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The resistance of tomato plants from seed treated with a magnetic field of 0.2 m T against *Fusarium* sp.

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ABSTRACT

The experiments were conducted to study the effect of a magnetic field of 0.2 mT treatment on tomato seeds to increase the resistance of tomato plants from the infection of *Fusarium* sp. The research was arranged in factorial, using a split striped plot design. The main plot is the exposure period to a magnetic field of 0.2 mT (M); subbplot is *Fusarium* sp. infection (F); and sub-sub plot is the seed soaking before treatment (S). The results showed that although the seed of tomato infected by *Fusarium* sp., the treatment of 0.2 mT magnetic field (M) on seeds improvesplant dry weight; amount of flowers; amount of fruit, fruit fresh weight, but not for fruit diameter. All the interaction treatment of magnetic field and seed soaking (M x S) also significantly affect all parameters above. Soaking the seeds before magnetic field treatment increases the dry weight of plant for all magnetic field treatment, the amount of flowers for magnetic fields treatment of 7min 48 sec, fruit fresh weight for magnetic fields treatment of 15 min 36 sec, and fruit diameter for magnetic fields treatment of 15 min 36 sec.

Key words: *Fusarium sp. Infection, Magnetic field 0.2 mT; Seed soaking*

Introduction

Promising prospects of the magnetic field (MF) energy utilization to improve the quality and agricultural field production is obtained from various studies. Atak *et al.* (2007) showed that the treatment of MF 2.9 to 4.6 mT for 2.2 to 9.8 seconds increases the formation of buds, roots, chlorophyll, peroxidase enzyme activity in cultured soybean cotyledons. The increase in germination capacity, decrease in number of diseased seedlings and deformed seedlings as a result of MF treatment is also shown from thelow quality carrot seeds due to infection by the fungus that cause rot sprouts (Dorna *et al.*, 2010).

The positive impact of MF treatment in plants has also been demonstrated on the seeds of green onion (Novitsky *et al.*, 2001), strawberry (Esitken and Turan, 2004), seed tobacco (Aladjadjiyan and Ylieva, 2003), and cotton (Nagy *et al.*, 2005). Previous research on tomato proves that the exposure of the dynamic MF of 120 mT for 10 min and 80 mT for 5 min improve all parameters of vegetative and reproductive growth (De Souza *et al.*, 2005). The same result on vegetative growth of tomato plants were also obtained from previous study where the MF treatment of 0.2mT for 7 min 48 sec increased the vegetatif growth rate. Soaking the seeds of tomatoes before MF treatment increased the vegetatif growth rate more (Agustrina *et al.*, 2016).

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops economically, because it can be used both as a vegetable and raw materials for various food industry (Dashti *et al.*, 2014). Tomato production is often constrained by pathogens including *Fusarium oxysporum*, that causes Fusarium wilt disease (Smith *et al*., 1988). Ignjatov *et al*. (2012) explain that Fusarium are the causal agents of tomato wilt cause root and basal stem deterioration and result in the wilting of vegetable plants and browning of the vascular tissue is strong evidence of fusarium wilt. In this study, we examined whether effects of magnetic fields on the growth and production of tomatoes is also followed by an increase in resistance of tomato to disease caused by *Fussarium* sp.

Materials and Methods

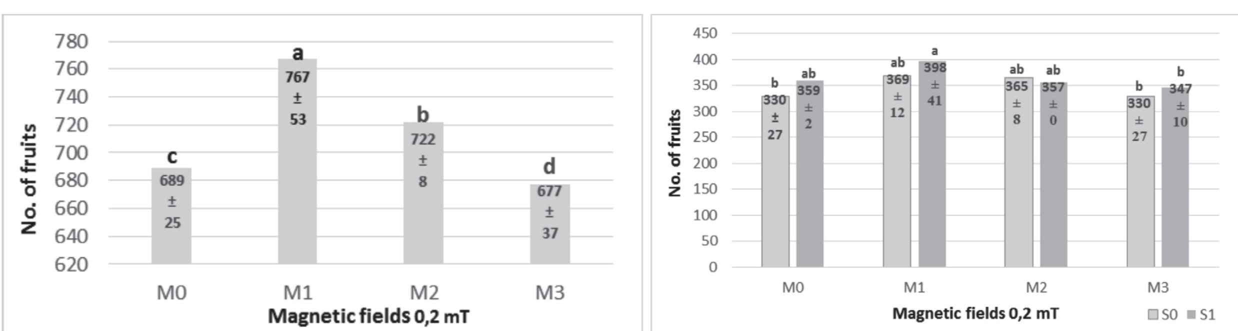
Tomato seeds were obtained from seed merchants with a germination rate of 95 %. Immerssion treatment (S1) conducted by immersed the seeds in tap water for 15 minutes before being given a 0.2 mT magnetic field (MF) treatment (M), while the untreated immersion of seeds (S0) directly exposed to a MF. MF treatment is given for 7 min 48 sec (M1); 11min 42sec (M2) and 15min 36 sec (M3) and control (M0).

