Influence of magnetic field on the capsules per leaf node of *Sesamum indicum* L.

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**ABSTRACT**

For studying the effect of magnetic field on the number of capsules in each *Sesamum indicum* L. node, an experiment was carried out in a factorial randomized complete block design with three replications in Mashhad/Iran during 2017. The experiment consisted of three time use of fixed magnetic field as 1 Tesla (MF1 = 0, MF2 = 1, and MF3 = 10 min), and two kinds of caps as single-cap (CAP1) and multi-cap (CAP2) seeds. The results showed that the highest number of single-cap nodes and multi-cap nodes per plant were obtained from the application of MF3 treatment in CAP2 as 33.9 and 21.9 nodes, respectively and also obtained the highest numbers of capsules per plant with MF3 in CAP2. There was a significant correlation between seed weight and number of capsules per plant too (R=0.53).

**Key words:** Capsule per plant, Multi capsule, Single capsule, Seed weight per plant.

**INTRODUCTION**

The impact of the magnetic field on living systems especially on plant growth has been reported in numerous investigations. This area is a sub branch of Electric Culture Technology that includes the effect of all sources dependant to emissions of waves including electricity, light, sound and magnetism and can increase its rate of growth, performance and quality and the energy generated by this system produces more products in less time with less labor and less cost while protecting plants against natural enemies (Nelson, 1999). Studies have shown that increasing the yield components depends on parameters such as soil quality, climatic conditions, and seed response to agronomic treatments (Khadare *et al.*, 2017; Zohmingliana *et al.*, 2017). In this regard, the development of high-yield varieties requires breeding and farm management (Anamika *et al.*, 2018). Another study showed that magnetic field changes increase growth and yield through the effect on the mineral uptake process (Bilalis *et al.*, 2013). Several reports have been provided so that the increase of the magnetic field to 30 mtesla and 50 Hz leads to an increase in the growth rate of wheat roots (Aksenov *et al.*, 2001). In another study, the effect of 20 utesla’s weak magnetic field increased the weight and height of sunflower plant and the amount of germination of wheat (Fischer *et al.*, 2004). Poorakbar *et al.* (2010) reported that the placement of *Nigella sativa* seeds in the magnetic field at 25 and 50 mtesla intensity for 0, 30, 60 and 120 minutes significantly increased the percentage and germination rate, root length and dry weight of the plant in comparison to the control. Sesame (*Sesamum indicum* L.) is one of the oldest oily seeds and is widely used in food and medicine for its quality oil, protein and antioxidants (Weiss, 2000). The yield of this plant is affected by various factors including genotype, planting date, plant density, moisture, temperature, light, and soil fertility. The sesame harvest index is low and the number of capsules in the leaf node is one of the important yield components and there is a positive and significant correlation with it. Naturally, only one capsule comes out of each sesame leaf node. However, there are ecotypes that 2, 3, 4 and even more capsules exist in each leaf node (Langham, 2007), so stimulating the reproductive seedlings to produce more capsules in each leaf node is one of the goals of increasing the production of this plant. So, this study was conducted with the aim of studying the effect of magnetic field on morphological characteristics and yield of two single-cap and multi-cap ecotypes in Mashhad climate conditions.

**MATERIALS AND METHODS**

In order to investigate the effect of magnetic field on morphological characteristics and yield components of sesame (Sabzevar) ecotype, a factorial experiment was conducted in a randomized complete block design with three replications in the field of applied science faculty of Agricultural Research and Education and Natural Resource Center of Khorasan Razavi Province in 2017. The first factor was seed type: single-cap (CAP1) and multi-cap (CAP2) and the second factor was three exposure times (MF1: zero, MF2: 1, and MF3: 10 minutes) to a constant magnetic field of 1 Tesla. Seeds were collected during three consecutive years by selecting seeds of three capsule plants from the field. So at the end of the third year, the plants with three capsules were selected and two kinds of seeds were prepared from their nodes. Seeds from nodes with a single-capule called mono capsule seeds and seeds from nodes with three

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capsules called three capsule seeds were selected (Fazeli Kakhaki and Tayebi, 2017). Although the source of the two types of seeds is one ecotype but the type of protein expressed to motivate the capsule differs among two kinds of nodes, which can be influenced by environmental conditions and has a direct effect on the stimulation of the number of flowers from the axis of each leaf. The seeds were dried in a quantity of 50 and placed in a test tube and exposed to a magnetic field with a specific time (1 and 10 minutes) by CENCO device (Fig. 1). The distance between the two poles of the device was 1 cm and the intensity of the field was first controlled by Teslameter and the treatment the seeds were planted in a plot of 1 square meter on May 12, 2017. After seed germination and growth of seedlings, harvested 10 plants from each plot and afterwards plant height, number of single-cap and multi-cap nodes per plant, number of seeds per capsule, number of capsules per plant and seed weight per plant were measured. The data were analyzed using Mstat-C and Minitab Ver13 software. The mean values were compared by LSR test at probability level of 5%.

