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Effect of Seed Exposure to Direct Electrical Current on Germination and Seedlings Growth of three Cowpeas *(Vigna unguiculata* L.) Cultivars

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A R T I C L E I N F O

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A B S T R A C T

The experiment was carried out during three weeks with San Martin, Gabs ton and West hillier cultivars of cowpea*(Vigna unguiculata* L.), seeds were exposed to 12V direct current (DC) electrical field in different exposure periods (0, 10, 20 and 40 minutes) before seed sowing. Generally, the best results were obtained from 20 min. exposure to DC electrical field of all studied cultivars, however, highest root characteristics except root dry weight obtained from control treatment. The highest germination percentage was in Gabs ton cultivar when exposed to DC electrical field for 20 min., and for the shoot length, shoot elongation speed/plant were obtained from two treatments (gaps ton cultivar without seed exposure to DC electrical field and with 20 min. exposure period). However the best root dry weight obtained from the seedlings of San martin cultivar when exposed to DC electrical field for 10min. The results shows that exposure of *(Vigna unguiculata* L.) seeds to (DC) electric (12V) improved germination percentage and seedlings vegetative growth.

1. INTRODUCTION

Cowpea is a member of the Dicotyledon plants, order Fabales, family Fabaceae, subfamily Faboideae and genus Vigna, the species *Vigna unguiculata* contain the cultivated cowpeas, this crop is important in many countries of South America, tropical Africa and Asia. Cowpeas grain and leaves are are rich and cheap sources of high-quality protein so they are edible products (Kabululu, 2008).

The movements of direct electrical current have effect on plant growth; the using of electrical devices in the agricultural biotechnology attracted the attention in the last few years. Many investigations have been done to evaluate the enhancement of direct electrical current on plant seed germination and growth, weeds can be exposed to electrical energy by use of electrostatic fields, microwaves, electric discharges or direct electric shocks using either alternating current or direct current and they have more advantages in weed control on compression to traditional methods (Diprose and Benson, 1984).

Tomato (*Lycopersicun esculentum L.*) seeds were treated with AC electric fields range from 4 to 12 kV/cm and AC magnetic flux densities ranging from 3 to 1000 Gauss for three time periods (started from 15 to 60 s) were accelerated seed germination rates about 2.8 times, however, AC electric fields more than 12 kV/cm for more than 60 s had an inhibitory effect (Moon and Chung, 2000). In another study the 30 KV/30 s electrical current treatment before sowing seeds were decreased growth of sticky spots of five cotton cultivars which belong to *Gossypium hirsutum* L. (Mustafayev *et al*., 2001). Lynikiene (2006) was used continuous current discharge electric field on carrot, radish, beet, beetroot and barley seeds, was accelerated seed germination in compression to non-treated seeds. Dannehl, *et al.* (2009) was applied the intermittent (DC) electric (200 mA, 600 Ma and 1000 mA) on radish (*Raphanus sativus* L.) plant during growth period (one hour per day) passed horizontally through the nutrient solution the plants, and was increased the current phenol content, anthocyanin and antioxidant activity. Gandhare and Patwardhan (2014) were found improvement germination, root shoot length and seed vigor of tomato plants by electrostatic field (2 kV/mm for 20 second interval). Ahmad *et al.* (2015) was used the electric fields and the electrical fields treated water which influenced the germination rate and stems height of young vegetables (Choy Sam' and bean sprout plants). A few studies have been reported the effects of different duration of electric field on plant seeds. Accordingly, the current study was conducted with the main objective to evaluating the influence of different seed exposing time to weak DC electrical field on seed germination and first stages of growth of the seedlings of three cowpea cultivars.

2. MATERIALS AND METHODS

The experiment was carried out during 5th to 26th September with three cultivars of cowpea (San martin, Gabs ton and West hillier) for each cultivar 200 uniformly seeds were soaked in 250mL tap water for 90 minutes and treated immediately with DC electrical field.

