Agricultural Reviews, 38 (1) 2017 : 1-14
Print ISSN:0253-1496 / Online ISSN:0976-0539

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com

Effect of physical seed treatment on yield and quality of crops: A review

M. Govindaraj, P. Masilamani*, V. Alex Albert and M. Bhaskaran[1]

Agricultural Engineering College and Research Institute
T.N.A.U., Kumulur-621 712, Tiruchirappalli, Tamil Nadu.
Received: 25-05-2016 Accepted: 29-11-2016 DOI:10.18805/ag.v0iOF.7304

ABSTRACT

Seed treatments are the biological, physical and chemical agents and techniques applied to seed to provide protection and improve the establishment of healthy crops. The benefits of seed treatments are increased germination, uniform seedling emergence, protect seeds or seedlings from early season diseases and insect pests improving crop emergence and its growth. Anthropogenic changes of the soil, water and atmosphere due to the use of different chemical additives for raising plants productivity led to searching alternative ways. Safe methods for increasing the yield includes the reasonable use of chemicals and substitution of some of them by appropriate physical treatments *viz*., magnetic field, gamma irradiation, electric field, laser irradiation, sound, healing energy, light and heat.

Key words: Energy treatment, Germination, Seedling vigour, Seedling growth, Seed yield.

Recently the use of physical methods for plant growth stimulation is getting more popular due to the less harmful influence on the environment. Physical factors can be used to get positive biological changes in crop plants without affecting the ecology. Growth, development and yield of dill seed is accelerated using physical treatment. All living processes are highly dependent on energy exchange between the cell and the environment. This is the core concept in "quantum agriculture" that has been intensively discussed in the last decades (www.btinternet.com). Energy treatment is an innovative area of research to improve the yield of crops. It initiates physiological and biochemical changes, which reflect the plant growth and development processes and ultimately improve the yield and quality of produce. Treatment led to change of seed vitality indices (germinating energy, germination, and uniformity of germination): In this paper, different types of energy treatments v*iz.,* magnetic field, gamma irradiation, electric field, laser irradiation, sound energy, healing energy, light and heat energy on germination, seed yield and quality of agriculture and horticulture crops.

MECHANISM INVOLVED IN ENERGY TREATMENT

Physical factors import different kind of energy into the cells. It is a kind of energy treatment that stimulates the enzymes and other biochemical reactions that helps in early germination. Imported energy is absorbed by the electrons in different molecules. The absorbed energy may be transformed in another kind of energy (most probably chemical one) and then used for accelerating the seed metabolism. It helps to elucidate the mechanisms of energy exchange in molecules and thus stimulation of plant development. In the case of chemical amelioration the necessary substances are directly inserted into the cell. Whereas in the physical treatment, energy introduced in the cell creates conditions for molecular transformations.

Magnetic field energy: Application of magnetic fields of extremely low frequencies positively affects seed germination, shoot development, plant length, fresh weight, fruit production and mean fruit weight (Cakmak *et al.,* 2010). The positive effects of magnetic fields have also been shown in the biosynthesis of proteins, cell production, photochemical activity, respiration rate, enzyme activity and nucleic acid content (Stange *et al.,* 2002). De Souza *et al*. (2005) treated tomato seeds (*Lycopersicon esculentum* Mill. cv.Vyta) using an electromagnet. The result revealed that magnetic treatments had a significant effect on growth parameter and fruit yield when compared to control.

The mechanism of magnetic exposure on seed germination and plant growth may be the result of bioenergetic structural excitement causing cell pumping and enzymatic stimulation. Jones *et al. (*1986) proposed that magnetic fields might affect the regulation of crucial ion mechanisms, such as the ATP hydrogen pump, and possibly the configuration of pivotal proteins. Kuzin *et al.* (1986) suggests that magnetic fields modulate the rate of recombination of free radicals during normal plant metabolism. Several authors suggest that magnetic fields might affect the activity of ion channels (Galt *et al.,* 1993) or ion transport within cells (Garcia-Sancho and Javier, 1994). However, the basic mechanisms responsible for the magnetic stimulation of plant growth remain a mystery.

*Corresponding author's e-mail: masil_mahesh@yahoo.com
[1]Tamil Nadu Open University, Chennai- 600 015, Tamil Nadu, India.

The results presented in Table 1 showed that the influence of pre-sowing treatment of seeds with low-frequency (50 Hz) alternating magnetic field (AMF) on the yields and chemical composition of sugar beet roots (Pietruszewski *et al,* 2007). The result revealed that in both the varieties altering magnetic field treated seeds showed increase root and sugar yield compared to control.

Galland and Pazur (2005) reported that a magnetic field of magnitude one or two orders above geomagnetic field strength (35 to 70 ìT) could affect plant growth and metabolism. Samy (1998) had found out early flowering and yield increase of cabbage as a result of the treatment with a magnetic field at 8-hours exposition. De Souza Torres *et al.,* (2006) found out that treatment with a static magnetic field with induction of 0, 08, 0, 1 and0, 17 T increased the germination of tomato seeds by 5 to25 %. Similar results for rice, sunflower and maize were reported by Carbonell *et al.* (2005).

Nedialkov *et al.* (1996) found out that the pre-sowing treatment with a magnetic field showed a positive impact on seeds of soybean, maize, peas, okra, and beans leading to an increase of yield for soybean – by 48 %, for peas – by 15,7 %, for okra – by 19,6 %, and for beans – by 21,3 %, respectively. The effect of magnetic field treatment on plant growth was reported in Table 2 (Pietruszewski and Martinez. 2015).

Electric field energy: It has been perceived that the electric and magnetic fields cause physiological and biochemical changes in seeds (Putincev and platonova. 1997). Researches indicate that electric and magnetic fields affect biological process including free radicals, excite the activity of proteins and enzymes to increase in seed vigor (Morar *et al.,* 1999). Bai *et al.* (2003) investigated the original mechanism of the biological effects of 4 kV/m electrostatic field on barley and 4.5 kV/mon sugar beet seeds for 10 minutes. Their results showed that the electrostatic fields with certain intensity could increase the content of free radicals in seeds. Kelentarov (1961) studied the effects of electric field on cotton seeds and concluded that the fibers of cotton were enhanced due to the effects of the field.

Smigel *et al.* (1968) reported that electric fields with high voltage have significant effects on potato cultivation. Mustafayev (1974) proved the effect of high voltage electric field on the precocity of cotton cultivars. Rotcharoen *et al.* (2002) studied the effects of electric field on rice growth and found that the electric field with the intensity of 193 kV/m and 4 kV/m has a significant effect on the growth rate and height of rice plant. Ozel (2003) studied the effects of high voltage electric field on the yield and yield components of different cultivars of bread wheat. Hanafy *et al.* (2005) reported that the chlorophyll content and carbonate hydrate of the broad beans were exposed to a 6 kV per centimeter increased significantly within 1, 3, and 5 days. Lynikeine *et al.* (2006) reported that the electric field not only increased the rate of germination but also increased the germination percentage of carrot, garden radish and beet were increased by 24, 12, and 9 % respectively.

The bean seeds were exposed with and without electric field with a temperature and relative humidity of 28ºC and 65% respectively. 5 kV DC voltage is applied to obtain electric field intensity of 25kV/m. The arithmetic means of the height of stems and the length of roots with electric field are higher and longer than of those without electric field of bean seeds. Experimental results indicate that the bean sprout in electric field has a better growth comparison to that of without electric field based on statistical analysis (Kiatgamjorn *et al.,* 2002).

Three cucumber seed lots used for experiment: 'Bingo I', 'Bingo II' and 'HB128' were subjected to hydropriming and electric field treatments. The result revealed that the EC of 'Bingo II' (the low germination seed lot) was higher than that of 'Bingo I' (the high germination seed lot), suggesting higher membrane leakage occurring in low vigour seed lot. Both HP and EF treatments reduced the EC of 'Bingo I' and 'Bingo II'; conversely, only slight increase in the EC of 'HB128' by both HP and EF treatments were found (Table 3).

The effects of hydropriming and electric field treatments on seed performance were different. Hydropriming tended to increase the speed of germination,

Table 1: Results of pre-sowing magnetic treatment on yield of sugar beet root.

