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Effect of seed priming on physiological changes associated with seed deterioration during storage periods in soybean (*Glycine max* L. Merill.)

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Abstract
This study was carried out in order to evaluate effect of seed priming on physiological changes associated with seed deterioration during storage periods in soybean (*Glycine max* L. Merill.) in Junagadh Agricultural University, Junagadh, in 2017. The experimental design was two factors factorial on basis of completely randomized block design with three replications. The first factor was genotypes (GJS-1, JS-20-29 and JS-335) and the second factor was seed priming treatments (control, cow urine (100%), cow urine (50%), KH_2PO_4 (2%), KH_2PO_4 (1%), KNO_3 (2%), KNO_3 (1%), $CaCl_2$ (2%), $CaCl_2$ (1%) and neem leaf extract (50%)). Results showed that seeds of the genotype JS-335 primed with $CaCl_2$ (2%) was better in germination percentage, viability test and electrical conductivity throughout the storage period followed by those KH_2PO_4 (2%) primed seeds of JS-335 genotype. While its non-significant effect on seedling length, seedling dry weight, vigour index-I, vigour index-II and accelerated ageing percentage.

Keywords: Soybean, priming treatment, storability

Introduction
Soybean [*Glycine max* (L.) Merill] is one of the most important protein and oil seed crop throughout the world. Its oil is the largest component of the world's edible oils. The world production of edible oils consists of 30 per cent soybean. It is an ingredient of more than 50% of the world's high protein meal. The native of soybean is Eastern Asia. Soybean was introduced to India during 1880. Soybean crop is known as "Golden Bean", "Miracle crop", "Wonder crop", and "Gold of Soil". Other than the whole phase, a lot of processed soya milk, soya flour, soya paneer and some fermented soya are its products. Being a legume, it fixes a large amount of atmospheric nitrogen in soil. From nutritional point of view, soybean contains 43.2 per cent protein and 20.0 per cent edible oil. Soybean protein is also rich in valuable amino acid "lysine" (5 per cent) which is deficient in most of the cereals (Hammond *et al.*, 2005). Soybean protein composed of ten properly balanced amino acids. In addition, it is a source of vitamin–B complex, thiamin and riboflavin (Gopalan *et al*., 1971) [8]. Besides oil and high quality protein, soybean fixes atmospheric nitrogen in the soil at the rate of 150-165 kg/ha with the help of symbiotic bacteria (*Rhizobium japonicum*) present in the root nodules (Koutroubas *et al.,* 2008) [15]. Therefore, it has a unique importance as a rotational crop in building up sustainable agriculture in cropping systems.

Seed deterioration is inexorable, and the best that can be done is to control its rate. In general, it is accepted that repair of seeds influenced by deteriorative events occurs by priming (McDonald, 1999) [18]. Seed priming is a commercially used technique for improving seed germination and vigour (Khan *et al*., 1978; Kuc, 1978) [14, 16]. It involves imbibition of seeds in water under controlled conditions to initiate early events of germination, followed by drying the seed back to its initial moisture content. Its benefits include rapid, uniform and increased germi-nation, improved seedling vigour and growth under a broad range of environ-ments resulting in better stand establishment (Beckers and Conrath, 2007) [2]. Dell'Aquila and Taranto (1986) [7] demonstrated that primed em-bryos of aged wheat seeds have a faster resumption of cell division and DNA synthesis on subsequent imbibition. Rao *et al*. (1987) [22] reported a reversal of chromosomal damage (induced during seed deterioration) with the partial hy-dration of lettuce seeds by osmo-priming. However, it is not clear whether seed size can influence both the deleterious effects of deterioration and the beneficial effects of priming on soybean germination characteristics and subsequent seedling growth.

