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Biological Activity of *Calotropisprocera*Grown Under High Voltage Transmission Lines in Jeddah Province, Saudi Arabia

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ABSTRACT:Electromagnetic field (EMF) may cause biological changes to wild plants growing around or near the electricity towers. To evaluate this argument a field study was conducted at north Jeddah city during 2013-14. A number of plant species found in the study areas, but *Calotropisprocera* L. was selected for this study. Sampling was performed from four different towers for Electricity high-pressure transmission lines north Jeddah province, build at different years (1981, 1991, 2008, and 2013). Three places has been selected away from the tower, starting from the bottom of the tower for this study, zero m (under the tower), 50 m and 100 m away from centre. A control site was also chosen far from electricity towers and lines. Plant morphology (height, number of branches, shelter width and leaf area), physiological activity (intercellular CO2, transpiration rate, net photosynthesis rate and chlorophyll contents) and some ion content in soil and plant leaves were measured. The results show that the plant health was improved morpho-physiologically at the center and older installations. Moreover by decreasing the distance from 100 m to 0 m, significant influence was found, it may be attributed to enhance exposure of electromagnetic field, as a consequence plant revealed some relief in terms of growth.

KEYWORDS:Electromagnetic field, Transmission lines, *Calotropisprocera*, Plant physiology, ion content.

I. Introduction

Calotropisprocera L. is a desert plant, perennial shrub and member of the milk-weed family Apocynaceae can grow up to five meters tall. Leaves are thick with waxy cuticle, bear violet green flowers and small seeds can easily disperse through anemochory. Herbivores avoid grazing *C. procera* despite of striking green appearance in arid areas due to irritant taste and odor of milky juice containing cardenolide a type of steroid. *C. procera* is widely distributed in arid and semiarid areas of Africa and Asia (Sharma et al, 2012). It's commonly used as medicinal plant for treatment of constipation, fever, joint pain and muscular spasm. Plant grows naturally throughout Saudi Arabia, anyhow its abundance was observed in western parts (Boutraa, 2010). Main stem and branches of the plant are protected with a thick Styrofoam-like cork and it has a thick cracked-fluted bark in the form of deep vertical flakes. Leaves are evergreen wide heart shape protected with a thick cuticle and wax, it can tolerate very hot temperature but beyond a certain limit then they dry up and die together with the young branches. After a drought break new branches and leaves can grow soon when a water supply is available (Mossa et al, 1991; Choedon et al, 2006).

Electromagnetic fields are invisible areas of energy associated with the use of electrical power and various forms of natural and man-made lighting. Organisms are exposed to electromagnetic fields generated by natural phenomena such as the earth magnetic field or lightning, but also by human activities, including the use of power lines and electrical appliances especially from the high voltage towers that transport the electricity between cities or countries (Martínez et al, 2009; Aksyonov et al, 2001). Several experiments conducted over the years still have some controversial results both positive (Aladjadjiyan, 2003; Ibrahim and Mohsen, 2013) and negative (Soja et al, 2003).

Application of magnetic and electromagnetic field usages in arable agriculture as a compromising technology for plant improvement against biotic and abiotic stresses along with boosted morphological, physiological and biochemical activity is developing as attractive approach (Efthimiadou et al, 2014).

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Several studies have been conducted to find out the effect of EMFs on the growth and physiology of the plants, nevertheless not much is known about the exact mechanism of action of EMFs in altering plant growth. Many studies have reported the effects of magnetic field on variety of agriculturally important plants such as studying effects of EMFs on seeds germination, seedlings growth and seed vigor (Bilalis et al, 2012). Magnetic fields affect the synthesis of DNA and RNA as well as the cellular proliferation. EMFs in both extremely low frequency (ELF) and radio frequency (RF) ranges activate the cellular stress response, a protective mechanism that induces the expression of stress response genes (Radhakrishnan et al, 2012). Consequently, EMFs alters gene expression, protein biosynthesis, enzyme activity, cell reproduction and cellular metabolism (Flórez et al, 2007). EMFs cytological effects include changing the mitosis control mechanisms, increase in the percentages of chromosomal aberrations such as stickiness, bridges and fragments, lagging and disorganized chromosomes (Hernandez-Aguilar et al, 2009). Magnetic field treatment altered growth of Zea mays, superoxide radical level, antioxidant enzymes and photosynthesis. Among the different growth parameters, leaf area and root length were the most enhanced parameters (Shine and Guruprasad, 2012).

