International Journal of Biotechnology and Microbiology
www.biotechnologyjournals.com
Online ISSN: 2664-7680, Print ISSN: 2664-7672
Received: 15-01-2023, Accepted: 31-01-2023, Published: 17-02-2023
Volume 5, Issue 1, 2023, Page No. 27-31

The Effect of electric field on plant height of *Vicia faba* cv. agabat plants

Abdelazim Ibraheem Elgasim[1*], Amina Aboubakr Bala[2], Bara'ah Ali El-Tahir[3]
[1] Assistant Professor, Department of Chemistry, Faculty of Education, University of Omdurman Islamic University, Khartoum, Sudan
[2] Assistant Professor, Department of Chemistry, Faculty of Education, University of the Holly Quran and Islamic Sciences, Khartoum, Sudan
[3] Assistant Professor, Department of Biology, Faculty of Education, University of the Holly Quran and Islamic Sciences, Khartoum, Sudan

Abstract
The study aimed to investigate the effect of external electric field on plant height *Vicia faba* L. cultivar Agabat plants. electric field created within pairs of copper plates forming electric capacitors in a DC current circuit connected to an electric source. The system was designed with two plates areas (225 cm^2 and 100 cm^2) and different voltages levels. Seeds of *V. faba* were located within spaces between each capacitor's plates and are exerted upon by different energy densities. The results showed that when employing a fixed voltage to each of two pairs of capacitor's plates with areas 225 cm^2 and 100 cm^2, the increase of plant height was greater when plates with larger areas were used. Generally, when varying values of voltages were employed, plant height increased with the increased voltage (range from 5.9v up to 33.5v). Voltages from 39.5v to 81.5v resulted in a greater decrease in plant height when compared with control plant.

Keywords: agabat – electric field – plant height – *Vicia faba*

Introduction
In this study the effect of electric field on plant height of *Vicia faba* cv. Agabat plants was investigated. Experiments were performed under laboratory and field conditions. *Vicia faba* has been chosen because its growing rate is very fast and simple to implement. The effect of electric field on crop plant growth have been studied by many researchers on different plants such as *Vicia faba* (Murr, (1966); Zimmermann and Scheurich, (1981); Inoue *et al*., (1985) [9]; Rabold *et al*., (1989); Kiatgamjorn, *et al*., (2002); Rajendra *et al*., (2005); Demiray, (2006); El-Tahir, (2011)) [5]. And the effect of electric field on plant growth (Murr1963, 1966 a and b, Ellis and Tuner 1978). Also, the effect of electric field on *Pisum sativum* (Miller *et al*., 1981; Robertson *et al*., 1981) [19], *Vigna* sp. (Wolverton *et al*., 1999) [20], *Lepidium sativum* L. (Behrens *et al*., 1982) [1], *Cucumis sativus* and *Cucurbita maxima* (Brayman and Miller, 1989) [2], White radish (Yuji *et al*., 2006; Nguyen 2008) [21, 23, 18], *Triticum* sp. (Hanafy *et al*., 2006) and many other plants. The study of Katarzyna *et al.* 2011 [10] shown that exposure of germinating barley to PEF affects radicle emergence without significantly affecting the seeds' gross metabolic activity, as quantified by isothermal calorimetry. study of Molamofrad *et al*. (2013) [15] showed that the maximum increase in seedling height was 9kV/cm in field intensity. The results of El-Tahir and Mohamed (2019) [6] suggested that electric field has direct effect on seed germination and development of *C. tetragonoloba* plants.

Research Objectives
The study aimed to investigate the effect of external electric field on plant height *Vicia faba* L. cultivar Agabat plants.

Methodology
1. Materials
Vicia faba seeds were provided by Dr. Abdel Wahab Hassan Abdalla, Agronomy Department, Faculty of Agriculture – University of Khartoum, Cultivar Agabat from the harvests of 2008.
Experimental set-up: The system consists of: - Power supply AC electric source / 220 volt/ 50 Hz, multi output transformer, multi rectifier, 12 pairs of isolated electrical wire 1 metre of length for each wire, electrical connection, 24 pairs of copper plates, wooden sheets and two sets of capacitors A and B (100 cm^2 and 225 cm^2). Each capacitor consists of 7 capacitors connected in parallel. The voltages in the system varied from 5 to 81.5 volt.