Exposure dose D = 67200 Jm3 s (B = 75 mT, t = 15 s)

Index	Seed dressing	Control plants	MF-treated plants	Control plants	MF-treated plants
		cv. Kaliwia		cv. Polko	
Yield of roots (t ha^{-1})	n. s.	46.4	49.5	59	61
	c. s.	52.9	52.5	56.7	60.6
Sugar (%)	n. s.	16.5	17.7	52.3	54.1
	c. s.	16.5	17.4	55.4	55.3
Biological yield of sugar (%)	n. s.	7.72	8.74	9.96	11.21
	c. s.	8.79	9.11	9.91	10.96

n. s. –Normal seeds and c. s. – Coated seeds (Source: Pietruszewski *et al.,* 2007)

Table 2: The Effect of magnetic field treatment on plant growth

Crop	Magnetic induction	Effect
Rice	150 and 200 mT	Better germination
Wheat	30 – 220 mT	Better germination
Maize	0, 15mT	25 % germination, 72 % weight & 25 % length
Barley	125 mT	Better germination
Black gram	87 – 226 mT	Better germination
Chickpea	20 – 200 mT	Increased root length
Lentil	150 mT	Better germination
Pea	60, 120, 180 mT	Better germination and increase of chlorophylls a and b
Sunflower	250 tm	Better germination and yields
Sugar beet	75 mT, 50 Hz	Better yields for cv. Maria
Tomato	10 mT	Better germination and yields
Potato	20, 40, 80 mT	Better yields
Radish	500 µT	Better germination and seedling properties
Broad bean	30 mT, 85 mT	Better germination and yields
Amaranthus	30 mT	Better germination
Cucumber	7 and 10 mT	Better germination
Tobacco	0, 15 mT	68 % germination
Soybean	0, 15 mT	37 % germination, 172 % weight & 37 % length

(Source: Pietruszewski and Martínez. 2015)

Table 3: The germination of cucumber seeds after electric field treatments.

Strength(kV/cm)	Time(min)	Germination (%)			Mean germination time (day)		
		Bingo I	Bingo II	HB128	Bingo I	Bingo II	HB128
1	1	89[a]	70[ab]	94[ab]	2.2[a]	3.3[a]	2.6[abc]
	3	93[a]	62[bc]	94[ab]	2.1[a]	3.5[a]	2.8[a]
	5	94[a]	71[ab]	90[abc]	2.1[a]	3.5[a]	2.7[ab]
3	1	90[a]	68[ab]	94[ab]	2.1[a]	3.3[a]	2.7[ab]
	3	92[a]	78[a]	94[ab]	2.1[a]	3.8[a]	2.5[abc]
	5	94[a]	64[abc]	91[abc]	2.1[a]	3.5[a]	2.1[d]
5	1	89[a]	71[ab]	87[bc]	2.1[a]	3.4[a]	2.4[bcd]
	3	91[a]	79[a]	87[bc]	2.1[a]	3.4[a]	2.5[abc]
	5	93[a]	78[a]	85[bc]	2.2[a]	3.7[a]	2.2[cd]
7	1	94[a]	50[c]	90[abc]	2.1[a]	3.1[a]	2.3[cd]
	3	97[a]	68[ab]	89[abc]	2.1[a]	3.4[a]	2.4[bcd]
	5	95[a]	64[abc]	87[bc]	2.1[a]	3.3[a]	2.4[bcd]
Control		94[a]	62[bc]	84[bc]	2.1[a]	3.1[a]	2.3[cd]

(Source: Huang *et al.,* 2006).

whereas electric field had the potential to increase the percentage of germination. Both hydropriming and electric field treatments could reduce electrolyte leakage in both high and low germination of 'Bingo' seed lots, and slightly increased that of the dormant seed lot of 'HB128' was observed by Huang *et al.* (2006).

The mean comparison of physiological properties of maize seed considering individual effects of electric field and exposing time are presented in Table 4. The results revealed that the effects of electric field and exposing time duration on all of the physiological properties of maize were statistically significant (Sedighi *et al.,* 2013).

Gamma irradiation: Gamma rays belong to ionizing radiation and are the most energetic form of electromagnetic radiation, having the energy level from around 10 kilo electron volts (keV) to several hundred keV. Therefore, they are more effective than other types of radiation such as alpha and beta rays (Kovacs and Keresztes, 2002). The biological effect of gamma-rays is based on the interaction with atoms or molecules in the cell, particularly water, to produce free radicals (Kovacs and Keresztes, 2002). These radicals can damage or modify important components of plant cells and have been reported to affect differentially the morphology, anatomy, biochemistry and physiology of plants depending on the radiation dose (Ashraf *et al*., 2003).

These effects include changes in the plant cellular structure and metabolism e.g., dilation of thylakoid membranes, alteration in photosynthesis, modulation of the anti-oxidative system, and accumulation of phenolic compounds (Ashraf, 2009). From the ultra-structural observations of the irradiated plant cells, the prominent

Table 4: Comparison of means of physiological properties of maize seed at different electric fields using Duncan's test method.

Electric fieldintensity (kv/m)	GP	MG	GS	C_u	LRo	LRa	S_l	L_p	W_w	W_d
0	28.00 a	2.51 d	34.97 dc	0.7 c	10.25 a	3.53 c	5.00 a	13.78 c	6.13 d	5.62 d
2	21.25 b	3.54 c	33.09 d	0.86 bc	9.57 b	6.68 b	2.39 c	16.26 b	7.64 c	7.14 c
4	25.83 ab	7.25 b	35.63 c	1.00 b	10.50 a	7.12 b	3.79 b	17.62 a	7.83 c	7.33 c
9	27.83 ab	11.21 a	48.36 a	1.33 a	9.35 b	8.38 a	2.53 c	17.73 a	8.93 a	8.43 a
14	24.00 ab	11.40 a	40.68 b	1.35 a	8.72 c	8.60 a	1.31 d	17.32 a	8.28 b	7.78 b

(Source: Sedighi *et al.,* 2013)

GP: Germination percentage, MG: Mean germination time, GS: Germination speed,
Uc: Coefficient of uniformity, LRo: Length of root, LRa: Length of radical, Sl: Leaf size, Lp: Length of plant, Ww: Wet weight of plant, Wd: Dry weight of plant

structural changes of chloroplasts after radiation with 50 Gy revealed that chloroplasts were more sensitive to a high dose of gamma rays than the other cell organelles. The irradiation of seeds with high doses of gamma rays disturbs the synthesis of protein, hormone balance, leaf gas-exchange, and water exchange and enzyme activity.

Yesim *et al.,* (2015) studied in Tokak-157/37 barley and Karahan-99 wheat when searched about the effects on root length, it has been determined that according to control, with the rise of radiation doses, the root length has declined (Table 5). *T.aestivum* (bread wheat) seeds were exposed to gamma irradiation the irradiated and non-irradiated seeds were sown under field condition. Samples were collected at five growth stages *viz.,* 90, 115, 135, 160 and 180 days after sowing (DAS), respectively.

Measurement of yield characteristics, at 180 DAS clearly indicates stimulation by gamma irradiation. Radiation however, inhibited or negatively affected certain other characteristics like total grain weight per spikelet, average grain weight per ear and 1000 grain weight when compared with unirradiated control (Table 6). Seed treatment of low dose of gamma radiation 0.01–0.10 kGy reduced plant height, improved plant vigour, flag leaf area, total and number of EBT. Gamma irradiation increased grain yield due to an increase in number of EBT and grain number while 1000 grain weight was negatively affected. Further uniformity in low dose radiation response in wheat in the field suggests that the affect is essentially at physiological than at genetic level and that role of growth hormones could be crucial (Singh and Datta, 2009).

