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Response of tomato seed germination to several extraction techniques and magnetic field exposure treatments

Abstract The superior seeds are indicated by clean, good germination rate, pest and disease-free. One of the problems in providing superior tomato seeds is the presence of pulp attached to the tomato seeds, leading to less clean of seed. To remove the muscus on tomato seeds, the seeds have to be extracted. Other than seeds extraction, seeds exposure also could optimize seeds growth by increasing the metabolism of the tomato. The aim of this research is to determine the best extraction technique and magnetic field exposure for obtaining high tomato seeds germination. The complete random design used in this research consist of two factors, seeds extraction and magnetic field with three time replications. The result showed that seeds extraction for 24 hours is the best treatment for improving the maximum germination percentage, growth potential, growth rate, speed growth, uniformity index than others. Magnetic exposure at 6mT is the best treatment to improve seeds maximum growth and seeds speed growth.

Keywords: Extraction · Germination · Magnetic field · Tomato

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Introduction

Tomato which is one of the five vegetable crops in Indonesia which contributes the largest production after chili is a fruit vegetable with high economic value. Tomato production in 2020 reached 1.08 million tons, while tomato consumption in 2020 reached 1.4 million tons (Statistics Indonesia, 2020). Optimizing tomato production in the field is still constraint low quality seed, pests and diseases, low percentage of fruitset, uncertain climatic conditions, and soil fertility. These constraints cause a decrease in tomato production, both in terms of quality and quantity, even if it is not immediately anticipated, it can cause crop failure (Hidayati & Dermawan, 2012).

Superior seeds are clean and healthy seeds, and also have good germination. One of the problems in providing tomato seeds is because of the pulp on the tomato seeds. To remove the pulp on the tomato seeds, the seeds needed to be extracted. If it is not extracted well, it would cause germination of the old seeds, easily contaminated by the microbes, and affect the vegetative and generative growth (Rismunandar, 2001).

Unclean tomato extraction could be characterized by the existence of juice and pulp on the tomato seeds and the physical appearance that looks yellow and dull (Karavina et al., 2009). There are several wet extraction techniques such as soaking with fermented tomato water, HCl solution, and NaOCl solution. Iriani et al. (2017) proved that the extraction technique with fermented tomato water for 24 hours resulted in a simultaneous growth of 91%, 91% germination, and normal dry sprout weight for 0,11 grams. This research also proved that the extraction technique with 2% HCl solution for 2 hours produced a 98.25% simultaneous growth, 98.25% germination rate, and 0.11 g normal dry sprout weight.

Other than fermented tomato water and HCl solution, NaOCl solution also could be used for the wet extraction technique. Purba et al. (2018) proved that the extraction technique with 9% NaOCl solution produced higher germination, seed growth rate, and maximum growth potential rather than soaking in regular water, 6% and 13% NaOCl. According to Gunarta (2014), tomato seed extraction treatment by soaking in 2% HCl solution for 2 hours showed the best average value for the physical and physiological quality of tomato seeds rather than washed directly using water.

Aside from providing good seeds, it is also needed to improve and optimize plant growth. In recent decades, physical techniques based on the application of magnetic fields are being developed in the agriculture sector. Studies showed that low magnetic field applications in agriculture can be used to improve the quality and quantity of the product. Numerous authors have reported the positive influence of the stationary magnetic field on the plant seeds.

Magnetic fields exposure of 125 mT and 250 mT for 12 hours increased the percentage of germination of lettuce (*Lactuca sativa* var. longifolia) seeds as well as root length, fresh weight and dry weight, and peroxidase enzyme activity of lettuce seeds (Mousavizadeh et al., 2013). Research on rice (*Oryza sativa* L.) seeds by Carbonell et al. (2000) showed that 150 mT and 250 mT magnetic fields increased germination. Giving a magnetic field affects the structure of cell membranes, so that permeability and ion transport which can affect metabolic pathways also increase (Iqbal et al., 2012)

Jedlicka et al. (2012) stated that a magnetic field could increase the germination speed, and vegetative and generative growth of tomato (Cakmak et al., 2010). Strong magnetic field induction as big as 0,2 mT could improve tomato plants' metabolism from the old seeds well so it could improve the vigor of seeds and vegetative growth of the tomato and also increase the chlorophyll and carbohydrates of the plants the same as the new seeds (Novitasari et al., 2019).

Methods and Material

This research was done at Seed Technology Laboratory, Faculty of Agriculture, Universitas Padjadjaran from May to June 2022. Materials used in this experiment are tomato cv. Elisha, seedling media (cocopeat, NPL, fungicide), 2% HCl, 9% NaOCl, equates, and CD paper (blurred). Tools used are a solenoid magnetic field and its coil, trays, tweezers, pipettes, measuring cups, Petri dishes, knives, and strainers.