The aim of this field study is to investigate the effect of electromagnetic field exposure to wild species (*Caltropisprocera*) grow under or near the transmission electricity towers in the arid region north of Jeddah at Saudi Arabia.

II. MATERIALS AND METHODS

STUDY AREA:

The Kingdom of Saudi Arabia extends between 16o 22- to 32o 14- North and it has different topography and climatic conditions. It consisting of deserts, valleys, coastal and mountains, North Jeddah , lies within the coastal desert plain at Tehama region west of Saudi Arabia. Jeddah province lied at the west of Saudi Arabia at the Red Sea coast (21° 25′ 0″ N 39° 49′ 0″ E), the elevation of this city began from zero at the west to more than 277 m above sea level at the north or east directions. The high voltage transmission lines transport electricity from Assoaebah Area (south coast of Jeddah) to different parts of Saudi Arabia. the Five towers north of Jeddah city were selected for this study (installed at different years). The description details of the investigated towers and date of installation of them and some other related information are provide in Table 1.

Table 1: Some information about the study area and electricity transmission lines.

Tower code	Coordinates	Installation date	Sampling distance m	Magnetic field intensity (milligauss)
A	22° 11' 0.3" N 39° 15' 48.5" E	1981	0	6.9
			50	1.9
			100	1.1
B	22° 30' 30.2" N 39° 10' 57.6" E	1991	0	8.2
			50	2.5
			100	1.5
C	22° 10' 57.3" N 39° 15' 41.8" E	2008	0	8.7
			50	2.1
			100	0.9
D	22° 29' 47.5" N 39° 13' 44.2" E	2013	0	8.2
			50	2.4
			100	0.9
N	22° 28' 54.78"N 39° 13' 44.35" E	No Tower (Control)		0

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The Arid conditions at the study area is extremely difficult (Fig 1). Average annual precipitation is less than 60 mm, summer temperature more than 45 °C, wind storms, wind erosion, salinity, drought and lack of fresh water resources are the key features of studied area. The climate in the study area is hot most of the year especially during summer time (Table 2). The diurnal mean of temperature fluctuated between a maximum of 39.7°C in June and 18.8°C in January with an annual mean temperature of 31.1°C. Also, the minimum temperature during the night ranges between 18.6°C in February and 29.1°C in August with a mean of 24.4°C in January and 34.4°C in June with a mean of 37.7°C. The relative humidity is high and ranged between a minimum of 81% and a maximum of 100 in December. The total precipitation is 128 mm with an average annual participation varies between zeros June to about 37.3 mm in November (Metrology and Environment, 2014).

Figure 1: A photo taken by other showing example of one sampling area which describing the field conditions

Table (2). Relative humidity, precipitation and temperature of the last ten years at Jeddah Metrology Station. (Source: Metrology and Environment, 2014).

Parameters	Relative Humidity (%)	Surface wind (Kts)		Precipitation (mm)	Temperature (C0) Mean		
Months	Mean	P.D.	Mean	Mean	Mx	Mn	M
January	61	N	7	12.6	29.2	18.8	23.6
February	62	N	7	2.9	30.7	19.4	24.6
March	60	N	7	0.0	32.4	20.3	25.8
April.	57	N	7	5.4	34.9	22.6	28.3
May	56	N	8	0.1	37.1	24.4	30.5
June	55	NNW	8	0.0	39.1	25.9	32.1
July	53	W	7	0.7	39.7	27.6	33.3
August	57	W	7	0.1	39.0	28.5	33.3
September	64	NNW	7	0.2	37.8	26.7	31.8
October	66	W	6	0.4	36.9	24.5	30.1
November	61	N	6	10.0	33.7	22.6	27.7
December	59	N	7	9.7	31.1	20.2	25.2