2. Methods
About 150 seeds of *Vicia faba* cv. Agabat were selected and soaked in tap-water for 3-4 hrs. The imbibed seeds were transferred to Petri-dishes containing moistened filter papers. After the emergence of the radicle to about 3-4 mm, the germinating seeds (3 seedlings /bag) were transferred and planted in black polythene bags (200 x 100mm) containing a soil mixture of sand and clay at the ratio of 1:1, v/v. For watering, the field capacity of polythene bag was determined (619 ml of water) prior to sowing and this amount was used to water the seeds.

Treatment of germinating seeds
Twenty-four bags were set in the gaps between the plates of the capacitors in group A and B. The electric circuit was switched on. One set of bags was isolated from any electric effect and left as the control. All the bags with plants were kept in the Botanic Garden under field conditions. Plant height was recorded every 7 days during the experimental period (14 days). Fig. 1 shows that general shape for plants between the capacitors of the system.

Statistical analysis methods
In this part of the experiment Plant height was followed for a period of 14 days for group A and B. Results were analyzed according to Gomez and Gomez (1984) [7].

Results

After 7 days of treatment, analysis of variance in Table 1.a showed that there were significant differences among the treatments. After 14 days of treatment, analysis of variance in Table 1.b showed that there were significant differences among the treatments. After 7 days of treatment, the results presented in Table 2 show that differences among the plates were not significant. Differences among the voltage levels were significant. The highest plant height was recorded for voltage 39.5v (17.19cm) and voltage 33.5v (16.99cm). Four voltage levels resulted in significantly lower plant height than the control. These were 5.9v (4.94cm), 52.5v (2.92cm), 73.5v (6.88cm) and 81.5v (5.5cm). The rest of the voltage levels were not significantly different from the control (10.67cm). In addition, the (voltage x plate) interaction was not significant just with (11.9v) plant height was 6.07cm for plate A and 13.17 cm for plate B. Fig. 2 and 3 show that treated plants after 7 days with plate A and B. After 14 days of treatment, Table 2 shows that differences among the plates were significant. Mean plant height was 20.1cm for plate B and 17.2cm for plate A. Also, differences among the voltage levels were significant. The highest plant height was recorded for voltage 33.5v (24.5cm). Two voltage levels resulted in significantly lower plant height than the control. These were 5.9v (10.15cm) and 52.5v (11.55cm). The rest of the voltage levels were not significantly different from the control (18.63cm). In addition, two treatments for the (voltage x plate) interaction were significant. These were, 5.9v (plant height was 6.3cm for plate A and 14cm for plate B) and 11.9v (plant height was 8.87cm for plate A and 22.1cm for plate B).

Table 1a: Analysis of variance (ANOVA), plant height (cm), in faba been cv. Agabat after 7 days

Source	D.F.	SS	MS	F-Value
Treatments	24	510.97	M_1= 21.3	M_1/M_2= 2.32**
Error	47	432.09	M_2= 09.2	
Total	71			

** Highly significant at $p \leq 0.01$

Table 1b: Analysis of variance (ANOVA), plant height (cm), in faba been cv. Agabat after 14 days

Source	D.F.	SS	MS	F-Value
Treatments	24	1791.40	M_1= 74.64	M_1/M_2= 6.03**
Error	47	0581.95	M_2= 12.38	
Total	71			

** Highly significant at $p \leq 0.01$

Table 2: Mean plant height (cm) of *Vicia faba* cv. Agabat seedlings at 7 and 14 days under treatment of different electric voltages.