Fusarium sp. monospore used for the treatment of *Fusarium* sp. infection (F) derived from isolate of *Fusarium* sp. provided by Agriculture Institute of Bogor (IPB), Indonesia culture collection. *Fusarium* sp. infection through the roots was conducted by soaking the MF-treated seedsin the suspension containing monospore of *Fusarium* sp. with a density of $1x10^7$ for 12 hours. While *Fusarium* sp. infection on the stem is conducted by injecting about 50 mL suspension of monospora *Fusarium* sp. on tomato stems at the age of 28 days after sowing (das). All the seeds treated *Fusarium* sp were planted in both sterile and non-sterile soil. The marking for the treatment of Fusarium sp. are as follows. F0 = uninfected-*Fusarium* sp. seeds grown in sterile soil, F1 = uninfected-*Fusarium* sp. seeds grown in non-sterile soil, F2 = infected-*Fusarium* sp seeds grown in setrile soil, F3 = infected-*Fusarium* sp. seeds grown in non-steriel soil, F4 = *Fussarium* sp. infection through the stem, grown in sterile soil, and F5 =*Fussarium* sp. infection through the stem, grown in non-sterile soil.

Planting and maintenance of the plant following the planting and maintenance of tomato plants as is usually done by farmers. The plant responses to the treatments of MF, *Fussarium* sp. monospore infection, and seed soaking was observed by measuring dry weight of plants at 42 das, the amount of flowers at the beginning of flowering, the amount of fruit, the fresh weight of fruit, and fruit diameter. Data were analyzed variance followed by LSD at á = 5% (Gomez and Gomez, 1984).

Results

Results of analysis of variance at $\alpha = 5\%$ indicates that the exposure of MF against the tomato seeds and the interaction of MF exposure and soaking the seeds before treatment MF (M x S) significantly affect all parameters measured (Figure 1 - 5). While the treatment of infection by *Fusarium* sp (F), the interaction of MF and infection *Fusarium*sp. (F x F), the



(a) (b)

Fig. 1. (a) Dry weigh of tomato plants at 42 days after seedling (das) under MF Trealment; (b) treatment interaction of MF and soaking seed before MF

interaction of infection *Fusarium* sp. and soaking the seeds before treatment MF (F x S), and the interaction of exposure MF, infection *Fusarium* sp, and soaking the seeds before treatment MF (M x F x S) had not impacted significantly.

The results demonstrated that the treatment of infection by *Fusarium oxysporum*, both alone and in interaction with the treatment of MF and soaking seeds before MF exposure did not affect the growth and production of tomato plants. Research results on the poor quality of seeds of carrot cv. 'Nantejska' and 'Perfekcja' due to fungal attack, showed that MF improve the germination capacity, although not significant in the cv. 'Perfekcja' and decrease the number of diseased seedlings in both cultivars (Dorna *et al.*, 2010).

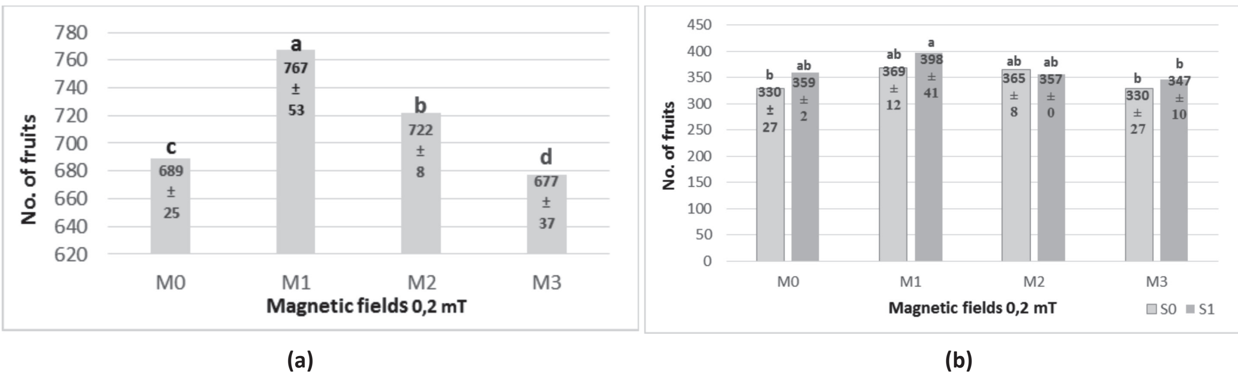


Fig. 2. (a) Number of flowers of tomato plants under MF trealment; (b) treatment interaction of MF and soaking seed before MF