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III. MATERIALS AND METHODS

To evaluate the interference and impact of electricity transmission lines and subsequent electromagnetic field on wild species, *Calotropisprocera*, a study was conducted at north of Jeddah province west of Saudi Arabia. Present study was conducted in two parts, field visits and lab analysis respectively. Field studies were planned to determine coordinates of towers, electromagnetic field, light intensity, along with plant and soil samples collection for lab studies. Second part of the study was planned to determine some ion concentration in soil and plant samples. Plant morphological and physiological of the leaf samples also measured.

Four transmission lines were selected according to their installation dates from the oldest to the newest (1981, 1991, 2008 and 2013). The research focused on numerous variables like, gradation of high voltage power lines, equal number of transmission lines, height from the ground, locality and plant species. The power of magnetic field was measured from the bottom of the tower until the power measured weak, then the effect of the magnetic field stated for three distances from the tower, 0 m, 50 m and 100 m. a control sample was taken from area far away from the effect of electromagnetic field which represent the fifth sample.

Sampling of soil and plant parts was performed at each site. Soil samples were analyzed to determine soil physiochemical characteristics. Plant leaves were collected randomly from pre-selected experimental area. Five samples from each site were collected from each distance. Samples were numbered accordingly and submitted to lab for further analysis. The collected *Calotropisprocera* leaves were thoroughly rinsed with distilled water. The samples were then dried in oven at 75° C for 48 hours until a constant weight was gained. The dried samples were then ground into fine powder and stored in fresh plastic polythene bags, ready for further use.

Plant height (cm), shelter width/perimeter (cm2), number of branches and leaf area (cm2) were measured according to Polster and Reichenbach, (1958). Plant gas exchange are measured using CIRAS-3 portable photosynthetic system: intercellular CO2 concentration (mmol m-2s-1), stomatal conductance (mmol m-2 s-1) and Net photosynthesis µmol m-2 s-1. Chlorophyll content was also analyzed by CL-01 Chlorophyll Content System. Some metabolic features of leaves were also studied (Harb et al., 2010). Plant macronutrients: K, Ca, Mg, and Na were measured using ICP-MS.

Statistical analysis of all plant leaf attributes along with heavy metals and micro and macro nutrients data were performed separately to confirm the dissimilarities and integrity of results through applying Fishers analysis of variance technique (Steel and Torri, 1997). Least significant difference LSD test $P \leq 0.05$ using SAS 6 were applied for comparing treatments means. Graphical representation of the data was constructed through MS excel.

IV. RESULTS

All studied sites and distances demonstrated significant difference for magnetic field intensity and light intensity. Magnetic field intensity is inversely related for distance studies from electric tower. Increasing the sampling distance from tower a smooth decrease in magnetic field intensity was recorded. Highest magnetic field intensity are (8.7) at tower build at 2008, while the minimum magnetic field intensity (0.90) under tower build at 1991 (Table 1).

Plant morphological characteristics, plant height, number of branches, leaf area and perimeter responded variably for tower installation and distance from middle/below tower (Table 3). A diverse trend for tower installation was of prime interest to evaluate the results with some logic. Plant height was almost similar for 1981 and 1991 installation and upgraded significantly for recent installations of 2008 and 2013. Number of branches and perimeter also produced almost same trend as plant height while observations for leaf area proved inconsistent. Highest leaf area was calculated in 2013 followed by 2008, 1991 and 1981 in a sequence (Table 3). Distance studies revealed as we move away from the source an upsurge in plant height, number of branches and perimeter was obvious but leaf area behaved in contradictory way. Electromagnetic field promoted leaf area for almost all sites.

