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Tomato Generative Growth from the Seeds Exposed to 0,2 mT of Magnetic Field and Infected by *Fusarium* sp.

R Agustrina*, E Nurcahyani, and B Irawan

Jurusan Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Lampung

*E-mail: rochmah.agustrina@fmipa.unila.ac.id

Abstract. Previous research has shown that magnetic fields can increase the vigor and growth of tomato plants resistant to *Fusarium* sp. In this study we investigated whether the increase of vigor and tomato growth of plants resistant to *Fusarium* sp. attack will continue with the resulting increase in generative growth. The research was conducted factorially using a split strip plot design consisting of 0.2 mT magnetic field exposure (M) as the main plot; infection of Fusarium sp. (F) as a sub plot; and seed soaking (S) for 15 'before the magnetic field treatment as strip plots. Each treatment unit was repeated 3 times. The generative growth parameters studied were the number of flowers, the rate of fruiting, the number of fruits, and the total fresh weight of the fruit per plant. The results of the analysis of variance at $\alpha = 1$ and 5% indicated that the magnetic field exposure (M) treatment and combination of magnetic field exposure and seed soaking treatment (MxS) affected all parameters measured. Treatment of infection of Fusarium sp. (F) only affect the speed of fruit formation. The S treatment and combination of MxF, FxS, and MxFxS did not affect all parameters measured. Exposure to magnetic fields for 7'48" produced ants with the highest rate of flower formation and the greatest number of fruits. The highest number of flowers and the highest rate of fruiting was obtained from the treatment of magnetic field exposure for 11'42". Fusarium-infected plant stems from soaked seeds which were grown on sterile soil produced plants with the lowest of fruiting rate (F5). Exposure of magnetic field for 7'48 "to the soaked seed yields the highest number of fruit. The highest number of flower was obtained from the treatment of magnetic field exposure on un-soaked seed while the highest rate of fruiting obtained from the treatment of the soaked beans without exposure to the magnetic field.

1. Introduction

Growth and development of plants is strongly influenced by various environmental factors that surround them including magnetic field [1], because the earth is a source of natural magnetic field which then known the earth's magnetic field or geomagnetic field. However, since the energy emitted by the Earth's magnetic field is very low, 25 to 65 microtesla [2], its presence and influence on plants is not widely recognized. However, the last few decades it has been known that the results of research that examine the prospect of the utilization of magnetic field energy to various types of plants began to appear. Although there are still many unexplained problems on how the reaction mechanism of energy generated by magnetic fields with plant cell systems[3], the results of previous studies have proven

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that magnetic fields can improve the viability of seeds from tobacco [4], corn [5], soybeans [6, 7], tomatoes [8, 9], growth of vegetation of various plants as indicated by the increase of dry weight [8], nutrient content [10], chlorophyll content [11,12,13,14], and various plant carbohydrates [15], as well as production of crops characterized by increasing fruit quantities, and fruit weight [9,10] produced.

The role of the magnetic field in improving vigor and crop production is heavily associated with the ability of the magnetic field to change the physico-chemical properties of water molecules [16]. It has been proven that the magnetic field lowers the surface tension and increases the viscosity of water. As a result water becomes more stable with lower molecular energies but higher activation energy. The treated water of magnetic field has been proven can increase the percentage of seed germination of *Pinus tropicalis* [17]. The hypothesis is that magnetic fields cause changes in the physics-chemical properties of water, among others: surface pressure, dissolving power, refractive index, and pH. As a result the water becomes more easily be absorbed by the seed so that it can break the dormancy faster and shorten the latent period of the seed.

Observations on water medium for soybean germination under magnetic field treatment [6] show that the results are consistent with the above proofs and hypotheses where the magnetic field strength of 110 and 160 A/m can increase the water evaporation rate respectively by 15.87% and 41.47%, while the magnetic field strength of 275 A/m increases the medium temperature by 2.5°C and the evaporation rate of 135.96%.

