VOL. 11, NO. 23, DECEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

THE EFFECTS OF STATIC ELECTRIC FIELD ON GERMINATION AND GROWTH OF MUNGBEAN SEEDS (*Vigna radiata* L.) IN VEGETATIVE PHASE

Siti N. Khotimah[1], Dzikri R. Romadhon[2] and Sparisoma Viridi[1]
[1]Nuclear Physics and Biophysics Research Division, Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung, Indonesia
[2]Master Programs in Physics Teaching, Institut Teknologi Bandung, Indonesia
E-Mail: nurul@fi.itb.ac.id

ABSTRACT

The food made of mungbean seeds (*Vigna radiata* L.) and bean sprouts can be found everyday in many Asian countries. This study discusses the germination and growth of mungbean seeds at early stage and the influence of static electric field to them. The germination percentage of mungbean seeds increased almost linearly in the first 8 hours and reached its maximum value at about 30 hours. This germination percentage had a germination rate about 0.12/h from the percentage of the number of seeds that have not germinated. This study used some variations of relatively low static electric field and short exposing time on wet seeds to investigate their influences in germination percentage. The field of 2.4 kV/m with exposing time of 2.5 hours appeared to increase the germination percentage in comparison to control so that its effect on early growth of mungbean seeds in vegetative phase was studied. The experimental results indicate that the bean sprouts grown from the treated seeds had heavier in fresh weight, longer roots, stems and leaves in comparison to the control.

Keywords: static electric field, mungbean seeds, germination, vegetative phase.

INTRODUCTION

When the seeds and seedlings were exposed to an electromagnetic field, they may respond differently to the process of germination and growth. Many studies have examined the effects of magnetic fields and electric fields separately. It has been reported that the exposures of magnetic fields on a wide variety of seeds (mungbean, maize, pea, tomato, chickpea) increased the germination or early growth [1-5]. The exposures of AC electric field on tomato seeds also accelerated the germination [4]. It was reported that the germination of the preliminary soaked seeds increased by about 10 % compared to the non-soaked seeds [6]. Besides the exposure on seeds, it was also studied when the seedlings were exposed to electromagnetic fields. The exposures of high static electric field (25 kV/m) continuously for 5 days on mungbean seedlings increased the growth [7]. In more recent study, Sedighi *et al* (2013) reported that there was an optimum value of the electric field intensity and exposing time for the growth of corns so that the rate of growth decreased after passing this value [8].

In many tropical countries, mungbean is one of the food sources of high vegetable protein in daily life. Mungbean seeds are cooked to be used as bread sandwich and porridge. Bean sprouts are consumed for other foodstuffs. In order to study the process of germination and growth, seeds of mungbean are exposed to static electric fields. In this study, wet mungbean seeds were exposed to low static electric fields up to 2.5 hours, the germination percentage and the fresh weights in vegetative phase were measured to be compared to control.

EXPERIMENTAL METHODS

Dry seeds of Vigna radiata were initially soaked in tap water for two hours. Then, the seeds were drained and placed between two plastic so that they were distributed in one layer. Seeds were then sandwiched between two parallel metal plates with diameter of 15 cm and the distance between the plates is 0.5 cm. The static electric field is generated between the plates by connecting the plates to the DC power supply [9]. The electric field is the ratio of the difference voltage between the plates, which was measured using a voltmeter, and the distance between the plates. Then the seeds were put on a glass dish containing a little water so that the seeds in wet conditions with partly seeds soaked in water. The water was renewed every 12 hours. Seeds having radicules more than 2 mm are said to be germinated. The germinated seeds were counted every 2 hours for the first 34 hours. The germination percentage was calculated for control and treated seeds [10].

To investigate the effects of electric field and exposing time on germination percentage, static electric fields of 0 (control), 0.8, 1.2, 1.6, 2.0, and 2.4 kV/m were used with exposing time of 0.5, 1.0, 1.5, 2.0 and 2.5 hours. To study further the effects on the growth in vegetative phase, a combination of static electric field and exposing time which gave a maximum positive effect than control was then used. For the growth in vegetative phase, the seedlings were rinsed every 4 hours and kept in a dark-damp place to grow to be bean sprouts. The fresh-weight of the bean sprout and the length of roots, stems, and leaves were measured at 110 hours or 108 hours after soaking in tap water.