Chlorophyll content, photosynthesis rate, intercellular CO2 concentration and stomatal conductance improvement was entangled with recent installations while older installations negatively interfered with plant physiological traits except photosynthesis rate and stomatal conductance. CO2 fixation and stomatal conductance were 12.72, 3.64, 380.44 and 366.11 for 2013, 1991, 2008 and 1991 respectively (Table 3). The middle distance (50 m) has non-significant difference on plant physiological attributes excluding chlorophyll contents, Chlorophyll contents decreased with increasing time of exposing to electromagnetic field (Fig. 2). Though, maximum values were observed for all studied parameters on different locations in different replications but overall trend insist that distance improved some of the feature while depress others. Leaf chlorophyll content was affected in the areas exposed to electromagnetic field when compare with the control area.

Leaf nitrogen percentage were higher in 1991 installation over the rest and was followed by 2013 installation. Proline and carbohydrate percentages were again prominent in 2013 installation. For the distance studies, 50 m and 100 m achieved maximum improvement in biochemical features of the studied leaves. The electric tower installed in 2013 and within highest intensity of electromagnetic field adversely affected leaf biochemical features over the rest.

The ion concentrations (K, Ca, Mg and Na) found in soil of the study areas were differ. Ca was the highest ions, and the Na, while Mg was the lowest one (Table 4). On the other hand, all four ions (K, Ca, Mg and Na) accumulate at the plant leaf either similar or more than the concentration in the soil (Table 5).

V. DISCUSSION

The impact of artificially developed electromagnetic field on plant and soil is studied at different locations. Plant morphology, physiological and ion concentration in plant leaves and soil are responded variably to electromagnetic effect. Leaf area, chlorophyll content, plant height, no of branches, photosynthesis rate, intercellular co2 concentration, stomata conductance and perimeter show different results may be that's because the effect of another environmental factors such as temperature, light intensity and soil variables; in edition plant age also another important factor .

Different lab studies concerning the effect of electromagnetic field have been done before. Pulsed electromagnetic field used for 0, 5, 10, 15 minutes as pre-sowing treatment of tomato seeds in field experiments for two years. Magnetic field applied for 10, and 15 days favor tomato growth and yield significantly. In another study on garden peas treated with magnetism responded negatively as compared to tomato. In cotton crop magnetism enhanced transpiration rate, photosynthetic rate, stomata conductance, root length, shoot growth and nitrogen, phosphorus, potassium, calcium and magnesium percentage over control (De Souza et al, 2010). This enhancement may be attributed to better availability and absorption of nutrients. In contrary to previous research on tomato 28-51 % higher tomato yield was achieved through treatment of electromagnetic field. Vigorous germination and seedling growth was also attained in corn crop under magnetic field stress (Carbonell et al, 2011).

Epicotyl and hypocotyl length studies in asparagus and seedling growth rate in lentil were improved less than 20 minutes pre-sowing treatment (Moon and chung, 2000). Static magnetic field studies in maize crop enhanced shoot fresh weight by 72% and shoot length by 25 % over control. So the static magnetic field application is major demand for future agriculture and forestry for organic and sustainable production. Duration of exposure plays vital role in the efficiency of these treatments (Aladjadjiyan 2002; Cakmak et al. 2010). A study on 50, 200 and 250 mT static field for two hour was highly effective for germination (Finch - Savage and Leubner - Metzger, 2006).

Exposure of rice field to static magnetic field was found accountable for improved leaf growth, meristematic tissues in stems and roots. Sunflower under magnetic field exposure for 90 minutes at intensity of 2000 Gauss produced positive mutation in term of germination, plant height, days to flowering, days to maturity, yield, oil content and oil quality of seeds over control (Carbonell et al, 2000). A-amylase is responsible for degradation of seed during germination. Enhanced exposure of seeds to electromagnetic field decreased a-amylose activity at 100 mT for 2 hours while reducing sugars were higher for wheat crop. Increase in activity of dehydrogenase enzyme is also associated with electromagnetic treatment. Exposure of electromagnetic field reacts like priming with almost similar improvements. Protease activity in germinating seeds significantly increased when treated with electromagnetic field (Kucera et al,

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2005). Revealing the relationships between magnetic field and plant responses is becoming more and more important as new evidence reveals the ability of plants to perceive and respond quickly to varying magnetic field by altering their gene expression and phenotype. The recent implications of magnetic field reversal with plant evolution opens new horizons not only in plant science but also to the whole biosphere, from the simplest organisms to human beings (Maffei, 2014).

