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Study of soybean seed quality and health in relation to electric field application during storage

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Abstract

Highly permeable seed coat of soybean seed imbibes moisture more easily leads to seed deterioration. Quality of soybean seed greatly influenced by seed moisture, temperature and relative humidity during storage. In order to prevent the quantitative and qualitative losses due to several biotic and abiotic factors during storage the application of electric field may be one of the effective tool. In view of this an experiment was laid out in factorial completely randomized design with three replications. Fresh and old seed lots of soybean seeds were treated with the combinations of different microwave power levels and exposure timings along with control. The seed quality parameters *viz:* germination, root shoot length, dry matter content, moisture content, seed mycoflora and vigour index were evaluated at 30 days interval. The treated seeds were kept in polythene bags for storage study. The study indicated that microwave power level and exposure timing had significant effect on seed quality during storage. The microwave power level of 80% with exposure timing of 20 sec. maintained better seed quality. Fresh seed lots of soybean variety JS 9305 was superior in retaining seed quality parameters during storage. However, old seed samples also improved their seed quality when applied microwave power levels.

Keywords: Seed deterioration, electric field, storage, seed quality, germination, vigour index

Introduction

Soybean is a miracle crop of the twentieth century. It has three benefits, a unique food, a valuable feed and an industrial raw material. Soybean contains about 40-42 per cent of protein, 20 per cent oil and a good source of vitamin-B complex, thiamin and riboflavin Gopalan *et al.* (1971) [11]. Soybean is also used in the preparation of antibiotics, bakery products, pharmaceuticals, confectionary, baby food, protein concentrates. Soybean fixes atmospheric nitrogen at the rate of 150-165 kg/ha/year. Due to this multifaceted advantages, soybean has progressed by leaps and bounds as an oil seed crop during last four decades.

Seed is an important basic and crucial input in agriculture. Availability of quality seed is the first and foremost requirement in higher seed production. Soybean seed quality deteriorates much faster than other crops. The production of high quality seed which could retains its viability during a storage period is a major challenge in most of the area of humid tropics and sub tropics. The rapid seed deterioration is thought to be due to lipid peroxidation subsequently resulting in loss of seed quality and viability. Soybean crop deteriorates faster than those of other crop (Priestely *et al.*, 1985) [22]. Seed deterioration leads to reduction in seed quality and germination per cent. In soybean, highly permeable seed coat contributes low storability. The storability of seed is largely determined by its inheritance, pre-storage, conditions and length of storage (Delouche *et al.*, 1973) [7].

In order to prevent the quantitative and qualitative losses due to several biotic and abiotic factors during storage electric and magnetic field applications are used as a non-chemical method in agriculture (Das and Bhattacharya, 2006) [6]. In order to maintain the quality of soybean seed, application of electric power levels at different exposure timing is recently initiated in the country. It has been observed that the electric and magnetic fields causes physiological-biochemical changes in seeds. Electric field is considered as a simple, cheap and non-chemical method for stimulation of germination and seedling growth as compared to traditional chemical process.

Several researchers indicated that electric and magnetic fields affect biological process including free radicals, excite the activity of proteins and enzymes to increase in seed vigour (Jia Ming, 1988^[16] and Morar *et al.*, 1999)^[20]. In view of this, the present investigation was undertaken to study the effect of the electric field application on seed quality parameters of soybean during storage.

Material and Methods

Fresh seed lots (L_1) and one year old seed lots (L_2) of Soybean variety JS 9305 was treated with the combination of three microwave power level *viz*; P_1 : 100%, P_2 : 80% and P_3 : 60% and exposure timing *viz*; T_1 : 20 sec, T_2 : 30 sec. and T_3 : 40 sec. The application of electric field were carried out at Electrical Engineering Laboratory. Treated seeds sealed in polythene bags and stored for storage study. The seed quality parameters *viz*; germination per cent, vigour index I, vigour index II and seed mycoflora were recorded at monthly interval.

Germination: Four replications each of 100 seeds from different treatment combinations were germinated using between paper method at 25 ± 2 °C in germinator for 8 days. The germination per cent was calculated on normal seedlings only.