VOL. 11, NO. 23, DECEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

EXPERIMENTAL RESULTS AND DISCUSSIONS

Germination percentage as a function of time

In our preliminary study, germination percentage as a function of time for control seeds was observed to study the characteristics of germination. Figures 1 show 5 curves from 5 groups containing 50 seeds in each group and the solid line represents its mean values. It seems that the rate of germination percentage is almost constant for the first 8 hours and germination percentage is almost constant after 30 hours. Each group of seeds has its own maximum germination percentage since few seeds seemed not to germinate up to 70 hours observation, i.e. might be few seeds were infertile.

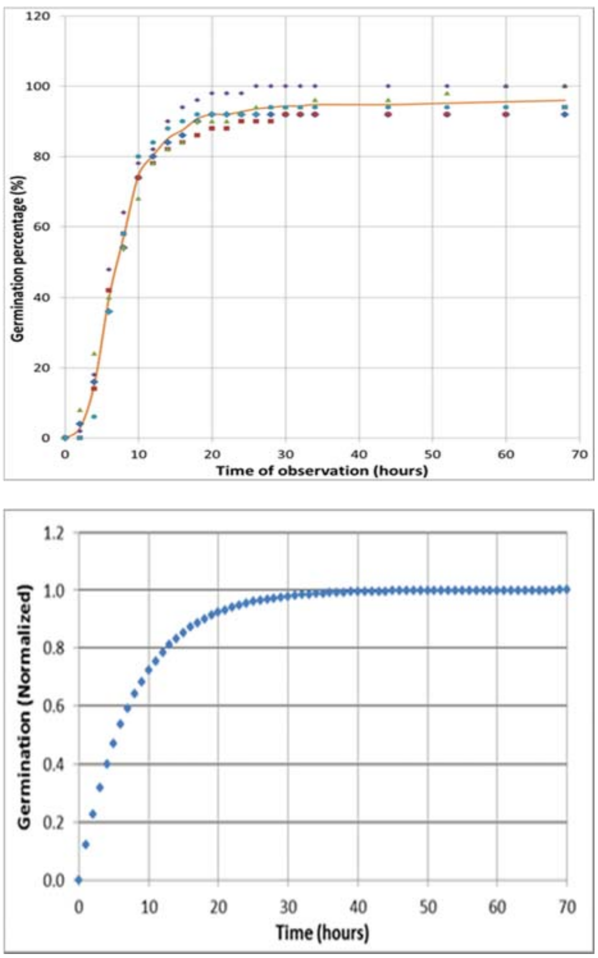

Figure-1. Germination as a function of time: (a) solid line represents the mean value from 5 groups of control seeds containing 50 seeds in each group, and (b) its simulation with germination rate of 0.12/h.

To predict the germination rate, a curve of normalized germination $\left(N_{germ}/N\right)$ is simulated as a function of time (t). The curve is an accumulation of the germinated seeds with a germination rate (r) depending only on the fraction of seeds that have not germinated $\left(N-N_{germ}\right)/N$ as follows.

$$\frac{dy}{dt} = r(1-y) \tag{1}$$

$$y \equiv \frac{N_{germ}}{N} \tag{2}$$

Numerical solution of the differential equation (1) is

$$\frac{N_{germ}}{N}(t+\Delta t) = \frac{N_{germ}}{N}(t) + r*\Delta t*\left[1-\frac{N_{germ}}{N}(t)\right]$$

Parameters used in Figure-1b are

Δt = time interval = 1 h

r = germination rate = 0.12/h

It seems that germination percentage had a germination rate about 0.12/h from the percentage of the number of seeds that have not germinated.

The effects of static electric fields and exposing time on germination percentage

The effects of both static-electric field and its exposing time were investigated on germination percentage of treated seeds in comparison with control. In this section, germination percentage was observed at t = 7.5 hours which its value may slightly vary among repetitions of the experiment (Figure-1a). The effects were namely positive (+) if germination percentage of treated seeds is higher than control seeds and neutral (0) if there is no effect as shown in Figure-2.