Table 5: The effects of gamma radiation on seedling height and root length of Tokak-157/37 barley andKarahan-99 wheat kinds

Doses	Tokak-157/37 barley		Karahan-99 wheat	
(Gy)	Seedling heights	Root lengths	Seedling heights	Root lengths
Control	100	100	100	100
50	97	120	91	97
100	93	113	93	96
150	89	103	77	90
200	87	97	80	83
300	87	97	57	77
400	71	97	46	80
500	46	99	14	61
600	32	103	5	57

(Source: Yesim *et al.,* 2015)

Mohammad and Abdollah (2011) studied two wheat cultivars (Alamut and Zagros) and sub-plots were six levels of gamma irradiation including 0 (control), 25, 50, 75, 100 and 125 Gy. The results of this study showed that 1000-grain weight, grain yield, grain protein content, LAI, CGR and NAR and harvest index were affected with different levels of irradiation. Wheat genotypes were irradiated with 100, 200, 300 and 400 Gy. The results showed that Mean Germination Time, root and shoot length, and seedling dry weight decreased with increasing radiation doses but final germination percentage was not significantly affected by radiation doses (Borzouei *et al.,* 2010).

Laser irradiation: Irradiation is considered as a new branch in agriculture (Jiang. 1981). The amazing characteristic of laser radiation, such as monochromatic, polarization, coherence and high density, can be used in all spheres of biology and plant growing (Dinoev *et al.,* 2004). The changes that occur in the physiological state of seeds and plants can stimulate or inhibit their development and resistance to fungal disease and depend closely on the laser radiation type, its wavelength, intensity and the duration of exposition (Vasilevski, 2003). Several authors in the world provide the possibility of accelerating the maturity of plants; increase their resistance to disease; influence alpha-amylase activity and the concentration of free radicals in the seeds of several plants using laser light (Hernandez *et al.,* 2010). A range of survey showed the impact of laser treatment on dynamics of germination and disease resistance for number of vegetables, and cereals, peas, wheat, radishes and corn (Nenadic *et al.,* 2008), but it is necessary to run more experiments to determine its potential in controlling plant diseases of seed.

Podlesny *et al.,* (2012) studied the effect of laser light treatment on physiological processes in seeds and seedlings of white lupine and faba bean. Significant differences in the dynamics of germination of seeds

Table 6: Effect of gamma irradiation on yield attributes of wheat plant.

Yield traits	Gamma radiation dose (kGy)					
	0	0.01	0.03	0.05	0.07	0.1
Number of ear bearing tillers (14.4)	5	13	12	17	17	13
Total grain yield/plants (g) (75.7)	31.9	75.8	57.1	80.4	91.2	74.1
Number of spikelet's/ear (30.4)	28	31	31	31	30.5	28.5
Number of grains/spikelet (4.2)	4.3	4.8	4.4	3.5	3.8	4.4
Grain weight/spikelet (mg) (191.8)	214	227	157	145	193	237
Number of grains/ear (133.5)	127	145.5	145	120	127	130
Average grain weight/ear (g) (5.3)	6.4	5.8	4.8	4.7	5.4	5.7
1000 grain weight (g) (43.6)	49	44	35	41	46	52

(Source: Singh and Datta, 2009)

pre-treated and not pre-treated with laser beams were noticed (Table 7). Irradiation of seeds effected also on the initial growth and development of white lupine and faba bean seedlings, and most of all on the length of roots and a hypocotyls.

Sound energy: Sound is known to affect the growth of plants (Creath and Schwartz. 2004). Studies have also shown that sound vibration can be used to stimulate a seed or plant (Braam and Davis, 1990). Previous studies indicate that musical sound has a significant effect on the number of seeds sprouted compared to noise and untreated control and sound vibrations directly affect living biologic systems (Creath and Schwartz. 2004). Foliage planted along freeways found to reduce noise pollution often grows differently than foliage planted in a quiet environment (Bache and Macaskill. 1984). It would be advantageous for plants to learn about the surrounding environment using sound, as acoustic signals propagate rapidly and detection of sound may have adaptive value in plants (Gagliano, 2012). Plants are complex multicellular organisms considered as sensitive as humans for initial assaying of effects and testing new therapies (Benford, 2002).

Several studies have been undertaken to understand the influence of sound and music on plants and plant growth. It has been reported that under optimal stimulation conditions (100dB and 800Hz) the sound field can enhance the growth of *Chrysanthemum callus* and moderate stress stimulation can enhance the assimilation of tissues or cells, improve their physiological activity and accelerate the growth of plants (Yiyaoa *et al.,* 2002). Other studies show that under suitable sound stimulation, the growth of Chrysanthemum roots could be accelerated and the sound stimulation could enhance the metabolism of roots and the growth (Yia *et al.,* 2003.). Playing appropriate tunes have been found to stimulate the plant's synthesis of its appropriate protein (Coghlan, 1994). The rate of water transpired out of leaves is also reportedly affected by sound waves (Lord, 1975) and this in turn affects the growth. Corn plants exposed to music sprouted faster, were greener, and their stems thicker and tougher than the corn plants which were in silence (Hicks, 1963). Music or sound can also have detrimental effects on plant growth. Some reports indicate that music containing hard-core vibrations could be devastating to plants. Certain types of music can wreak havoc on plants. Even played at a low volume, heavy metal music can be very damaging to a sensitive plant. On the other hand, classical or devotional music enhances the plant growth. Classical music has a gentle vibration, and it's easy on plants. Violin music in particular is known to significantly increase plant growth. Carrot seed exposed to UV treatment for 5 min showed higher germination (%), germination energy (%) and fresh weight (g) compared to all other treatment including control Aladjadjiyan and Kakanakova (2009); (Table 8).

Creath and Schwartz, 2004 contacted experiment to measure the biologic effects of music, noise, and healing energy without human preferences or placebo effects using

Table 7: Germination dynamics of seeds of faba bean and white lupine treated and non-treated with laser beams

Irradiation doses	Time from sowing (h)						
	12	24	48	72	96	120	144
Faba bean							
D_0	0.0a	16.4a	21.3a	53.4a	58.7a	96.8a	100.0a
D_3	3.3b	22.8b	27.8b	59.5b	74.6b	97.9b	100.0a
D_5	6.0c	22.3b	32.5c	67.7c	75.0b	98.1b	100.0a
White lupine							
D_0	0.0a	20.6a	30.5a	57.8a	84.1a	95.8a	100.0a
D_3	6.3b	26.0b	41.4b	66.5b	97.2b	98.3b	100.0a
D_5	7.4c	26.5b	46.7c	87.8c	97.0b	99.3b	100.0a

D_0-no irradiation, D_3-triple irradiation, D_5-fivefold irradiation (Source: Podlesny *et al.,* 2012)

Table 8: The Effect of ultrasound treatment on carrot seeds (*cv. Nantes*) germination

Exposure time (min)	Germination (%)	Germinative energy (%)	Fresh weight (g)
0	76.3	65.3	67.6
1	75.3	65.6	68.0
5	89.3	79.6	82.6
10	83.0	68.6	73.6

(Source: Aladjadjiyan and Kakanakova, 2009)

seed germination as an objective biomarker (Fig. 1). The result revealed that the musical sound had a highly statistically significant effect on the number of seeds sprouted compared to the untreated control over all five experiments for the main condition and over time. This effect was independent of temperature, seed type, position in room, specific petri dish, and person doing the scoring. Musical sound had a significant effect compared to noise and an untreated control as a function of time while there was no significant difference between seeds exposed to noise and an untreated control.

Chivukula and Ramaswamy, (2014) studied the effect of different types of music on *Rosa chinensis* plants. 30 *Rosa chinensis* plants which were grafted on the same day from a single mother plant were potted in similar sized pots with equal amount of mud containing a uniform mixture of various constituents. They were divided in to five groups with six plants in each group, chosen at random. One of the groups was kept in silence as control group. Each of the other four groups was exposed to one of the following types of music, Indian classical music (Violin music of *Raaga Sindhu Bhairavi*), Vedic chants (Rig Veda), Western classical music (Pachelbel's Canon in D-Soothing) and Rock music (Hate Eternal "Bringer of Storms") for 60 minutes in the morning between 6:00 AM – 7:00 AM, immediately after sun-rise for a period of 62 days. Care was taken to ensure minimal ambient noise and to ensure that the amount of sunlight and water was equal for all the plants.