Other studies have shown that magnetic field treatment is also known to increase peroxide enzyme activity [18, 12, 19]. Peroxidase is an enzyme that plays an important role in the formation of polysaccharides within cell walls such as phenol oxidation, suberation, and lignification that plants will use as defence against pathogens [20]. *Fusarium* sp. is an important pathogenic fungus causes Fusarium wilt disease, and in tomatoes cultivation this fungus also often becomes as a major constraint [21, 22]. This paper discusses the effect of 0.2 mT magnetic field exposure on the seeds of tomatoes infected by *Fusarium* sp on the number of flowers, the rate of fruiting, as well as the number and weight of the fruit.

2. Materials and methods

The tomato seeds used are obtained from the farm shop with the germination percentage reaching 95%. Before the magnetic field is exposed, the seeds are soaked for 15 minutes (S1) and the un-soaked seeds function as the control for the immersion treatment (S0). The treatment exposures of 0.2 mT magnetic fields (M) given respectively are 7'48" (M1); 11'42" (M2), 15'36"(M3), and control (M0) is without exposure to magnetic fields.

Monospora *Fusarium* sp. which is used for seed infections is obtained from propagation of *Fusarium* sp., from IPB Culture collection. *Fusarium* sp. infections are performed in two ways: first, by soaking the seeds exposed to the magnetic field in a monospore suspension with a density of 1x 10^7 or 12 hours and the second, injecting of 50 µl monospore suspension in to the stem of tomato plant when the age of the plant reaches 28 days after seeding. The notation for *Fusarium* sp. are as follows:

F0 = control, seeds not infected by *Fusarium* sp. and planted on sterile soil,
F1 = seeds not infected by *Fusarium* sp. and planted on non-sterile soil,
F2 = seed is infected by *Fusarium* sp. through soaking the seeds and planted on sterile soil
F3 = seed is infected by *Fusarium* sp. through soaking the seeds and planted on non-sterile soil
F4 = seed infected by *Fusarium* sp. through the stem of the plant at 28 days after seedling and planted on sterile soil
F5 = seed infected with *Fusarium* sp. through the stem of the plant at 28 days after seedling and planted on non-sterile soil

This research was conducted factorially with a split-strip plot design. Exposure to magnetic field is as main plot (M), treatment of infection of Fusarium sp. (F) is as sub plot, and seed soaking (S) as

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sub-sub plot. All treatment units were repeated 3 times. The process of seeding, planting, and maintaining crops in the field follows a common way of tomato farmers. The generative growth parameters observed were the number of flowers, the rate of fruiting, the number of fruits, and the total fresh weight of the fruit. The data obtained were analyzed by variance at α = 1 and / or 5% and continued with the test among treatments using the LSD Test at α = 5%

3. Results and discussion

The results of variance analysis in this study can be seen in Table 1 below which shows the effect of soaking treatment (S0 and S1), exposure to magnetic fields (M0, M1, M2, and M3), and *Fusarium* sp. infection (F0, F1, F2, F3, F4, and F5) on the measured generative parameters.

Table 1. The results of variance analysis of the effect of 0.2 mT magnetic field exposure on tomato seeds infected by *Fusarium* sp.

No	Generative Parameters	Treatments						
		S	M	F	M x F	M x S	F x S	M x F x S
1	Rate of flowering	ns	1%	ns	ns	ns	ns	ns
2	Number of flower	ns	1%	ns	ns	5%	ns	ns
3	Rate of fruiting	ns	1%	1%	ns	5%	ns	ns
4	Number of fruit	ns	1%	ns	ns	1%	ns	ns

Note: S = seed soaking, M = magnetic field exposure, F = *Fusarium* sp. infectiom, ns = not significans, and the numbers in % show the level of α.

Figure 1. Flowers of tomato have begun to appear when the plants were 42 days after seedling (4 weeks after planting)

From table 1, it shows that the *Fusarium* sp. infection only gives a significant ffect on the rate of fruiting, while the magnetic field exposure treatment (M) affects all parameters measured. The combination of treatment between magnetic field exposure and soaking of seeds before magnetic field treatment (M x S) affects the number of fruits, the rate of flowering and the rate of fruiting.

In this study, the plants start to flower between 3-4 weeks after planting. The rate of flowering is significantly influenced by magnetic field treatment. Exposure period to the magnetic field that yields the plant with the highest rate of flowering is for 7'48 "(M1) (Fig. 2).