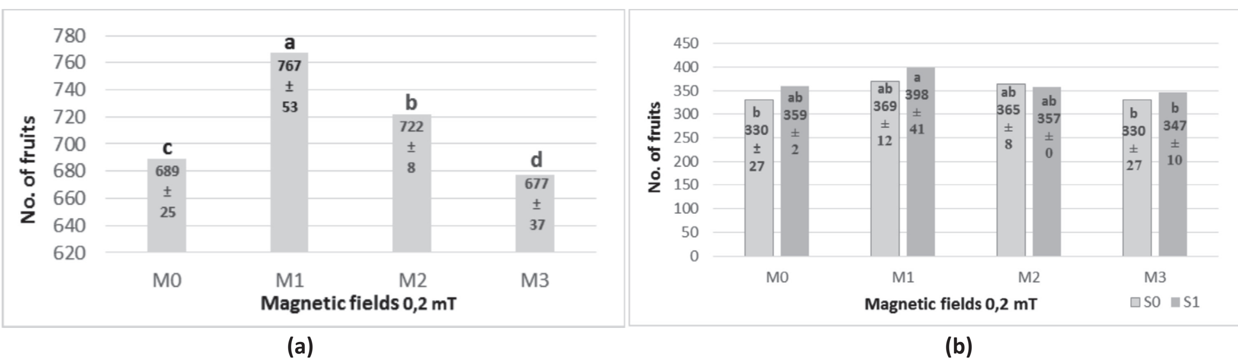


Fig. 3. (a) Number of fruits of tomato plants under (b) MF trealment and treatment interaction of MF and soaking seed before MF

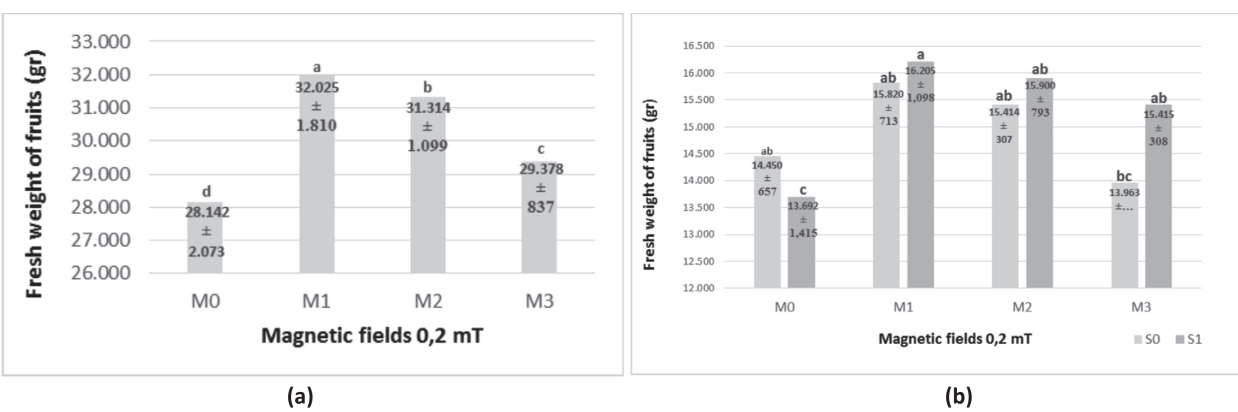


Fig. 4. (a) Fresh weight of fruits of tomato plants at 42 das under MF trealment; (b) treatment interaction of MF and soaking seed before MF