Treatments Voltages (v)	Days after treatment					
	7 days			14 days		
	A	B	Voltage Mean	A	B	Voltage Mean
Control (0)	10.67*	10.67	10.67	18.93*	18.93	18.63
05.9	03.50	06.37	04.94	06.30	14.00	10.15
11.9	06.07	13.17	09.60	08.87	22.10	15.49
18.0	09.90	12.93	11.42	19.67	21.97	20.82
21.0	11.30	11.63	11.47	21.77	22.37	22.07
29.0	12.13	14.83	13.48	20.80	23.90	22.35
33.5	17.40	16.57	16.99	25.70	23.83	24.77
39.5	17.37	17.00	17.19	25.67	23.33	24.50
41.0	10.10	08.87	09.49	18.83	20.30	19.57
49.5	11.53	11.87	11.56	20.60	21.43	21.02
52.5	02.90	02.93	02.92	10.00	13.10	11.55
73.5	04.93	08.83	06.88	13.40	18.77	16.09
81.5	05.67	05.47	05.57	12.47	17.03	14.75
Plate means	09.50	10.90	-	17.20	20.10	-
LSD: Voltages Plates Interaction	3.52 1.43 4.99		-	4.09 1.67 5.79		-
S.E.±	3.0		-	3.5		-

A ≡ small plates, B ≡ large plates. *Mean value of 3 replicates.

Fig 1: General shape for plants between the capacitors of the system.

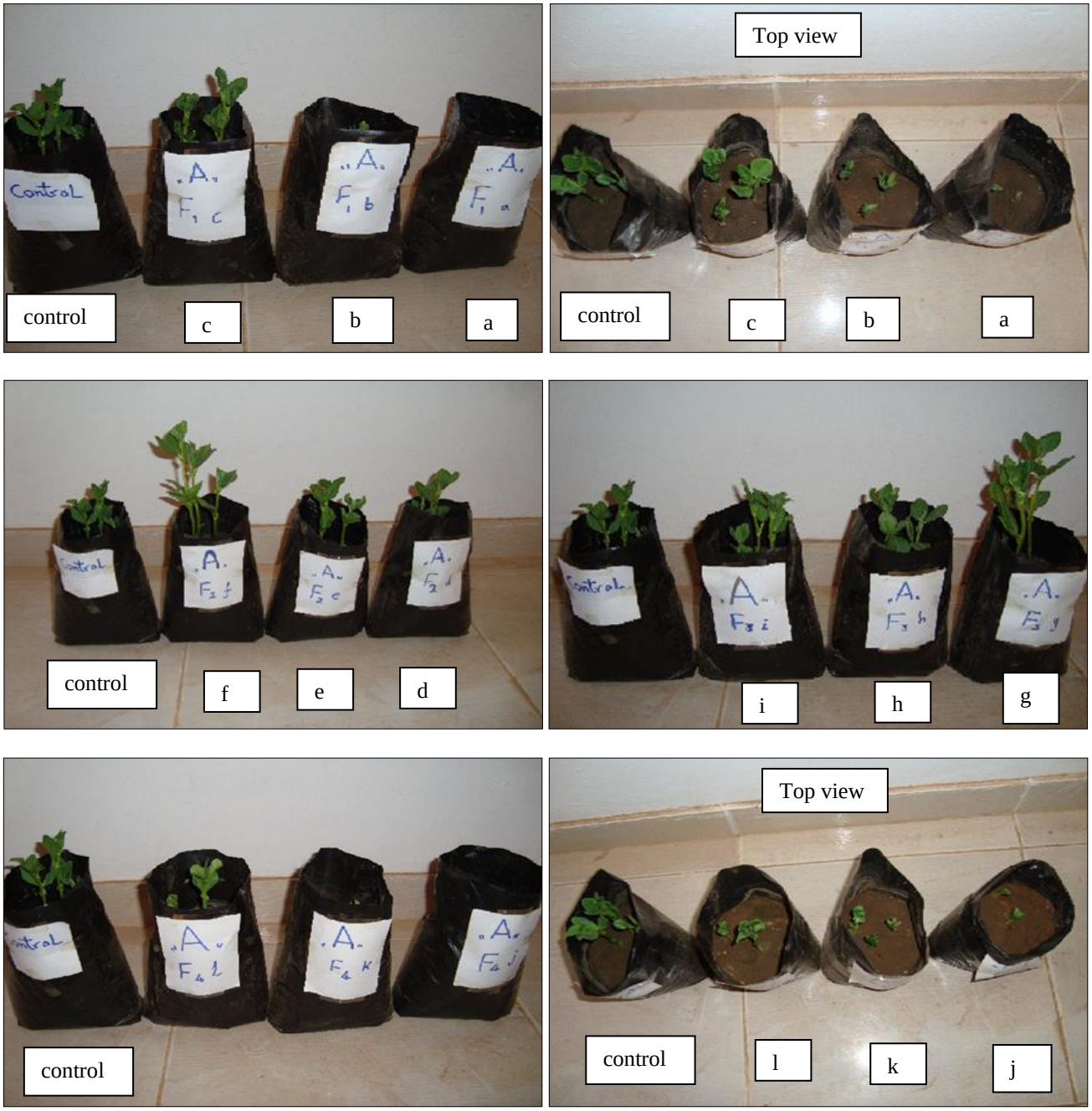
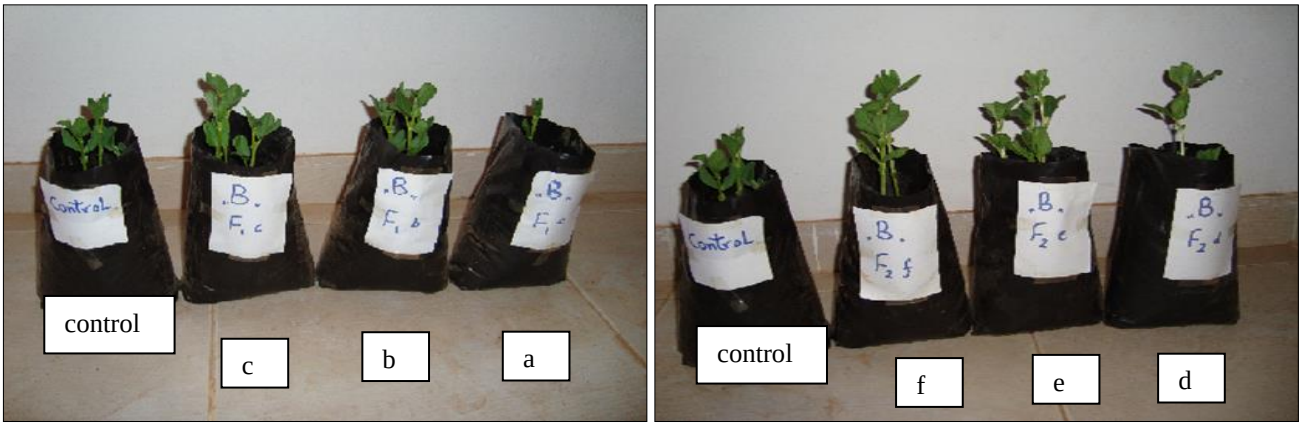