RESULTS AND DISCUSSION

Plant height: The results of analysis of variance showed that plant height was significantly affected (p ≤ 0.05) by the interaction of magnetic field on the capsule. The highest plant height was obtained in interaction of 1 Tesla magnetic field for 10 minutes in single-capsule seedling (93.1 cm) and lowest was observed in control and multi-capsule seeds (CAP2) as 78.5 cm at the zero level of magnetic field (Fig. 2 and Table 2). In this regard, other studies showed that the use of magnetic field has increased the growth indices in tomato (De Souza et al., 2006), soya (Bilalis et al., 2013) and cotton (Shine et al., 2012). It seems that the effect of the magnetic field has changed the permeability of the membrane, ion translocation and increased mineral absorption (Shine et al., 2012). In another study, the effect of magnetic field on the fennel roots showed that root length affected by the magnetic field was significantly higher than that of the control (Pourakbar, 2012).

Number of single-cap and multi-cap nodes in plant: In terms of the number of single-cap nodes, the results showed that the effect of MF3 treatment with 22 nodes produced 56 and 67 percent more single-cap node than MF1 and MF2 treatments, respectively. CAP1 produced more single-cap nodes (20.3) compared to CAP2. The interaction effect of treatments showed that the number of single-capsule nodes was highest in MF3 × CAP2 treatment and at all levels of magnetic field (MF1 and MF2), the number of single-capsule nodes produced less percentage of the total number of nodes. The effect of exposure time to the magnetic field on the production of multi-capsule nodes was in the range of 13.4 to 18.4 per unit, so that the MF3 treatment with 18.4 nodes produced about 27 and 30 percent more multi-cap nodes compared to the MF1 and MF2 treatments. Although, the plant from multi-cap seeds, produced more multi-cap nodes but it did not have a significant difference with CAP1. The interaction effect of treatments showed that MF3

Fig 1: A view of the CENCO device for supplying a magnetic field to the value of 1 Tesla and the left-hand shape shows the seed placement in the magnetic field.

Fig 2: Effect of three exposure duration to magnetic field (MF1=0, MF2=1, and MF3=10 minutes) on seeds of two types of sesame and its effect on plant height.
The interaction effect of treatments showed that CAP2 treatment had more capsules with exposure time of 1 minute (MF2) and 10 minutes (MF3) with mean values of 58.9 and 57.1 seeds, respectively and lowest was recorded with MF1 × CAP1 treatment. The magnetic treatments applied to the plant from single-cap seeds (CAP1) produced less seeds in comparison with the same treatments in CAP2 (Table 2). The results of Naz et al. (2012) showed that exposing okra seeds to 99 mtesla magnetic fields for 3 to 11 minutes caused an increase in the number of seeds per capsule, capsules per plant and flowers per plant. It is probable that the magnetic field has an effect on the expression of the gene that was also mentioned in protein synthesis in a number of experiments (Xi et al., 1994).

Number of capsules per plant: The number of capsules per plant were significantly differed under different treatments (Table 1). In the magnetic field of 1 tesla with time of zero (MF1), 1 (MF2), and 10 (MF3) minutes was recorded the number of capsules per plant of 41.7, 36.5 and 68.4, respectively. Plants from multi-cap seeds (CAP2) produced about 17% more capsules per plant than plants from single-cap seeds (CAP1). The interaction effect of treatments showed that lowest and highest numbers of capsules per

| Treatment | Plant height(cm) | Number of single-capsules nodes per plant | Number of multi-capsules nodes per plant | Number of seeds per capsule | Number of capsules per plant | Seed weight per plant |
|-----------|------------------|------------------------------------------|------------------------------------------|-----------------------------|-----------------------------|-----------------------|
| MF1       | 84.6a            | 9.53b                                    | 13.4b                                    | 52.5a                       | 41.7b                       | 6.47b                 |
| MF2       | 85.4a            | 7.20b                                    | 12.8b                                    | 50.1a                       | 36.5b                       | 5.51b                 |
| MF3       | 89.0a            | 22.0a                                    | 18.4a                                    | 46.6a                       | 68.4a                       | 9.74a                 |
| CAP1      | 88.3a            | 20.3a                                    | 14.7ns                                   | 42.4b                       | 44.2b                       | 7.03a                 |
| CAP2      | 84.4a            | 5.46b                                    | 15.1ns                                   | 57.1a                       | 53.5a                       | 7.44a                 |
| MF1×CAP1  | 79.5bc           | 2.06d                                    | 10.5b                                    | 36.1c                       | 29.8c                       | 7.33b                 |
| MF1×CAP2  | 78.5c            | 17.0b                                    | 12.9b                                    | 55.2ab                      | 53.7b                       | 5.61c                 |
| MF2×CAP1  | 84.9bc           | 4.2cd                                    | 12.7b                                    | 41.2c                       | 37.5c                       | 5.69c                 |
| MF2×CAP2  | 89.8ab           | 10.2c                                    | 16.2ab                                   | 58.9a                       | 35.4c                       | 5.31c                 |
| MF3×CAP1  | 93.1a            | 10.1c                                    | 15.0b                                    | 49.9b                       | 65.2a                       | 8.07b                 |
| MF3×CAP2  | 92.4a            | 33.9a                                    | 21.9a                                    | 57.1ab                      | 71.5a                       | 11.4a                 |

