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Effect of pulsed electromagnetic field treatment on seed quality enhancement and storage in soybean

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ABSTRACT An experiment was conducted to study the effects of pulsed electromagnetic field treatment on seed quality of fresh and revalidated seeds of soybean cv. JS9305 at Seed Quality Testing and Research Laboratory, National Seed Project (NSP), University of Agricultural Sciences, Dharwad. Seedswere exposed in four pulsed electromagnetic field treatment frequencies *viz.*, control(untreated), 1Hz, 10Hz, 50Hz and 100Hz. The seed quality parameters were influenced by the pulsed electro-magnetic field treatment in both fresh and revalidated seed. Among the seed lot the effect of pulsed electromagnetic field treatments was more pronounced by recording higher seed quality parameter as compared to revalidated seed lot during the storage period. Irrespective of pulsed electromagnetic field treatments, significantly higher germination (61.87%), seedling dry weight (0.80g), vigour index (62),protein content(35.39%) and oil content (16.13%) of seeds recorded from the fresh seed lot (L_1) compared to revalidated seed lot (L_2) during the storage period. Among pulsed electromagnetic field treatments the 50Hz (F_4) recorded enhanced seed quality parameters by registering higher seed germination (62.67%), seedling dryweight(0.77g), vigour index (63), seed protein content (35.20%) and seed oil content (15.79%) compared to untreated seeds at the end of ten months of storage period.

Keywords: Soybean, pulsed electro-magnetic, germination, vigour

In the evolution process, earth's magnetic field is considered as a natural phenomenon of the environment for all living organism alike plants and animals. The effect of magnetic fields on seed germination, plant growth, biochemical changes and yield has been the subject of intense research in recent years, but a systematic study is necessary to locate the exact mechanism of magnetic action on tissues and to identify its useful applications in seed quality performance. The uses of specific and highly safe, natural approach of extremely low frequency magnetic fields on biological systems like dry seeds of field crops, silkworm eggs, plant propagules and in horticultural seeds have shown marked effect on these systems when exposed to pulsed magnetic field (PMF). An alternating current surging forward and backward in a coil winding generates a magnetic field surging back and forth in the coil along its axis. Such a magnetic field is referred to as the PMF. Exposure ofseeds to pulsed electromagnetic field before planting to change and stimulate a series of biochemical and biological effects in seeds and plants to achieve the goal of optimizing seed quality [1].

The positive impact of electro-magnetic impulses on seed germination and growth may be caused not only by the current induced but probably also by ionic or parametric resonance. These effects can be caused through the interaction of cell synthesis with electromagnetic impulse stimulation at the level of intracellular signals. The effect of electromagnetic field on plant growth and development has been investigated in a large number of plant species. However, the mechanism of these actions is still not clearly

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understood and feasibility of the effect of magnetic field being beneficial for plants and animals has been discussed for more than a century.

The present study has been attempted to analyse the positive effect of pulsed electromagnetic field treatment on seed storage and enhancement of seed quality parameters of soybean and also worked on screening the optimum frequency of pulsed electromagnetic field treatment to enhance storage potentialityof soybean fresh and revalidated seedlots.

MATERIALS AND METHODS

The Fresh and revalidated seeds lots of soybean cv. JS9305 were treated with electro-magnetic field with the help of pulsed electro-magnetic set up at Madras Institute of Magnetobiology (MIM), Chennai. Both fresh and revalidated were exposed to four different frequencies of pulsed electro-magnetic field treatment (PMF): 1, 10, 50 and 100Hz and unexposed seeds were considered as control.

Treated seeds were packed in HDPE bag and stored under room condition at Seed Quality Testing and Research Laboratory, National seed project, University of Agricultural Sciences, Dharwad for ten months. The observationson seed quality parameters were recorded at bimonthly interval during storage period

Protocol

Two soybean lots of differentvigour levels were used for the treatment. Each lot was subjected to electro-magnetic field (EMF) exposure for standardization of EMF frequency (Hz). Other parameter such as the intensity(1500 nT), wave form (sine wave) and the duration of exposure (5 h a day for 15 days) were remained same as standardised by the Madras Institute of Magnetobiology (MIM).

