# INFLUENCE OF LOW-FREQUENCY ELECTROMAGNETIC FIELD ON THE VEGETATIVE GROWTH OF GRAPE CV. USLU

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## ABSTRACT

Low-frequency electromagnetic field (ELF) at 50 Hz, 0.15 mT was applied to canes of 'Uslu' grape for 5, 10, 15 and 20 minutes. The canes were prepared by cutting them into 50-60 mm one-bud scions. The scions were planted with the density of 40 x 40 mm into propagation boxes. The experiment was arranged in randomized complete blocks design with 4 replicates and each replicate consisted of 15 scions. The parameters of vigour (shoot growth) of the first three weeks, bud-break percentage of the first three weeks, bud-break percentage, vigour, rooting percentage, root development, root weight, number of root, shoot length, shoot weight, number of node, node height, root/shoot weight and shoot + root weight were included in the study. As a result, different durations of 50 Hz frequency resulted in significant differences on mean rooting percentage, mean root development, mean root weight, mean number of root, mean shoot weight and mean shoot+root weight.

**Key words: 'Uslu' grape, low-frequency electromagnetic field, vegetative growth.**

## INTRODUCTION

Human beings, animals, plants and our surrounding are under the effects of electromagnetic fields by the use and necessity of electrical energy as a result of the development of industrialization and technology. All the electrical devices that we use produce low-frequency electromagnetic field (ELF). Especially those who live near the electrical transformers or high voltage distribution lines are affected from it. ELF, supplied by electricity systems is quite low frequency (50 Hz) and can be effective at different intensity depending on the distance to the system and the power of system [21]. It is known that biological systems give different biological responses to applications of ELF at different frequencies and intensities [13]. Various living organisms are differently affected from ELF, and these effects vary according to the regions applied and they occur at the level of the cell [21].

Magnetic field (MF) and electromagnetic field (EMF) which have started to draw an increasing attention by the researchers are related to each other. Many researchers working in fields such as biology, medicine, and agriculture have been interested about the influences of MF and EMF exchanges on the biological structures and much work has been carried out on this topic. As a result of these researches, it was determined that there were no significant differences between MF and EMF's effect on mechanisms of the biological systems [22].

Studies on the meristem cells of the plants have shown that MF is an element that affects normal cell metabolisms and also has impacts on the cell division [6, 12]. However, it is difficult to evaluate the effects on the organisms that have been exposed to EMF. The reason is the complexity of the biological systems' structures. In numerous experiments, it has been investigated that EMF's effects on organisms vary depending on the intensity of the magnetic field, frequency, exposure duration to EMF, genotype of organisms and the biological system [1, 5, 7, 13, 17].

The first studies on the effects of magnetic field on the plant growth were conducted by Savostin who found a 100% increase on the height of wheat seedlings depending on the effect of MF [16]. In another research, it was found out that there were positive effects on the rooting percentage and plant growth of komatsuda depending on ELF [18]. In other investigations, it was stated that productivity and yield of various plants such as sunflower, cereals, and soybean were positively affected by MF [8, 9, 11, 19, 22].

Bhatnagar and Deb (1977) implemented a magnetic field of 0.05 T to 0.30 T on the seeds of wheat, barley and oat. They found that magnetic field had a positive effect on the germination rate as well as root and shoot lengths [4]. In addition, the magnetic field exposure for each plant species and environmental conditions (temperature, humidity, etc.) during MF application were also important. As the plants show genotypic differences, they respond differently to magnetic field applications for some parameters such as shooting rate, the growth of seedlings and rooting.

The demand for it in Turkish markets is very high. Since it has been pointed out that the positive effects of ELF applications on rooting, this culture variety has been chosen as a material. The research which is a basic study has no practical purposes. Thus, the objectives of the research were to eliminate some unclear points in start-up mechanism and to determine electromagnetic field exposure and durations by examining the effects of ELF on the vegetative growth of dormant-bud canes of 'Uslu' grape.

## MATERIALS AND METHODS

Canes of 'Uslu' grape used in the study were supplied from Canakkale Fruit Production Station, Agriculture and Rural Affairs Ministry in 2003 and 2004. The canes were cut in winter pruning in February and kept at 3-4 °C for 2 months in thick black plastic bags [15]. For the stimulation of ELF at 50 Hz frequency 0.15 mT, Helmoltz circle was used. Helmoltz device is a system which is designed by the use of 5 helix copper wire coils with 0.75 mm diameter. To give 0.15 mT ELF at 50 Hz and 4.5 V, electricity was applied at the Physics Department Laboratory, Science Faculty, Canakkale Onsekiz Mart University in Turkey. ELF intensity was measured by teslameter. The canes were placed into the centre of Helmoltz coil and ELF was applied for the durations of 5, 10, 15 and 20 minutes at the room temperature (22 °C).