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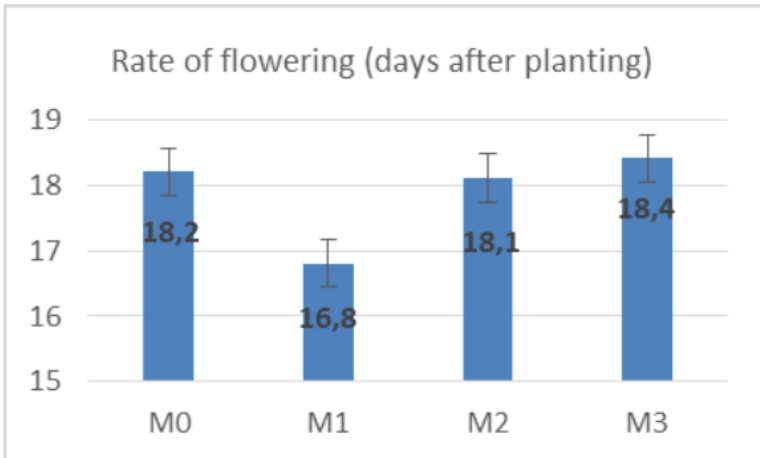

Figure 2. The effect of the exposure of magnetic field 0,2 mT (M) on the rate of flowering

The results of this study confirm the results of previous research which proved that the 120 mT magnetic field treatment for 10 minutes and 80 mT for 5 minutes can increase the rate of flowering of tomato plants compared to the control [9]. It has been proven that exposure to 10 mT magnetic fields for 1, 2 and 4 hours every day within 10 days can increase assimilation pigments and nucleic acids of corn and sweet pumpkin so as to increase the content of chlorophyll a and b [13]. Increased chlorophyll content in response to exposure to magnetic fields is also found in sugar beets [14] and soybeans [19].

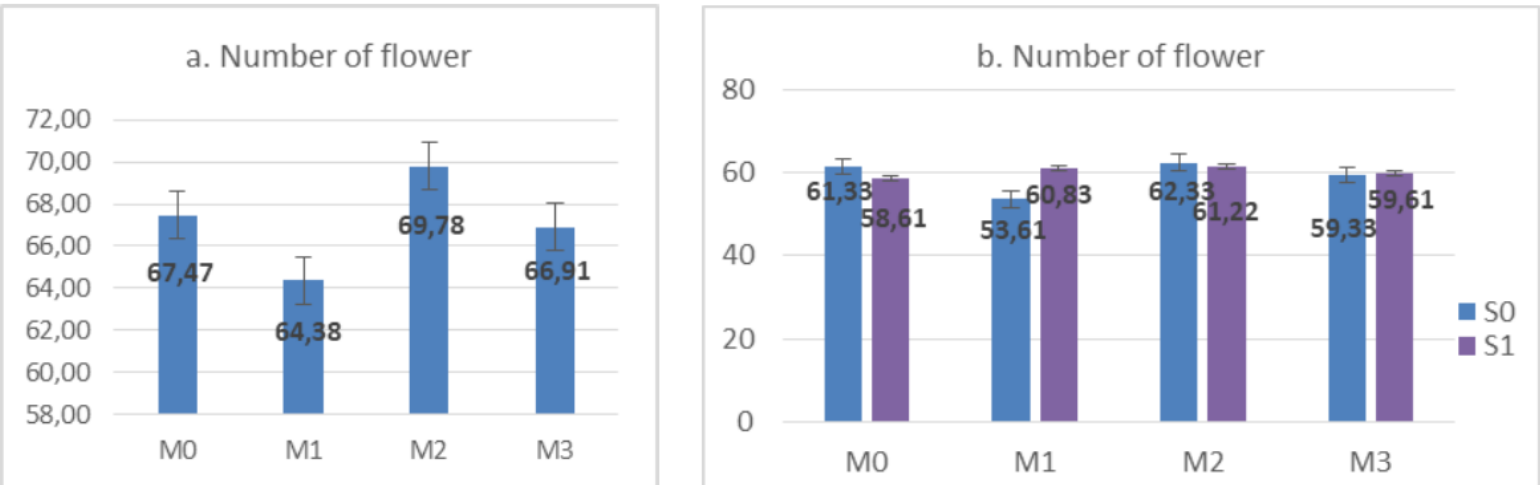

Figure 3. The effect of (a) the exposure of magnetic field 0,2 mT (M) and (b) the treatment combination between the exposure of magnetic field 0,2 mT and seed soaking (M x S) on the number of flower