2.1 Application of DC electric fields

Soaked seeds were exposed to DC electrical field by inserting them into the parallel aluminum plates connected with the 12V DC as in figure 1. The seeds were inserted into the parallel plate type (Moon and Chung, 2000). The exposing times were 0, 10, 20 and 40 minutes before seed sowing (Gabdrakhmanova and Qussiny, 2011; Sedighi *et al*., 2013 and Gui *et al*., 2013).

Ten uniform seeds were selected per replicate (Chowdhury and Havern,2012; Sozharajan and Natarajan, 2014), polystyrene seedling trays were used with 77 cells, each cell about 59.31 cm^3 capacity, 2.5cm in width and 6.5cm in height filled with peat moss (Pokon Naturado BV, Veenendaal, Holland), pH of 5.2-6.2, NPK (14:16:18) and 50% organic matter. The climatologically data of temperature and humidity during the experiment period are shown in the table 1.

2.2 Experimental parameters

2.2.1 Germination percentage (GP)

After two weeks from seed sowing the germination percentage (GP) was calculated following the International Seed Testing Association (ISTA) method according to Mousavizadeh *et al*. (2013) and Sozharajan and Natarajan (2014).

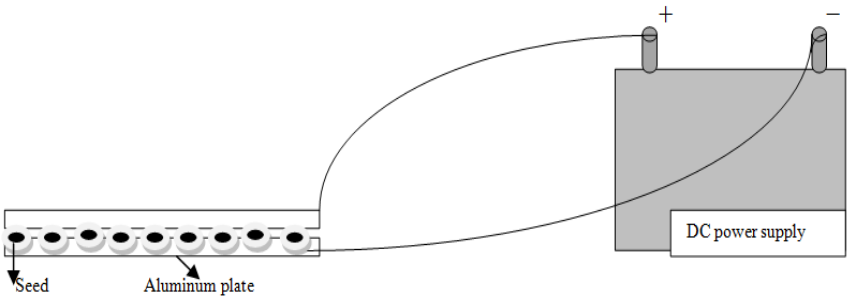

Figure 1, Experimental set-up: Seed exposure to DC.

Table 1, Maximum and minimum air temperature and humidity throughout the experiment period.

September days	Air temperature C°		Relative humidity%	
	maximum	minimum	maximum	minimum
5	39.54	24.03	35.18	5.64
6	38.33	22.89	34.65	14.85
7	39.04	23.83	28.35	8.77
8	38.74	23.79	36.36	11.42
9	37.42	23.03	37.95	11.83
10	35.81	20.96	37.05	16.20
11	36.94	22.06	34.35	9.21
12	38.62	20.59	37.52	5.41
13	38.59	21.63	32.43	7.19
14	36.61	22.08	32.05	10.35
15	36.84	21.62	31.22	12.00
16	37.78	24.10	38.54	12.43
17	36.04	22.12	41.22	17.00
18	35.44	19.58	40.21	15.60
19	35.81	22.76	32.39	12.77
20	37.41	23.24	34.28	13.91
21	38.90	20.93	42.04	12.36
22	33.95	18.46	33.15	14.55
23	32.40	19.75	39.21	12.20
24	32.57	20.39	40.42	17.34
25	33.28	22.76	41.89	18.46
26	34.25	20.92	56.58	23.74

$$GP = \frac{\text{Number of normally germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

2.2.2 Morphological characteristics

The morphological characteristics of the three tested cultivars seedlings were calculated according to Qadir (2006) and Sozharajan and Natarajan (2014). All of seedlings were used for measuring the studied parameters at the end of the experiment,

-shoot length (cm) was measured from plant tip to the surface of the soil.

-Number of leaves/plant (visible leaves had been counted), longest leaf (from the base to the leaf to the top end). -Shoot elongation speed (stem length at the end of experiment / number of days required for elongation).

-Shoot fresh and dry weights (g).

-Shoot elongation speed (stem length at the end of experiment / number of days required for elongation).