Seed vigour index: The vigour index of the seed lot was assessed by the method suggested by Abdul Baki and Anderson (1973)^[1]. Seed vigour index I and II were calculated by using following formulae

- Vigour Index I = Average root + shoot length (cm) x germination per cent
- Vigour Index II = Average dry seedling weight (g) x germination per cent

Seed mycoflora: Seed mycoflora was determined by blotter test Anonymous (1999)^[3]. Three layers of blotter size fitting to the size of petridish soaked in sterilized distilled water were placed in petridish. Ten seed were placed in each petridish at equidistance and the petridish was kept in a incubator at 20 ± 2 °C for 7 days beneath near ultra-violet light with a cycle of 12 hours light and 12 hours darkness by maintaining four replications. The seed was examined on 8th day under stereoscopic binocular microscope. The fungi were identified on the basis of sporulations and their fruiting structure. The data was analyzed statistically by using Factorial Completely Randomized Design through analysis of variance (ANOVA) technique for factorial controlled randomized design and presented at 5% level of significance ($P = 0.05$) suggested by Panse and Sukhatme (1967)^[21].

Results and Discussion

Seed Germination

The data on effect of power level and exposure timing on soybean seed during storage are presented in Table 1. The seed germination of soybean during storage was significantly affected by the seed lots, microwave power level and exposure timing. Data presented in Table 1 revealed that the initial germination per cent was higher in fresh seed lots (ranged between 69.00 to 84.00 per cent) than old seed lots (ranged between 56.00 to 66.67 per cent). The fresh seed lot treated with 80% microwave power level and 20 sec. exposure timing ($L_1P_2T_1$) had significantly higher seed germination (84.00%) over rest of the treatments. This treatment could maintain seed germination per cent above MSCS (70%) up to 120 days of storage (72.37%). The seeds

of old lot could not maintained seed germination per cent up to MSCS level (70%). It was observed that initial seed germination was significantly higher in treated seeds (68.26%) than untreated control (59.00%) and the same trend observed throughout the storage periods (Table 1). It was observed that the germination declined progressively with the increase in storage period irrespective of seed lot, microwave power level and exposure timing. The decrease in seed quality during storage may be attributed to natural ageing effect, leading to depletion of food reserves and decline in synthetic activity of the embryo apart from death of seeds because of fungal invasion (Gupta *et al.*, 1993)^[13]. During the period of storage, quality of seed is greatly influenced by seed moisture, temperature and relative humidity of the storage place. Lipid peroxidation resulting in loss of seed quality and viability. Besides lipid peroxidation, highly permeable seed coat of soybean leads to the lower storability of soybean. Application of electric fields causes physiological changes in seed that resulting faster water absorption increased the biological process capacity of seed (Molamofrad *et al.*, 2013)^[19]. The exposure of electric current to barley seeds causes physiological and to biochemical stimulation and activation of cells which may be due to the increase in absorption of microelements (Trifonova 1970)^[26]. The interaction of the retention time and power level is an important parameter affecting the quality of dried corn (Fanslow and Soul 1971)^[9]. The high seed germination in corn could be maintained by using power levels of 0.25 W/g of seeds (Shivare *et al.*, 1991)^[24].

Seed vigour indices

It is an important parameter of seed quality and plays a major role in determining the seed vigour. In the present investigation, interaction of seed lots, microwave power level and exposure timing had significant effect on seedling vigour Index I and II. Data presented in Table 2 and 3, revealed that fresh and old seed lots when exposed for 20 sec at microwave power level of 80% ($L_1P_2T_1$), recorded significantly higher initial seedling vigour index I (fresh 2870 and old 2235) and seedling vigour index II (fresh 141.10 and old 108.80). Higher seedling vigour index I and II were recorded throughout the storage periods by the fresh seed lots exposed for 20 sec at microwave power level of 80% ($L_1P_2T_1$). This could be ascribed due to the ageing or deterioration of seed, which is progressive process accompanied by accumulation of metabolites, which progressively depress germination and growth of seedling with increased age ultimately resulted in reduced dry matter content and vigour of soybean seed during storage (Floris 1970)^[10]. Similar results of decreased vigour were reported by Stewart and Bewley (1980)^[25], Duke *et al.* (1983)^[8] and Charjan and Tarar 1992)^[5]. The electric field exposure to the seed may result in breaking of hydrogen bonding in ultra structural elements of cell. This structural alteration may increase enzyme activity depending on the strength of electric field and exposure trimming. This might have resulted increase in seed germination, seedling length and dry matter content which enhanced seed vigour than untreated control. It was observed that initial seedling vigour index I and II were significantly higher in treated seeds (2175, 95.68) than untreated control (1712, 68.73). The same trend observed throughout the storage periods (Table 2 and 3). Lin (2004)^[17] reported the positive effects of low power microwave radiation on germination and growth rate in wheat, bengal gram, mothbean and green gram. With application of electric field increased seed quality parameters were also reported by Alexander and Doijode (1995)^[2] in onion.