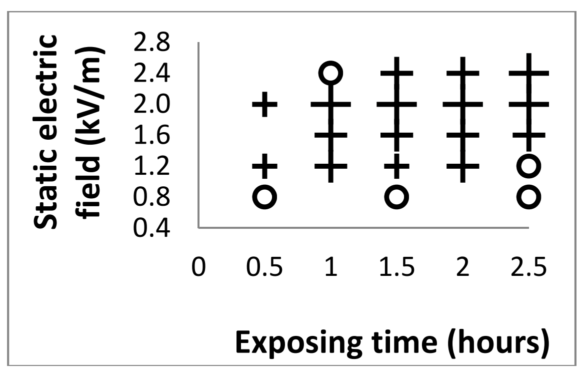

Figure-2. The effects of electric field and exposing time on the germination percentage.

Figure-2 shows that the exposure to static electric field of 1.2 kV/m within half an hour leads to increase the germination percentage; areas with positive effect mostly at the field at least 1.2 kV/m and exposing time at least half an hour. Higher positive effect was obtained using static electric field of 2.0 kV/m with exposing time of 1 to 2.5 hours. This study use much lower electric field intensity and much shorter exposing time than a previous

VOL. 11, NO. 23, DECEMBER 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

study by Kiatgamjorn *et al* [7] who used electric fields of 10 kV/m and 15 kV/m for 5 days to produce better growth of bean sprout.

The effects of static electric field in vegetative phase

This section is focused on the growth of the seedlings in vegetative phase, i.e. the increase of fresh weight and the length roots, stems, and leaves. Static electric field of 2.4 kV/m and exposing time of 2.5 hours is used for treatment to be compared to control. In this study, the treated group was repeated five times and control group is one times; each group consisted of 50 seeds. Some representative of treated and control bean sprouts are shown in Figure-3.

(a) (b)

Figure-3. Representative bean sprouts: (a) control and (b) treated seedlings [10].

At the initial before soaking the seeds (t = 0), the mass of 50 seeds $\left(m_{50}^{0}\right)$ in each group was measured. At the final observation (t =110 hours), the mass (fresh weight) of 50 bean sprouts $\left(m_{50}^{110}\right)$ was measured. The data are listed in Table-1. The average mass of each bean sprout is the increased mass divided by the number of bean sprouts, i.e. $m_{1}^{sprout}=\left(m_{50}^{110}-m_{50}^{0}\right)/50$. Fresh weight of treated bean sprout was greater than control. The increased mass of treated sprout in comparison to control was in the range of (12-68) %.

Table-1. The mass of 50 seeds at initial and 50 bean sprouts at final for control and treated groups.

	m_{50}^{0} (grams)	m_{50}^{110} (grams)	$\left(m_{50}^{110}-m_{50}^{0}\right)/50$ (grams)	$\dfrac{\left(m_{1,treat}^{sprout}-m_{1,control}^{sprout}\right)}{m_{1,control}^{sprout}}\times 100\%$
Control group	3.65	8.81	0.103	0
Treated group 1	3.62	9.41	0.116	12
Treated group 2	3.86	11.95	0.162	57
Treated group 3	3.57	12.20	0.173	68
Treated group 4	3.56	10.01	0.129	25
Treated group 5	3.47	9.88	0.128	24

The length of roots, stems, and leaves of the seedling in vegetative phase was measured at the final observation (t =110 hours). The mean values and their standard deviations are listed in Table-2. The mean values of the length of roots, stems, and leaves of treated seedlings higher than controls, the exception was obtained for treated group 4. However, the greater standard deviations for treated seedlings means that the length of roots, stems, and leaves varied in a larger range. Using the mean values, the increased length of roots, stems, and leaves of treated seedlings was in the range of (0-89) %, (4.8-77) % and (6.5-59)% respectively in comparison to control.

ARPN Journal of Engineering and Applied Sciences

Table-2. The length of roots, stems, and leaves of the seedlings at *t* =110 hours.