The results revealed that the average increase of shoot length, number of flowers and diameter of the flowers is highest in plants being subjected to Vedic chants suggesting that the plant growth is enhanced when it is exposed to Vedic chants. The increase in shoot length indicates that the sound of Vedic chants stimulates their growth (Table 9). The

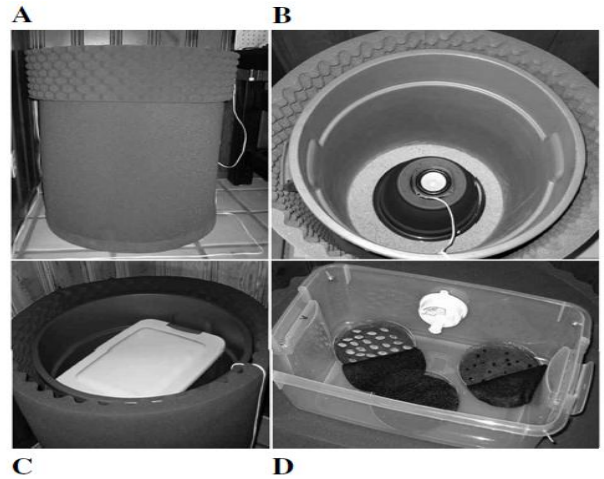

Fig 1: Growth chambers. **A:** Outside view. **B:** Speaker in bottom.**C:** Seed container suspended in chamber. **D:** Open seed container showing petri dishes with seeds covered with felt and datalogger (Creath and Schwartz, 2004).

maximum increase of length of the internode is seen in the plants exposed to Indian classical music. Western classical music also stimulates the growth of plants but not as much as Vedic chants and Indian classical music. On the other hand, it is seen that the Rock music stifles the plant growth as the average increase is significantly lower than the rest. Infact, it can be seen that the average growth of the plants subjected to Rock music is also lower than the control set indicating that the vibrations or the sound of Rock music actually has a detrimental effect on the plant growth. This could be because of the plants being unable to take up the required amount of nutrients and some kind of a stasis in protein synthesis' leading to a reduction in growth.

Healing energy: Healing energy studies have been performed with seeds rather than with humans (Roney-Dougal and Solfvin, 2002). Creath and Schwartz (2004) studied the measuring effect of healing energy using a seed germination bioassay. A series of five experiments were performed utilizing okra and zucchini seeds germinated in acoustically shielded, thermally insulated, dark, humid growth chambers. Conditions compared were an untreated control and healing energy. Healing energy was administered for 15-20 minutes every 12 hours with the intention that the treated seeds would germinate faster than the untreated seeds.

Table 9: Effect of different types of the music on the plant growth of *Rosa chinensis*

Music Type	No. of plants	Average increase in plant height (cm)	Average internodes elongation (cm)	Average number of flowers	Average diameter of the flowers (cm)
Indian classical	6	7.334	4.000	0.598	5.376
Vedic chants	6	7.834	3.833	0.675	5.408
Western classical	6	5.251	2.183	0.525	4.690
Rock	6	3.667	1.350	0.380	3.704
Silence	6	4.833	2.700	0.476	4.876

(Source: Chivukula and Ramaswamy 2014).

The number of seeds sprouted out of groups of 25 seeds counted at 12-hour intervals over a 72-hour growing period. Temperature and relative humidity were monitored every 15 minutes inside the seed germination containers. Healing energy also had a significant effect compared to an untreated control and over time with a magnitude of effect comparable to that of musical sound.

The biofield therapy used for the healing energy condition was a relatively new therapeutic modality Vortex Healing (VH) founded by Ric Weinman, B.A., in 1994 (Weinman, 2000). It is a recognized therapy of the Associated Bodywork and Massage Professionals (ABMP). VH claims to trace its roots to a man named Mehindra who lived 5600 years ago in India. It is a bioenergetic therapy purportedly taught via transmission. Sets of seeds receiving healing energy were treated for 15–20 minutes twice per day with VH by Creath after the seeds were monitored receiving a total of six treatments during a trial. Petri dishes of seeds were stacked for treatment. Seeds were in the dark under black felt for the treatments. Four points of the hands (tip of ring fingers and side edge of palms) barely touched the top of the stack of three petri dishes as shown in Figure (2 & 3). The contact on the dishes was minimal. The center of the palms was approximately 3 inches away from the top center of the stack.

A treatment consisted of (1) consciously connecting to the seeds, (2) focusing intention for the seeds to germinate faster than the controls, (3) asking for energetic structures to enable this, (4) letting all energetics necessary for this to flow, (5) help from divine consciousness to integrate and ground this energy, and finally (6) becoming an open channel for divine energy to flow through. This sequence is standard practice in VH treatments. The practitioner mentally focuses on each of these steps sequentially.

These results suggest that a seed germination bioassay can objectively measure effects due to different types of applied energy. Because practitioner healing energy for seeds of okra and Zucchini to germinate faster are similar to healing energy for a specific human ailment, this bioassay has potential as a means of determining practitioner effectiveness and as a means of screening practitioners for studies of effects on human populations.

Fig 2: Hand position for healing energy (Vortex Healing (Creath and Schwartz, 2004)).

Light energy: Plants can be classified in terms of their responses to light for germination as follows: (i) those that require light to germinate, (ii) those that require darkness to germinate and (iii) those that have a large percentage of seeds neutral to light. These groups have been named positive photoblastic, negative photoblastic and neutral photoblastic by Baskin and Baskin (2014). Small seeded plants that form soil seed banks for instance, are expected to germinate only in the presence of light, as a mechanism to avoid germinating too deep in the soil where they would deplete seed nutrients before reaching light for photosynthesis (Pons 2000). Germination responses of light are likely to vary between habitats, for instance in shaded environments such as forests, the presence of strong light can be associated with a canopy gap that increases probabilities of establishing seedlings (Khurana and Singh 2001), The influence of light on germination has also been associated with plant growth form (seeds from columnar cacti being neutral photoblastic and the barrel-shaped and globose being positive photoblastic; Rojas-Arechiga *et al.* 1997); perenniality (light promotes the germination of annual species; De Villiers *et al.* 2002); plant size (seeds from shorter plants have a stronger light requirement for germination than those from taller plants; Flores *et al.* 2011); and seed size (seeds requiring light are small; Flores *et al.* 2011). Positive photoblastism is also considered to be associated with phylogeny (Flores *et al.* 2011) and with temperature variation during seed development (Rojas-Arechiga *et al.* 1997).

There was a significant effect of species and light treatments, and the interaction of both factors was significant. Seven species had at least 71% germination in light conditions, so they were not considered dormant; five species and the two varieties of *Ferocactus latispinus* were considered dormant (Table 10). All species were considered neutral photoblastic. For these, they found two response patterns: (i) 11 species having similar seed germination in both light and dark conditions and (ii) two species (*M. compressa* and the two varieties of *F. latispinus*) showing higher germination in light than in dark conditions (Flores *et al.,* 2015).

Red and far-red light have been shown to affect photomorphogenesis, thus, the ratio of red and far-red light also plays an important role in regulation of flowering (Simpson and Dean. 2002). Flowering in plants is mainly regulated by phytochromes (a group of plant pigments), which occur in two forms: Pr (responds to red light) and Pfr (responds to far-red light). These two pigments (Pr and Pfr)

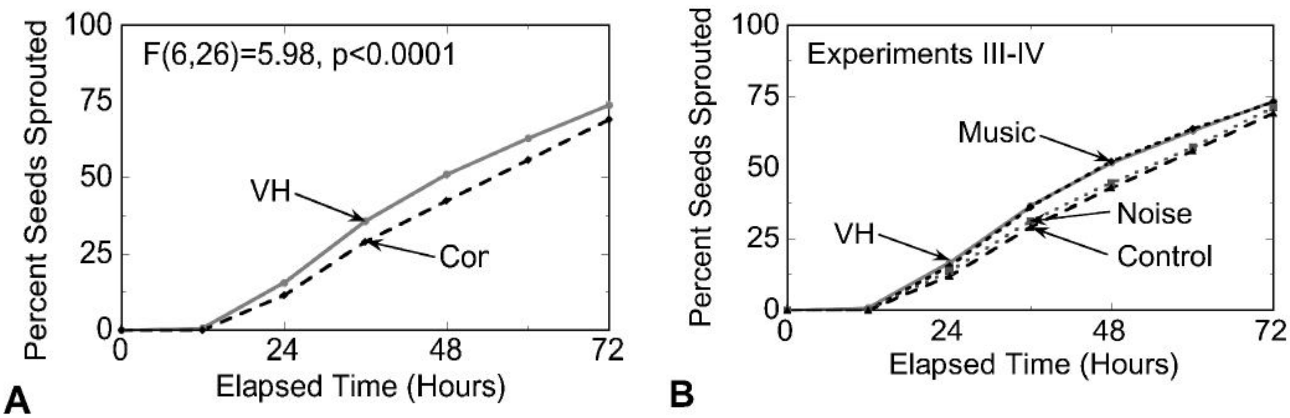

Fig 3 A: Percentage of seeds sprouted averaged over seed type, dishes and experiments III–IV versus time for healing energy (Vortex Healing (VH)) and control. **B:** Same as (**A**) with the addition of the musical sound and noise conditions(Creath and Schwartz, 2004).