Increased chlorophyll content will increase detectable photosynthetic rates by increasing carbohydrate and biomass contents [15]. The increase in chlorophyll as a result of magnetic field treatment is thought to be closely related to the increase in dry weight of plants and may eventually increase other growth rate parameters, such as the rate of flowering [8].

The response of the rate of flowering (Fig. 2) and the number of flowers (Fig. 3a) to the rate of fruiting (Fig. 4b) and the number of fruits (Fig. 5a) does not show a positive relationship, but the rate of the flowering (Fig. 2) is in line with the response of the number of fruits (Figure 5a) to the magnetic field treatment. Treatment of 0.2 mT magnetic field exposure on the seeds for 7'48" (M1) produced the plant with the highest flowering rate (Figure 2), but the least number of flowers produced (Figure 3a) with the slowest fruiting rate (Fig. 4a). However it produces the largest number of fruits (Figure 5a). In contrast, the treatment of 0.2 mT magnetic field exposure on the seeds for 11'36 "(M2) yielded plants with flowering rate significantly lower than the flowering rate of the plants of M1 treatment Fig. 1). The plants from M2 treatment yielded the highest number of flowers (Fig. 3a) and the fastest fruiting

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rate (Fig. 4a), and the number of fruits produced was quite large, the second most after the treatment of M1 (Fig. 5a).

Figure 4a below shows that the treatment of *Fusarium* sp. affected the speed of fruit formation. The results of the research team in our lab [23] found that the treatment of *Fusarium* sp. also affected the size of the fruit, especially on small fruits. The vegetative growth parameters did not show a significans response to the treatment of *Fusarium* sp. on the seeds exposed to magnetic field (Nastiti, personal communication). Thus the data on the results of this study are in line with the results of the other study [24] indicating that the symptoms of *Fusarium* sp. attack in early growth will cause plant death, but when the symptoms of Fusarium sp. seen after adult plants, plants can still grow but the production will decrease. This result led to the allegation that the treatment of 0.2 mT magnetic field exposure in the seeds prior to infection of *Fusarium* sp. was able to maintain the vigor of tomato plants so as to escape the attack of *Fusarium* sp. especially for the treatment of Fusarium sp F2 and F3 wherein infections of the *Fusarium* monospora are administered by soaking the seeds. In this case, exposure to the magnetic field in the seed is able to prevent and cause the plant resistant to the spread of infection *Fusarium* sp. derived from infected seeds, so that the plant does not show symptoms of *Fusarium* wilt disease during the vegetative phase. However, it appears that the effects of *Fusarium* sp. is still there so affect the size of the fruit produced [23]. This means that the magnetic field treatment is suspected to be able to increase the vigor of the plant originating from the seeds that escaped the *Fusarium* sp attack through soaking the seeds.