	Length of roots (mm)	**Length of stems** (mm)	**Length of leaves** (mm)
Control group	(8.8±5.0)	(37.6±16.7)	(13.8±5.5)
Treated group 1	(9.6±6.1)	(40.7±28.2)	(14.7±8.6)
Treated group 2	(13.0±9.1)	(61.2±38.2)	(18.8±10.4)
Treated group 3	(16.6±7.3)	(66.4±34.7)	(21.9±10.4)
Treated group 4	(8.8±5.0)	(39.4±27.1)	(15.5±7.8)
Treated group 5	(10.6±6.1)	(47.3±18.6)	(15.8±5.1)

CONCLUSIONS

This study has shown the curve characteristics of the germination percentage of control seeds which had a germination rate about 0.12/h from the percentage of the number of seeds that have not germinated. The influence of static electric field on wet mungbean seeds depended on both of field strength and exposing time. The exposure to static electric field of 1.2 kV/m with exposing time of half an hour leads to increase the germination percentage; the clearly positive effect was obtained using static electric field of 2.0 kV/m with exposing time of (1-2.5) hours. The 2.5 hours exposure with static electric field of 2.4 kV/m on wet mungbean seeds affects the growth in vegetative phase so that they had heavier fresh weight and longer length of roots, stems, and leaves in comparison to control.

ACKNOWLEDGEMENTS

Gratitude is expressed by the authors to Institut Teknologi Bandung and Ministry of Higher Education and Research Indonesia for financial supporting during this work through Penelitian Unggulan Perguruan Tinggi - Riset Desentralisasi Dikti 2016.

REFERENCES

[1] Chen Yi-Ping, He Jun-Min and Li Ran. 2012. Effects of Magnetic Fields Pretreatment of Mungbean Seeds on Sprout Yield and Quality. African Journal of Biotechnology. 11(36): 8932-8937.

[2] Florez M., Carbonell M.V. and Martínez E. 2007. Exposure of Maize Seeds to Stationary Magnetic Fields: Effects on Germination and Early Growth. Environmental and Experimental Botany. 59: 68-75.

[3] Podleoeny J., Pietruszewski S., and Podleoena A. 2005. Influence of Magnetic Stimulation of Seeds on the Formation of Morphological Features and Yielding of the Pea. International Agrophysics. 19: 61-68.

[4] Moon J.D. and Chung H.S. 2000. Acceleration of Germination of Tomato Seed by Applying AC Electric and Magnetic Fields. Journal of Electrostatics. 48(2): 103-114.

[5] Vashisth A. and Nagarajan S. 2008. Exposure of Seeds to Static Magnetic Field Enhances Germination and Early Growth Characteristics in Chickpea (*Cicer Arietinum* L., Bio Electro Magnetics. 29(7): 571-578.

[6] Aladjadjiyan A. 2007. The Use of Physical Methods for Plant Growing Stimulation in Bulgaria, Journal of Central European Agriculture. 8(3): 369-380.

[7] Kiatgamjorn P., Khan-ngern W., and Nitta S. 2002. The Effect of Electric Field on Bean Sprout Growing. Proceeding International Conference on Electromagnetic Compatibility, Bangkok, Thailand. http://www.unite.lima-city.de/uzc/bohnensprossen2.pdf

[8] Sedighi N.T., Abedi M. and Hosseini S.E. 2013. Effect of Electric Field Intensity and Exposing Time on Some Physiological Properties of Maize Seed, European Journal of Experimental Biology. 3(3): 126-134.

[9] Romadhon D.R. and Khotimah S.N. 2015. Pengaruh Besar Medan Listrik Statis Homogen dan Lama Waktu Paparan Terhadap Perkecambahan Biji Vigna Radiata, dan Oryza Sativa, Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains 2015 (SNIPS 2015) 8-9 Juni 2015, Bandung, Indonesia. pp. 629-632.

[10] Romadhon D.R. 2015. Pengaruh Medan Listrik Statis Homogen dan Lama Waktu Paparannya terhadap Perkecambahan Biji Vigna Radiata sampai Fase Vegetatif, Tesis MPFis, Institut Teknologi Bandung, Indonesia, 2015. Tesis MPFis, Institut Teknologi Bandung, Indonesia.