm $hr^{-1}$) | 1.50 | | 1.50 | |
| Hydraulic conductivity, (m $day^{-1}$) | 0.92 | | 0.92 | |
| Field capacity, (%) | 23.15 | | 22.80 | |
| Permanent wilting point, (%) | 20.22 | | 20.11 | |
| **Soil chemical properties** | **Season-I** | **Season-II** | **Season-I** | **Season-II** |
| EC ($dSm^{-1}$) | 1.24 | 1.45 | 0.86 | 1.08 |
| pH | 7.89 | 7.86 | 7.80 | 7.77 |
| Organic carbon, (%) | 0.75 | 0.72 | 0.79 | 0.69 |
| Available N, (kg $ha^{-1}$) | 180.00 | 178.00 | 170.00 | 166.00 |
| Available $P_2O_5$, (kg $ha^{-1}$) | 15.50 | 14.40 | 16.30 | 15.50 |
| Available $K_2O$, (kg $ha^{-1}$) | 98.10 | 96.10 | 95.10 | 90.00 |

**Table 4. Properties of irrigation water before and after magnetization during gherkins crop period**

| Parameters | Season-I | | Season-II | |
|---|---|---|---|---|
| | Before magnetization | After magnetization | Before magnetization | After magnetization |
| pH | 7.51 | 8.11 | 7.86 | 8.05 |
| EC (dS $m^{-1}$) | 0.94 | 0.83 | 0.85 | 0.83 |
| TDS | 462.00 | 457.00 | 458.00 | 451.00 |
| $Ca^{2+}$ (mmol $l^{-1}$) | 3.00 | 2.50 | 2.80 | 2.80 |
| $Mg^{2+}$ (mmol $l^{-1}$) | 2.20 | 2.10 | 2.10 | 2.10 |
| $Na^{+}$ (meq$l^{-1}$) | 5.91 | 5.25 | 5.85 | 5. 48 |
| $Cl^{-}$ (mmol $l^{-1}$) | 2.15 | 2.00 | 2.20 | 2.10 |
| $CO_3^{2-}$ (mmol $l^{-1}$) | 0.35 | 0.15 | 0.31 | 0.20 |
| $HCO_3^{-}$(mmol $l^{-1}$) | 4.73 | 4.50 | 4.80 | 4.30 |
| SAR (meq $l^{-1}$) | 3.67 | 3.46 | 3.74 | 3.50 |
| RSC (mmol $l^{-1}$) | 0.20 | 0.20 | 0.20 | 0.20 |

The anions such as $Cl^-$, $CO_3^{2-}$ and $HCO_3^-$ present in irrigation water before and after magnetization was determined. Chlorides ($Cl^-$) ion during 2020 before and after magnetization was 2.15 meq $l^{-1}$ and 2 meq $l^{-1}$ (6.98 per cent decreases) and during 2020-21 before and after magnetization was 2.20 meq $l^{-1}$ and 2.10 meq $l^{-1}$ respectively. Similarly, Carbonate ($CO_3^{2-}$) ion during 2020 before and after magnetization was 0.35 meq $l^{-1}$ and 0.15 meq $l^{-1}$ (57.14 per cent decreases) and during 2020-21 before and after magnetization was 0.31 meq $l^{-1}$ and 0.20 meq $l^{-1}$ (35.48 per cent decreases), respectively. $HCO_3^-$ (meq $l^{-1}$) during 2020 before and after magnetization was 4.73 meq $l^{-1}$ and 4.50 meq $l^{-1}$ (4.86 per cent decreases) and during 2020-21 before and after magnetization was 4.80 meq $l^{-1}$ and 4.30 meq $l^{-1}$ (10.42 per cent decreases) respectively. Sodium absorption ratio (SAR) during 2020 before and after magnetization was 3.67 meq $l^{-1}$ and 3.46 meq $l^{-1}$ (5.72 per cent decreases) and during 2020-21 before and after magnetization was 3.74 meq $l^{-1}$ and 3.50 meq $l^{-1}$ (6.42 per cent decreases) respectively. Residual sodium carbonate (RSC) was 0.2 meq $l^{-1}$ before and after magnetization during both season 2020 and 2020-21 respectively. Effect of magnetic treatment on soluble anions and cations ($Cl^-$, $CO_3^{2-}$, $HCO_3^-$, $Na^+$, $Ca^{2+,}$ $Mg^{2+}$, RSC and SAR) decreased after magnetization because of changes in hydrogen bonding and increased mobility of ions.

## 3.3 Crop Growth Parameter of Gherkins

**The crop growth parameters such as** vine length, number of branches, node of first flower, chlorophyll content, leaf area index, crop root length, crop root spread and biomass were measured and results are presented in Table 4 and Table 5.

The vine length recorded on a pooled data basis found highest in shade net with magnetized water at 80 per cent ET ($S_1M_1T_2$) 75.77, 206.70, 228.96 and 229.85 cm at 30, 60, 90, and 120 DAS, respectively. While open field with non-magnetized water at 60 per cent ET ($S_2M_2T_1$) resulted in the lowest vine length of 63.35, 163.67, 201.07 and 204.47 cm at 30, 60, 90, and 120 DAS, respectively.