Priming in its traditional sense, soaking of seeds in water before sowing, has been the experience of farmers in India in an attempt to improve crop stand establishment but the practice was without the knowledge of the safe limit of soaking duration (Harris, 1996) [10]. Moreover, Harris *et al*. (1999) [11], promoted a low cost, low risk technology called 'on-farm seed priming' that would be appropriate for all farmers, irrespective of their socioeconomic status. Seed priming is basically a pre-sowing seed treatment. Primed and dried seeds normally have a more rapid and uniform germination when subsequently re-hydrated, especially under adverse environmental conditions. The mechanism of seed drying after chemical priming is known as the hydration-dehydration process or dry back and is used to reduce the degree of moisture in seeds to levels compatible with storage and maintaining the beneficial effects of the treatment, without quality loss caused by rapid seed deterioration. Park *et al.* (1997) [21] reported that the priming aged seeds of soybean resulted in good germination and stand Seed pre-treatment establishment in the field trials.

2. Material and Methods

Samples of 400 grams of soybean seeds Cv. GJS-1 (G_1), JS-20-29 (G_2) and JS-335 (G_3) were dipped in priming solution (control (T_1), cow urine (100%) (T_2), cow urine (50%) (T_3), KH_2PO_4 (2%) (T_4), KH_2PO_4 (1%) (T_5), KNO_3 (2%) (T_6), KNO_3 (1%) (T_7), $CaCl_2$ (2%) (T_8), $CaCl_2$ (1%) (T_9) and neem leaf extract (50%) (T_{10})) for 6 hours. Afterwards, primed seeds were allowed to dry back to their original moisture content under the shad for one day and in the sun for two days then stored in cloth bag. The primed seeds were evaluated for seed quality parameters at initially and quarterly throughout the 12 month of storage periods as below.

1. Standard germination (%)

Three repetitions with 100 seeds for each genotypes/treatments were placed on sufficiently moistened rolled papers (BP) at 25°C temperature with 90-95% relative humidity in the seed germinator. Final count was recorded on 7th day (ISTA, 1999) [12]. Normal seedlings were expressed as percent germination.

2. Seedling length (cm)

Seedling length was measure on 10 randomly select normal seedlings taken from three repetitions of standard germination test and average of 10 seedlings were recorded in centimetre for final calculation.

3. Seedling dry weight (mg)

Seedling dry weight was assessed after the final count in the standard germination test (7 days). The 10 seedlings of each genotype were taken and repeated thrice. Seedlings were dry in a hot air oven for 24 hours at 80±1°C. The dry seedlings of each repetition were weight and average seedling dry weight of each genotype was calculated.

4. Vigour Index-I (on seedling length basis)

Seedling vigour index-I was calculated according to the method suggested by Abdul-Baki and Anderson (1973) [1]:

Vigour index-I = Standard Germination (%) × Seedling length (cm)

5. Vigour Index-II (on seedling dry weight basis)

Seedling vigour index-II was also calculated according to the method suggested by Abdul-Baki and Anderson (1973) [1]:

Vigour index-II = Standard Germination (%) × Seedling dry weight (mg)

6. Electrical conductivity (µS/cm/seed)

To measure the electrical conductivity, 50 normal and uninjure seeds in three repetitions were soaked in 75 ml deionized water in 100 ml beakers. Seeds were immersed completely in water and beakers were covered with foil. Thereafter, these samples were kept at 25°C for 24 h. The electrical conductivity of the seed leachates was measured using a systronic reading conductivity meter. The conductivity was expressed in µS/cm/seed.

Statistical Analysis

The data obtained from experiment conducted in FCRD was analyzed as per standard method suggested by Cochran and Cox (1957) [6].

3. Results and Discussion

Quality parameters assessed on the resultant seeds differ significantly due to the difference in genotypes. Significantly higher germination percentage (92.20, 81.41, 69.37 and 60.45 %), seedling length (29.71, 25.18, 20.92 and 16.78 cm), seedling dry weight (109.79, 94.79, 80.49 and 66.21 mg), vigour index-I (2750.16, 2060.71, 1460.19 and 1021.84), vigour index-II (10201.56, 7795.21, 5649.40 and 4068.03) and lower electrical conductivity (1629.28, 1682.91, 1875.80 and 2094.01 µS/cm/seed) at initially, 4 month, 8 month and 12 month of storage periods, respectively recorded in seeds of genotype JS-335 (G_3) over the other two genotypes. The better performance of JS-335 genotypes tested for seed quality parameters during storage periods is presumably due to the genetic characters of that genotype.