RESULTS AND DISCUSSION

Exposure of soybean seeds to different frequencies of pulsed electro-magnetic field treatment significantly improved seed quality and storability performance during the storage period.

The results of seed germination percentage as influenced by pulsed electro-magnetic treatment (PMF) during storage are presented in Table 1. With the advancement of storage period, the average germination percentage declined from 84.23 percent at the initial stage to 44.03 per cent at the end of storage period, irrespective of pulsed electro-magnetic treatment (PMF) and between the seed lots.

The significant differences among seed lots, pulsed electro-magnetic field frequency treatments and their interaction combinations were observed at the end of ten months of storage period. The seed germination was influenced by the age of seed lots. Fresh seed lot recorded significantly higher Seed germination 87.0 percent and revalidated lot was 81.47 percent at initial storage period and it was declined to 61.87 percent and 54.20 percent, respectively at the end of ten month of storage. There were no significant differences in different electro-magnetic field frequency treatments and their interaction combinations at initial period.

At the end of ten months of storage period, pulsed electro-magnetic field frequency treatment 50Hz (F_4) recorded significantly highest germination (62.67%) compared to control (52.83 %) (F_1). Between the interaction combination fresh seed lot treated with 50Hz (L_1F_4) and revalidated seed lot treated with 100 Hz (L_2F_5) recorded significantly highest germination (69.33 and 57.33 % respectively) compared to fresh seed lot and revalidated seed lot without pulsed electro-magnetic field frequency treatment 54.33 (L_1F_1) and 51.33 % (L_2F_1), respectively. It

Table1. Effect of pulsed electromagnetic field treatment on seed germination (%) of Soybean

Treatments	Months after storage					
	0	2	4	6	8	10
Seed lots (L)						
L_1	87.00 (68.91)	83.67 (66.15)	78.47 (62.36)	73.00 (58.68)	69.13 (56.25)	61.87 (51.89)
L_2	81.47 (64.50)	79.53 (63.08)	72.73 (58.53)	67.67 (55.35)	62.47 (52.22)	54.20 (47.39)
Mean	84.23 (66.71)	81.60 (64.62)	75.60 (60.45)	70.33 (57.02)	65.80 (54.24)	58.03 (49.64)
SEm±	0.52	0.26	0.48	0.37	0.45	0.35
CD (p=0.01)	2.08	1.03	1.93	1.48	1.83	1.41
PMF (F)						
F_1	83.67 (66.27)	80.67 (63.92)	73.67 (59.18)	67.50 (55.28)	61.83 (51.86)	52.83 (46.61)
F_2	84.33 (66.79)	81.83 (64.80)	74.33 (59.60)	69.17 (56.29)	65.50 (54.04)	55.50 (48.14)
F_3	85.33 (67.58)	81.67 (64.67)	76.00 (60.68)	70.00 (56.79)	65.33 (53.95)	58.17 (49.71)
F_4	83.83 (66.39)	82.00 (64.90)	77.50 (61.73)	72.50 (58.37)	69.33 (56.38)	62.67 (52.39)
F_5	84.00 (66.51)	81.83 (64.80)	76.50 (61.04)	72.50 (58.37)	67.00 (54.96)	61.00 (51.35)
Mean	84.23 (66.71)	81.60 (64.62)	75.60 (60.45)	70.33 (57.02)	65.80 (54.24)	58.03 (49.64)
SEm±	0.82	0.40	0.76	0.58	0.72	0.56
CD (p=0.01)	NS	NS	NS	2.35	2.89	2.24
L×F						
L_1F_1	86.33 (68.33)	82.67 (65.37)	77.33 (61.59)	71.33 (57.61)	65.00 (53.73)	54.33 (47.47)
L_1F_2	87.00 (68.95)	84.00 (66.42)	77.67 (61.79)	72.33 (58.25)	69.00 (56.15)	57.67 (49.39)
L_1F_3	88.33 (70.03)	83.67 (66.16)	78.67 (62.47)	72.33 (58.24)	69.00 (56.17)	63.33 (52.71)
L_1F_4	86.33 (68.39)	83.67 (66.14)	80.33 (63.65)	74.33 (59.54)	72.00 (58.03)	69.33 (56.35)
L_1F_5	87.00 (68.85)	84.33 (66.67)	78.33 (62.30)	74.67 (59.76)	70.67 (57.18)	64.67 (53.51)
L_2F_1	81.00 (64.20)	78.67 (62.48)	70.00 (56.77)	63.67 (52.94)	58.67 (49.98)	51.33 (45.75)
L_2F_2	81.67 (64.63)	79.67 (63.17)	71.00 (57.41)	66.00 (54.32)	62.00 (51.93)	53.33 (46.89)
L_2F_3	82.33 (65.13)	79.67 (63.17)	73.33 (58.89)	67.67 (55.33)	61.67 (51.73)	53.00 (46.70)
L_2F_4	81.33 (64.39)	80.33 (63.66)	74.67 (59.81)	70.67 (57.19)	66.67 (54.72)	56.00 (48.43)
L_2F_5	81.00 (64.17)	79.33 (62.94)	74.67 (59.78)	70.33 (56.99)	63.33 (52.74)	57.33 (49.20)
Mean	84.23 (66.71)	81.60 (64.62)	75.60 (60.45)	70.33 (57.02)	65.80 (54.24)	58.03 (49.64)
SEm±	1.16	0.57	1.07	0.82	1.02	0.79
CD (p=0.01)	NS	NS	NS	NS	NS	3.16