Table 10: Seed germination of 13 species from the Chihuahuan Desert at 25°C under light and darkness treatments

Species	Seed germination (%)	
	Light	Darkness
Agave americana	82[a]	73[a]
Agave angustifolia	29[a]	19[a]
Agave asperrima	9[a]	6[a]
Agave gentryi	93[a]	82[a]
Agave lechuguilla	99[a]	98[a]
Agave salmiana	25[a]	8[a]
Yucca carnerosana	91[a]	94[a]
Yucca filifera	95[a]	99[a]
Yucca potosina	71[a]	80[a]
Yucca queretaroensis	37[a]	42[a]
Coryphanta clavata	100[a]	100[a]
Ferocactus latispinus (yellow)	36 [a]	14[b]
Ferocactus latispinus (red)	64[a]	21[b]
Mammillaria compressa	51[a]	19[b]

(Source: Flores *et al.,* 2015)

convert back and forth. Pr is converted into Pfr under red light illumination and Pfr into Pr with far-red light. The active form which triggers flowering is Pfr. Pr is produced naturally in the plant. The ratio of Pr to Pfr is in equilibrium when the plant receives light (day) because Pr is converted into Pfr by red light and Pfr is converted back to Pr by far-red light. Back conversion of Pfr is however also possible in a dark reaction, so it is the night (dark) period which mainly affects the ratio of Pr to Pfr and controls the flowering time in plants (Downs and Thomas. 1982).

Solid state lighting using light-emitting diode (LED) technology represents a fundamentally different and energy efficient approach for the greenhouse industry that has proficient advantages over gaseous discharge-type lamps (high pressure sodium lamps) currently used in most greenhouses (Mitchell *et al.,* 2012).

LEDs source for plants: LEDs as a source of plant lighting were used more than 20 years ago when lettuce was grown under red (R) LEDs and blue (B) fluorescent lamps. Several reports have confirmed successful growth of plants (Table 11) under LED illumination (Singh *et al.,* 2015; Yanagi and Okamoto, 1997). Red (610-720 nm) light is required for the development of the photosynthetic apparatus and photosynthesis, whereas blue (400-500 nm) light is also important for the synthesis of chlorophyll, chloroplast development, stomatal opening and photomorphogenesis (Saebo *et al.,* 1995). Several horticultural experiments with potato, radish and lettuce (Stutte *et al.,* 2009) have shown the requirement of blue (400-500 nm) light for higher biomass and leaf area. However, different wavelengths of red (660, 670, 680 and 690 nm) and blue (430, 440, 460 and 475 nm) light might have uneven effects on plants depending on plant species (Li *et al.,* 2012). Far-red LED light (700-725 nm) which is beyond the PAR has been shown to support the plant growth and photosynthesis (Stutte *et al.,* 2009). Goins *et al.,* (1997) reported that wheat (*Triticum aestivum* L., cv. 'USU-Super Dwarf') can complete its life cycle under red LEDs alone but larger plants (higher shoot dry matter) and greater amounts of seed are produced in the presence of red LEDs supplemented with a quantity of blue light. Folta (2004) evaluated the effect of green (525 nm) LED light on germination of *Arabidopsis* seedlings and results showed that seedlings grown under green, red and blue LED light are longer than those grown under red (630 nm) and blue (470 nm) alone. Supplementation of green light enhanced lettuce growth under red and blue LED illumination (Kim *et al*., 2004). Green light alone is not enough to support the growth of plants because it is least absorbed by the plant but when used in combination with red, blue, and far-red, green light will certainly show some important physiological effects.

Vertical pink farming: Harnesses the technology to grow crops: We are entering the techno-agricultural era. Agricultural science is changing the way we harvest our food. Robots and automation are going to play a decisive role in

Table 11: Effect of LED lighting on physiology of vegetables

Plant	Radiation source	Effect on plant physiology
Indian mustard (*Brassica juncea* L.) Basil (*Ocimum gratissimum* L.)	Red (660 and 635 nm) LEDs with blue (460 nm)	Delay in plant transition to flowering as compared to 460 nm + 635 nm LED combination.
Cabbage (*Brassica olearacea* var. *capitata* L.)	Red (660 nm) LEDs	Increased anthocyanin content.
Baby leaf lettuce (*Lactuca sativa* L. cv. Red Cross)	Red (658 nm) LEDs	Phenolics concentration increased by 6%
Tomato (*Lycopersicum esculentum* L. cv. Momotaro Natsumi)	Red (660 nm) LEDs	Increased tomato yield.
Green onions (*Allium cepa* L.)	Red (638 nm) LEDs and natural illumination.	Reduction of nitrate content.
Green baby leaf lettuce (*Lactuca sativa* L.)	Red (638 nm) LEDs (210 µmol m-2 S-1) with HPS lamp (300 µmol m-2 S-1).	Total phenolics, tocopherols, sugars and antioxidant capacity increased but vitamin C content decreased.
Sweet pepper (*Capsicum annuum* L.)	Red (660 nm) and far- red (735 nm) LEDs, total PPF maintained at 300 µmol m^{-2} S^{-1}	Addition of far-red light increased plant height with higher stem biomass.
Red leaf lettuce 'Outeredgeous' (*Lactuca sativa* L.) Baby leaf lettuce 'Red Cross'(*Lactuca sativa* L.)	Red (640 nm, 270 µmol m^{-2} S^{-1}) LEDs with blue (440 nm, 30 µmol m^{-2} S^{-1}) LEDs. Blue (476 nm, 130 µmol m^{-2} S^{-1}) LEDs	Anthocyanin content, antioxidant potential and total leaf area increased. Anthocyanin (31%) and carotenoids (12%) increased.
Cucumber 'Bodega' (*Cucumis sativus*) and tomato 'Trust' (*Lycopersicon esculentum*)	Blue (455 nm, 7-16µmol m^{-2} S^{-1}) LEDs with HPS lamp (400- 520 µmol m^{-2} S^{-1}).	Application of blue LED light with HPS increased total biomass but reduced fruit yield.

(Source: Singh *et al.,* 2015)

the way we hunt and gather. The most important and disruptive idea is what they call "Vertical Pink Farms" and it is set to decentralise the food industry forever. The United Nations (UN) predicts by 2050 80% of the Earth's population will live in cities (www.npr.org). Climate change will also make traditional food production more difficult and less productive in the future. We will need more efficient systems to feed these hungry urban areas. Thankfully, several companies around the world are already producing food grown in these Vertical Pink Farms and the results are remarkable. Vertical Pink Farms will use blue and red LED lighting to grow organic, pesticide free, climate controlled food inside indoor environments. Vertical Pink Farms use less water, less energy and enable people to grow food underground or indoors year round in any climate. Traditional food grown on outdoor farms are exposed to the full visible light spectrum. This range includes Red, Orange, Yellow, Green, Blue and Violet. However, agricultural science is now showing us that O, Y, G and V are not necessary for plant growth. You only need R and B.LED lights are much more efficient and cooler than indoor florescent grow lights used in most indoor greenhouses. LED lights are also becoming less expensive as more companies begin to invest in this technology. Just like the solar and electric car revolution, the change will be exponential. By 2025, we may see massive Vertical Pink Farms in most major cities around the world.