-Shoot fresh and dry weights (g).

-Root length (cm) was measured from the contact point with the stem to the tip of longest root, -root elongation speed (means of root length at the end of experiment / number of days required for elongation).

-Root fresh and dry weights (g).

For dry weights of shoot and root systems were separately dried in an oven at 70^{o}C to constant weights then measured using sensitive balance (Mohammad-Amin, 2008).

2.3 Data analysis

Factorial complete randomized design was conducted (Al-Rawi and Khalaf-Alla 1980), totally, 12 treatments represented three cultivars of cowpea (San martin, Gabs ton and West hillier) and 4 exposing time to DC electrical field (0, 10, 20 and 40 minutes) each with three replicates, the replicate contained ten seedlings (thirty seedlings for one treatment). Analysis of variance (ANOVA) was used to analyse the data, and the significant differences of the means were compared using the Duncan's multiple range tests at 5% significant level using SAS program (SAS institute, 2005).

3. RESULTS AND DISCUSSION

3.1 Germination percentage:

Table 2 illustrated that Gab ston cultivar had a high response among the cultivars. However, 20 min. exposing time gave high significant results.

Results of multiple ranges Duncan's method indicated that exposing of San martin, Gabs ton and West hillier cultivars, time of exposure to different times(0, 10, 20 and 40 minutes) to DC electrical field before seed sowing were affected significantly on germination percentage. The highest germination percentage found in Gabs ton cultivar when exposed for 20 min. to DC electrical field, and further increase in the exposing time to DC electrical field caused a decrease in Germination percentage (table, 2).

3.2 Morphological characteristics

3.2.1 Vegetative growth characteristics

Figure (2) shows that type of cultivars did not affect significantly on the shoot length, number of leaves/plant, longest leaf shoot elongation speed, shoot fresh and dry weights. While, exposing time of seeds to DC electrical fields caused significant effects on shoot fresh and dry weights of seedling vegetative growth, the best results were recorded from 20 min. exposure period (figure, 3).

Table 2, Response of *(Vigna unguiculata* L.) cultivars and exposing time to DC electrical field represented by germination percentage.

Cultivars	Exposing time to DC electrical field (min.) 0	10	20	40	Mean. cultivars
San martin	40.00 d	46.67 cd	60.00 bcd	46.67 cd	49.09 c
Gabs ton	90.00 a	70.00 abc	83.33 ab	66.67 abc	77.50 a
West hillier	60.00 bcd	63.33 bcd	70.00 abc	53.33 cd	61.67 b
Mean. exposing time	66.25 ab	60.00 ab	71.11 a	55.56 b	

*Values within each column followed with the same latter are not significantly different from each other according to Duncan's Multiple Range test at the 0.05 level.