* Figures in the parentheses indicate arc sign transformed values. NS: Non Significant

L_1 : Fresh lot
L_2 : Revalidated lot

F_1 : Control
F_2 : 1 Hz
F_3 : 10Hz
F_4 : 50Hz
F_5 : 100Hz

was observed that increase in germination percentage, emergence of seeds and seedling vigour in pulsed electro-magnetic field treated seeds may be due to overall stimulating effect particularly bio-stimulation of the germination and increased physiological activity on seed [2- 4].

Seedling dry weight as influenced by effect of pulsed electro-magnetic treatment during storage are presented in Table 2. With the advancement of storage period, the average seedling dry weight declined from 1.10 g at the initial stage to 0.75 g at the end of storage period, irrespective of pulsed electro-magnetic treatment (PMF) and between the seed lots.

Seedling dry weight (mg) was found to be significant due to the application of pulsed electro-magnetic treatments at initial period of storage. Significantly higher seedling dry weight (1.13g) was recorded in fresh seed lot (L_1) compared to revalidated seed lot (L_2) (1.07g). However, there were no significant differences between pulsed electro-magnetic field frequencytreatments and their interaction combinations.

After the tenth month of storage period, seed lots and pulsed electro-magnetic treatments differ significantly for seedling dry weight. Between the seed lots fresh seed lot (L_1) recorded significantly higher seedling dry weight (0.80g) as compared to revalidated seed lot (L_2) (0.71g). The pulsed electro-magnetic field frequency 50 Hz (F_4) recorded significantly higher seedling dry weight (0.78g) compared to control (F_1) (0.73g). There were no significant differences in interaction combinations. Improvement in seedling dry weight by effect of pulsed electro-magnetic treated seed as compared to untreated seed may due to an increased rate of cell division in root tip and earlier start of emergence [5].

The result on seedling vigour index as influenced by pulsed electro-magnetic treatments are presented in Table.3. The average seedling vigour indexdecreased from 92.45 at the initial stage to 58.03 after ten months of storage irrespective of pulsed electro-magnetic treatments and between the seed lots. Significantly highest vigour index (98) recorded in fresh seed lot (L_1) compared to revalidated seed lot (L_2) (87). There was non-significant results showed in pulsed electro-magnetic field frequency treatments and their interaction combination at initial period of storage.