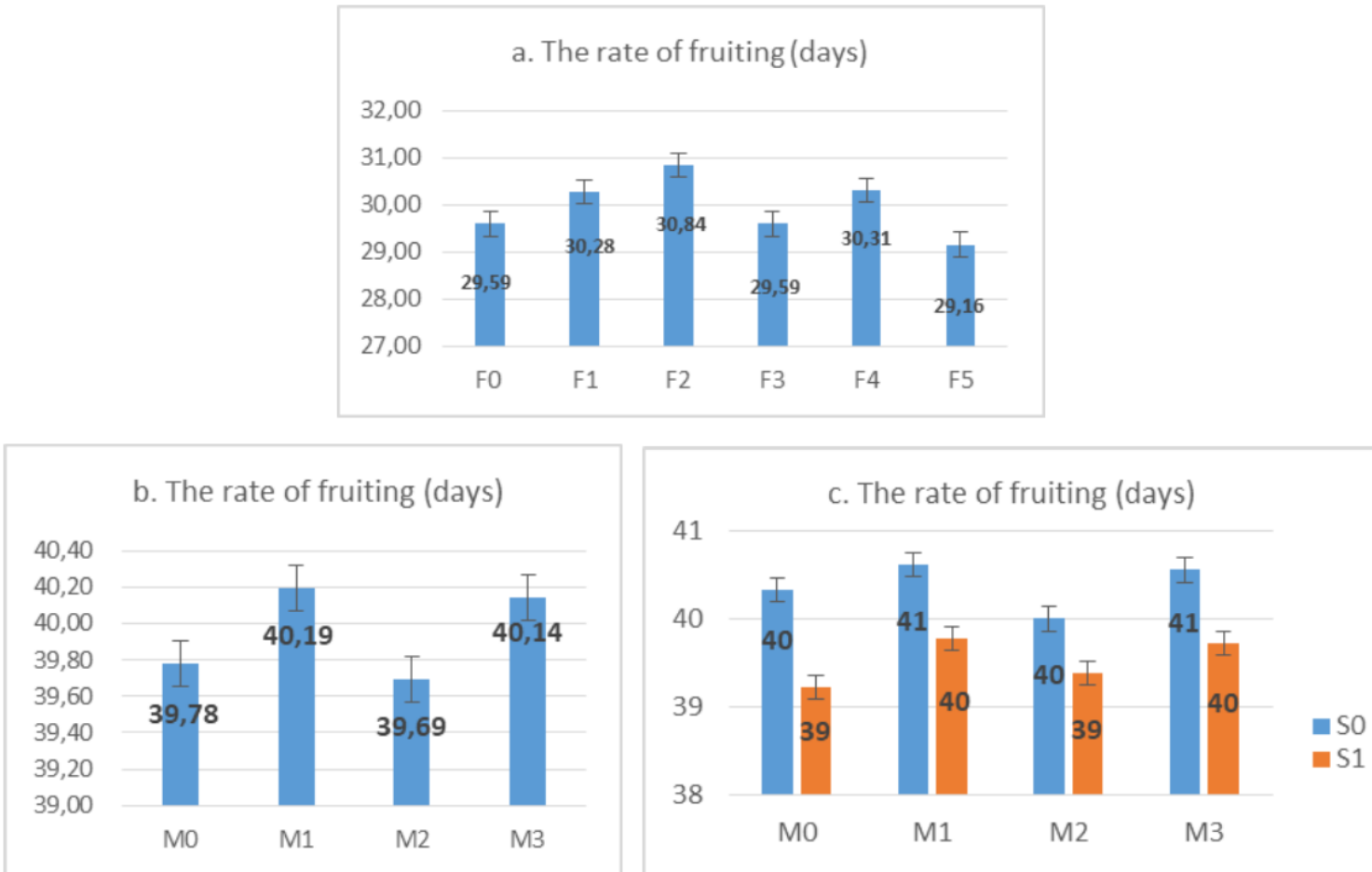

Figure 4. The effect of *Fusarium* sp. infection/F (a), 0,2 mT magnetic field exposure/M (b), and the combination treatment of magnetic field exposre and seed soaking/M x S (c) on the rate of fruiting

Treatment of infection of *Fusarium* sp. F3 and F5, produced plants with the lowest fruiting rate (Fig. 4a) and yielded a small average diameter of fruits (Listiany, personal communication) and this represents an opposite response to each other. The small size of the fruit diameter of the plants from the treatment of F4 and F5 which have high fruiting rate can not be explained yet how the interrelationship among each other. Although there were decreases in fruit diameter from F4 and F5

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from the infection of *Fusarium*, the plants were still able to produce fruit faster 28 days after seedling, considering the initial magnetic field exposure did slower the plant's growth and development. More studies are needed to observe the role of magnetic field exposure in maintaining vigor and production of tomato plants infected by pathogens through stems.