5 ways vertical farms are changing the way we grow food

(http://www.npr.org/sections/thesalt/2013)

Vertical farms can defy any weather
Vertical farms are a great response to climate change
Vertical farms adapt to disaster
Vertical farms are becoming more advanced
Vertical farms are saving lives

Fig 4: Vertical pink farming

We may even see small Vertical Pink Farm units in our homes in the future (Figure 4).

Leading agriculture's pink revolution is, perhaps unsurprisingly, Japan. The numbers are pretty impressive the country's largest indoor vertical pink farm produces 10,000 heads of lettuce per day. That's 100 times more per square foot than traditional methods! And this is achieved with 40 percent less power, 80 percent less food waste and 99 percent less water usage than outdoor fields. And it's fast catching on across Asia. The farm in question has already announced a new facility using the same technologies in the works in Hong Kong, with Mongolia, Russia and mainland China on the agenda. As for the rest of the world, farmers in North America are definitely on board, with Green Sense Farm showing the way; it produces 4,000 cases of fresh produce in a week. Less water, waste, energy and surface area needed, and high yield.

Heat energy: Many environmental changes are innocuous with respect to crop yield, production, and quality, but others are either beneficial or harmful to crops. Observational evidence indicates that recent regional changes in climate, particularly temperature increases, have already affected a diverse set of physical and biological system in many parts of the world (Beggs, 2004). Furthermore, with intensive agriculture, soil degradation and particularly salinization are becoming major concerns. Added to these stress comes, a threat-global environmental change resulting from increased green house gas concentrations in the atmosphere because of anthropogenic activities. In contrast, post-flowering conditions affect yield mainly by influencing ovary or seed abortion, or by changing seed filling duration (SFD) or seed filling rate (SFR). In general, SFD is more plastic than SFR. In spite of the importance of individual seed size, yield variation is more often due to changes in seed number per unit of ground area than to individual seed mass at maturity. Warming hastens crop development and therefore shortens the SFD. Seed number can be reduced *via* the direct effects of high temperature on reproduction, particularly pollen formation and function. Because warming speeds reproductive development, the seeds that do develop are often small. Although SFR is sometimes stimulated by warming, this effect often does not fully compensate for shortened SFD

The seeds of some species have physical dormancy and the inherent hard seed coat might have been cracked through exposure to fire, making it possible for water absorption and subsequent germination of the seeds (Baskin, 2003). The hard seed coats of some species are cracked and become permeable following the effect of fire as in the case of some *Acacia* tree species (Walters *et al.*, 2004). Hard seed coat imposes physical dormancy on seeds, causing delays in the seed germination (Mohammadi *et al.*, 2012). Removal of restriction on water imbibitions by seeds as a result of hard seed coat may be effected through the application of various dormancy breaking treatments, including application of heating under constant temperatures (Wahab, 2011), high and highly fluctuating temperatures (Mckeona and Mott, 1982) to promote early seed germination. Heat treatment of *C. olitorius* seeds is often recommended for farmers to attain early seed germination and seedling emergence. Unchilled seeds of *C. olitorius* subjected to a temperature treatment of 25ºC did not germinate but pre-chilling followed by temperature of 35ºC treatment produced 88% seed germination (Nkomo and Kambizi, 2009). Constant temperature of 30ºC with light applied for 8hrs per day was suggested for the *Corchorus spp.* seed germination test in gene banks. In a laboratory experiment by Wahab (2011), optimum seed germination of *C. olitorius* was obtained from seeds that were subjected to a constant dry heat pre-treatment at 90ºC for five minutes while other five dry heat temperature regimes tested (40ºC; 50ºC; 60ºC; 70ºC and 80ºC) produced varying percentage germination.

The influence of high dry heat treatment of three accessions of *Corchorus olitorious* seeds on seed germination, seedling emergence and seedling vigour was evaluated in Nigeria. The result revealed that there were significant differences in the viability and vigour responses of the crop seed to the varying heat treatments; where seed germination and seedling emergence were initiated at 80ºC, but optimum seed germination, seedling emergence and seedling vigour index were obtained at 120ºC for 5 minutes of exposure (Table 12). Therefore indication that there may be corresponding increase in seed germination and seedling emergence of *C. olitorious* seed if it is exposed to higher temperature treatment(s) for 5 minutes (Denton *et al.,* 2013).

Umechuruba *et al.* (2013) studied dry heat and hot water treatment of seeds of *Solanum gilo* and the resultant effect on percentage seed germination. In dry heat treatment (oven) of seeds at 60ºC for 20, 40 and 60 minutes significantly resulted in higher percentage seed germination when compared with treatment at 30ºC and 90ºC. The highest percentage germination was recorded at 60ºC for 40 minutes (83.26% and 81.00%). Seed germination reduced significantly at 90ºC for 20 minutes and completely inhibited in seeds treated at 90ºC for 40 and 60 minutes. In hot water treatment the seed germination recorded on seeds treated at

Table 12: Means of percentage germination, seedling length and seedling vigour index for *Corchorus olitorius* seeds under five temperature regimes.

Temperature	Germination (%)	Seedling length (cm)	vigour index
80°c	79.56^{e}	2.71^{e}	215.77^{e}
90°c	82.00^{d}	3.36^{d}	275.50^{d}
100°c	84.89^{c}	3.56^{c}	302.22^{c}
110°c	88.00^{b}	3.75^{b}	330.32^{b}
120°c	90.44^{a}	4.20^{a}	377.23^{a}

(Source: Denton *et al.,* 2013)

30ºC at 20, 40 and 60 minutes were not significantly higher than those of untreated seeds in the two samples Hot water treated seeds at 60ºC for all the time periods gave percentage seed germination that was significantly higher than the control. The highest percentage seed germination for both samples of 79.21% and 70.12% respectively was recorded by seeds given hot water treatment at 60ºC for 40 minutes. Seeds given 90°C treatments at 40 and 60 minutes gave no germination.

Sangeeta (2016) studied the effect of temperature on seed germination of *Sida cordifolia L.* and the result revealed that the germination percentage increases with increasing temperature up to 40^0C but it decreases when temperature increasing from 40^0C. There is no germination at 60^0C. Seeds of *Sida cordifolia* lose their germinability with the increasing period of temperature in hours. The result revealed that alternate temperature treatment is quite effective in increasing the germination percentage of seeds. The best duration for such a treatment, however is limited to 12 hours storage in refrigerator at 5-7^0C and 12 hours in oven at 100^0 C, after which the percentage germination becomes very low.

CONCLUSION

Physical methods of seed treatment is an innovative area of research which improves yield of crops. Although, plant responses to the physical treatment, yet, it has not been fully exploited on commercial scale. During last two decades, commendable attempts have been made to increase yield by pre-sowing treatments. Heat treatment (dry heat and hot water) are alternative physical techniques in place of chemicals to reduce seed borne fungi and therefore increase in percentage germination of seed. The clear effect of high temperature on pollen production and pollen grain germination will have major implications on the fertilization process and fruit set in sensitive crop under future climates. Environmental changes have important implications, some positive and others negative, for future crop yield and production. Although, improvement in yield by application of this technology has been reported in several crops, yet the physiological and biochemical mechanisms by which electrical stimulus influences the yield is yet to be understood clearly. Further, there is a need to develop a simple and cost effective devise so that the technology could be popularized for effective usage.

REFERENCES

Aladjadjiyan, A. and Kakanakova, A. (2009). Physical methods in agro-food chain. *Journal of Central European Agriculture*. **9:** 789-793.

Ashraf, M. (2009). Biotechnological approach of improving plant salt tolerance using antioxidants asmarkers. *Biotech. Adv.* **27:** 84-93.

Ashraf, M., Cheema, A. A., Rashid M. and Qamar, Z. (2003). Effect of gamma rays on M1 generation in Basmati rice. *Pak. J. Bot.,* **35:** 791-795.

Bache D. H. and Macaskill, I. A. (1984). "Vegetation in civil and landscape engineering," in Vegetation in Civil and Landscape Engineering, Granada, London, p. 317.