Seedling vigour index due to pulsed electro-magnetic treatments differed significantly in seed lots, pulsed electro-magnetic field frequency treaments and their interaction at the end of ten months of storage period. Among the seed lots highest seed vigour index (62) was recorded in fresh seed lots (L_1) compared to revalidated lot (L_2) (54). In different pulsed electromagnetic field frequencytreatments highest vigour index (63) was observed in 50Hz treatment (F_4) compared to control (F_1) (53). The highest seed vigour indices (69) was recorded in fresh seed lot treated with 50 Hz treatment (L_1F_4) and where in revalidated seed lot seed treated with pulsed electro-magnetic field frequency treaments (L_2F_5) recorded highest seed vigour index (57) compared to other treatment combination.

Seedling vigour index increased with respect to electro-magnetic treatment may be due to increase in physiological activity, increased moisture absorption and length of roots in treated seeds [6].

The readings on seed protein content (%) during storage are presented in Table 4. With the advancement of storage period, the average seed protein content percentage declined from 37.28 percent at the initial stage to 35.01 percent at the end of advancement of storage period, the average seed oil content percentage declined from 17.96 percent at the initial stage to 15.52 percent at the end of

Table 2. Effect of pulsed electromagnetic field treatment on seedling dry weight (g/10 seedlings) of soybean

Treatments	Months after storage					
	0	2	4	6	8	10
Seed lots (L)						
L_1	1.13	1.10	1.04	1.00	0.89	0.80
L_2	1.07	1.03	1.00	0.88	0.81	0.71
Mean	1.10	1.06	1.02	0.94	0.85	0.75
SEm±	0.002	0.005	0.003	0.003	0.005	0.003
CD (p=0.01)	0.009	0.021	0.011	0.013	0.019	0.010
PMF (F)						
F_1	1.10	1.06	1.01	0.93	0.82	0.73
F_2	1.10	1.06	1.02	0.93	0.84	0.75
F_3	1.09	1.06	1.02	0.94	0.86	0.75
F_4	1.10	1.07	1.03	0.96	0.87	0.78
F_5	1.10	1.07	1.03	0.95	0.87	0.77
Mean	1.10	1.06	1.02	0.94	0.85	0.75
SEm±	0.004	0.008	0.004	0.005	0.008	0.004
CD (p=0.01)	NS	NS	NS	0.021	0.031	0.016
L×F						
L_1F_1	1.12	1.09	1.03	0.99	0.86	0.78
L_1F_2	1.13	1.09	1.04	0.99	0.87	0.79
L_1F_3	1.13	1.10	1.04	1.00	0.91	0.80
L_1F_4	1.13	1.11	1.05	1.01	0.92	0.83
L_1F_5	1.12	1.10	1.05	1.01	0.91	0.82
L_2F_1	1.07	1.02	1.00	0.87	0.79	0.68
L_2F_2	1.06	1.03	1.00	0.87	0.81	0.70
L_2F_3	1.06	1.03	1.00	0.89	0.81	0.70
L_2F_4	1.06	1.03	1.00	0.90	0.83	0.73
L_2F_5	1.08	1.03	1.01	0.89	0.82	0.72\
Mean	1.10	1.06	1.02	0.94	0.85	0.75
SEm±	0.005	0.012	0.006	0.007	0.011	0.006
CD (p=0.01)	NS	NS	NS	NS	NS	NS

NS: Non Significant

L_1 : Fresh lot
L_2 : Revalidated lot

F_1 : Control
F_2 : 1 Hz
F_3 : 10Hz
F_4 : 50Hz
F_5 : 100Hz

Table 3. Effect of pulsed electromagnetic field treatment on seed vigour index (Germination×Seedling dry weight) of soybean