The number of branches in the shade net with magnetized water at 80 per cent ET ($S_1M_1T_2$) resulted in more branches i.e., 7.31, 16.53, 27.40 and 29.1130, 60, 90, and 120 DAS, respectively. Open field with non-magnetized water at 60 per cent ET ($S_2M_2T_1$) resulted in a smaller number of branches of 2.78, 5.73, 12.18 and 12.50 at 30, 60, 90, and 120 DAS, respectively.

The treatment shade net with magnetized water at 80 per cent ET ($S_1M_1T_2$), there was a reduction in the number of nodes for the first female flower by 1.88. Conversely, the treatment in the open field with non-magnetized water at 60 percent ET ($S_2M_2T_1$) exhibited an increase in the number of nodes for the first female flower by 5.45, as observed in pooled data.

Chlorophyll content of leaf on a pooled basis in the shade net with magnetized water at 80 per cent ET ($S_1M_1T_2$) resulted the highest i.e., 62.83, 93.53, 117.12 and 54.66 µmol $m^{-2}$ at 30, 60, 90, and 120 DAS, respectively. While, the open field with non-magnetized water at 60 per cent ET ($S_2M_2T_1$) resulted in the lowest chlorophyll content of leaf was 35.88, 48.08, 75.32 and 29.99 µmol $m^{-2}$ at 30, 60, 90, and 120 DAS, respectively.

Leaf area index on a pooled basis were found higher in shade net with magnetized water at 80 per cent ET ($S_1M_1T_2$) i.e., 1.30, 2.76, 2.97 and 2.34 at 30, 60, 90 and 120 DAS, respectively. While, the open field with non-magnetized water at 60 per cent ET ($S_2M_2T_1$) resulted in lowest leaf area index of 0.97, 1.94, 2.50 and 1.60 at 30, 60, 90 and 120 DAS, respectively. Because of controlled environment in the shade net the rate of photosynthesis will be more and maximum foliage and canopy can be seen.

Crop root length and crop root spread on a pooled basis were maximum in shade net with magnetized water at 80 per cent ET ($S_1M_1T_2$) i.e., 41.17 cm and 41.67 cm, respectively. The open field with non-magnetized water at 60 per cent ET ($S_2M_2T_1$) resulted in lowest root length and crop root spread of 29.17 cm and 29.33 cm, respectively.

Biomass on a pooled basis in a shade net field with magnetized water at 80 per cent ET ($S_1M_1T_2$) resulted in highest value of 465.41 kg ha$^{-1}$. While, the open field with non-magnetized water at 60 per cent ET ($S_2M_2T_1$) resulted the lowest biomass of 301.28 kg ha$^{-1}$.

### 3.4 Crop Yield

The total yield on a pooled basis (Table 7) was maximum in shade net with magnetic water device at 80 per cent ET (28.64 t ha$^{-1}$), followed by 25.95 t ha$^{-1}$ in 100 per cent ET, 25.05 t ha$^{-1}$ 120 per cent ET and minimum yield was at 60 per cent ET (23.84 t ha$^{-1}$).Second highest yield was exhibited in shade net without magnetic water device at 80 per cent ET (22.72 t ha$^{-1}$) this was followed by 21.89 t ha$^{-1}$ in 100 per cent ET, 21.03 t ha$^{-1}$ in 120 per cent ET and minimum yield was recorded at 60 per cent ET (20.01 t ha$^{-1}$).

In open field the maximum yield was found (Table 8) with magnetized water at 80 per cent ET (18.91 t ha$^{-1}$), followed by 18.33 t ha$^{-1}$ in 100 per cent ET, 17.36 t ha$^{-1}$ in 120 per cent ET and minimum yield was recorded at 60 per cent ET (16.83 t ha$^{-1}$). The lowest yield was noticed in open field with non magnetized water, in which the treatment at 80 per cent ET had a maximum yield of 16.29 t ha$^{-1}$, followed by 100 per cent ET (15.35 t ha$^{-1}$), 120 per cent ET (14.06 t ha$^{-1}$) and minimum yield was recorded in 60 per cent ET (12.33 t ha$^{-1}$).

### 3.5 Efficiency Parameters

Application efficiency was higher in shade net with magnetized water at 60 per cent ET (93.75**%**) and lowest in shade net with non magnetized water at 120 per cent ET (91.52 %). In the open field the application efficiency was higher in open field with magnetized water at 60 per cent ET (93.31 %) and lowest in open field with non magnetized water at 120 per cent ET (90.94%).