*Means with the same letter are not significantly different by LSR (least significant range) test at probability level of 5%.
*MF1, MF2, and MF3 are three exposure times of 0, 1, and 10 minutes to magnetic field of 1 Tesla respectively. - CAP1 and CAP2 are derived from single and multi-cap seeds respectively.
plant were recorded from MF1 × CAP1 and MF3 × CAP2 treatments with 29.8 and 71.5 capsules per plant; however, MF3 × CAP1 treatment with 65.2 capsules per plant were in the next rank. The increasing trend of the number of capsules in the CAP1 treatment had increasing relation with an increase in the time of exposure to magnetic field (Table 2). Maffei (2014) reported that the effect of magnetic field treatment could be similar to the effect of auxin on plant growth, which would increase the length of the growth period by increasing the flowering period, which resulted in increase the number of fertile capsules in the plant. The increase in the number of capsules per plant was reported by Naz et al. (2012). The present study has consistent with the results of that research.

**Seed weight per plant:** The highest effect of the magnetic field on the increase of seed weight per plant was found from MF3 treatment, which was 33% higher than the control as there was a significant difference between the MF treatments (Table 1, 2). Plants from multi-cap seeds (CAP2) had about 0.41 grams more seed weight per plant compared to plants from single-cap seeds (CAP1). However, there was no significant statistical difference among them. The effects of interaction showed that exposure to 1 tesla (MF3) magnetic field for 10 minutes had the highest values of this trait in CAP2 with 11.4 g/seed per plant followed by 8.07 g seed per plant with CAP1 and MF3. The lowest seed weight per plant was received from the exposure to a magnetic field of 1 tesla (MF2) for one minute in CAP2 plant of 5.31 g seed weight per plant in control and with CAP1 and CAP2 plant types were 7.33 and 5.61 g, respectively (Fig. 3 and Table 2).

The results of the study by Marghayizadeh et al. (2014) showed that the effect of the magnetic field of 0.5 tesla (5,000 gauss) in 15 minutes caused an increase of 69 per cent of the economic yield of Ajwain (Trachyspermum ammi) in comparison with the control (without magnetic field) of 187.9 kg / ha and 605.1 kg / ha with magnetic field treatment. The study of Esitken and Turan (2004) showed that the magnetic field increased the yield and accumulation of nutrients in strawberry. Another study by Fagenabi et al. (2009) in safflower showed that the yield in the magnetic field treatment was four times more than the control which might be due to the increase in the number of heads and seeds per head.

![Fig 3: Effect of exposure duration of sesame seeds to three magnetic field (MF1=0, MF2=1, and MF3=10 minutes) on seed weight per plant.](image)

The highest correlation coefficients were observed between seed weight per plant with the number of capsules per plant \((r = 0.53)\) (Table 3). Nezami et al. (2014) reported that grain yield in sesame has a positive and significant correlation with number of capsule per plant \((r = 0.28)\). It seems that the magnetic field changes the shape and level of energy in chemical processes, which results in changes in the molecular and tissue levels that increase the transfer of intercellular materials and eventually accelerating the cellular processes paves the way for initial growth and development and the plant sends more photosynthetic material into reproductive organs by increased biomass and increases seed yield per plant (Shabrangi and Majd, 2009).

In general, the results showed that the effect of magnetic field on the morphological traits and positive yield of sesame was significant. Depending on the duration of exposure to the magnetic field, the increase in the traits was different. It seems that using physical treatments such as magnetic field while ensuring productivity will improve the nutrition and environment. Therefore, considering the results of the present study, treatment of 10 minutes exposure to a magnetic field of 1 tesla can increase the yield of sesame.

**Table 3:** Results of correlation between plant height, number of single-caps nodes, number of multi-caps nodes, number of capsules per plant, number of seeds per capsule, seed weight per plant in sesame under exposure to magnetic field of 1 Tesla.

|                  | 1   | 2   | 3   | 4   | 5   | 6   |
|------------------|-----|-----|-----|-----|-----|-----|
| 1-plant height   | 1   |     |     |     |     |     |
| 2-number of single-caps nodes | 0.216ns | 1   |     |     |     |     |
| 3-number of multi-caps nodes | 0.454*  | 0.157ns | 1   |     |     |     |
| 4-number of capsules per plant | 0.517*  | 0.721** | 0.750** | 1   |     |     |
| 5-number of seeds per capsule | -0.573*  | 0.463*  | -0.389ns | -0.081ns | 1   |     |
| 6-seed weight per plant | 0.199*  | 0.495*  | 0.182*  | 0.53*  | 0.083ns | 1   |

*, **, and *** are non-significant and significant at the 5 and 1% probability level respectively.
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