The canes were exposed to electromagnetic field applications on 23rd March 2003 and on 19th April 2004. They were then excised as one bud scion with size of 50-60 mm and treated with a fungicide. These one-bud scions of the variety were planted with a density of 40 x 40 mm into 400 x 500 x 200 mm propagation boxes containing perlite (3 mm particle size). The study was conducted in randomized complete blocks design with 4 replicates and each replicate consisted of 15 scions.

100 kg $ha^{-1}$ ammonium nitrate, 40 kg $ha^{-1}$ mono ammonium phosphate and 150 kg $ha^{-1}$ potassium sulphate fertilizers were applied for each box at planting. Measurements on the scions were taken on 11th May 2003 for the first year and 8th June 2004 for the second year.

A 0-5 scale was used to determine vigour (shoot growth) of one–bud scions. (0: dormant bud, 1: hair

Table 1. The effects of ELF on vigour of the first 3 weeks and bud-break percentage of the first 3 weeks

| Application (minute) | Vigour of the first 3 weeks (0-5) | | | Bud-break percentage of the first 3 weeks (%) | | |
|---|---|---|---|---|---|---|
| | 2003 | 2004 | Mean | 2003 | 2004 | Mean |
| Control | 1.05 | 0.88 | 0.97 | 25.00 | 29.44 | 27.22 |
| 5 | 1.04 | 0.94 | 0.99 | 25.60 | 28.89 | 27.25 |
| 10 | 1.16 | 1.10 | 1.13 | 27.39 | 36.11 | 31.75 |
| 15 | 1.10 | 1.06 | 1.08 | 26.79 | 35.00 | 30.90 |
| 20 | 0.98 | 1.03 | 1.01 | 21.43 | 33.33 | 27.38 |
| $LSD_{0.05}$ | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

NS= not significant.
0= dormant bud, 1= hair formation on the bud, 2= shooting on the primary bud, 3= 1-2 leaves, 4= 3-4 leaves and 5= 5-6 leaves.

formation on the bud, 2: shooting on the primary bud, 3: 1-2 leaves, 4: 3-4 leaves, 5: 5-6 leaves) [10]. Besides, vigour (shoot growth) of the first three weeks (0-5), bud-break percentage of the first three weeks (%), bud-break percentage (at the end of the 8th week) (%), vigour (shoot growth at the end of the 8th week) (0-5), rooting percentage (%), root development (0-4), root weight (g), number of root (number), shoot length (mm), shoot weight (g), number of node (number), node length (mm), root weight/shoot weight and shoot+root weight (g) parameters were investigated. To examine the root development, a 0-4 scale was used (0: no rooting, 1: very weak one-sided root formation, 2: weak two-sided root formation, 3: three-sided root formation, 4: vigorous entire root formation). Root and shoot-related parameters were measured by electronic compass and balance.

Evaluations of the data were done by TARIST statistical software programme [2].

## RESULTS

Parameters obtained at the end of ELF treatments applied to grape cv. Uslu for 0, 5, 10, 15 and 20 minutes are shown in Table 1-7. When vigour of the first 3 weeks and bud-break percentage of the first 3 weeks are considered (Table 1), although there were increases in 10 and 15 minutes of ELF applications, the difference was not significant. With respect to bud-break percentage and vigour, there were no significant differences as well (Table 2).

It was found out that ELF leads to acceleration of rooting percentage and root growth. Rooting percentage which was 90.42 % at control, increased to 96.61 % at 10 minute application. The one-bud scions exposed to 20 minute ELF had the lowest rooting percentage (88.04 %) and were significantly different from 10 minute application. Root growth in one-bud scions at the end of 10 minute application significantly increased compared to control, reaching 3.12. The lowest values were found at 20 minute application (2.54) and at control (2.68) ($p<0.05$) (Table 3).

10 minute ELF treatment increased root weight to 0.63 g. 5 and 15 minutes applications gave the value of 0.52 g. The root weight remained at the lowest values in control and 20 minute application. On account of the number of the root, 10 minute application had the first rank with 9.95 again. The lowest number of root was 7.25 for 20 minute application ($p<0.05$) (Table 4).