Treatments	Months after storage					
	0	2	4	6	8	10
Seed lots (L)						
L_1	98	84	78	73	69	62
L_2	87	80	73	68	62	54
Mean	92.45	81.6	75.6	70.33	65.8	58.03
SEm±	0.73	0.337	0:71	0.6	0.76	0.609
CD (p=0.01)	2.94	1.36	2.86	2.41	3.06	2.45
PMF (F)						
F_1	92	81	74	68	62	53
F_2	93	82	74	69	66	56
F_3	94	82	76	70	65	58
F_4	92	82	78	73	69	63
F_5	92	82	77	73	67	61
Mean	92.45	81.6	75.6	70.33	65.8	58.03
SEm±	1.16	0.53	1.12	0.95	1.20	0.96
CD (p=0.01)	NS	NS	NS	3.82	4.84	3.88
L×F						
L_1F_1	97	83	77	71	65	54
L_1F_2	99	84	78	72	69	58
L_1F_3	100	84	79	72	69	63
L_1F_4	97	84	80	74	72	69
L_1F_5	98	84	78	75	71	65
L_2F_1	86	79	70	64	59	51
L_2F_2	87	80	71	66	62	53
L_2F_3	87	80	73	68	62	53
L_2F_4	87	80	75	71	67	56
L_2F_5	87	79	75	70	63	57
Mean	92.45	81.6	75.6	70.33	65.8	58.03
SEm±	1.63	0.75	1.59	1.34	1.70	1.36
CD (p=0.01)	NS	NS	NS	NS	NS	5.481

NS: Non Significant

L_1 : Fresh lot
L_2 : Revalidated lot

F_1 : Control
F_2 : 1 Hz
F_3 : 10Hz
F_4 : 50Hz
F_5 : 100Hz

Table 4. Effect of pulsed electromagnetic field treatment on seed protein content (%) of soybean

Treatments	Months after storage					
	0	2	4	6	8	10
Seed lots (L)						
L_1	37.73	37.19	36.91	36.30	35.97	35.39
L_2	36.83	36.32	36.08	35.64	35.22	34.64
Mean	37.28	36.75	36.49	35.97	35.59	35.01
SEm±	0.04	0.01	0.01	0.01	0.01	0.01
CD (p=0.01)	0.15	0.05	0.05	0.05	0.03	0.04
PMF (F)						
F_1	37.25	36.72	36.42	35.83	35.47	34.79
F_2	37.25	36.73	36.46	35.92	35.53	34.90
F_3	37.32	36.74	36.51	35.98	35.60	35.05
F_4	37.31	36.78	36.55	36.09	35.71	35.20
F_5	37.29	36.80	36.53	36.03	35.66	35.14
Mean	37.28	36.75	36.49	35.97	35.59	35.01
SEm±	NS	NS	NS	0.02	0.01	0.02
CD (p=0.01)	0.24	0.08	0.08	0.08	0.04	0.07
L×F						
L_1F_1	37.63	37.09	36.84	36.19	35.82	35.13
L_1F_2	37.69	37.14	36.85	36.23	35.90	35.26
L_1F_3	37.87	37.19	36.94	36.31	36.00	35.43
L_1F_4	37.73	37.27	36.96	36.43	36.09	35.57
L_1F_5	37.72	37.24	36.93	36.34	36.03	35.54
L_2F_1	36.86	36.34	36.00	35.47	35.12	34.44
L_2F_2	36.80	36.31	36.06	35.61	35.16	34.54
L_2F_3	36.77	36.29	36.08	35.64	35.19	34.66
L_2F_4	36.89	36.28	36.13	35.74	35.33	34.82
L_2F_5	36.86	36.36	36.13	35.72	35.28	34.73
Mean	37.28	36.75	36.49	35.97	35.59	35.01
SEm±	0.09	0.03	0.03	0.03	0.02	0.02
CD (p=0.01)	NS	NS	NS	NS	NS	NS

NS: Non Significant

L_1 : Fresh lot
L_2 : Revalidated lot

F_1 : Control
F_2 : 1 Hz
F_3 : 10Hz
F_4 : 50Hz
F_5 : 100Hz

Table 5. Effect of pulsed electromagnetic field treatment on seed oil content (%) of soybean

