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**ORIGINAL ARTICLE**

# Effect of magnetic field on the Yield and Chemical composition of *Raphanus sativus* L. seedlings

**Saeideh Najafi[1*], Rashid Jamei[2]**
[1,2]Department of Biology, Faculty of Science, Urmia University, Iran
*Corresponding Author: najafi.saide@yahoo.com

**ABSTRACT**
*In order to study the effect of silver nanoparticles and magnetic field on Raphanus sativus. experiments were carried out with four treatments in 10 days. Treatments were including (CON) control, (MF) magnetic field with B=1.8 mT for 1h per day in 10 days, (SNPs) silver nanoparticles (50 ppm), (MF+SNPs) magnetic field plus silver nanoparticles. Results showed that silver nanoparticles (SNPs) had the highest yield and chemical composition while rate of yield and chemical composition in group of treated by magnetic field (MF) had the lowest. Experiment treatments had significantly effects on traits such as the plant height, fresh and dry weight, lenght of root and shoot. It seems that silver nanoparticles (50 ppm) had the best effect on Raphanus sativus growth, root and stem length, weight of stem fresh and dry, germination rate, seedling height, phenol, flavonoid, chlorophyll a and b content.*
*Key words: Antioxidant activity, Physiological factors, Magnetic field, Silver nanoparticles, Raphanus sativus*

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## INTRODUCTION
Pre-sowing seed treatment including chemical and physical treatment like MFs electrical, nanoparticles, microwave and irradiation are known to positive or negative effects on modifications of plant metabolism and seed preferment that are favorable or inappropriate to plant growth and yield. MF and nanoparticles stimulation seem to be especially promising. Whether plants respond to MF is a subject under investigation. Silver nanoparticles influences a variety of plant functions such as growth [1,2] and chlorophyll content [3]. In contrast, magnetic field influences on growth [4,5], chlorophyll content [6,7], MDA content and protein content [8]. It was shown that the natural geomagnetic field has an important role on biological systems. The use of a magnetic field creates a stress condition for plant growth stimulation just as environmental stresses like salinity, drought, UV light, heat and chilling cause. Celik [9] in reported that all these condition cause the production of reactive oxygen species in the cells of plants. Physical methods are frequently used in seed germination and growth stimulation [10,11]. Physical factor such as magnetic field abroad in our natural environment and agriculture is the aim to prepare seeds for sowing and which have a positive influence on considerable acceleration and uniformity of seeds germination and other features as well as on obtaining abundant good-quality yield. Nowadays, magnetic field is used as a physical method in agriculture [12]. The purpose of this study was to investigate of magnetics field and silver nanoparticles have any considerable effects the growth and biochemical parameters of *Raphanus sativus*.

## MATERIAL AND METHODS
### Seed pretreatment with MF
Seeds of *Raphanus sativus* were obtained from Esfahan in Research Center in 2012, Iran. Seeds of *Raphanus sativus* have been used for investigating the influence of magnetic field on the development of plants. The induction of magnetic field has been *B*= 1.8 mT, measured with a digital tesla-meter (PHYWE, Germany). Magnetic-field-induction value has been chosen according to the opinion that weaker magnetic field has stronger effect on plant productivity. The healthy uniform dry seeds 8.6% of moisture content were selected and seeds kept at the geometric Centre of coil assemblies. Control seeds were kept under similar condition local geomagnetic field only but in the absence of magnetic field. Exposure was 10 days

for 1 h per day and control seeds were kept under the similar condition in the absence of the MF. The experiments have been performed in 2012 under laboratory conditions. The natural light cycle was 16 h–light/8h darkness with daily temperature 25°Cand night temperature 22°C.

**Seed germination and seedling development**

MF pretreated and control seeds were surface sterilized with 1% NaOCl (w/v) for 5 min, washed thoroughly 3 times with distilled water and then propagated in pots containing soil and sand mixture (1:2). The pots were maintained under natural photoperiod with 35% (w/w) soil moisture content. Seed germination observed at 7th day, and germination seedlings were uprooted and measured the length, fresh and dry weight of 10 days for both control and treated seedlings.