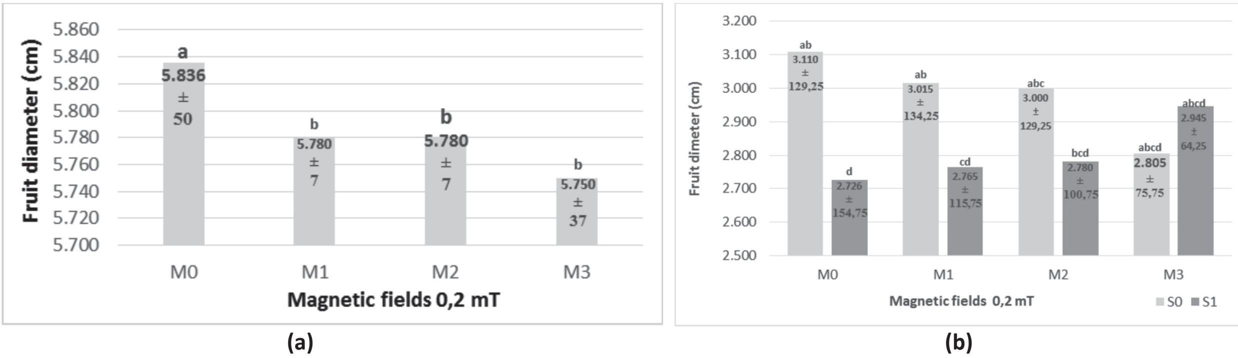


Fig. 5. (a) Fruit diameter of tomato plants at 42 das under MF trealment; (b) treatment interaction of MF and soaking seed before MF. Tomato seeds without MF treatmen (M0), exposure to MF for 7 min 48 sec (M1); 11 min 42 sec (M2) and 15 min 36 sec (M3). Tomato seeds were not soaked (S0) and soaked (S1) before MF treatments. The same letter within the figure indicates the lack of a significant difference ($p < 0.05$) according to LSD test

Discussion

Dorna *et al.* (2010) suspected that the MF treatments controlled to some extent the growth of fungi which can decrease in both the number of diseased seedlings and dead seeds. El-Nabi *et al.* (2013) proved that exposure to the dynamic MF of 7-15 gauss decrease disease severity and the disease incidence on onion seedling. The magnitude of the power dynamic MF given did not give different results but increasing the exposure time period of dynamic MF will further reduce the severity of disease and the onset of disease. Other studies on the effect of MF on the growth of several fungal pathogens indicated that the use of MF 0.1, 0.5, and 1 mT decreased the growth ofcolonies by 10%. At the same time, the number conidia of *Fusarium oxysporum* conidia decreased by 79-83 percentbut the number of the developed conidia of *Alternaria alt*ernata and *Curvularia inaequalis* increased by 68-133 percent (Nagy, 2005)

The MF treatment significantly increased the dry weight of tomato plant measured at 42 days after seeding (Figure 2a), the number of flowers (Figure 3a), the number of fruits (Figure 4a), and the weight of fresh fruit (Figure 5a). The results obtained in this study are consistent with previous research (De Souza *et al.,* 2005), which proved that MF improve the dry weight of roots, stems, and leaves of tomato compared to controls, as well as flower number, fruit number and fruit weight. There was no difference in all measured parameters from the MF exposure treatment of 120 mT for 10 min and 80 mT for 5 min.

An increase in dry weight of tomato plants of this result is confirmed by the result of previous research that MF increased the fresh weight of tomato plant (Agustrina *et al.,* 2016). De Souza *et al*. (2005) stated that increasingdry weight on tomato plants indicates a positive result and intial effect of MF since they appearto induce an improved capacity for nutrient and wateruptake, providing greater physical support to thedeveloping shoot. Increasing of root length affected by MF were also appeared on lettuce germination (Mousavizadeh *et al*., 2013; Soltani and Kashi, 2004). In cotyledon tissue culture of soybean, the MF exposure of 2.9 – 4.6 mT for 2.2 – 19.8 sec increased the root generation (Atak *et al.*, 2007).

Dorna *et al.* (2010) explained that he influence of a magnetic field on seeds may be short-term, e.g. 10 min, followed bythe effect in the form of increased water absorption occurring after several hours and lasting for at least several days (Reina *et al*., 2001). This The presssumption is convinced by the variant, in which an effectiveaction of a MF on plants, including germination, may be replaced by the MF exposure on water or substrate which is used to water plants (Aboe El-Yazied *et al*., 2011; Hozayn and Qados, 2010; Morejón *et al*., 2007). Water is an important factor for the metabolic processes in the cell. The magnetic field affects the physical and chemical properties of water by lowering the surface tension and increases the viscosity of the water so it is more stable with lower molecular energy and higher activation energy Cai *et al.* (2009). The studies on water exposed to the action of a magnetic field indicate an altered, usually reduced, surface tension, viscosity (Pangand Deng, 2008). Based on several other studies (Morejón *et al*., 2007) explain that magnetic field exposure to normal water (water+ions) changes some of its physical and chemical properties such as: surface tension, conductivity, solubility of salts, refractive index and pH. By application of magnetically treated water (MTW) in pine seed germination, he showed that it improves germination percentage. The result leads to a hypothesis that MTW properties as mentioned above make it much easier to penetrate inner parts of the seed. Several other theories have also been proposed to explain the mechanism of MF effect in plant germination metabolisma, including biochemical changes or altered enzyme activities (Majdand Shabrangi, 2009) such as amylase (Rochalska and Grabowska, 2007) protease, lipase (Rajendra *et al*., 2005). Then an increase in vigor as a result of MF treatment is thought to have an important role in inducing subsequent metabolism necessary for plant growth and development so that the plant reached the phase of vegetative and reproductive.