In conclusion, we can suggest through our results and previous findings that most of the plant morphological, physiological and ion content attributes presented improvement through different levels. Major variation was achieved in physiological and biochemical attributes. Electromagnetic field exposure may be helpful for seed improvement against dormancy or yield improvement under biotic and abiotic stress.

Table 3: Influence of various installation times and distance from centre of electrical tower on morphology and physiological characteristics of *Calotropisprocera*

Parameter	Leaf area (cm2)	Chlorophyll %	Plant height (cm)	No of Branches	Photosynthesis rate	intercellular CO2 concentration	Stomata conductance	Perimeter
Locations								
1981	51.73b	11.84b	241.11 d	6.78c	3.47	358.33b	403.33a	268.38b
1991	36.10c	11.85b	241.22 d	9.56b	3.64	364.22ab	366.11a	231.00c
2008	33.84c	11.88b	330.01 a	7.56c	1.33	380.44a	294.22c	289.00b
2013	55.90a	12.72ab	268.33 c	12.78a	2.61	376.33ab	200.89b	272.89b
Control	46.04b	14.02ab	294.43 b	9.43a	4.69	353.86b	339.01a	317.86a
F. Test	**	**	**	**	NS	**	**	**
LSD at 0.05	12.25	1.05	19.97	1.18	--	18.15	110.23	20.23
Distances								
0	50.16	14.41a	271.47 a	8.53b	2.87	369.53	293.53	235.77c
50	41.41	14.28ab	260.62 b	8.47b	3.74	364.84	258.46	265.00b
100	42.01	11.77b	288.47 b	10.54a	2.74	367.01	279.45	319.93a
F. Test	NS	**	**	**	NS	NS	NS	**
LSD at 0.05	--	1.54	14.45	0.86	--	--	--	15.26

Results followed by the same letters are not statistically different at P≤ 0.05

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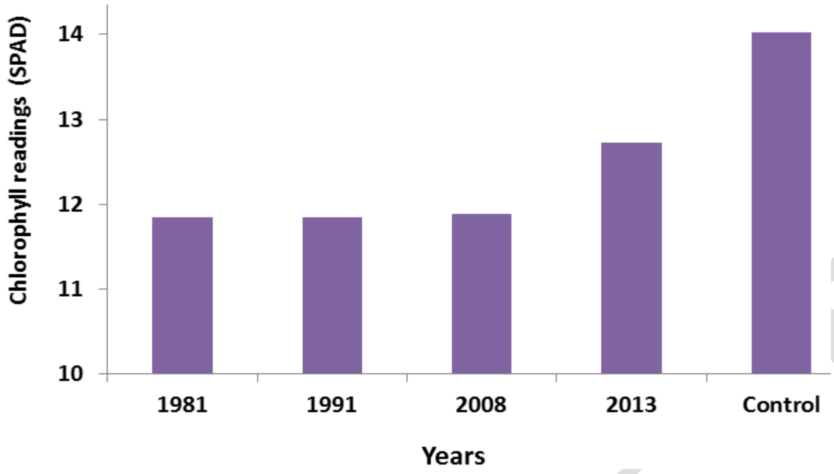

Figure 2. Effect of high electromagnetic field on chlorophyll content (%) of *Calotropisprocera* plants

Table 4: Means of potassium, calcium, sodium and magnesium (mg/kg-1soil) in investigated soils as affected by the combined locations and its distances.