Seed mycoflora

Data presented in Table 4 revealed that the interaction of seed lot, microwave power level and exposure time had significant effect on seed mycoflora during the storage. Fresh seed lots when exposed for 20 sec. at microwave power level of 80% recorded significantly lower seed mycoflora throughout the storage periods. At the initial stage of storage period fresh seed lots and old seed lots when exposed for 20 sec at microwave power level of 80% recorded significantly lower seed mycoflora 5.16 per cent and 8.63 per cent, respectively. It was observed that per cent seed mycoflora was lower in treated seeds than untreated control during the storage (Table 4). Various fungi, bacteria and viruses may infect soybean seed during storage which causes diseases. This leads to reduce in economic profit, reducing yield and deteriorating seed quality. Seed mycoflora of soybean increased with subsequent increase in storage periods.

Increased susceptibility of fungal invasion can be correlated with the increased metabolites in seed leachate (Isley 1957)^[14]. Increased leaching from the seed may supply a ready source of food for different pathogens for their growth (Singh *et al.*, 1995)^[23]. Gupta and Kumar (2003)^[12] reported the microwave heating reduced the incidence of mycoflora incidence by 50 per cent on rice grains without adverse effect on aroma and cooking quality. Similarly, Lozano *et al.* (1986)^[18], James *et al.* (1988)^[15] and Bhaskara Reddy *et al.* (1998)^[4] reported the decrease in the eradication of *Fusarium* spp. from microwave treated seeds. The seed mycoflora are sensitive to heat and moisture content of seed, due to dielectric characteristics of seed which subjected to microwave power level for different timings which creates the heating and reducing the moisture content. This affects the growth, development and reproduction of mycoflora. Higher microwave power level and exposure timing causes the eradication of seed mycoflora.

Table 1: Effect of microwave power level and exposure timing on seed germination per cent of fresh and old seed lots of soybean during seed storage.