The maximum water use efficiency was recorded in the shade net with magnetized water at 60 per cent ET (199.49 kg ha$^{-1}$ mm$^{-1}$) ($S_1M_1T_1$) followed by 80 per cent ET (185.87 kg ha$^{-1}$ mm$^{-1}$) ($S_1M_1T_2$) and minimum in shade net with non magnetized water at 120 per cent ET($S_1M_2T_4$) (87.90kg ha$^{-1}$ mm$^{-1}$). Among the open field, the water use efficiency was higher in open field with magnetized water at 60 per cent ET (68.28 kg ha$^{-1}$ mm$^{-1}$) ($S_2M_1T_1$) followed by 80 per cent ET (57.22 kg ha$^{-1}$ mm$^{-1}$) ($S_2M_1T_2$) and lowest in open field with non magnetized water at 120 per cent ET (28.59 kg ha$^{-1}$ mm$^{-1}$) ($S_2M_2T_4$). The results highlight the significant impact of using shade nets and magnetized water on water use efficiency in gherkins cultivation. The treatment involving the shade net with magnetized water at 60 per cent ET irrigation levels depicted the highest water use efficiency, indicating that this treatment allowed the most effective utilization of water resources to achieve a maximum productive crop yield. On the other hand, the treatment consisting of open field with non-magnetized water at 120 per cent ET irrigation levels exhibited poor water use efficiency, suggesting that this approach was less effective in utilizing the available water to support crop growth and yield.

The nutrient use efficiency on pooled basis was found maximum in shade net with magnetized water at 80 per cent ET ($S_1M_1T_2$) for nitrogen (190.91kg ha$^{-1}$ mm$^{-1}$), phosphorous (381.80 kg ha$^{-1}$ mm$^{-1}$) and potassium (286.36 kg ha$^{-1}$ mm$^{-1}$) on pooled basis. While, the minimum fertilizer use efficiency was in open field with non magnetized water at 60 per cent ET ($S_2M_2T_1$) for nitrogen (82.19 kg ha$^{-1}$ mm$^{-1}$), phosphorous (164.39 kg ha$^{-1}$ mm$^{-1}$)and potassium (123.29 kg ha$^{-1}$ mm$^{-1}$). The controlled environment of shade net, magnetized water has influence on plant uptake of nutrients, With increased soil EC, decrease in soil pH, optimum soil moisture and temperature, deficit irrigation without leaching of any nutrients magnetic water enhances the uptake of nutrients from soil, as already documented in results of soil EC, soil pH, soil moisture and temperature and all biometric parameters of gherkin crop.

**Table 5. Crop growth parameter of gherkin as influenced by field conditions, type of irrigation water and irrigation levels during 2020 (January to May) and 2020-21 (December to March)**

| Treatment | Crop growth parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vine Length (Cm) | | | Number Of Branches | | | Node Number Of First Flower | | | Chlorophyll Content | | |
| | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled |
| **Factor –I (S):** | | | | | | | | | | | | |
| $S_1$: Shade net | 199.25 | 221.77 | 210.51 | 24.02 | 27.08 | 25.55 | 3.75 | 2.07 | 2.91 | 97.51 | 107.35 | 102.43 |
| $S_2$: Open field | 126.92 | 161.17 | 144.05 | 12.22 | 19.40 | 15.81 | 5.33 | 3.57 | 4.45 | 83.67 | 92.10 | 87.88 |
| S.Em± | 0.44 | 0.28 | 0.36 | 0.12 | 0.05 | 0.08 | 0.02 | 0.02 | 0.02 | 0.29 | 0.18 | 0.24 |
| CD ($p<0.05$) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **Factor –II (M):** | | | | | | | | | | | | |
| $M_1$: Magnetized water | 170.34 | 197.34 | 183.84 | 19.19 | 25.13 | 22.16 | 4.29 | 2.57 | 3.43 | 93.80 | 103.90 | 98.85 |
| $M_2$: Non magnetized water | 155.83 | 185.61 | 170.72 | 17.04 | 21.34 | 19.19 | 4.80 | 3.07 | 3.93 | 87.38 | 95.54 | 91.46 |
| **S.Em±** | 0.44 | 0.28 | 0.36 | 0.12 | 0.05 | 0.08 | 0.02 | 0.02 | 0.02 | 0.29 | 0.18 | 0.24 |
| **CD ($p<0.05$)** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **Factor –III (T):** | | | | | | | | | | | | |
| $T_1$: Irrigation with 60 % ET | 146.34 | 183.62 | 164.98 | 16.41 | 21.93 | 19.17 | 5.29 | 3.53 | 4.41 | 82.17 | 92.27 | 87.22 |
| $T_2$: Irrigation with 80 % ET | 177.90 | 197.86 | 187.88 | 19.84 | 24.90 | 22.37 | 3.80 | 2.15 | 2.98 | 99.20 | 106.98 | 103.09 |
| $T_3$: Irrigation with 100 % ET | 167.43 | 193.99 | 180.71 | 18.76 | 23.51 | 21.14 | 4.27 | 2.54 | 3.40 | 92.14 | 101.27 | 96.70 |
| $T_4$: Irrigation with 120 % ET | 160.68 | 190.43 | 175.55 | 17.46 | 22.61 | 20.03 | 4.82 | 3.06 | 3.94 | 88.85 | 98.36 | 93.60 |
| **S.Em ±** | 0.88 | 0.55 | 0.72 | 0.24 | 0.10 | 0.17 | 0.04 | 0.04 | 0.04 | 0.59 | 0.37 | 0.48 |
| **CD ($p\leq0.05$)** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **Interaction (S x M x T):** | | | | | | | | | | | | |
| $S_1M_1T_1$ | 187.71 | 221.23 | 204.47 | 24.63 | 27.48 | 26.06 | 4.23 | 2.57 | 3.40 | 88.00 | 104.94 | 96.47 |
| $S_1M_1T_2$ | 226.33 | 233.37 | 229.85 | 27.50 | 30.72 | 29.11 | 2.57 | 1.20 | 1.88 | 114.50 | 119.74 | 117.12 |
| $S_1M_1T_3$ | 212.10 | 231.92 | 222.01 | 26.03 | 28.72 | 27.38 | 3.40 | 1.67 | 2.53 | 100.33 | 110.65 | 105.49 |
| $S_1M_1T_4$ | 205.48 | 229.53 | 217.51 | 25.10 | 28.22 | 26.66 | 3.57 | 1.74 | 2.65 | 93.17 | 106.72 | 99.94 |
| $S_1M2T_1$ | 162.33 | 207.23 | 184.78 | 20.23 | 24.41 | 22.32 | 4.63 | 2.84 | 3.73 | 92.49 | 98.71 | 95.60 |
| $S_1M_2T_2$ | 213.18 | 222.57 | 217.87 | 23.83 | 26.64 | 25.24 | 3.57 | 1.87 | 2.72 | 102.95 | 109.31 | 106.13 |
| $S_1M_2T_3$ | 198.17 | 216.63 | 207.40 | 23.43 | 25.67 | 24.55 | 3.67 | 2.00 | 2.83 | 95.10 | 105.05 | 100.08 |
| $S_1M_2T_4$ | 188.73 | 211.70 | 200.21 | 21.37 | 24.77 | 23.07 | 4.40 | 2.67 | 3.53 | 93.57 | 103.65 | 98.61 |
| $S_2M_1T_1$ | 125.78 | 158.67 | 142.22 | 11.00 | 20.60 | 15.80 | 5.90 | 4.20 | 5.05 | 77.25 | 85.75 | 81.50 |
| $S_2M_1T_2$ | 138.68 | 171.43 | 155.06 | 14.33 | 22.70 | 18.51 | 4.33 | 2.50 | 3.42 | 95.43 | 106.77 | 101.10 |