## RESULTS AND DISCUSSIONS

Exposure of *Raphanus sativus* seeds to magnetic field and silver nanoparticles treatments prior to germination altered germination-related characters, such as germination percentage, shoot and root length, seedling fresh weight, seedling dry weight, seedling vigor index and biochemical compounds. one day after treatments, magnetic field decreased germination percentage, in comparison with other groups. Also, the highest and the lowest percentage of germination were observed in silver nanoparticles and magnetic field treatment, respectively(Fig1).

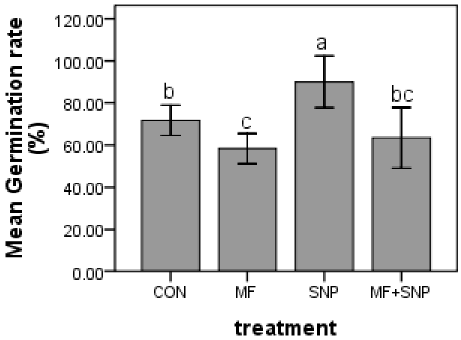


Fig. 1. Influence of magnetic field on rate of seed germination of *Raphanus sativus*. Bars represents means ± standard error. Means followed by the same letter are not significantly different ($P<0.05$) as determined by Duncan's multiple-range test.

Results showed that different effect of magnetic field and silver nanoparticles on physiological factors in *Raphanus sativus*. Maximum and minimum root and shoot length were observed in silver nanoparticles and magnetic field treatments, respectively (Fig2). Penuelas [13] showed that magnetic field with 17.6 mT decreased germination, seedling height, length of stem and root in Lens culinaris, Glycine soja and Triticum aestivum, whereas Aladjadjyan [14] reported that magnetic field with 150 mT increased germination, seedling height, length of stem and root in Zea mays.

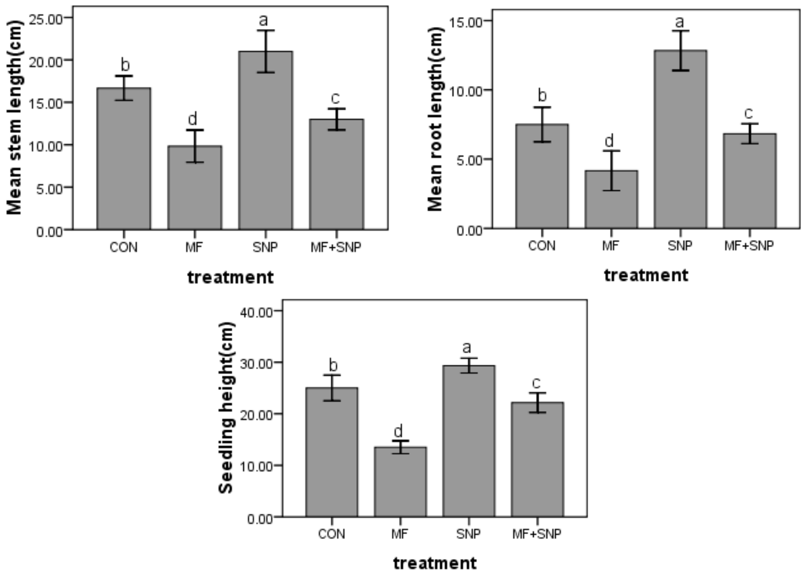


Fig. 2. Influence of magnetic field on *Raphanus sativus* seedling height, length of root and stem. Bars represent means ± standard error. Means followed by the same letter are significantly different ($P< 0.05$) as determined byDuncan's multiple-range test.