Treatment	Germination (%)						% decrease over initial
	Storage period (Days)						
	Initial	30	60	90	120	150	
L ₁ P ₁ T ₁	74.00 (59.30)	71.86 (58.00)	68.72 (56.13)	65.54 (54.10)	62.34 (52.12)	59.08 (50.20)	20.16
L ₁ P ₁ T ₂	79.00 (62.70)	76.88 (61.31)	73.73 (59.19)	70.53 (57.09)	67.36 (55.11)	64.12 (53.20)	18.84
L ₁ P ₁ T ₃	71.09 (57.41)	68.86 (56.13)	65.70 (54.21)	62.55 (52.29)	59.35 (50.40)	56.08 (48.49)	21.11
L ₁ P ₂ T ₁	84.00 (66.38)	81.87 (64.81)	78.71 (62.50)	75.51 (60.39)	72.37 (58.31)	69.08 (56.20)	17.76
L ₁ P ₂ T ₂	72.00 (58.10)	69.87 (56.71)	66.73 (54.80)	63.54 (52.88)	60.24 (51.00)	57.08 (49.10)	20.72
L ₁ P ₂ T ₃	76.09 (60.77)	73.84 (59.31)	70.69 (57.20)	67.56 (55.29)	64.65 (53.30)	61.08 (51.41)	19.73
L ₁ P ₃ T ₁	69.00 (56.20)	66.86 (54.89)	63.74 (53.00)	60.55 (51.10)	57.84 (49.19)	54.08 (47.31)	21.62
L ₁ P ₃ T ₂	71.00 (57.41)	68.88 (56.10)	65.72 (54.18)	62.50 (52.29)	59.31 (50.40)	56.08 (48.49)	21.01
L ₁ P ₃ T ₃	82.00 (64.90)	79.89 (63.28)	76.74 (61.29)	73.56 (59.00)	70.34 (57.07)	67.08 (55.09)	18.20
L ₂ P ₁ T ₁	61.00 (51.40)	58.82 (50.09)	55.64 (48.21)	52.42 (46.39)	49.16 (44.52)	45.85 (42.60)	24.84
L ₂ P ₁ T ₂	66.03 (54.30)	63.83 (53.00)	60.62 (51.10)	57.43 (49.30)	54.19 (47.40)	50.85 (45.51)	22.99
L ₂ P ₁ T ₃	57.01 (49.00)	54.81 (47.80)	51.64 (45.89)	48.42 (44.10)	45.18 (42.23)	41.85 (40.30)	26.59
L ₂ P ₂ T ₁	66.67 (54.70)	64.49 (53.41)	61.31 (51.48)	58.09 (49.70)	54.83 (47.83)	51.52 (45.91)	22.73
L ₂ P ₂ T ₂	60.10 (50.80)	57.80 (49.50)	54.63 (47.70)	51.45 (45.79)	48.16 (43.91)	44.85 (42.00)	25.37
L ₂ P ₂ T ₃	62.00 (51.90)	59.79 (50.71)	56.64 (48.79)	53.42 (47.00)	50.17 (45.10)	46.85 (43.21)	24.44
L ₂ P ₃ T ₁	56.00 (48.40)	53.82 (47.18)	50.64 (45.41)	47.46 (43.47)	44.16 (41.60)	40.85 (39.68)	27.05
L ₂ P ₃ T ₂	57.00 (49.00)	54.81 (47.80)	51.64 (45.91)	48.47 (44.09)	45.13 (42.18)	41.85 (40.31)	26.58
L ₂ P ₃ T ₃	65.00 (53.71)	62.83 (52.40)	59.61 (50.63)	56.42 (48.71)	53.18 (46.79)	49.85 (44.89)	23.31
SE (±)	0.38	0.38	0.37	0.37	0.41	0.4	
CD at 5%	1.1	1.08	1.06	1.05	1.16	1.15	
Treated	68.26 (55.90)	66.10 (54.58)	62.94 (52.61)	59.74 (50.71)	56.51 (48.78)	53.23 (46.89)	22.03
Untreated control	59.00 (50.21)	56.80 (48.88)	53.61 (47.11)	50.38 (45.21)	46.64 (43.09)	43.32 (41.10)	26.58
SE (±)	0.38	0.38	0.37	0.26	0.41	0.40	
CD at 5%	1.10	1.08	1.06	1.05	1.16	1.15	

Table 2: Effect of microwave power level and exposure timing on seedling vigour index I of fresh and old seed lots of soybean during seed storage.

Treatment	Vigour Index I						% decrease over initial
	Storage period (Days)						
	Initial	30	60	90	120	150	
L ₁ P ₁ T ₁	2375	2161	1963	1774	1541	1400	41.05
L ₁ P ₁ T ₂	2624	2398	2189	1989	1749	1598	39.10
L ₁ P ₁ T ₃	2200	1995	1805	1624	1410	1275	42.04
L ₁ P ₂ T ₁	2870	2633	2414	2204	1921	1788	37.70
L ₁ P ₂ T ₂	2236	2029	1837	1655	1430	1294	42.13
L ₁ P ₂ T ₃	2441	2223	2023	1830	1592	1448	40.68
L ₁ P ₃ T ₁	2069	1870	1687	1512	1305	1175	43.21
L ₁ P ₃ T ₂	2143	1940	1753	1574	1361	1221	43.02
L ₁ P ₃ T ₃	2752	2519	2305	2099	1850	1694	38.44
L ₂ P ₁ T ₁	1932	1744	1566	1397	1201	1077	44.25
L ₂ P ₁ T ₂	2160	1962	1773	1593	1390	1257	41.81
L ₂ P ₁ T ₃	1748	1570	1402	1241	1066	949.7	45.67
L ₂ P ₂ T ₁	2235	2034	1842	1658	1443	1307	41.52
L ₂ P ₂ T ₂	1843	1659	1486	1321	1138	1010	45.20