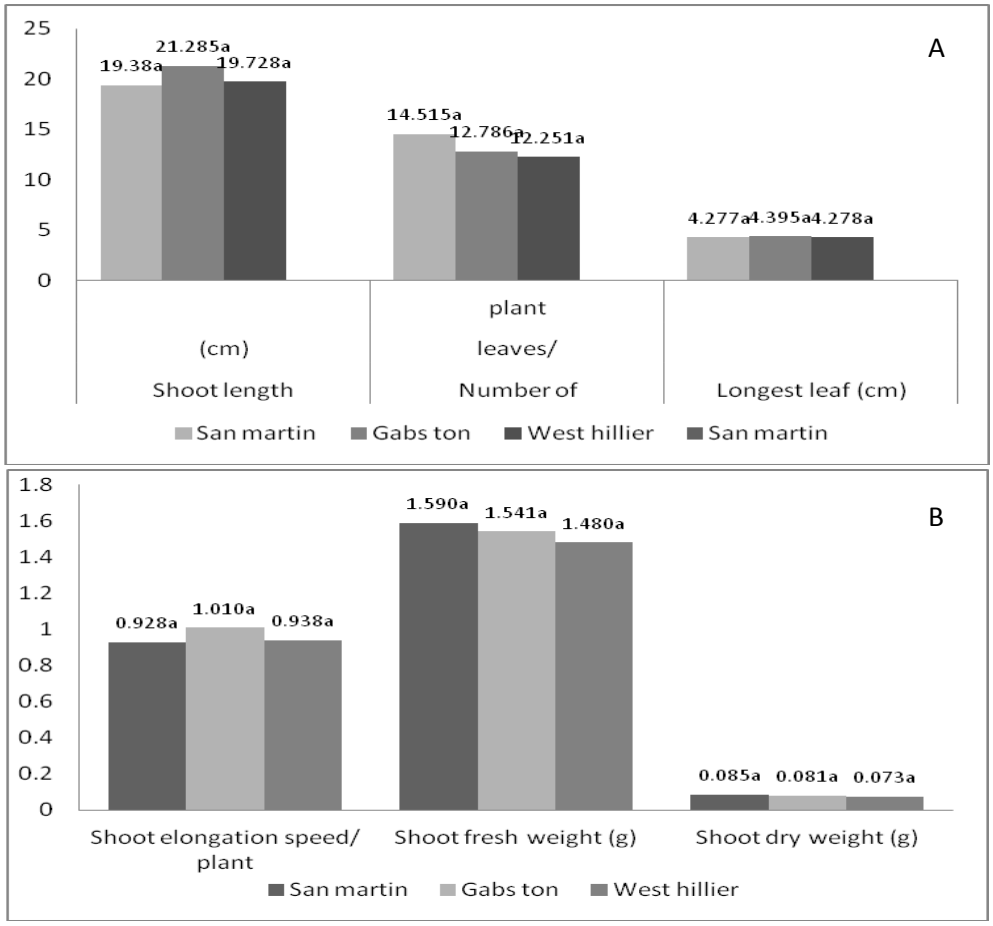

Figure 2(A and B), Effects of *(Vigna unguiculata* L.) cultivars on vegetative growth characteristics according exposing time to DC electrical field.

*(columns with the same letter are not significantly different from each other according to Duncan's Multiple Range test at 0.05 level).