The present results were correlated with Penelas et al [15] results, who have found decreased growth of root in *Lens culinaris*, *Glycine soja*, and *Triticumaestivum* plants when seed pretreatment with magnetic field. In this study, in an attempt to understand the mechanism by which MF and silver nanoparticle change the growth, yield and biochemical of crop plants. In all the antiparallel experimental runs it is evident, to a level of confidence of 95% or higher, that antiparallel treatment results in a significant inhibition of the rate of plant growth. A similar analysis of antiparallel in present study gave essentially identical results. For the parallel case, a significant result was observed in some case, and in this case a stimulation effect of growth is present which is quite similar to that reported by Pittman for other plants [16]. can be confine free radicals over extended periods that are long enough to allow an external magnetic field to affect spin evolution. Shah and Belozerova [1] reported that metal nanoparticles decreased length of root, however, it enhanced germination and root length in Lettuce seeds.

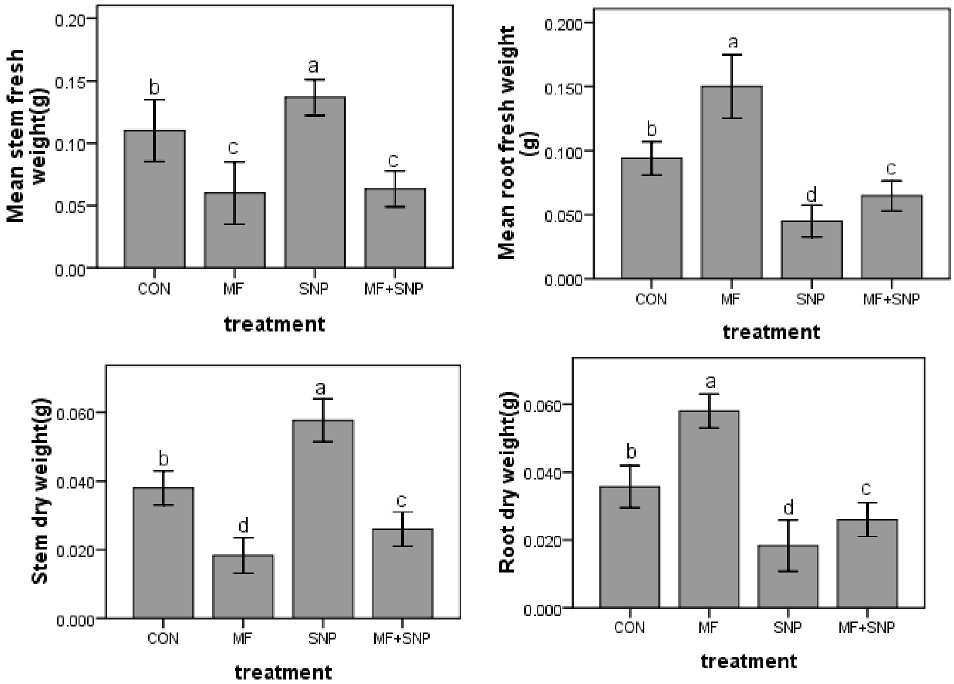


Fig. 3. Influence of magnetic field on wet and dry weight in root and stem of *Raphanus sativus*. Bars represent means ± standard error. Means followed by the same letter are not significantly different ($P < 0.05$) as determined by Duncan's multiple-range test.

The highest and the lowest percentage of fresh and dry weight of stem were observed in silver nanoparticles and magnetic field treatment, respectively. Whereas, The highest and the lowest percentage of fresh and dry weight of root were observed in magnetic field and silver nanoparticles treatment, respectively. In present study, magnetic field has a positive effect on growth of ramification roots, while decreased length of roots. On the other hands, silver nanoparticles has a negative effect on growth of ramification, fresh and dry weight of roots. Magnetic fields significantly increased total fresh and dry weight in sunflower seedlings [17]. Seedling vigor indexes showed significant increases in most inte nsities and duration of exposure. This result is similar to experiences of Vashisth and Nagarajan [18] on chickpea seeds.