| Treatment | Crop growth parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vine Length (Cm) | | | Number Of Branches | | | Node Number Of First Flower | | | Chlorophyll Content | | |
| | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled |
| $S_2M_1T_3$ | 137.38 | 167.43 | 152.41 | 12.97 | 21.46 | 17.22 | 4.73 | 2.94 | 3.83 | 93.01 | 101.47 | 97.24 |
| $S_2M_1T_4$ | 129.29 | 165.10 | 147.20 | 11.99 | 21.16 | 16.58 | 5.57 | 3.75 | 4.66 | 88.72 | 95.19 | 91.96 |
| $S_2M_2T_1$ | 109.53 | 147.33 | 128.43 | 9.77 | 15.23 | 12.50 | 6.40 | 4.50 | 5.45 | 70.95 | 79.69 | 75.32 |
| $S_2M_2T_2$ | 133.41 | 164.07 | 148.74 | 13.71 | 19.53 | 16.62 | 4.73 | 3.04 | 3.88 | 83.93 | 92.09 | 88.01 |
| $S_2M_2T_3$ | 122.07 | 159.97 | 141.02 | 12.60 | 18.20 | 15.40 | 5.27 | 3.55 | 4.41 | 80.10 | 87.91 | 84.00 |
| $S_2M_2T_4$ | 119.22 | 155.37 | 137.29 | 11.37 | 16.30 | 13.83 | 5.73 | 4.09 | 4.91 | 79.93 | 87.89 | 83.91 |
| **S.Em±** | 3.52 | 2.22 | 2.87 | 0.96 | 0.40 | 0.68 | 0.16 | 0.17 | 0.16 | 2.34 | 1.47 | 1.90 |
| **CD (p<0.05)** | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| **General mean** | 163.09 | 191.47 | 177.28 | 18.12 | 23.24 | 20.68 | 10.26 | 17.62 | 13.94 | 90.59 | 99.72 | 95.16 |

**Table 6. Crop growth parameter of gherkin as influenced by field conditions, type of irrigation water and irrigation levels during 2020 (January to May) and 2020-21 (December to March)**