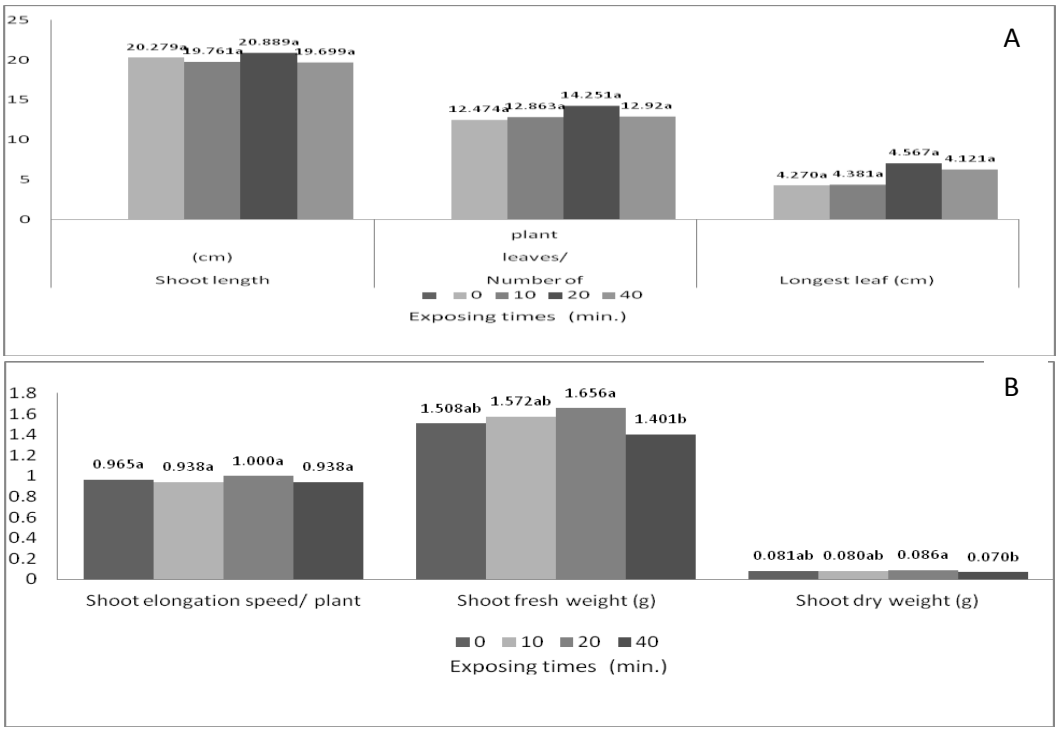

Figure 3 (A and B), Effects of seed exposing time to DC electrical field on vegetative growth characteristics of *(Vigna unguiculata* L.).

*(columns with the same letter are not significantly different from each other according to Duncan's Multiple Range test at 0.05 level).

The effects of cultivars and exposing time on vegetative growth parameters value are illustrated in table, 3. Significant effects were recorded except in number of leaves/plant and longest leaf. The highest values of shoot length, shoot elongation speed/plant were obtained from gaps ton cultivar with 20 min. exposing time when compared with the other treatments. The comparison between the treatments showed that the best values of fresh and dry weights were recorded from the San Martin cultivar when the seeds exposed to DC electrical field for 10min.

3.2.2 Root growth characteristics

There was no significant response among studied cultivars on root growth characteristics (figure, 4). Root length, root elongation speed and root dry weight decreased with increasing of exposing time to DC electrical field and the best results were obtained from the control. While, 10 min. exposing time to DC electrical field gave more significant value of root dry weight with no differences with control (figure 5).

Exposure of San martin, Gabs ton and West hillier seeds for different times to DC electrical field caused significant decline of root length, root elongation speed and root dry weight. It can be observed that the highest values of root length and root elongation speed were recorded from the control of West hillier cultivar. However, the highest root dry weight obtained from San martin cultivar and 10min exposing time to DC electrical field when compared with the other treatments with no significant differences with the control of the cultivars (table,4).

Table 3, Response of *(Vigna unguiculata* L.) cultivars to seed exposing time to DC electrical field represented by vegetative growth characteristics

Cultivars	Exposing time (min.)	Shoot length (cm)	Number of leaves/ plant	Longest leaf (cm)	Shoot elongation speed/ plant	Shoot fresh weight (g)	Shoot dry weight (g)
San martin	**0**	16.060 b	13.415 a	3.640 a	0.765 b	1.360 ab	0.075 abc
	10	20.663 ab	14.577 a	4.800 a	0.987 ab	1.740 a	0.093 a
	20	20.327 ab	14.867 a	4.533 a	0.983 ab	1.656 ab	0.090 ab
	40	19.363 ab	14.833 a	4.133 a	0.923 ab	1.526 ab	0.080 abc
Gabs ton	**0**	21.997 a	12.593 a	4.380 a	1.047 a	1.530 ab	0.087 ab
	10	20.797 ab	10.097 a	4.453 a	0.980 ab	1.616 ab	0.08 abc
	20	22.630 a	14.877 a	4.667 a	1.077 a	1.700 ab	0.087 ab
	40	19.717 ab	13.577 a	4.080 a	0.940 ab	1.316 b	0.070 abc
West hillier	**0**	21.373 a	11.727 a	4.580 a	1.017 a	1.586 ab	0.080 abc
	10	17.823 ab	13.917 a	3.890 a	0.847 ab	1.360 ab	0.067 bc
	20	19.700 ab	13.010 a	4.500 a	0.937 ab	1.613 ab	0.083 abc
	40	20.017 ab	10.350 a	4.143 a	0.950 ab	1.360 ab	0.060 c

*Values within each column followed with the same latter are not significantly different from each other according to Duncan's Multiple Range test at the 0.05 level.