Treatments	Months after storage					
	0	2	4	6	8	10
Seed lots (L)						
L_1	18.33	18.08	17.71	17.22	16.81	16.13
L_2	17.60	17.26	16.82	16.16	15.63	14.91
Mean	17.96	17.67	17.26	16.69	16.22	15.52
SEm±	0.01	0.01	0.01	0.01	0.01	0.01
CD (p=0.01)	0.03	0.03	0.03	0.03	0.04	0.04
PMF (F)						
F_1	17.91	17.62	17.15	16.51	15.97	15.23
F_2	17.99	17.64	17.26	16.60	16.03	15.39
F_3	17.95	17.64	17.30	16.74	16.23	15.51
F_4	17.99	17.77	17.34	16.83	16.45	15.79
F_5	17.99	17.69	17.28	16.78	16.40	15.69
Mean	17.96	17.67	17.26	16.69	16.22	15.52
SEm±	0.01	0.01	0.01	0.01	0.01	0.02
CD (p=0.01)	0.05	0.05	0.04	0.05	0.06	0.06
L×F						
L_1F_1	18.31	18.04	17.65	17.04	16.63	15.94
L_1F_2	18.35	18.02	17.69	17.14	16.67	16.01
L_1F_3	18.33	18.04	17.72	17.30	16.87	16.14
L_1F_4	18.33	18.19	17.77	17.35	16.95	16.31
L_1F_5	18.35	18.11	17.69	17.27	16.91	16.25
L_2F_1	17.51	17.19	16.64	15.98	15.32	14.51
L_2F_2	17.62	17.26	16.83	16.06	15.40	14.76
L_2F_3	17.57	17.24	16.87	16.18	15.59	14.88
L_2F_4	17.64	17.34	16.91	16.30	15.94	15.26
L_2F_5	17.63	17.28	16.86	16.29	15.89	15.12
Mean	17.96	17.67	17.26	16.69	16.22	15.52
SEm±	0.02	0.02	0.02	0.02	0.02	0.02
CD (p=0.01)	NS	NS	0.06	0.07	0.08	0.09

NS: Non Significant

L_1 : Fresh lot
L_2 : Revalidated lot

F_1 : Control
F_2 : 1 Hz
F_3 : 10Hz
F_4 : 50Hz
F_5 : 100Hz

storage period, irrespective of pulsed electromagnetic treatments (PMF) and between the seed lots.

Significant difference was observed in seed lots treatments at the initial stage of storage period. Fresh seed lot (L_1) recorded highest seed oil content (18.33%) compared to revalidated seed lot (L_2) (17.60%). Among pulsed electro-magnetic treatments 50Hz (F_4) and 100Hz (F_5) registered significantly higher seed oil content (17.99 % each) as compared to control (17.91%)(F_1). There was no significant difference in the treatment combination.

The treatments differ significantly for seed oil content during tenth month of storage period. Highest seed oil content (16.13 %) was recorded in fresh seed lot (L_1) compared to revalidated seed lot (L_2)(14.91%). Highest seed oil content (15.79%) was recorded in 50 Hz treatment (F_4) and the least was (15.23%) in control (F_1). The fresh seed and revalidated seed lots treated with 50 Hz treatment (L_1F_4 and L_2F_4) were recorded highest seed oil content (16.31 and 15.26 % respectively) compared to other treatment combination.

In the present investigation noticed that pulsed electro-magnetic treated seeds are assumed to maintain enhanced seed oil content during the storage period due to bio-chemical process that involves free radicles and by stimulating the minerals, oil content in the seed and induced both activation of ions and polarization of dipoles in living cells [8].

In conclusion, exposure of fresh and revalidated soybean seed to pulsed electro-magnetic treatments significantly increased the seed performance. Among the different frequencies of pulsed electro-magnetic treatments 50Hz (F4) frequency exposure yielded superior results.

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