The effect of ELF on the shoot length of the scions was significant in the first year. Especially, increases in 10 and 15 minute applications were observed. The highest shoot weight was obtained from 10 minute application (1.00 g). The lowest shoot weights were obtained from 5 minute (0.85 g) and 20 minute (0.84 g). Control and 15 minute formed 0.87 g and 0.90 g shoot weight in order ($p<0.05$) (Table 5). Although it can be seen in Table 6 that ELF applied to the canes caused some increases in number of node and node length, these differences were not significant.

However the effects of ELF on root weight/shoot weight were not significant, shoot+root weights were found to be the highest value for 10 minute application. Control, 5, 15 and 20 minute treatments gave rise to 1.36 g, 1.37 g, 1.42 g and 1.28 g, respectively. Statistical analyses resulted that the differences between shoot+root weight values were significant at 0.05.

## DISCUSSION

The aims of the research were to investigate the effects of ELF on the vegetative growth of one-bud scions of ‘Uslu’ grape, and to compare the differences among the exposure times.

It is stated that magnetic field intensity and various

Table 2. The effects of ELF on bud-break percentage and vigour

| Application (minute) | Bud-break percentage (%) | | | Vigour (0-5) | | |
|---|---|---|---|---|---|---|
| | 2003 | 2004 | Mean | 2003 | 2004 | Mean |
| Control | 96.43 | 88.09 | 92.26 | 3.45 | 3.02 | 3.23 |
| 5 | 98.22 | 91.07 | 94.65 | 3.36 | 3.14 | 3.25 |
| 10 | 98.22 | 98.22 | 98.22 | 3.55 | 3.45 | 3.50 |
| 15 | 98.08 | 92.98 | 95.53 | 3.43 | 3.18 | 3.30 |
| 20 | 93.75 | 94.99 | 94.37 | 3.16 | 3.35 | 3.25 |
| $LSD_{0.05}$ | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

NS= not significant.
0= dormant bud, 1= hair formation on the bud, 2= shooting on the primary bud, 3= 1-2 leaves, 4= 3-4 leaves and 5= 5-6 leaves.

Table 3. The effects of ELF on rooting percentage and root development

| Application (minute) | Rooting percentage (%) | | | Root development (0-4) | | |
|---|---|---|---|---|---|---|
| | 2003 | 2004 | Mean | 2003 | 2004 | Mean |
| Control | 87.50 ab | 93.33 | 90.42 ab | 2.74 ab | 2.63 b | 2.68 b |
| 5 | 89.29 ab | 93.33 | 91.31 ab | 2.80 ab | 2.88 ab | 2.84 ab |
| 10 | 98.22 a | 95.00 | 96.61 a | 3.16 a | 3.09 a | 3.12 a |
| 15 | 87.09 ab | 96.67 | 91.88 ab | 2.62 ab | 2.92 ab | 2.77 ab |
| 20 | 82.74 b | 93.33 | 88.04 b | 2.40 b | 2.68 ab | 2.54 b |
| $LSD_{0.05}$ | 15.048* | N.S. | 8.170* | 0.711* | 0.429* | 0.369* |

NS= not significant, *= significant at 5%.
0= no rooting, 1= very weak one-sided root formation, 2= weak two-sided root formation, 3= three-sided root formation and 4= vigorous entire root formation.

Table 4. The effects of ELF on root weight and number of root

| Application (minute) | Root weight (g) | | | Number of root (number) | | |
|---|---|---|---|---|---|---|
| | 2003 | 2004 | Mean | 2003 | 2004 | Mean |
| Control | 0.46 ab | 0.51 b | 0.49 b | 10.82 | 6.72 b | 8.77 ab |
| 5 | 0.47 ab | 0.58 ab | 0.52 ab | 9.06 | 7.45 ab | 8.25 ab |
| 10 | 0.59 a | 0.68 a | 0.63 a | 10.50 | 9.40 a | 9.95 a |
| 15 | 0.46 ab | 0.57 ab | 0.52 ab | 8.28 | 7.78 ab | 8.03 ab |
| 20 | 0.36 b | 0.52 ab | 0.44 b | 7.43 | 7.06 ab | 7.25 b |
| $LSD_{0.05}$ | 0.206* | 0.161* | 0.125* | N.S. | 2.357* | 1.983* |

NS= not significant, *= significant at 5%.