The experiment design used is Complete Random Design (CRD) factorial patern with two factors and three times replication. The first factor is seeds is the extraction methods, consisting of four treatments: E0 = control

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(without extraction), E1 = soak by water 24 hours, E2 = HCl 2% 2 hours, and E3 = NaOCl 9% 15 minutes, and the second factor is magnetic field exposure: M0 = control (without exposure), M1 = 0,2 mT, M2 = 4 mT and M3 = 6 mT. The magnetic field was exposed for 7 minutes and 48 seconds (Rohma et al., 2013).

The seeds that were extracted according to the treatment were then exposed to the magnetic field in the amount of each treatment for 7 minutes and 48 seconds. Those seeds later on germinated with Top of The Paper Test (TP) method and used CD paper (blurred) on the petri dish and observed for 2 weeks to know the seed sprout's parameter.

Observing parameter consist of germination, maximum growth potential, growth rate, and simultaneous growth.

a) Germination Capacity (GC)

This observation was done twice, from the first-day count on day 5 and the last-day count on day 14. At the end of this period, the seedlings are categorized normal, abnormal, or dead or hard seeds. The observation was done by counting the normal seedling that meet the criteria for normal seedling and calculated by the formula as follows :

$$GC = \frac{\Sigma \text{ Normal Seedling}}{\Sigma \text{ Number of seed sown}} \times 100\%$$

b) Maximum growth potential (MGP)

Growth potential is counted based on the percentage of germinated seeds at the end of observation, which is day – after germination. Seeds germination was done with the same method as the germination capacity. The calculation formula is as follows:

$$MGP = \frac{\Sigma \text{ Grown seeds}}{\Sigma \text{ Planted seeds}} \times 100\%$$

c) Germination Speed Index (GSI)

Growth rate is calculated based on the percentage accumulation of normal seedling per etmal (24 hours) for the germination period which is until day 14 with the formula as follows:

$$GSI = \sum_{0}^{tn} \frac{N}{t}$$

Description:

t = Day of counting

N = Normal percentage every observation time

tn = Days of final count (day 14)

d) Uniformity Index (UI)

The calculation of uniformity index was done to the strong normal sprout on day 9, which is between the first day count (day 5) and last day count (day 14) after planting and stated in percent. The simultaneous growth used the equation formula as follows:

$$UI = \frac{\Sigma \text{ Normal seedling}}{\Sigma \text{ Planted sprouts}} \times 100\%$$

Data collected was then analyzed for the variance using SPSS software. If count showed significant effect, then it would be continued to Duncan Multiple Range Test (DMRT) on 5% real stage.

Results and Discussion

The result of variance analysis on the impact of seeds extraction as a whole has a very significant effect on seed viability and vigor, while the effect of the magnetic field treatment only significantly affected the growth rate parameter and interaction between seeds extraction and magnetic field significantly affect on the germination capacity parameter.

Table 1. Analysis of seeds extraction and magnetic field treatment to the tomato seed viability and vigor.

Seed Quality Parameter	Treatment and Its Interaction		
	Extraction Technique (E)	Magnetic Field Exposure (M)	E X M
GC	**	ns	**
MGP	**	ns	ns
GSI	**	*	ns
UI	**	ns	ns

Description: GC (germination capacity), MGP (maximum growth potential), GSI (germination speed index), UI (uniformity index). * (significantly different in 0.05 degree), ** (significantly different in 0.01 degree), ns (not significant).

Figure 1. Control

Figure 2. 24 hours fermentation

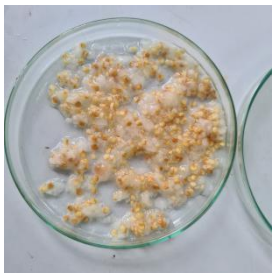

Figure 3. HCl 2% 2 hours

Figure 4. NaOCl 9% 15 minutes

Tabel 2. The effect of extraction methods on germination capacity (GC) of tomato seeds

Treatment	Germination Capacity (%)
Control (E0)	73.33 a
24 hours fermentation (E1)	93.00 b
HCl 2% 2 hours (E2)	89.67 b
NaOCl 9% 15 minutes (E3)	73.00 a

Description: Mean followed by the same letter on the same column showed no significant difference based on Duncan's Multiple Range test at 5% level.

The seeds extraction technique with fermenting tomato method for 24 hours showed the best germination percentage. This is because pulp on the seeds could be removed maximum such as shown in Figure 1. On the 2% HCl for 2 hours, there is seen a little pulp left and unclean color (Figure 2), and for control treatment and NaOCl it could be seen the pulp is still on the seeds (Figure 3 and 4). This is because acids are effective at cleaning the pulp attached to the seeds, where the longer the seeds are soaked, the more pulp is released from the seeds (Tarigan et al., 2018). Whereas in the control and NaOCl treatments it was seen that the pulp was still attached to the seeds (Figures 1 and 4). The slime will hinder the germination process, because it contains inhibitory substances.