Atak *et al.* (2007) proved that MF exposure increases chlorophyll content also and the surface area of leaves (De Souza *et al*., 2005). All the process parameters of growth are inextricably linked to each other so that eventually resulted in higher dry weight (Figure 1a). This study also showed soaking seeds MF exposure increases dry weight (Figure 2b), which reinforced the results of previous research on tomato (De Souza *et al*., 2005). Data from this research and previous studies reinforce the confidence in the essential evidence of the effect of the MF exposure to increase in the rate of photosynthesis. Sources of energy produced from photosynthesis in the late vegetative stage should be sufficient to support the processes of development and differentiation plant to enter the phase metabolic reproduction, which is the very complex process of metabolism and requires a lot of energy, among others in the process of establishing tissue cells needed to form reproductive organs.

Fig. 6. A healthy tomato plants (S0F3M2-1/**a** and S1F2M1-2/**b**) and tomato plants infected by Fusarium wilt disease (S0F5M3-2/**c** and S1F1M0-2/**d**)

The data in Figure 1a and 2a shows that in the treatment of MF which resulted in high dry weight, forming the few number of flowers. In this study, dry weight measurements carried out at the same time calculating the amount of inumber of flowers, when the plant has entered the generative phase. It seems that, in plants that produce more flowers, spend more energy source of photosynthesis, so the remaining energy sources become less (Figure 2a). The initiation of owering buds implies a fundamental change in developmental programme, as indicated by the large change in RGR from a two-compartment system (shoot and root) to a three-compartment system (shoot, root and reproductive structures). Leaf massfraction (LMF, fraction of total resources invested in leaves) declined during the reproductive stage but when calculated as fraction of the total vegetative resources it stayed the same (Koelewijn, 2004). The results on the number of fruits, fruit weight, and fruit size do not indicate a consistent response to the treatment of MF and soaking the seeds before being exposed to a MF. The MF treatment that produce the highest number of flowers was not followed by the highest results of the fruit number. These results are thought to be related to the influence of *Fusarium* sp. infection in seed or stem in this study although it statistically not give effect significantly.

Figure 6 shows the plants attacked by *Fusarium* sp. although they can survive and bear fruit. Steinkellner *et al*. (2005) explains when symptoms due to *Fusarium* sp attack occurred at the beginning of growth will lead to the death of the plant, but when symptoms due to *Fusarium* sp attack occurred after the plant is mature, the plants can still grow but production will decline. An increase in the activity of enzymes peroksidase on plants from seed is exposed to a magnetic field (Atak *et al*., 2007) led to a tomato plant in the study can survive the attacks of infection *Fusarium* sp.. Ojha and Chatterjee (2012) found that higher peroxidase activity in tomato leaves infected Fussarium oxysporum sp than the healthy leaves and increases with increasing duration of inoculation fungus on the leaves. Peroxidases (POX) are heme-containing glycoproteins and suggested have important role in lignication, suberization, and self-defense against pathogens (Hiraga *et al*., 2001).

In this study is also known that soaking seeds before MF exposure increases the fresh weight of fruits (Fig. 4b), but did not increase fruit size (diameter) (Fig. 5b). This result is due to the weight of the fruit measured is the total weight of the fresh fruit produced by the plants, resulting in plants that have a more number of fruit will produce fruit with a smaller size than the plants that produce less fruits.

Conclusion

Exposure of MF on tomato seeds can increase the resistance of tomato plant against *Fusarium oxysporum* infection because MF exposure on seeds: 1) can inhibit fungal growth and sporulation and 2) can increase the synthesis of peroxidase. Soaking the seeds prior to MF exposure increases plant dry weight, but the response of the reproductive parameters to the seed soaking treatment before MF exposure are inconsistent despite showing real impact.

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