Fig 2: *Vicia faba* cv. Agabat, 7 days after treatment with electric field by small plates (A)

a = 5.9volt, b = 11.9volt, c = 18volt, d = 21volt, e = 29volt, f = 33.5volt, g = 39.5volt, h = 41 volt, i = 49.5volt, j = 52.5volt, k = 73.5volt, l = 81.5 volt.



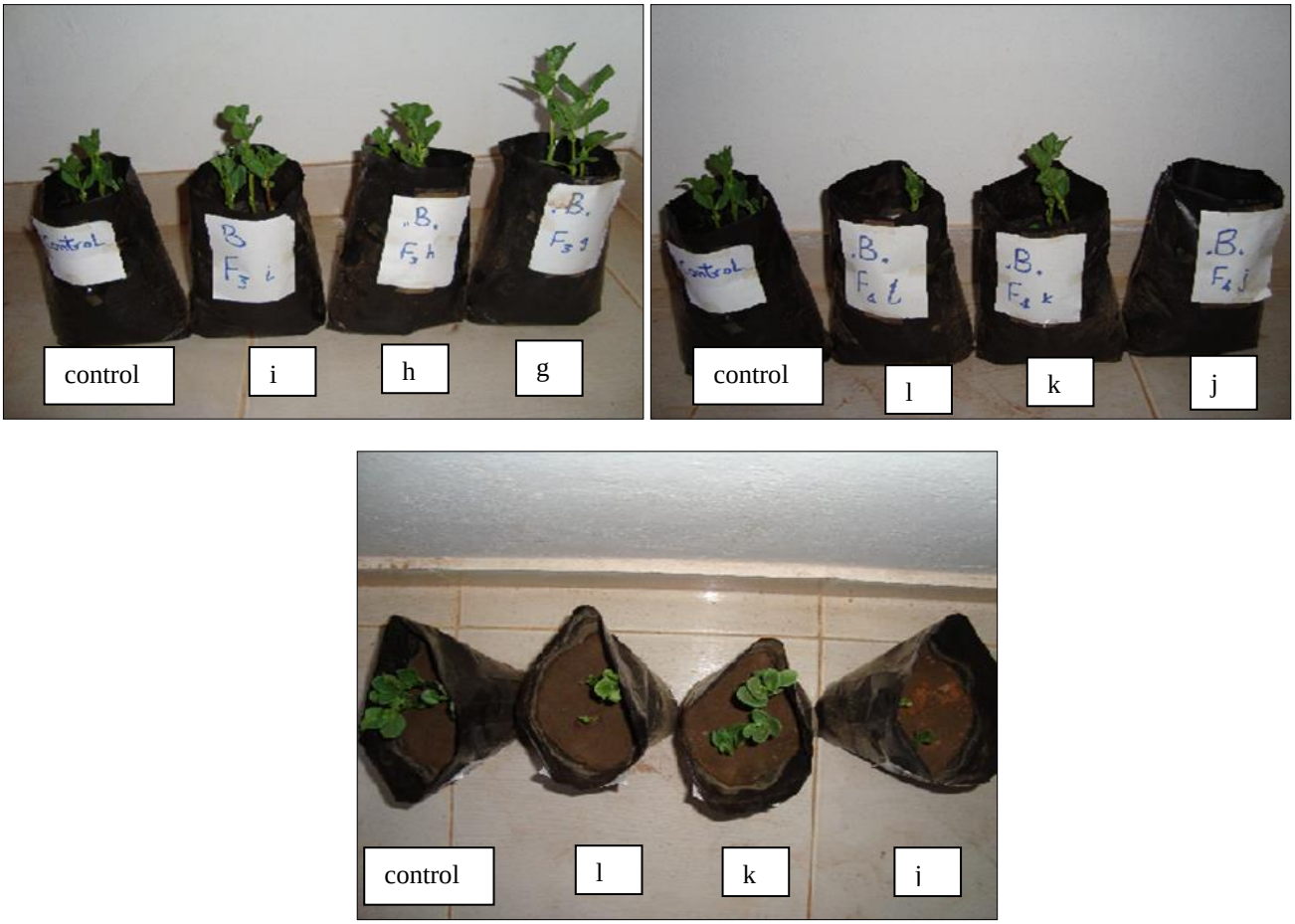


Fig 3: *Vicia faba* cv. Agabat, 7 days after treatment with electric field by large plates (B)

a = 5.9volt, b = 11.9 volt, c = 18 volt, d = 21 volt, e = 29 volt, f = 33.5 volt, g = 39.5 volt, h = 41 volt, i = 49.5 volt, j = 52.5 volt, k = 73.5 volt, l = 81.5 volt.

Recommendations and suggestions

The results of this study could be used in the following respects;

- For the improvement of plant growth by application of electric pulses i.e., to grow crops with less effort, time and expense without the use of chemical or genetic modifications.
- On the other hand, the techniques used in this study could be extended to other kinds of plants in order to improve the quality of their outcomes by enhancing the processes of growth, branching, flowering and fruiting.

This can be experimentally applied by employing

1. A.C. electric field of different frequencies
2. Purely magnetic field
3. By monochromatic wave- guided electromagnetic field
4. Laser of properly chosen wave length
5. Any non-destructive type of radiation

These options open avenues for further research

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