Treatments		K	Ca	Na	Mg
1981	0	3.24	14.18	35.29	1.83
	50	6.47	14.13	29.42	5.31
	100	8.45	79.66	41.80	5.67
1991	0	5.04	27.63	11.97	3.73
	50	8.20	39.54	16.82	2.17
	100	15.75	49.95	19.69	6.59
2008	0	4.18	48.47	19.76	6.80
	50	6.85	46.02	12.65	5.88
	100	11.40	44.22	42.22	7.11
2013	0	5.10	41.64	19.29	7.24
	50	5.95	47.13	26.61	6.19
	100	7.99	52.66	26.84	8.10
Control		7.40	36.39	14.12	8.77

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F. Test	*	--	**	*
LSD at 0.05	4.03	NS	99.23	5.36

Table 5: Means of nitrogen (%), potassium, calcium and magnesium (mg / kg DWplant-1) in investigated plants as affected by the combined locations and its distances.

Treatments		N	K	Ca	Na	Mg
1981	0	1.26	21.17	48.03	23.31	29.68
	50	1.6	25.91	47.30	35.17	37.79
	100	1.51	27.61	50.75	30.91	32.25
1991	0	1.55	24.30	36.06	26.07	31.31
	50	1.4	21.08	40.73	32.71	35.11
	100	1.59	27.85	44.64	13.88	48.68
2008	0	1.44	28.31	58.75	22.49	32.62
	50	2.04	25.91	52.11	21.96	28.61
	100	1.63	24.06	41.01	20.03	26.06
2013	0	1.70	29.36	50.89	24.22	23.07
	50	1.97	28.03	57.58	37.29	30.32
	100	1.59	29.69	42.54	19.13	28.59
Control		1.28	34.07	55.7	20.69	33.34
F. Test		**	--	**	*	*
LSD at 0.05		0.05	NS	8.25	156.28	5.23

REFERENCES

[1] Aksyonov, S. Bulychev, A. Grunina, T.Y. Goryachev, S. and Turovetsky, V. 2001. Effects of ELF-EMF treatment on wheat seeds at different stages of germination and possible mechanisms of their origin Electromagnetic. Biology and Medicine 20 (2):231-253

[2] Aladjadjiyan, A. 2002. Study of the influence of magnetic field on some biological characteristics of Zea mays. Journal of Central European Agriculture 3.

[3] Aladjadjiyan, A. 2003. Use of physical factors as an alternative to chemical amelioration. J Environ Protec and Ecol 4 (3):662-667

[4] Bilalis, D. Katsenios, N. Efthimiadou, A. Efthimiadis, P. and Karkanis, A. 2012. Pulsed electromagnetic fields effect in oregano rooting and vegetative propagation: A potential new organic method ActaAgriculturaeScandinavica, Section B-. Soil & Plant Science 62(4):94-99

[5] Boutraa, T. 2010. Effects of water stress on root growth, water use efficiency, leaf area and chlorophyll content in the desert shrub Calotropisprocera. J Int, Environ Appl, Soi 5:124-132

[6] Cakmak, T. Dumlupinar, R. and Erdal, S. 2010. Acceleration of germination and early growth of wheat and bean seedlings grown under various magnetic field and osmotic conditions. Bioelectromagnetics 31(6):120-129

[7] Carbonell, M. Flórez, M. Martínez, E. Maqueda, R. and Amaya, J. 2011. Study of stationary magnetic fields on initial growth of pea (Pisumsativum L.) seeds. Seed Science and Technology 39(1):673-679

[8] Carbonell, M.V. Martinez, E. and Amaya, J.M. 2000. Stimulation of germination in rice (Oryza sativa L.) by a static magnetic field. Electromagnetic Biology and Medicine 19(3):121-128

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ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2014