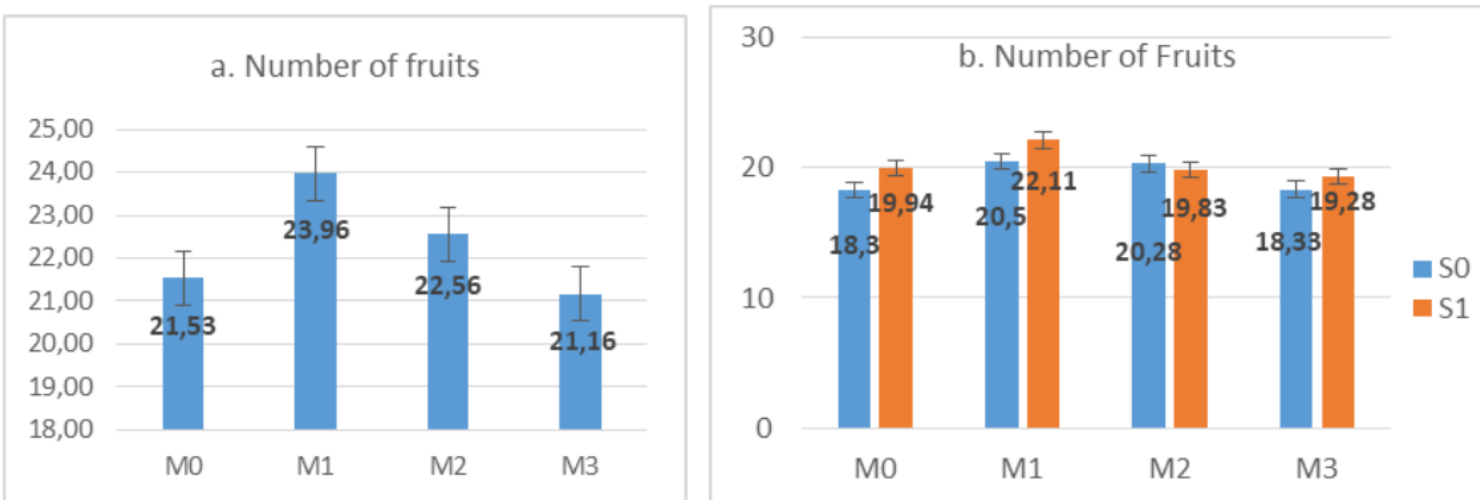

Figure 5. The effect of (a) the exposure of magnetic field 0,2 mT (M) and (b) the treatment combination between the exposure of magnetic field 0,2 mT and seed soaking (M x S) on the number of fruit

The seed soaking treatment (S) alone did not have a significant ffect on the parameters measured, but the combination treatment of seed soaking and magnetic field exposure significantly increased the number of flowers (Figure 3b), the rate of fruiting (Figure 4c), and the number of fruits (Figure 5b). Overall, the results of this study show that exposure to 0.2 mT magnetic field in tomato seeds can increase the production of tomato plants. Exposure to 0.2 mT magnetic field is able to retain the vigor of tomato seed infected by *Fusarium* sp. both infections through soaking the seeds in the suspension of the monospora isolate *Fusarium* sp. as well as through injection of monospora isolates on the stem at 28 days after seedling. As a result of magnetic field treatment on plants that survive from the attack of *Fusarium* sp. can grow well and produce faster, more flowering and fruiting. Exposure of 0.2 mT magnetic field to the seeds infected by *Fusarium* sp. becomes more effective in increasing the generative growth rate when done on seeds soaked for 15 minutes before being treated with magnetic fields.

4. Conclusions

Exposure to 0.2 mT magnetic field for 7'48" on tomato seed infected by *Fusarium* sp.produced plants with the highest rate of flowering and the largest number of tomatoes. Exposure to 0.2 mT magnetic field for 11'36 "in tomato seed infected by *Fusarium* sp. as M70 plants with the most number of flowers and the highest rate of fruiting. Soaking tomato seeds for 15 minutes before the 0.2 mT magnetic field treatment gave a better effect to increase the rate of the plants to form flowers, fruits, and increase the number of fruits.

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