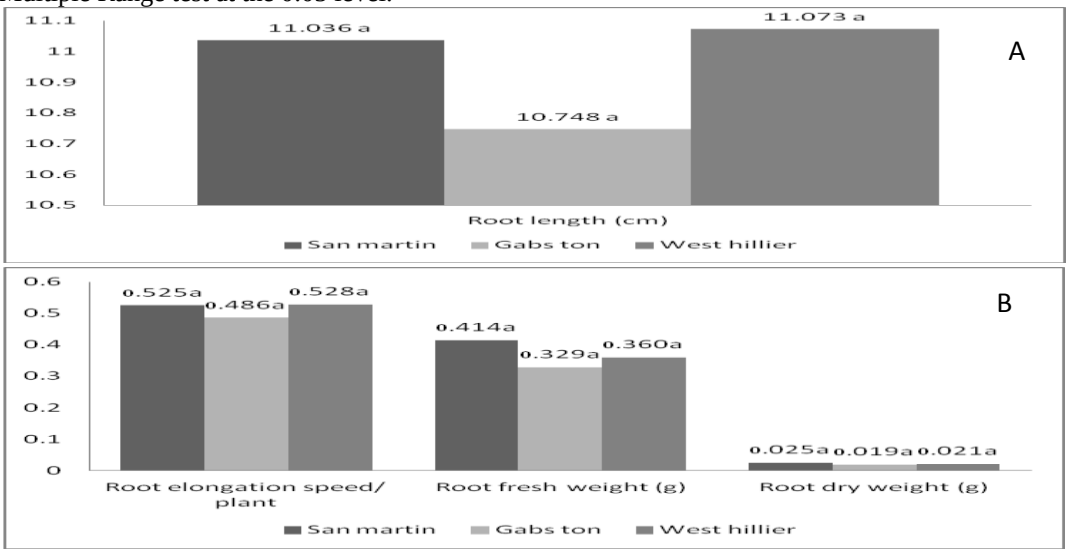

Figure 4 (A and B), Effect of *(Vigna unguiculata* L.) cultivars on root growth characteristics according exposing time to DC electrical field.

*(columns with the same letter are not significantly different from each other according to Duncan's Multiple Range test at 0.05 level).