| Treatment | Crop growth parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leaf area index | | | Crop root length | | | Crop root spread | | | Biomass | | |
| | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled | 2020 | 2020-21 | Pooled |
| **Factor –I (S):** | | | | | | | | | | | | |
| $S_1$: Shade net | 2.75 | 2.84 | 2.79 | 37.54 | 37.71 | 37.63 | 38.21 | 39.13 | 38.67 | 435.38 | 431.22 | 433.30 |
| $S_2$: Open field | 2.53 | 2.63 | 2.58 | 31.96 | 32.92 | 32.44 | 33.29 | 34.25 | 33.77 | 339.24 | 345.87 | 342.56 |
| **S.Em±** | 0.01 | 0.01 | 0.01 | 0.05 | 0.06 | 0.05 | 0.08 | 0.05 | 0.06 | 0.21 | 0.41 | 0.31 |
| **CD (p<0.05)** | NS | NS | NS | 0.14 | 0.16 | 0.15 | NS | NS | NS | 0.62 | 1.20 | 0.91 |
| **Factor –II (M):** | | | | | | | | | | | | |
| $M_1$: Magnetized water | 2.69 | 2.78 | 2.74 | 36.29 | 36.83 | 36.56 | 37.42 | 38.25 | 37.83 | 409.40 | 403.82 | 406.61 |
| $M_2$: Non magnetized water | 2.58 | 2.69 | 2.64 | 33.21 | 33.79 | 33.50 | 34.08 | 35.13 | 34.60 | 365.23 | 373.26 | 369.25 |
| **S.Em±** | 0.01 | 0.01 | 0.01 | 0.05 | 0.06 | 0.05 | 0.08 | 0.05 | 0.06 | 0.21 | 0.41 | 0.31 |
| **CD (p<0.05)** | NS | NS | NS | 0.14 | 0.16 | 0.15 | NS | NS | NS | 0.62 | 1.20 | 0.91 |
| **Factor –III (T):** | | | | | | | | | | | | |
| $T_1$: Irrigation with 60 % ET | 2.55 | 2.73 | 2.64 | 33.25 | 34.33 | 33.79 | 33.83 | 35.17 | 34.50 | 378.07 | 372.63 | 375.35 |
| $T_2$: Irrigation with 80 % ET | 2.71 | 2.81 | 2.76 | 36.17 | 36.42 | 36.29 | 37.33 | 38.17 | 37.75 | 395.74 | 402.65 | 399.19 |
| $T_3$: Irrigation with 100 % ET | 2.66 | 2.70 | 2.68 | 35.17 | 35.50 | 35.33 | 36.42 | 37.00 | 36.71 | 390.19 | 393.43 | 391.81 |

| Treatment | Crop growth parameter | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Leaf area index** | | | **Crop root length** | | | **Crop root spread** | | | **Biomass** | | |
| | **2020** | **2020-21** | **Pooled** | **2020** | **2020-21** | **Pooled** | **2020** | **2020-21** | **Pooled** | **2020** | **2020-21** | **Pooled** |
| $T_4$: Irrigation with 120 % ET | 2.64 | 2.70 | 2.67 | 34.42 | 35.00 | 34.71 | 35.42 | 36.42 | 35.92 | 385.25 | 385.46 | 385.36 |
| **S.Em ±** | 0.01 | 0.01 | 0.01 | 0.10 | 0.11 | 0.11 | 0.16 | 0.10 | 0.13 | 0.43 | 0.83 | 0.63 |
| **CD (p≤0.05)** | NS | NS | NS | 0.29 | 0.32 | 0.30 | NS | NS | NS | 1.24 | 2.39 | 1.81 |
| **Interaction (S x M x T):** | | | | | | | | | | | | |
| $S_1M_1T_1$ | 2.57 | 2.86 | 2.72 | 37.33 | 37.67 | 37.50 | 38.67 | 39.33 | 39.00 | 450.79 | 428.24 | 439.52 |
| $S_1M_1T_2$ | 2.97 | 2.97 | 2.97 | 41.33 | 41.00 | 41.17 | 41.33 | 42.00 | 41.67 | 475.79 | 455.03 | 465.41 |
| $S_1M_1T_3$ | 2.70 | 2.92 | 2.81 | 39.67 | 39.67 | 39.67 | 40.00 | 40.67 | 40.33 | 465.81 | 447.42 | 456.61 |
| $S_1M_1T_4$ | 2.81 | 2.88 | 2.85 | 38.00 | 38.67 | 38.33 | 39.33 | 40.33 | 39.83 | 460.71 | 440.81 | 450.76 |
| $S_1M2T_1$ | 2.69 | 2.79 | 2.74 | 35.00 | 35.67 | 35.33 | 34.00 | 36.00 | 35.00 | 404.46 | 411.14 | 407.80 |
| $S_1M_2T_2$ | 2.69 | 2.82 | 2.75 | 37.00 | 36.67 | 36.83 | 38.33 | 39.00 | 38.67 | 410.30 | 432.18 | 421.24 |
| $S_1M_2T_3$ | 2.82 | 2.75 | 2.78 | 36.33 | 36.33 | 36.33 | 38.00 | 38.33 | 38.17 | 408.45 | 418.15 | 413.30 |
| $S_1M_2T_4$ | 2.75 | 2.72 | 2.74 | 35.67 | 36.00 | 35.83 | 36.00 | 37.33 | 36.67 | 406.76 | 416.75 | 411.76 |
| $S_2M_1T_1$ | 2.60 | 2.62 | 2.61 | 32.33 | 34.00 | 33.17 | 34.33 | 35.00 | 34.67 | 348.07 | 357.57 | 352.82 |
| $S_2M_1T_2$ | 2.67 | 2.77 | 2.72 | 34.00 | 35.00 | 34.50 | 36.00 | 37.00 | 36.50 | 359.30 | 370.12 | 364.71 |
| $S_2M_1T_3$ | 2.62 | 2.56 | 2.59 | 34.00 | 34.33 | 34.17 | 35.00 | 36.00 | 35.50 | 358.40 | 366.83 | 362.61 |
| $S_2M_1T_4$ | 2.61 | 2.63 | 2.62 | 33.67 | 34.33 | 34.00 | 34.67 | 35.67 | 35.17 | 356.30 | 364.57 | 360.43 |
| $S_2M_2T_1$ | 2.35 | 2.64 | 2.50 | 28.33 | 30.00 | 29.17 | 28.33 | 30.33 | 29.33 | 308.97 | 293.58 | 301.28 |
| $S_2M_2T_2$ | 2.50 | 2.68 | 2.59 | 32.33 | 33.00 | 32.67 | 33.67 | 34.67 | 34.17 | 337.57 | 353.25 | 345.41 |
| $S_2M_2T_3$ | 2.48 | 2.57 | 2.53 | 30.67 | 31.67 | 31.17 | 32.67 | 33.00 | 32.83 | 328.11 | 341.32 | 334.71 |
| $S_2M_2T_4$ | 2.39 | 2.57 | 2.48 | 30.33 | 31.00 | 30.67 | 31.67 | 32.33 | 32.00 | 317.24 | 319.71 | 318.48 |
| S.Em± | 0.04 | 0.05 | 0.05 | 0.40 | 0.45 | 0.42 | 0.62 | 0.41 | 0.51 | 1.72 | 3.31 | 2.51 |
| **CD (p<0.05)** | NS | NS | NS | 1.15 | 1.29 | 1.22 | NS | NS | NS | 4.96 | 9.56 | 7.26 |
| **General mean** | 2.64 | 2.73 | 2.69 | 34.75 | 35.31 | 35.03 | 5.20 | 3.32 | 4.26 | 387.31 | 388.54 | 387.93 |