Bai, X. D., Gao, P. X., Wang, Z. L. and Wang, E. G. (2003). Dual-mode mechanical resonance of individual ZnO nanobelts. *Appl. Phys. Lett.* **82:** 4806-4808.

Baskin, C. C. (2003). Breaking physical dormancy in seeds-Focussing on the lens. *New Phytol.* **158:** 229-232.

Baskin, C. C. and Baskin, J. M. (2014). Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination, 2nd edn. Academic Press, San Diego, CA.

Beggs, P.J. (2004). Impacts of climate change on aeroallergens: past and future. *Clin Exp Allergy*. **34:** 1507-1513.

Benford M. S. (2002). Implications of plant genome research to alternative therapies: A case for radiogenic metabolism in humans *J. Theoretics*. **4:** 1-14.

Borzouei, A., Kafi, M., Khazaei, H., Naseriyan, B. and Majdabadi, A. (2010). Effects of gamma radiation on germination and physiological aspects of wheat (*Triticum aestivum L.*) seedlings. *Pak. J. Bot.* **42:** 2281-2290.

Braam, J. and Davis, R. W. (1990). Rain-, wind-, and touch-induced expression of calmodulin and calmodulin-related genes in Arabidopsis, *Cell.* **60:** 357–364.

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:** 120-129.

Carbonell, M. V., Martinez, E. and Flores, M. (2005). Influencia de campos magneticos estacionarios de 125 mT en la germinación de semillas de girasol. *Revista Eidenar.* **1:** 34-39.

Chivukula, V. and Ramaswamy, S. (2014). Effect of different types of music on rosa chinensis plants. *Int. J. Environ. Sci. Dev.* **5:** 431.

Coghlan A., (1994). Good vibrations give plants excitations, *New Sci.*. **142:** 10.

Creath, K. and Schwartz, G. E. (2004). Measuring effects of music, noise, and healing energy using a seed germination bioassay. *J Altern Complem Med.* **10:** 113-122.

De Souza, A., Garcia, D., Sueiro, L., Licea, L. and Porras, E. (2005). Pre-sowing magnetic treatment of tomato seeds: effects on the growth and yield of plants cultivated late in the season. *Span J. Agric. Res.* **3:** 113-122

De Souza A., Garcia, D., Sueiro, L., Gilart, F., Porras, E. and Licea, L. (2006) Pre-sowing magnetic treatments of tomato seeds increase the growth and yield of plants. *Bioelectromagnetics*, **27:** 247-257.

De Villiers A.J., Van Rooyen, M. W. and Theron, G. K. (2002) Germination strategies of Strandveld Succulent Karoo plant species for revegetation purposes: I. Temperature and light requirements. *Seed Sci. & Technol*. **30:** 17-33.

Denton, O. A., Oyekale, K. O., Nwangburuka, C. C., Daramola, D. S. and Adeyeye, J. (2013) Influence of High Dry Heat Temperature on Seed Germination, Seedling Emergence and Seedling Vigour of three Cultivars of *Corchorus olitorious* Seeds. *Am J Res Comm.* **1:** 98-114.

Dinoev St., Antonov, M., Stoyanov, T. and Gerogieva, Chr. (2004). Spectral impact of low-power laser radiation on wheat and maize parameters. *Bulg Acad Sci*. 54.

Downs, R. J. and Thomas J. F. (1982). Phytochrome regulation of flowering in the long-day plant, Hyoscyamusniger. *Plant Physiol*. **70:** 898–900.

Flores, J., Jurado, E. and Chapa-Vargas, L. (2011). Seeds photoblastism and its relationship with some plant traits in 136 cacti species. *Environ Exp Bot*. **71:** 79-88.

Flores, J., Gonzalez-Salvatierra, C. and Jurado, E. (2015). Effect of light on seed germination and seedling shape of succulent species from Mexico. *J plant Ecol*. 1-6

Folta K. M. (2004). Green light stimulates early stem elongation, antagonizing light-mediated growth inhibition. *Plant Physiol*. **135:** 1407-1416.

Gagliano, M. (2012). Green symphonies: a call for studies on acoustic communication in plants, *Behav Ecol.* ars206.

Galland, P. and Pazur, A. (2005) Magnetoreception in plants. *J Plant Res.* **118:** 371-389.

Galt, S., Sandblom, J., Hamnerius, Y., Hjerik, P., Saalman, E. and Nardon, B. 1993. Experimental search for combined AC, DC magnetic field effects. *Bioeletromagnetics*, **14:** 315-327.

Garcia-Sancho, F. and Javier, P. (1994). Effects of extremely low-frequency electromagnetic fields on ion transportin several cells. *Bioenergetics*. **15:** 6-10.

Goins G. D., Yorio, N. C., Sanwo, M. M. and Brown, C. S. (1997). Photomorphogenesis, photosynthesis and seed yield of wheat plants grown under red light-emitting diodes (LEDs) with and without supplemental blue lighting. *J Exp Bot*. **48:** 1407-1413.

Hanafy, M. S., Husein, G. and Abdelmoty, E. (2005). Effect of 50 Hz 6 kV/m electric field on the protein molecular structureand the growth characteristics of the broad bean. *Phys Alive*. **13:** 41-54.

Hernandez A. C., Dominguez, P. A., Cruz- Orea A., Ivanov R., Carballo, C.A. and Zepeda, B. R. (2010). Laser in agriculture (Review). *Int.* Agrophys. **24:** 407-422.

Hicks C. (1963). "Growing corn to music," *Popular Mechanics*, **183:** 118-121.

Huang, R., Sukprakarn S., Phavaphutanon L., Juntakool, S. and Chaikul, C. (2006). A comparison of electric field treatments to hydropriming on cucumber seed germination enhancement. *Kasetsart J (Nat Sci)*. **40:** 559-65.

Jiang, X. L. (1981). A preliminary experimental report on killing pests by laser. (Liangsh; zhuzangHubifood school, wuhan, china. **4:** 33-36.

Jones D. B., Bolwell, G. P. and Gilliat, G. J. (1986). Amplification,by pulsed electromagnetic fields, of plantgrowth regulator phenylalanine ammonialyase during differential in suspension cultured plant cells. *Bioelectricity*, **5:** 1-12.

Kelentarov, M. I. (1961). The Use of high voltage electrical current on cotton production. *J Azerbaijan Sci Acad*. **17:** 25-29.

Khurana E. and Singh, J. S. (2001) Ecology of tree seed and seedlings: implications for tropical forest conservation and restoration. *Curr Sci*. **80:**748–57.

Kiatgamjorn, P., Khan-ngern, W. and Nitta, S. (2002). The Effect of Electric Field on Bean Sprout Growing. In International Conference on Electromagnetic Compatibility (ICEMC2002), Bangkok, *Thailandededs*. 237-241.

Kim, H. H., Goins, G. D., Wheeler, R. M. and Sager, J. C. (2004). Green- light supplementation for enhanced lettuce growth under red and blue light-emitting diodes. *Hort Sci.,* **39:**1617-1622.

Kovacs, E. and Keresztes, A. (2002). Effect of gamma and UV-B/C radiation on plant cell. Micron.

Kuzin A. M., Vagabova M. E., Vilenchk, M. N. and Gogvadze, V. G. (1986). Stimulation of plant growth by exposure to low levelã'radiation and magnetic field, and their possible mechanism of action. *Environ Exp Botany*. **26:** 163-167.

Li, H., Tang, C., Xu Z., Liu, X. and Han, X. (2012). Effects of different light sources on the growth of non heading chinese cabbage (*Brassica campestris* L.). *J Agr Sci*. **4:** 262–273.

Lord A. E. (1975). Proceedings of the Technical Program, in *Proc. National Noise and Vibration Control Conference*, Chicago, Illinois. Acoustical Publications. Inc.

Lynikiene, S., Pozeliene, A. and Rutkauskas, G. (2006). Influence of corona discharge field on seed viability and dynamics of germination. Institute of Agricultural Engineering. Lithuanian Agricultural University. Raudondvaris. Kaunor.L.T.54132. Lithuania.