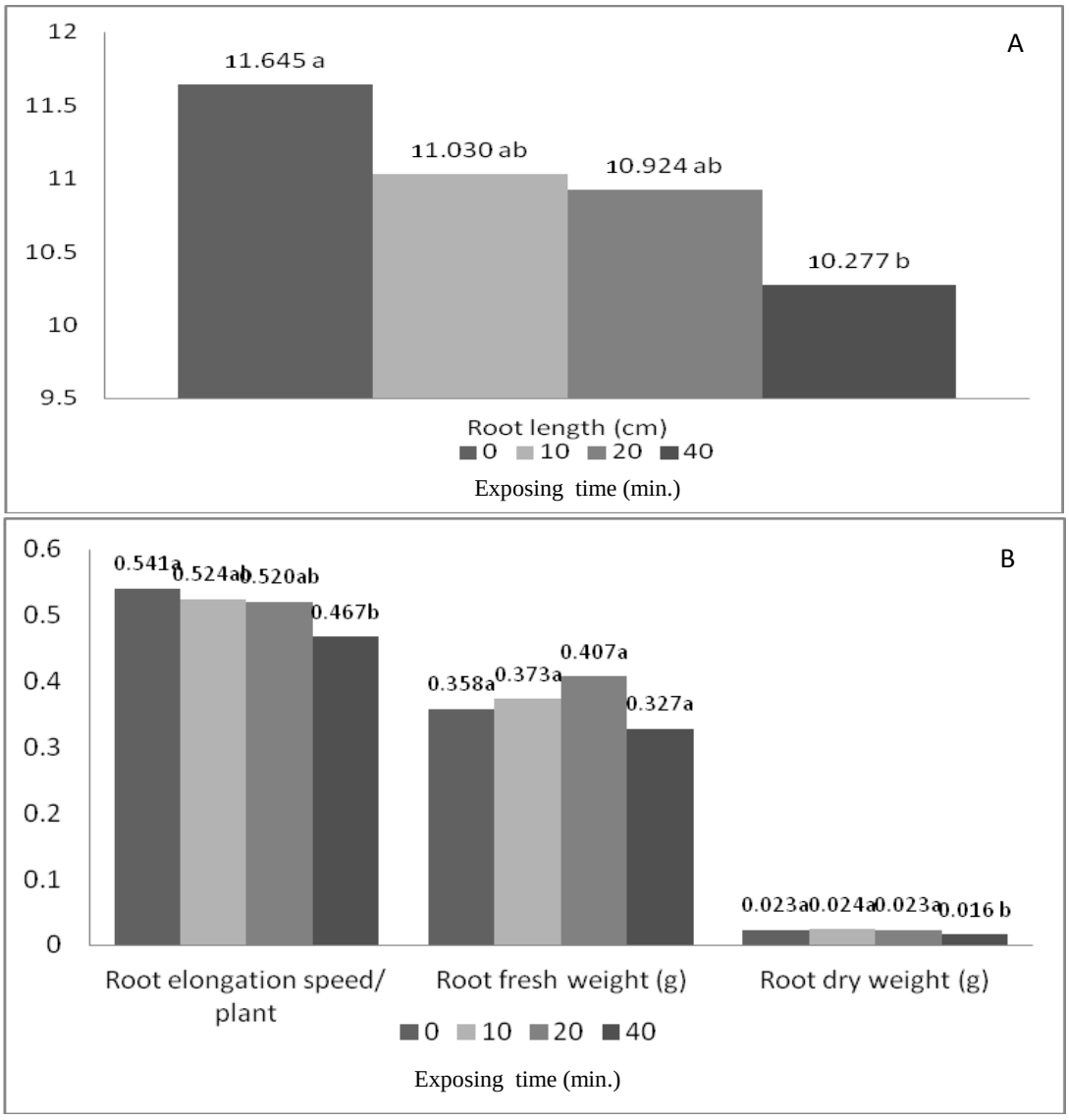

Figure 5 (A and B), Effects of seed exposure periods to DC electrical field on root growth characteristics of *(Vigna unguiculata* L.).
*(columns with the same letter are not significantly different from each other according to Duncan's Multiple Range test at 0.05 level).

4. DISCUSSION

The difference between the germination values as related to the studied factors (three cultivars of cowpea; San martin, Gabs ton and West hillier seeds exposed to 12V DC at different times (0, 10, 20 and 40 min. before sowing) was obtained experimentally. The results of cowpeas seed germination indicate that generally the studied exposing times to DC electrical field had a good reflect compared with control treatments except the time of 20 min. and differences was observed among the studied cultivars. The results partially agree with results of Lynikien and Pozeliene (2003)

Table 4, Response of *(Vigna unguiculata* L.) cultivars to seed exposing time to DC electrical field represented by root growth characteristics.

Cultivars	Exposing time (min.)	Root length (cm)	Root elongation speed/ plant	Root fresh weight (g)	Root dry weight (g)
San martin	**0**	11.150 ab	0.530 ab	0.310 a	0.020 abc
	10	11.363 ab	0.540 ab	0.447 a	0.030 a
	20	11.363 ab	0.540 ab	0.447 a	0.027 ab
	40	10.303 ab	0.490 ab	0.413 a	0.020 abc
Gabs ton	**0**	11.457 ab	0.510 ab	0.347 a	0.023 abc
	10	10.153 ab	0.483 ab	0.313 a	0.023 abc
	20	10.733 ab	0.513 ab	0.377 a	0.017 bc
	40	10.650 ab	0.437 b	0.280 a	0.012 c
West hillier	**0**	12.163 a	0.580 a	0.400 a	0.023 abc
	10	11.573 ab	0.550 a	0.357 a	0.020 abc
	20	10.677 ab	0.507 ab	0.397 a	0.027 ab
	40	9.877 b	0.473 ab	0.287 a	0.015 bc