The priming treatments had significant influence in the resultant seed across all the seed quality parameters tested. Significantly higher germination percentage (97.34, 86.47, 74.36 and 65.63 %), seedling length (32.72, 28.70, 24.46 and 19.98 cm), seedling dry weight (129.23, 114.55, 100.38 and 86.46 mg), vigour index-I (3186.39, 2482.60, 1819.13 and 1311.59), vigour index-II (12583.13, 9908.27, 7467.55 and 5676.70) and lower electrical conductivity (751.48, 855.69, 939.76 and 1147.65 µS/cm/seed) at initially, 4 month, 8 month and 12 month of storage periods, respectively recorded in seed primed with $CaCl_2$ (2%) (T_8) over the other priming treatments. Significantly lowest germination percentage (70.90, 60.03, 47.92 and 39.19 %), seedling length (25.48, 21.90, 17.84 and 14.17 cm), seedling dry weight (81.67, 67.19, 53.02 and 39.11 mg), vigour index-I (1807.94, 1314.41, 855.77 and 555.96), vigour index-II (5794.10, 4036.38, 2549.39 and 1539.58) at initially, 4 month, 8 month and 12 month of storage periods, respectively recorded in seed primed with neem leaf extract (50%) (T_{10}); while highest electrical conductivity (4022.70, 4123.56, 4267.55 and 4522.65 µS/cm/seed) at initially, 4 month, 8 month and 12 month of storage periods, respectively recorded in seed primed with cow urine (100%) (T_2).

The higher germination noticed in $CaCl_2$ (2%) (T_8), primed seeds might be due to the role of calcium in membrane integrity. Christiansen and Foy (1979) reported seed calcium concentration and germination percentage were positively related suggesting the role of calcium as an important component in membrane stabilization and as an enzyme cofactor. According to Bhingarde *et al.* (2015) the greater efficiency of priming with $CaCl_2$ is possibly related to the osmotic advantage that Ca^{2+} have in improving cell water

saturation, and that they act as co-factors in the activities of numerous enzymes and also the role of calcium as an important component in membrane stabilization. Kulkarni and Eshanna (1988) [17], Bellur (2009) [3], Narayanareddy and Biradapatil (2012) [20], Jamadar and Chandrashakhar (2015) [13] and Chavan and Tagad (2015) [4] reported similar beneficial results on seed quality parameter due to priming with calcium chloride.

KH_2PO_4 also showed a relatively positive effect presumably because phosphorous activates the respiratory enzymes involved in the biosynthesis of seed and extends the seed storability. According to Sanjeeva Kumar (2000) [23] phosphorous reserves in the seed play very important role in the metabolism of germinating seed. The major phosphorous reserve in the seed, phytic acid, in addition to its nutritional role, is believed to act as a natural antioxidant.

Interaction effect between genotypes and seed priming treatments was found to differ significantly for seed quality parameters during storage periods. Germination showed non-significant at initial and 4 month after storage periods; while seedling length, seedling dry weight, vigour index-I, vigour index-II and accelerated ageing percentage showed non-significant at all the month of storage periods. Significantly higher germination percentage (75.68% and 66.77%) at 8 and 12 month of storage periods, respectively recorded in G_3T_8; while lower germination was recorded in G_2T_{10}. Significantly lower electrical conductivity (428.58, 490.88, 513.83 and 715.87 µS/cm/seed) at initial, 4, 8 and 12 month of storage periods, respectively recorded in G_3T_8; while higher electrical conductivity was recorded in G_2T_2.