Mckeona, G. M. and Mott, J. J. (1982). The effect of temperature on the field softening of hard seed of *Sylosanthes humilis* and *S. hamate* in a dry monsoonal climate. *Aust J Agr Res.* **33:**75-85.

Mitchell, C. A., Both, A., Bourget, C. M., Kuboto, C., Lopez, R. G., Morrow, R. C. and S. Runkle, (2012). LEDs: The future of greenhouse lighting. *Chronica Horticulture*. **55:** 6-12.

Mohammad, M. R. and Abdollah, B. (2011). Influence of Gamma Irradiation on Some Physiological Characteristics and Grain Protein in Wheat (*Triticum aestivum* L.). *World Appl Sci J.* **15:** 654-659.

Mohammadi, G., Khah, E. M., Honarmand, S. J., Shirkhani, A. and G. Shabani. (2012). Effects of Seedhardness Breaking Techniques on Okra (*Abelmoschus esculentus* L.) Germination. *Int J Agric Crop Sci.,* **4:** 264-273.

Morar, R., Munteanu, R., Simion, E., Muteanu, I. and Dascalescu, L. (1999). Electrostatic treatment of bean seeds, IEEE-IA. **35:** 208-212.

Mustafayev, S. A. (1974). Using of high voltage electrical current on obtaining early maturing cotton cultivars. In Proceeding of the Conference of USSR on Science and Social Sciences, Baku-Azerbaijan, 150-153.

Nedialkov, N., Nenov, S. and Parmakov, D. (1996). Pre-sowing treatment of seeds by magnetic field. Zemes Ukio Inzinerija, Nokslo Darbai. **27:** 141-150.

Nenadic, K., Franjo, J. and Stjepan, P. (2008). An investigation of automatic treatment of seeds with low power laser beam. *Automatika*. **49:** 127-13.

Nimmi, V. and Madhu, G. (2009). Effect of pre-sowing treatment with permanent magnetic field on germination and growth of chili (*Capsicum annun L.*). *Int. Agroph*. **23:** 195-198.

Nkomo, M. and Kambizi, L. 2009. Effects of pre-chilling and temperature on seed germination of *Corchorus olitorius* L. *Afr J Biotech*. **8:** 1078-1081.

Ozel, B. (2003). High voltage electrical current on the yield and yield components of different bread wheat cultivars. M.Sc Thesis, University of Kahramanmaras Sutcu Imam. Institute of Natural and Applied Sciences. Department of Field Crops, Turkey.

Pietruszewski, S. and Martinez, E. (2015). Magnetic field as a method of improving the quality of sowing material: a review. *Int Agrophys.* **29:** 377-389.

Pietruszewski, S., Muszynski, S. and Dziwulska, A. (2007), Electromagnetic fields and electromagnetic radiation as non-invasive external stimulants for seeds (selected methods and responses). *Int Agrophys.* **21:** 95.

Podlesny, J., Stochmal, A., Podlesna, A. and Misiak, L. E. (2012). Effect of laser light treatment on some biochemical and physiological processes in seeds and seedlings of white lupine and faba bean. *J Plant Growth Regul*. **67:** 227-233.

Pons, T. L. (2000) Seed responses to light. In Fenner M (ed). Seeds: The Ecology of Regeneration in Plant Communities, 2nd ed. Wallingford, UK: CABI Publishing, 237–60.

Putincev, A. F. and Platonova, N. A. (1997). Treatment of seed in electromagnetic field (in Russian). *Agriculture*, 4: 45-46.

Rojas-Arechiga, M., Orozco-Segovia, A. and Vazquez-Yanes, C. (1997) Effect of light on germination of seven species of cacti from the Zapotitlan Valley in Puebla, Mexico. *J. Arid. Environ.* **36:** 571–8.

Roney-Dougal, S. M. and Solfvin, J. (2002). Field study of enhancement effect on lettice seeds: Their germination rate, growth and health. *J Soc Psychical Res.* **66:** 129–143.

Rotcharoen, T., Khan-ngern, W. and Nitta, S. (2002). The effect of electric field to rice plant growing. ICEMC, Bangkok.

Saebo, A., Krekling, T. and Appelgren, M. (1995). Light quality affects photosynthesis and leaf anatomy of brich plantlets *in vitro*. *Plant Cell Tiss Org*. **41:**177–185.

Samy, C. G. (1998). Magnetic seed treatment. I . Influence on flowering, siliqua and seed characters of cauliflower. *Orissa* J. *Hort*. **26:** 68-69.

Sangeeta, M. (2016). Effect of temperature and light on the seed germination of *Sida cordifolia L. Int J Scientific & Res Publ.* **6:** 264-266.

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. *Eur J Exp Biol.* **3:** 126-134.

Simpson, G. G. and Dean, C. (2002). *Arabidopsis*, the Rosetta stone of flowering time? Science. **296:** 285-289.

Singh, B. and Datta P. S. (2009). Gamma irradiation to improve plant vigour, grain development, and yield attributes of wheat. *Radiat Phys Chem.* 1-5.

Singh, D., Basu, C., Meinhardt-Wollweber, M. and Roth, B. (2015). LEDs for energy efficient greenhouse lighting. *Renewable Sustainable Energy Rev.* **49:** 139-147.

Smigel, V. N., Kovalenko A. F. and Babitsin G. S. (1968). Shocking of potato before planting with high voltage electrical current. *Journal of Mechanization and Electrification Research Institute of Celyabinsk*, **31:** 76-82.

Stange, B. C., Rowland, R. E., Rapley B. I. and Podd, J. V. (2002). ELF magnetic fields increase aminoacid uptake into *Vicia faba* L. roots and alter ion movement across the plasma membrane. *Bioelectromagnetics*. **23:** 347-354.

Stutte, G. W., Edney, S. and Skerritt, T., (2009). Photoregulation of bioprotectant content of red leaf lettuce with light-emitting diodes. *Hort Science.* **44:** 79–82.

Umechuruba, C. I., Bassey, I. N. and Harold, K. O. (2013). Effect of Physical Treatments on Seed Germination of *Solanum gilo* Raddi grown in Akwa Ibom State. *Acad for Environ & Life Sci.* **2:** 27- 30.

Vasilevski, N. L. (2003). Bergman space structure, commutative algebras of Toeplitz operators, and hyperbolic geometry. *Integr Equat Oper Th.* **46:** 235-251.

Wahab, O. D. (2011). Effect of Dry Heat Temperature on Seed Germination and Seedling Emergence of three Cultivars of *Corchorus olitorious* Seeds. *B. Agric. Project Report.* Department of Agronomy and Landscape Design, Babcock University, Nigeria. 32pp.

Walters, M., Midgley, J. and Somers, M. J. (2004). Effects of fire and fire intensity on the germination and establishment of *Acacia karroo*, *Acacia nilotica*, *Acacia luederitzii* and *Dichrostachys cinerea* in the field. *BMC ecology*, 4.

Weinman, R. (2000). The Recovery of VortexHealing. In: London and Southeast Connection. Series The Recovery of VortexHealing. Online document at: www.vortexhealing.com.

Yanagi, T. and Okamoto. K. (1997). Utilization of super-bright light emitting diodes as an artificial light source for plant growth. *Acta Hort.* **418:** 223-228.

Yesim, K., Zeynep, E. and Havser E. V. (2015). The Effect of Different Gamma Radiation Applied on Tokak-157/37 Barley (*Hordeum vulgare*) and Karahan-99 Wheat (*Triticum aestivum*) on M1 Generation. *International Journal of Secondary Metabolite*, **2:** 8-12.

Yia J., Bochua, W., Xiujuana, W. and Daohonga, W. (2003). "Effect of sound wave on the metabolism of Chrysanthemum roots," *Colloids and Surfaces B: Biointerfaces*, **29:** 115-118.

Yiyaoa L., Wanga, B., Xuefenga, L., Chuanrena, D. and Sakanishib, A. (2002). "Effects of sound field on the growth of Chrysanthemum callus," *Colloids and Surfaces B: Biointerfaces.* **24:** 321-329.

www.btinternet.com/nlpwessex/ Documents/quantumbiology.htm

www.npr.org/sections/thesalt/2013/05/21/185758529/vertical-pinkhouses-the-future-of-urban-farming