*Values within each column followed with the same latter are not significantly different from each other according to Duncan's Multiple Range test at the 0.05 level.

on barley and with (Gui *et al*., 2013) on coat seed germination; they concluded that the content of energy conveyed to plant seeds depends on the strength of the electrical field and electrical properties of seed, moreover seed vigor was obviously changed by exposure to electrostatic field. Electrostatic field represents a fast, effective and economic method for the pre treatment shallow dormancy of thin coat seeds as in cowpea. During the exposure the direction of electrostatic field does not change (Lynikien and Pozeliene, 2003).

As mentioned in previous sections, that most of growth parameters considering the spatially organized cell walls. Moreover, the position of sessile cells rather than their lineage has a predominant role in dictating their combination effects of exposing times to DC electric field with studied cultivars had significant effects comparing with control treatment this agree with the results of Sedighi *et al. (*2013) on maize seeds. Nevertheless, root parameters gave fewer values in the longest exposing time, it is recognized that cell polarity, characterized by asymmetric distribution of subcellular structures and molecules, is a fundamental attribute to the development of all eukaryotic organisms. The unique significance of cell polarity in plant development is confirm by the fact that plant cell morphogenesis is largely defined by developmental fates. (Yang, 1998), because of this polarity the electric current can affect the direction and movement of storage nutrients of

the seeds to the cell walls and accelerate meristem cells division which consists of undifferentiated, rapidly dividing cells and improve tissues and organs of the postembryonic plant, this indicates that the organizing centre for plant morphogenesis is meristem cells (Kerk and Feldman, 1995). The electrical stimulation may cause the formation of free radicals as ionizing radiation in the cells (Bratton and Haenry, 1977). Furthermore the results can be explained by the activating effect of DC on plant hormones in beans when DC treatment was increased germination viability of them (Gabdrakhmanova and Qussiny, 2011). Likewise may be DC electrical field affect on the direction of plant hormones when they had been tried with various concentrations *(*cytokinin (Thidiazuron) and auxin (Indol 3-Acetic Acid)*)* that stimulate a metabolism of seedlings, like change the auxin and cytokinin ratio in the seeds which leading to the germination of *Chlorophytum borivilianum* seeds (Trivedi and Tiwari, 2016). The hydraulic and electrical systems of a plant cell were therefore intimately coupled, with the both sensory and motor components (Shepherd, 2012).

5. CONCLUSION

The effect of exposure times of DC electric fields on cowpea seed germination and seedling growth have been investigated as a potential means to accelerate the germination and improve the growth of the seedlings. The following conclusions have been obtained:

1. Based on the findings of this trial generally, it was concluded that exposing cowpea seeds to weak voltage direct electrical current (12V) before sowing for 20 minutes was the best for seed germination.

2- Exposure for different times to direct electrical current had different effects on the cultivars regarding seedling growth parameters. 10 min. exposure was more effective for San martin for most seedling growth characteristics. Depending to exposing times to DC electrical field the other two cultivars were varied in recording growth values, with no significant differences with the control treatment.

Based on the results referred to, and to improve seedlings growth, good quality of seedlings before transplanting which is reflected on the cowpea production, the following recommendations are suggested:

1- More studies in this area need to be done, especially for more exposing times and for more intensity of direct electrical fields in wide ranges.

2- Continuous studies under different growth conditions (as controlled conditions in glass or plastic houses) are required to know the effects of San martin, Gabs ton and West hillier seeds exposure for different times to DC electrical field (12V) on the germination, seedling growth and yield quality and quantity of cowpea plant.

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