**Table 7. Water application efficiency, Water use efficiency and Nutrient use efficiencies on pooled basis of gherkins as influenced by field conditions, type of irrigation water and irrigation levels during 2020 (January to May) and 2020-21 (December to March)**

| Treatment | Water application efficiency (%) | Water use efficiency (kg ha$^{-1}$ mm$^{-1}$) | Nutrient use efficiencies (kg yield per kg of nutrient applied) | | |
|---|---|---|---|---|---|
| | | | N | P | K |
| $S_1M_1T_1$ | 93.68 | 199.49 | 158.91 | 317.82 | 238.37 |
| $S_1M_1T_2$ | 93.58 | 185.87 | 190.91 | 381.80 | 286.36 |
| $S_1M_1T_3$ | 92.86 | 130.30 | 173.03 | 346.06 | 259.55 |
| $S_1M_1T_4$ | 91.54 | 104.83 | 167.02 | 334.04 | 250.53 |
| $S_1M_2T_1$ | 93.64 | 167.48 | 133.40 | 266.80 | 200.10 |
| $S_1M_2T_2$ | 93.27 | 142.32 | 151.46 | 302.90 | 227.18 |
| $S_1M_2T_3$ | 92.56 | 109.74 | 145.96 | 291.92 | 218.94 |
| $S_1M_2T_4$ | 90.79 | 87.90 | 140.20 | 280.39 | 210.30 |
| $S_2M_1T_1$ | 93.49 | 68.28 | 112.19 | 224.38 | 168.28 |
| $S_2M_1T_2$ | 93.22 | 57.22 | 126.06 | 252.13 | 189.10 |
| $S_2M_1T_3$ | 92.55 | 44.39 | 122.17 | 244.34 | 183.25 |
| $S_2M_1T_4$ | 91.54 | 35.22 | 115.71 | 231.42 | 173.56 |
| $S_2M_2T_1$ | 93.38 | 49.88 | 82.19 | 164.39 | 123.29 |
| $S_2M_2T_2$ | 93.20 | 49.60 | 108.60 | 217.20 | 162.90 |
| $S_2M_2T_3$ | 92.02 | 37.47 | 102.32 | 204.64 | 153.48 |
| $S_2M_2T_4$ | 90.64 | 28.59 | 93.71 | 187.43 | 140.57 |

**Table 8. Economics feasibility of cultivation of gherkins as influenced by field conditions, type of irrigation water and irrigation levels during 2020 (January to May) and 2020-21 (December to March) on pooled basis**