Table 1: Effect of seed priming treatments to different genotypes and their interaction on standard germination (%) in soybean during storage

Treatments	Storage period (months)			
	Initial	4 months	8 months	12 months
Genotype (G)				
G_1 - GJS-3	91.57	80.24	68.24	59.83
G_2 - JS-20-29	90.23	79.74	67.45	58.58
G_3 - JS-335	92.20	81.41	69.37	60.45
S.Em±	0.49	0.48	0.45	0.46
CD at 5%	1.37	1.37	1.28	1.30
Priming treatment (T)				
T_1 - Control	91.87	81.00	68.89	60.16
T_2 - Cow urine (100%)	90.63	79.76	67.65	58.92
T_3 - Cow urine (50%)	90.95	80.08	67.97	59.24
T_4 - KH_2PO_4 (2%)	96.62	85.75	73.64	64.91
T_5 - KH_2PO_4 (1%)	92.89	82.02	69.91	61.18
T_6 - KNO_3 (2%)	94.64	83.77	71.66	62.93
T_7 - KNO_3 (1%)	92.96	82.09	69.98	61.25
T_8 - $CaCl_2$ (2%)	97.34	86.47	74.36	65.63
T_9 - $CaCl_2$ (1%)	94.50	83.63	71.52	62.79
T_{10} - Neem leaf extract (50%)	70.90	60.03	47.92	39.19
S.Em±	0.89	0.88	0.83	0.84
CD at 5%	2.51	2.49	2.34	2.37
Interaction (G × T)				
$G_1 \times T_1$	92.08	80.75	68.54	60.13
$G_1 \times T_2$	91.02	79.69	68.69	60.30
$G_1 \times T_3$	91.23	79.90	68.18	59.78
$G_1 \times T_4$	96.99	85.66	74.52	66.13
$G_1 \times T_5$	93.02	81.69	68.95	60.54
$G_1 \times T_6$	94.92	83.59	71.85	63.45
$G_1 \times T_7$	93.21	81.88	69.97	61.56
$G_1 \times T_8$	97.56	86.23	74.09	65.69
$G_1 \times T_9$	94.86	83.53	72.01	62.50
$G_1 \times T_{10}$	70.80	59.47	45.20	36.76
$G_2 \times T_1$	90.74	80.25	67.76	58.88
$G_2 \times T_2$	89.68	79.19	67.90	59.04
$G_2 \times T_3$	89.89	79.40	67.40	58.52
$G_2 \times T_4$	95.65	85.16	73.74	64.88
$G_2 \times T_5$	91.68	81.19	68.17	59.28
$G_2 \times T_6$	93.58	83.09	71.07	62.20
$G_2 \times T_7$	91.87	81.38	69.18	60.31
$G_2 \times T_8$	96.22	85.73	73.31	64.43
$G_2 \times T_9$	93.52	83.03	71.57	62.70
$G_2 \times T_{10}$	69.46	58.97	44.42	35.51
$G_3 \times T_1$	92.80	82.01	70.37	61.46
$G_3 \times T_2$	91.20	80.41	66.36	57.41
$G_3 \times T_3$	91.73	80.94	68.33	59.40
$G_3 \times T_4$	97.23	86.44	72.66	63.72
$G_3 \times T_5$	93.98	83.19	72.61	63.71
$G_3 \times T_6$	95.43	84.64	72.06	63.13
$G_3 \times T_7$	93.80	83.01	70.79	61.86

$G_3 \times T_8$	98.25	87.46	75.68	66.77
$G_3 \times T_9$	95.12	84.33	70.64	61.70
$G_3 \times T_{10}$	72.45	61.66	54.15	45.30
Mean	91.33	80.46	68.35	59.62
S.Em±	1.54	1.53	1.44	1.45
CD at 5%	NS	NS	4.06	4.11
CV %	2.91	3.29	3.64	4.22

Table 2: Effect of seed priming treatments to different genotypes and their interaction on seedling length (cm) in soybean during storage