[9] Choedon, T. Mathan, G. Arya, S. Kumar, V.L. and Kumar, V. 2006. Anticancer and cytotoxic properties of the latex of Calotropisprocera in a transgenic mouse model of hepatocellular carcinoma. World Journal of Gastroenterology 12:2517
[10] De Souza, A. Sueiro, L. García, D. and Porras, E. 2010. Extremely low frequency non-uniform magnetic fields improve tomato seed germination and early seedling growth. Seed Science and Technology 38:61-72
[11] Efthimiadou, A. Katsenios, N. Karkanis, A. Papastylianou, P. Triantafyllidis, V. Travlos, I. Bilalis, D.J. 2014. Effects of Presowing Pulsed Electromagnetic Treatment of Tomato Seed on Growth, Yield, and Lycopene Content. The Scientific World Journal 2014
[12] Finch- Savage, W.E. and Leubner- Metzger, G. 2006. Seed dormancy and the control of germination. New Phytologist 171:501-523
[13] Flórez, 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
[14] Harb, A. Krishnan, A. Ambavaram, M.M. and Pereira, A. 2010. Molecular and physiological analysis of drought stress in Arabidopsis reveals early responses leading to acclimation in plant growth. Plant Physiology 154 (6):1254-1271
[15] Hernandez-Aguilar, C. Dominguez-Pacheco, A. Cruz-Orea, A. Ivanov, R. Carballo-Carballo, A. Zepeda-Bautista, R. and Galindo Soria, L. 2009. Laser irradiation effects on field performance of maize seed genotypes. Int Agrophysics 23(1):327-332
[16] Ibrahim, A. and Mohsen, B. 2013. Effect of irrigation with magnetically treated water on faba bean growth and composition.
[17] Kavi, P. 1977. The effect of magnetic treatment of soybean seed on its moisture absorbing capacity [India] Science and Culture.
[18] Kucera, B. Cohn, M.A. and Leubner-Metzger, G. 2005. Plant hormone interactions during seed dormancy release and germination. Seed Science Research 15(1):281-307
[19] Maffei, M.E. 2014. Magnetic field effects on plant growth, development, and evolution Frontiers in plant science. 5.
[20] Martínez, E. Carbonell, M. Flórez, M. Amaya, J. and Maqueda, R. 2009. Germination of tomato seeds (Lycopersiconesculentum L.) under magnetic field. Int Agrophysics 23:45-49.
[21] Metrology and Environment, 2014. Climatological Normals for KSA, 2004-2013, Environmental Center, Jeddah.
[22] Moon, J.D. and Chung, H.S. 2000. Acceleration of germination of tomato seed by applying AC electric and magnetic fields. Journal of electrostatics 48:103-114
[23] Mossa, J. Tariq, M. Mohsin, A. Ageel, A. Al-Yahya, M. Al-Said, M. and Rafatullah, S. 1991. Pharmacological studies on aerial parts of Calotropisprocera. The American journal of Chinese medicine 19(3):223-231
[24] Polster, H. and Reichenbach, H. 1958. Bestimmung von Blattflächen in situ durchlineareMessungen. BiolZentralblatt 77(6):265-277
[25] Radhakrishnan, R. Ranjitha, and Kumari, B.D. 2012. Pulsed magnetic field: A contemporary approach offers to enhance plant growth and yield of soybean. Plant Physiology and Biochemistry 51(2):139-144
[26] Sharma, R. Thakur, G.S. Sanodiya, B.S. Savita, A. Pandey, M. Sharma, A. and Bisen, P.S. 2012. Therapeutic Potential of Calotropisprocera: A giant milkweed. J Pharm BiolSci 4:42-57
[27] Shine, M. and Guruprasad, K. 2012. Impact of pre-sowing magnetic field exposure of seeds to stationary magnetic field on growth, reactive oxygen species and photosynthesis of maize under field conditions. ActaPhysiologiaePlantarum 34:255-265.
[28] Soja, G. Kunsch, B. Gerzabek, M. Reichenauer, T. Soja, A.M. Rippar, G. ad Bolhar- Nordenkampf, H. 2003. Growth and yield of winter wheat (Triticumaestivum L.) and corn (Zea mays L.) near a high voltage transmission line.
[29] Steel, R.G.D. and J.H. Torri. 1997. Principles and procedures of statistics: A Biometrics Approach, 2nd ed. McGraw-Hill, New York.