| | | | Pooled data | | | |
|---|---|---|---|---|---|---|
| **Treatment** | **Total yield ($t\ ha^{-1}$)** | **Cost of cultivation ($Rs\ ha^{-1}$)** | **Gross returns ($Rs\ ha^{-1}$)** | **Net returns ($Rs\ ha^{-1}$)** | **B:C ratio** | **Payback period** |
| $S_1M_1T_1$ | 23.84 | 215488 | 339168 | 123680 | 1.57 | 0.64 |
| $S_1M_1T_2$ | 28.64 | 215488 | 404647 | 189160 | 1.88 | 0.54 |
| $S_1M_1T_3$ | 25.95 | 215488 | 366573 | 151086 | 1.70 | 0.59 |
| $S_1M_1T_4$ | 25.05 | 215488 | 356958 | 141471 | 1.66 | 0.60 |
| $S_1M_2T_1$ | 20.01 | 212727 | 275390 | 62663 | 1.29 | 0.78 |
| $S_1M_2T_2$ | 22.72 | 212727 | 328604 | 115877 | 1.54 | 0.65 |
| $S_1M_2T_3$ | 21.89 | 212727 | 311072 | 98345 | 1.46 | 0.68 |
| $S_1M_2T_4$ | 21.03 | 212727 | 297039 | 84312 | 1.40 | 0.72 |
| $S_2M_1T_1$ | 16.83 | 141481 | 219776 | 78295 | 1.55 | 0.64 |
| $S_2M_1T_2$ | 18.91 | 141481 | 248313 | 106831 | 1.76 | 0.57 |
| $S_2M_1T_3$ | 18.33 | 141481 | 239020 | 97538 | 1.69 | 0.59 |
| $S_2M_1T_4$ | 17.36 | 141481 | 228617 | 87136 | 1.62 | 0.62 |
| $S_2M_2T_1$ | 12.33 | 138721 | 155388 | 16667 | 1.12 | 0.89 |
| $S_2M_2T_2$ | 16.29 | 138721 | 211120 | 72399 | 1.52 | 0.66 |
| $S_2M_2T_3$ | 15.35 | 138721 | 197988 | 59267 | 1.43 | 0.70 |
| $S_2M_2T_4$ | 14.06 | 138721 | 176731 | 38011 | 1.27 | 0.79 |

*Factor –I (S): S1: Shade net; S2: Open field*
*Factor -II (M): M1: Magnetized water; M2: Non magnetized water*
*Factor -III (T): T1: Irrigation with 60 % ET; T2: Irrigation with 80 % ET; T3: Irrigation with 100 % ET; T4: Irrigation with 120 % ET*

### 3.6 Cost of Cultivation

The cost incurred in cultivation of gherkins, including, installation of drip, magnetic water device, and field operations were worked out. Gross returns, net return, benefit-cost ratio (B:C ratio) and payback period were calculated separately for each treatment per hectare basis. The cost of cultivation under a shade net with a magnetic water device was highest (Rs.215488 $ha^{-1}$ $season^{-1}$) followed by a shade net without a magnetic water device (Rs. 212727 $ha^{-1}$ $season^{-1}$). Open field with magnetic water device recorded lower cost of cultivation (Rs.141481 $ha^{-1}$ $season^{-1}$). The lowest cost of cultivation was in an open field without a magnetic water device (Rs. 138721 $ha^{-1}$ $season^{-1}$).

The gross returns on a pooled basis was found maximum in shade net with magnetic water device at 80 per cent ET (Rs. 404647 $ha^{-1}$ $season^{-1}$) and minimum in 60 per cent ET (Rs. 339168 $ha^{-1}$ $season^{-1}$). Followed by, shade net without magnetic water device maximum gross return in 80 per cent ET (Rs. 328604 $ha^{-1}$ $season^{-1}$) and minimum in 60 per cent ET of Rs. 275390 $ha^{-1}$ $season^{-1}$. The open field with magnetic water device had maximum gross return in 80 per cent ET (Rs. 248313 $ha^{-1}$ $season^{-1}$) and minimum in 60 per cent ET (Rs. 219776 $ha^{-1}$ $season^{-1}$). At last the open fields without magnetic water device the maximum gross return in 80 per cent ET (Rs. 211120 $ha^{-1}$ $season^{-1}$) and minimum gross return in 60 per cent ET (Rs. 155388 $ha^{-1}$ $season^{-1}$).

The net returns on a pooled basis was found maximum in shade net with magnetic water device were in 80 per cent ET (Rs. 189160 $ha^{-1}$ $season^{-1}$) and minimum in 60 per cent ET (Rs. 339168 $ha^{-1}$ $season^{-1}$). Followed by, shade net without magnetic water device was maximum in 80 per cent ET (Rs. 115877 $ha^{-1}$ $season^{-1}$) and minimum in 60 per cent ET (Rs. 62663 $ha^{-1}$ $season^{-1}$). Open field with magnetic water device was maximum in 80 per cent ET (Rs. 106831 $ha^{-1}$ $season^{-1}$) and minimum in 60 per cent ET (Rs. 78295 $ha^{-1}$ $season^{-1}$). At last the open field without magnetic water device was maximum in 80 per cent ET (Rs. 72399 $ha^{-1}$ $season^{-1}$) and minimum in 60 per cent ET (Rs. 16667 $ha^{-1}$ $season^{-1}$).

The highest benefit cost ratio on pooled data basis was reported from the shade net with a magnetic water device at 80 per cent ET ($S_1M_1T_2$) (1.88). This was followed by, B:C ratio in open field with a magnetic water device in 80 per cent ET ($S_2M_1T_2$) (1.76). The lowest benefit-cost ratio of 1.12 was reported in an open field without a magnetic water device at 60 per cent ET ($S_2M_2T_1$).

The higher payback periods of 0.89 years were observed under the treatment $S_2M_2T_1$ (open field with non magnetic water at 60 per cent ET) and lower payback periods of 0.54 years were observed under the treatments $S_1M_1T_2$ (shade net with magnetic water at 80 per cent ET).