Table 5. The effects of ELF on shoot length and shoot weight

| Application (minute) | Shoot length (mm) | | | Shoot weight (g) | | |
|---|---|---|---|---|---|---|
| | 2003 | 2004 | Mean | 2003 | 2004 | Mean |
| Control | 36.20 ab | 35.59 | 35.90 | 1.04 ab | 0.70 | 0.87 ab |
| 5 | 32.90 b | 40.85 | 36.88 | 0.91 bc | 0.78 | 0.85 b |
| 10 | 40.90 a | 43.44 | 42.17 | 1.11 a | 0.90 | 1.00 a |
| 15 | 38.80 ab | 40.60 | 39.70 | 0.97 abc | 0.83 | 0.90 ab |
| 20 | 32.30 b | 40.10 | 36.20 | 0.86 c | 0.82 | 0.84 b |
| $LSD_{0.05}$ | 0.758* | N.S. | N.S. | 0.138* | N.S. | 0.137* |

NS= not significant, *= significant at 5%.

Table 6. The effects of ELF on number of node and node length

| Application (minute) | Number of node (number) | | | Node length (mm) | | |
|---|---|---|---|---|---|---|
| | 2003 | 2004 | Mean | 2003 | 2004 | Mean |
| Control | 3.07 | 2.86 | 2.97 | 11.84 | 12.31 | 12.08 |
| 5 | 2.85 | 3.15 | 3.00 | 11.52 | 12.95 | 12.24 |
| 10 | 3.29 | 3.49 | 3.39 | 12.52 | 12.58 | 12.55 |
| 15 | 3.27 | 3.15 | 3.21 | 11.93 | 12.87 | 12.40 |
| 20 | 2.86 | 3.13 | 2.99 | 11.41 | 12.72 | 12.07 |
| $LSD_{0.05}$ | N.S. | N.S. | N.S. | N.S. | N.S. | N.S. |

NS= not significant.

Table 7. The effects of ELF on root/shoot weight and shoot+root weight

| Application (minute) | Root/Shoot weight | | | Shoot+Root weight (g) | | |
|---|---|---|---|---|---|---|
| | 2003 | 2004 | Mean | 2003 | 2004 | Mean |
| Control | 0.44 | 0.73 | 0.54 | 1.51 ab | 1.21 | 1.36 b |
| 5 | 0.52 | 0.76 | 0.64 | 1.38 ab | 1.36 | 1.37 b |
| 10 | 0.54 | 0.76 | 0.65 | 1.69 a | 1.58 | 1.64 a |
| 15 | 0.48 | 0.70 | 0.59 | 1.43 ab | 1.41 | 1.42 b |
| 20 | 0.42 | 0.64 | 0.53 | 1.23 b | 1.34 | 1.28 b |
| $LSD_{0.05}$ | N.S. | N.S. | N.S. | 0.311* | N.S. | 0.207* |

NS= not significant, *= significant at 5%.

environment conditions (temperature, seed moisture, etc.) are very important for each plant species which respond differently to these conditions with respect to shoot rate, root and shoot growth etc. [5]. In a previous research, more than 25 % increase in root growth of maize was determined by 5 kgauss magnetic field application [14]. In another research on magnetic field's effect on potato, it was concluded that magnetic field had positive effects on the root length, tuber formation and root weights [20]. Aladjadjiyan found out that the magnetic field stimulated the shoot development and led to the increase of the germinating energy, germination, fresh weight and shoot length in maize treated with a magnetic field of 0.15 T for 10, 15, 20 and 30 minutes. 10 minutes application resulted in highest values of fresh weight and shoot length [3]. Therefore, our finding that root development parameters of grape cv. Uslu in one-bud scions increased as a result of ELF applications are in line with the results of other researchers. Prolonged exposures of plant to ELF may cause various biological effects at the cellular, tissue and organ stages.

Consequently, the effect of 10 and 15 minute applications of 0.15 mT ELF at 50 Hz on the one year old scions of 'Uslu' grape gave rise to the highest values. Although there was not a particular study published on the effects of ELF on the vegetative parts of woody plants, our findings demonstrated that ELF had significant effects on grapevine cuttings, especially in rooting. Another field of future research area could be investigating the effects of ELF on the rooting of the horticultural species where grafting is not involved. In addition, it is of great importance in the identifications of ELF's effect (positive and/or negative) on living organisms that have gained importance in recent years because of rapidly increasing usage and demand of electricity. Moreover, it will be beneficial to use the results that were put forward in this research and to combine these with molecular techniques in order to determine the influences and differences of ELF on plants at the cell level.

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