L ₂ P ₂ T ₃	1971	1781	1601	1430	1231	1106	43.88
L ₂ P ₃ T ₁	1661	1488	1324	1168	997.4	885.2	46.70
L ₂ P ₃ T ₂	1702	1526	1360	1203	1021	907.7	46.66
L ₂ P ₃ T ₃	2195	1993	1802	1621	1395	1277	41.82
SE (±)	19.45	18.2	17.25	16.39	24.05	49.62	
CD at 5%	55.68	52.12	49.39	46.94	68.85	70.16	
Treated	2175	1974	1785	1605	1391	1259	42.11
Untreated control	1712	1536	1369	1211	1013	908	42.96
SE(±)	19.45	18.20	17.25	16.39	24.05	49.62	
CD at 5%	55.68	52.12	49.39	46.94	68.85	142.1	

Seed lots: (L₁) Fresh and (L₂) one year old

Microwave power levels: P₁: 100%, P₂: 80% and P₃: 60%

Exposure timings: T₁: 20 sec, T₂: 30 sec. and T₃: 40 sec.

Table 3: Effect of microwave power level and exposure timing on seed vigour index II of fresh and old seed lots of soybean during seed storage.

Treatment	Vigour Index II						% decrease over initial
	Storage period (Days)						
	Initial	30	60	90	120	150	
L ₁ P ₁ T ₁	105.80	97.02	90.03	78.00	73.23	65.81	37.79
L ₁ P ₁ T ₂	120.90	111.40	103.90	90.99	86.27	78.21	35.31
L ₁ P ₁ T ₃	96.56	88.14	81.50	70.04	65.91	58.86	39.04
L ₁ P ₂ T ₁	141.10	132.60	124.40	108.8	102.20	95.75	32.14
L ₁ P ₂ T ₂	100.80	92.22	85.41	73.71	69.08	61.88	38.61
L ₁ P ₂ T ₃	112.50	103.40	96.18	83.75	78.81	71.12	36.78
L ₁ P ₃ T ₁	89.01	80.90	74.56	63.56	59.63	52.91	40.55
L ₁ P ₃ T ₂	93.73	85.39	78.87	67.54	63.48	56.21	40.03
L ₁ P ₃ T ₃	131.20	121.40	113.50	100.00	95.05	86.59	34.00
L ₂ P ₁ T ₁	78.08	70.59	64.55	54.52	50.52	44.42	43.11
L ₂ P ₁ T ₂	92.66	84.48	77.86	66.81	61.87	55.80	39.77
L ₂ P ₁ T ₃	69.54	62.49	56.81	47.44	44.04	38.36	44.84
L ₂ P ₂ T ₁	106.90	98.92	91.57	79.23	74.30	67.17	37.16
L ₂ P ₂ T ₂	75.01	67.65	61.75	51.93	48.36	42.09	43.88
L ₂ P ₂ T ₃	82.46	74.78	68.54	58.23	54.08	47.78	42.05
L ₂ P ₃ T ₁	63.84	57.05	51.66	42.67	39.45	34.05	46.66
L ₂ P ₃ T ₂	67.83	60.86	55.26	46.00	42.34	36.76	45.80
L ₂ P ₃ T ₃	94.25	86.06	79.32	68.26	64.14	57.29	39.20
SE (±)	1.05	0.92	0.97	0.67	1.22	1.93	
CD at 5%	3.01	2.63	2.79	1.91	3.51	5.54	
Treated	95.68	87.52	80.87	69.53	65.15	58.39	38.98
Untreated control	68.73	63.72	58.02	46.65	42.36	37.89	44.87
SE (±)	1.05	0.92	0.97	0.67	1.22	1.93	
CD at 5%	3.01	2.63	2.79	1.91	3.51	5.54	

Table 4: Effect of microwave power level and exposure timing on seed mycoflora (%) of fresh and old seed lots of soybean during seed storage.