## 4. DISCUSSION

Change in Physico-chemical properties of water is because of change in hydrogen ion bond due to electro-magnetic effect after magnetization on properties of water the results of the study were on par with the findings of Hasaani et al. [13] conducted an experiment and found reduction in EC, TDS and increase pH after magnetization. From the results, it was noticed that there was an increase in pH and decreased EC and TDS after magnetization in all concentration of salinity water. When water passed through EMC device during that phase, process of magnetic induction in conjunction with the speed of the water through the magnetic device there was an effect of magneto-hydrodynamic resonance (vibration) between electromagnetic frequency and the natural vibration of water. This initiates a second order phase transition a change in structure of water during which hydrogen bonds broken, dismantling clusters in to individual molecules which leads to changes in the properties of EC, pH, TDS, anions and cations which are present in the water. The results obtained from the study were on par with the findings of Hasaani et al [13] and reported that there was reduction in EC, TDS and increase pH after passing the irrigation water of different salinity through magnetic field.

The effect of magnetization on soluble cations ($Ca^{2+}$, $Mg^{2+}$ and $Na^{+}$) were significantly decreased after magnetization because of changes in hydrogen bonding and increased mobility of ions. Similar results were found with Kishore et al. [14] who report that magnetic treatments of water significantly influenced Na content in all the treatments, this may be due to mineral ions' crystallization and precipitation processes resulting from the magnetic treatment. A higher sodium concentration was registered in magnetic untreated saline water and was decreased by treating with a magnetic field. The magnetic force breaks hydrogen bonds between water molecules and ions, causing separation of ions to join with other elements and precipitate, resulting in a concentration difference. Chang and Weng, [15] reported a similar conclusion, mentioning that the enhanced mobility of the ions in a magnetic field disturbs the hydrogen bonding in the high sodium concentration solution. On the other hand, in a low sodium concentration solution, the structural behavior may be governed by the properties of the water and thus the bonding ability of hydrogen molecules may be enhanced by increasing the strength of the magnetic field.

The increase in vine length of gherkins may be due to the effect of the magnetic treatment on the amount and rate of water absorption compared with the non-magnetized water. A magnetic field induces changes in ionic concentration and osmotic pressure, which regulates the entrance of water into the roots. These positive effects of magnetic treatment may be due to some alterations within plant systematic biochemical levels and their possible effects at cell level and are mainly due to increased water content in root zone. Moon and Chung [16] says that external electric and magnetic fields have been reported to influence both the activation of ions and polarization of dipoles in living cells. Javed, et al. [17] who studied the moringa seedlings with drought exhibited lower relative water content, which indicated that drought stress induces water imbalance and osmotic stress. The use of magnetic water restored the water loss by increasing the relative water content in the drought-affected seedlings. The chlorophyll content increased in the leaves of gherkins under magnetized water compare to non-magnetized water during both the seasons. The current results were in line with the findings of Hozayan et al. [18] who found that irrigation of sugar beet plants with magnetized water increased photosynthetic pigment significantly. Similar results were obtained by Atak et al. [19] who found an increases in chlorophyll content specifically appeared after exposure to a magnetic field for a short time. It was opined that, increase in photosynthesis pigment through the increase in cytokinin synthesis was accompanied by an increase in auxin synthesis which was induced by magnetic field treatment of soybean. Hassan, et al. [20] studied chlorophyll content and reported an increased in the leaves of Moringa seedlings under magnetized water. Radhakrishnan and Kumari [21] reported that enhanced chlorophyll content in soybean and maize leaves due to magnetized water. For instance, a study on cucumber showed shade net cultivation significantly increased plant biomass due to improved light distribution and reduced heat stress, resulting in better plant growth and higher biomass production Barbieri, et al. [22]. Another study on watermelon found that plants irrigated with magnetized water exhibited increased biomass and higher nutrient uptake compared to those irrigated with non-magnetized water Mallikarjun Reddy [23]. Additionally, research on melon indicated that plants subjected to optimal irrigation levels had greater biomass accumulation, leading to improved fruit yield and quality Chambery *et al.* [24]. Adequate moisture availability is essential for the plants to grow optimally and reach their full yield potential. Pawar et al. [25] also reported that a treatment combination of 80 per cent ET through drip irrigation and 100 per cent RDF of N, P and K through fertigation produced maximum yield in cucumber with the use of magnetized water.

## 5. CONCLUSION

Among the different factors, the shade net gives best result compare to open field but its initial investment is high. In magnetized water results were best over non magnetized water and in irrigation levels, best results were recorded with 80 per cent ET, followed by 100 per cent ET and minimum/lest was found in 60 per cent ET through drip irrigation system. In general, based on different parameters tested, the shade net with magnetized water at 80 per cent ET could be recommended for growing of gherkin crop. This recommendation would be especially advantageous if the structure is already present in the field. Alternatively, if such a structure does not exist in field, it is suggested that open field with magnetized water at 80 per cent ET should be adopted for growing the gherkin crop in order to achieve the highest B:C ratio as compared to shade net field.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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