The pulp would obstruct the germination process because it contains inhibitors. The red color of the tomato contains lycopene pigment which is part of the carotenoids, and carotenoids are one of the raw materials for abscisic acid, a phytohormone inhibitor for plant physiological processes (Zoran et al., 2014).

Table 3 showed that tomato fermentation for 24 hours treatment is the treatment with highest percentage of maximum growth potential. It is suspected because when it is soaked in fermented water, seeds are imbibed well so it could improve seed viability and vigor. Good imbition speed causes water needs for the seeds fulfilled so the seeds' metabolism process could go well (Juhanda et al., 2013).

The best magnetic field treatment for the maximum growth potential percentage parameter is 6 mT. Maximum growth potential percentage increases along with the improve of the amount of magnetic field exposure. It is because the magnetic field affects most of the cell membrane that could protect cells that are again surrounding by the membrane, and also it is no to induce seeds, respiration, and it's metabolism (Nurbaity et al., 2019).

According to the Table 4, the highest seed growth rate is also tomato fermentation seeds extraction for 24 hours treatment, it is because seeds germination power gave an impact on the seeds growth rate. Seeds that are clean of pulp will cause loss of germination inhibitory substance that exists in tomato pulp, so the less

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pulp the faster the germination will be (Purba et al., 2018).

Table 3. The effect of extraction techniques and magnetic field exposure treatments on maximum growth potential (MGP) of tomato seeds

Treatment	Maximum Growth Potential (%)
Seeds Extraction €	
Control (E0)	79.33 a
24 hours fermentation (E1)	97.00 c
HCl 2% 2 hours (E2)	95.00 c
NaOCl 9% 15 minutes (E3)	88.00 b
Magnetic Field (M)	
Control (M0)	86.33 a
2 mT (M1)	89.00 ab
4 mT (M2)	90.00 ab
6 mT (M3)	94.00 b

Description: Mean followed by the same letter on the same column and factor showed no significant difference based on Duncan's Multiple Range test at 5% level.

Table 4. The effect of extraction techniques and magnetic field exposure treatments on seed germination speed index (GSI) of tomato seeds

Treatment	Germination Speed Index (GSI)
Seeds Extraction (E)	
Control (E0)	6.71 a
24 hours fermentation (E1)	15.68 c
HCl 2% 2 hours (E2)	12.95 b
NaOCl 9% 15 minutes (E3)	7.10 a
Magnetic Field (M)	
Control (M0)	9.15 a
2 mT (M1)	10.71 b
4 mT (M2)	11.52 b
6 mT (M3)	11.05 b

Description: Mean followed by the same letter on the same column and factor showed no significant difference based on Duncan's Multiple Range test at 5% level.

Ahamed et al. (2012) stated that paprika seeds exposed to the magnetic germinate one day faster than others that did not expose to the magnetic field. Seeds that are given a magnetic field also have the highest germination percentage rather to seeds that are only soaked in the water and seeds that are not exposed to the magnetic field. It is probably caused by the interaction between the magnetic field with the ion in plants' cell membranes that induces the change of osmosis pressure and ion concentration on both sides of the cell membrane.

Table 5. The effect of extraction technique on uniformity index (UI) of tomato seeds

Treatment	Uniformity Index (%)
Seeds Extraction (E)	
Control (E0)	57.00 a
24 hours fermentation (E1)	94.33 b
HCl 2% 2 hours (E2)	89.00 b
NaOCl 9% 15 minutes (E3)	56.33 a

Description: Mean followed by the same letter on the same column showed no significant difference based on Duncan's Multiple Range test at 5% level.

From Table 5 it showed that that tomato soak by water for 24 hours is a treatment that has the highest percentage of simultaneous growth. High simultaneous growth indicates high seed vigor. It is in line with the previous parameter that showed tomato fermentation for 24 hours technique treatment has the highest seeds, vigor, and viability. On tomato fermentation for 24 hours technique treatment, the seeds will be soaked with the water from fermentation shed the seeds from the tomato seeds. The amount of time for fermentation is related to the pulp level (pulp) that still sticks on the seed coat surface. The pulp that remains on the seed coat could be the source of disease contamination on the seeds and could cause seeds vigor low (Daryanto & Yulianti, 2019). Tomato seeds that look clean from the pulp and have bright yellow color is a successful extraction process (Karavina et al., 2009).

Conclusion

In general, seed extraction technique in form of fermentation for 24 hours and fermentation with 2% HCl could produce higher seed viability and vigor, but fermentation for 24 hours produced the best seed vigor. The exposure of the magnetic field only affeced maximum growth potential with the best treatment in 6 mT. There was no interaction between both factors.

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