Treatment	Seed mycoflora					
	Storage period (Days)					
	Initial	30	60	90	120	150
L ₁ P ₁ T ₁	18.73 (25.65)	22.65 (28.12)	25.98 (30.65)	30.82 (33.72)	32.55 (34.79)	34.95 (36.24)
L ₁ P ₁ T ₂	15.23 (22.97)	19.15 (25.95)	22.48 (28.31)	27.32 (31.51)	29.05 (32.62)	31.45 (34.11)
L ₁ P ₁ T ₃	23.57 (29.04)	27.49 (31.62)	30.82 (33.72)	35.66 (36.66)	37.39 (37.69)	39.78 (39.10)
L ₁ P ₂ T ₁	5.16 (13.13)	9.09 (17.54)	12.42 (20.63)	17.26 (24.55)	18.99 (25.83)	21.38 (27.54)
L ₁ P ₂ T ₂	21.73 (27.79)	25.65 (30.43)	28.98 (32.57)	33.82 (35.56)	35.55 (36.60)	37.95 (38.03)
L ₁ P ₂ T ₃	17.33 (24.60)	21.25 (27.45)	24.58 (29.72)	29.42 (32.85)	31.15 (33.93)	33.55 (35.39)
L ₁ P ₃ T ₁	27.43 (31.59)	31.35 (34.05)	34.68 (36.08)	39.52 (38.95)	41.25 (39.96)	43.65 (41.35)
L ₁ P ₃ T ₂	25.30 (30.20)	29.22 (32.72)	32.55 (34.79)	37.39 (37.70)	39.12 (38.72)	41.51 (40.11)
L ₁ P ₃ T ₃	11.17 (19.52)	15.09 (22.86)	18.42 (25.41)	23.26 (28.83)	24.99 (29.99)	27.38 (31.55)
L ₂ P ₁ T ₁	22.23 (28.13)	26.15 (30.76)	29.48 (32.89)	34.32 (35.86)	36.05 (36.90)	38.45 (38.32)
L ₂ P ₁ T ₂	18.73 (25.65)	22.65 (28.42)	25.98 (30.65)	30.82 (33.72)	32.55 (34.79)	34.95 (36.24)
L ₂ P ₁ T ₃	27.13 (31.39)	31.05 (33.87)	34.38 (35.90)	39.22 (38.780)	40.95 (39.79)	43.35 (41.18)
L ₂ P ₂ T ₁	8.63 (17.08)	12.55 (20.75)	15.88 (23.49)	20.72 (27.08)	22.45 (28.28)	24.85 (29.90)
L ₂ P ₂ T ₂	25.30 (30.20)	29.22 (32.72)	32.55 (34.79)	37.39 (37.70)	39.12 (38.72)	41.51 (40.11)
L ₂ P ₂ T ₃	20.90 (27.20)	24.82 (29.88)	28.15 (32.04)	32.99 (35.06)	34.72 (36.10)	37.11 (37.53)
L ₂ P ₃ T ₁	31.00 (33.83)	34.92 (36.22)	38.25 (38.20)	43.09 (41.03)	44.82 (42.03)	47.21 (43.40)
L ₂ P ₃ T ₂	28.87 (32.50)	32.79 (34.93)	36.12 (36.94)	40.96 (39.79)	42.69 (40.79)	45.08 (42.18)
L ₂ P ₃ T ₃	14.73 (22.57)	18.65 (25.59)	21.98 (27.96)	26.82 (31.19)	28.55 (32.30)	30.95 (33.80)
SE (±)	0.126	0.008	0.008	0.004	0.170	0.009
CD at 5%	0.362	0.023	0.023	0.011	0.240	0.025
Treated	20.18 (26.28)	24.10 (29.12)	27.43 (31.37)	32.27 (34.47)	34.00 (35.55)	36.39 (37.00)

Untreated control	34.35 (35.87)	37.94 (38.01)	41.76 (40.25)	44.92 (42.08)	48.61 (44.20)	55.20 (48.00)
SE (\pm)	0.126	0.008	0.008	0.004	0.170	0.009
CD at 5%	0.362	0.023	0.022	0.011	0.485	0.025

Conclusion

The microwave seed treatment with power level of 80% and exposure timing 20 sec. to soybean seeds was found better for retaining seed quality during storage.

Fresh seed lots of soybean variety JS 9305 was superior in retaining seed quality parameters during storage. However, old seed samples also improved their seed quality when applied microwave power levels.

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