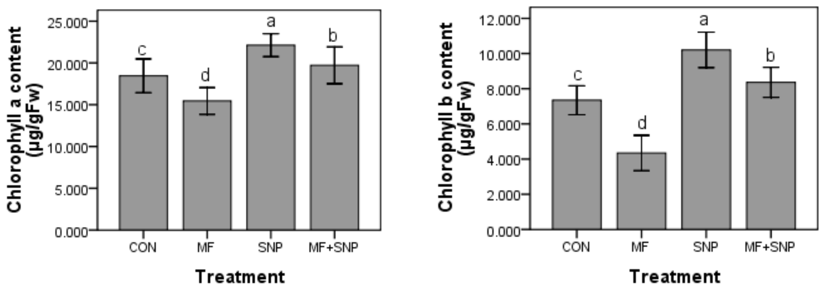


Fig. 4. Influence of magnetic field on pigments content (Chlorophyl a and b) of *Raphanus sativus.* Bars represent means ± standard error. Means followed by the same letter are significantly different ($P<0.05$) as determined by Duncan's multiple-range test.

Racuciu et al [19] observed that the magnetic field decreased content of chlorophyll a and b in all treatment compared with control in maize. The decrease in the chlorophyll a and b content can have a negative impact of magnetic field on the photosynthesis process in *Raphanus sativus* seedling, while silver nanoparticles increased content of chlorophyll. The content of photosynthesis pigments in leaves is only one of the physical factors having influence on the intensity of the photosynthesis process. Another important physical like magnetic field factor is the intensity of the photosynthesis process. Chlorophyll a, b and carotenoids take part in light absorption in the light-dependent phase of photosynthesis[20]. In some studies, Nano-TiO2 enhanced photosynthesis and other metabolisms in Spinach [21].

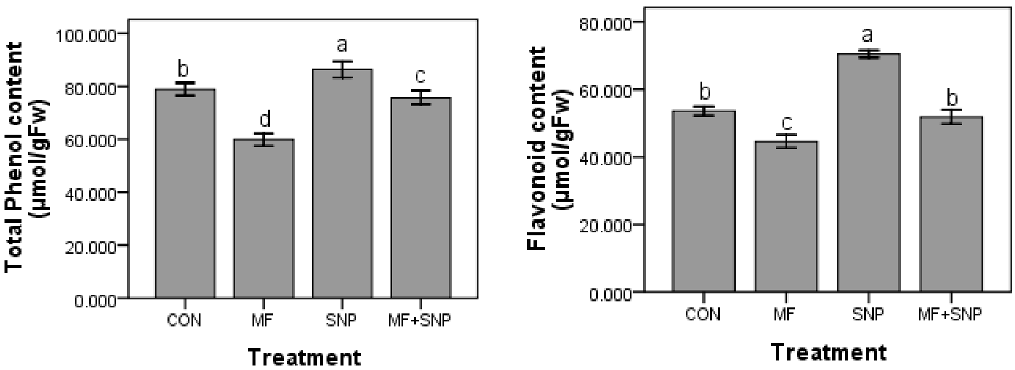


Fig. 5. Influence of magnetic field on flavonoid and Phenol content of *Raphanus sativus.* Bars represent means plus standard error. Means followed by the same letter are significantly different ($P$<0.05) as determined by Duncan's multiple-range test.

In this study, silver nanoparticles and magnetic field increased and decreased content of the flavonoid and phenol, respectively. Flavonoid and Phenol content can be confine free radicals over extended periods that are long enough to allow an external magnetic field to affect spin evolution. Najafi et al. [22] observed that magnetic field with 1.8 mili Tesla decreased chlorophyll, phenol and flavonoid content in *Phaseolus volgaris.*

## CONCLUSION

The finding of the present study indicated that, magnetic field and silver nanoparticles had different effects on growth and biochemical parameters in *Raphanus sativus* plants. Generally, it can be concluded that the applied magnetic field decreased growth parameters and plant development at the early stages of growth in *Raphanus sativus* plant whereas silver nanoparticles increased these factors.

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