Treatments	Storage period (months)			
	Initial	4 months	8 months	12 months
Genotype (G)				
G_1 - GJS-3	29.26	24.92	20.74	16.53
G_2 - JS-20-29	29.18	24.69	20.44	16.37
G_3 - JS-335	29.71	25.18	20.92	16.78
S.Em±	0.16	0.14	0.12	0.09
CD at 5%	0.46	0.39	0.33	0.27
Priming treatment (T)				
T_1 - Control	27.65	23.77	19.45	15.11
T_2 - Cow urine (100%)	26.99	22.45	18.23	13.82
T_3 - Cow urine (50%)	27.16	22.60	18.50	14.26
T_4 - KH_2PO_4 (2%)	32.12	27.25	23.18	19.12
T_5 - KH_2PO_4 (1%)	30.59	25.72	21.17	16.99
T_6 - KNO_3 (2%)	30.99	26.37	22.13	18.21
T_7 - KNO_3 (1%)	29.17	24.41	20.15	16.06
T_8 - $CaCl_2$ (2%)	32.72	28.70	24.46	19.98
T_9 - $CaCl_2$ (1%)	30.95	26.13	21.86	17.87
T_{10} - Neem leaf extract (50%)	25.48	21.90	17.84	14.17
S.Em±	0.30	0.25	0.22	0.17
CD at 5%	0.83	0.72	0.61	0.49
Interaction (G × T)				
$G_1 \times T_1$	27.45	23.78	19.44	15.02
$G_1 \times T_2$	26.99	22.47	18.22	13.91
$G_1 \times T_3$	27.06	22.59	18.57	14.28
$G_1 \times T_4$	32.05	27.27	23.14	19.10
$G_1 \times T_5$	30.57	25.75	21.18	17.00
$G_1 \times T_6$	31.00	26.28	22.19	18.12
$G_1 \times T_7$	29.07	24.40	20.15	16.01
$G_1 \times T_8$	32.40	28.72	24.53	19.92
$G_1 \times T_9$	30.97	26.08	21.96	17.85
$G_1 \times T_{10}$	25.02	21.90	17.95	14.11
$G_2 \times T_1$	27.41	23.59	19.17	14.98
$G_2 \times T_2$	26.89	22.22	18.02	13.45
$G_2 \times T_3$	26.99	22.41	18.15	14.02
$G_2 \times T_4$	32.00	26.98	23.05	18.87
$G_2 \times T_5$	30.44	25.42	20.96	16.68
$G_2 \times T_6$	30.89	26.02	21.79	18.10
$G_2 \times T_7$	28.98	24.18	20.00	15.95
$G_2 \times T_8$	32.31	28.48	24.13	19.85
$G_2 \times T_9$	30.88	25.82	21.55	17.74
$G_2 \times T_{10}$	24.96	21.71	17.53	14.05
$G_3 \times T_1$	28.08	23.93	19.74	15.32
$G_3 \times T_2$	27.08	22.67	18.46	14.09
$G_3 \times T_3$	27.43	22.81	18.77	14.48
$G_3 \times T_4$	32.30	27.50	23.34	19.38
$G_3 \times T_5$	30.76	25.99	21.38	17.28
$G_3 \times T_6$	31.08	26.81	22.40	18.41
$G_3 \times T_7$	29.47	24.66	20.30	16.23
$G_3 \times T_8$	33.44	28.90	24.71	20.18
$G_3 \times T_9$	31.00	26.49	22.06	18.03
$G_3 \times T_{10}$	26.45	22.09	18.04	14.36
Mean	29.38	24.93	20.70	16.56
S.Em±	0.51	0.44	0.37	0.30
CD at 5%	NS	NS	NS	NS
CV %	3.01	3.04	3.13	3.11

Table 3: Effect of seed priming treatments to different genotypes and their interaction on seedling dry weight (mg) in soybean during storage

Treatments	Storage period (months)			
	Initial	4 months	8 months	12 months
Genotype (G)				
G_1 - GJS-3	107.67	93.45	79.49	65.17
G_2 - JS-20-29	106.02	91.39	77.16	64.01
G_3 - JS-335	109.79	94.79	80.49	66.21
S.Em±	1.06	0.96	0.81	0.62
CD at 5%	3.00	2.72	2.30	1.75
Priming treatment (T)				
T_1 - Control	98.40	83.00	68.83	54.92
T_2 - Cow urine (100%)	96.55	80.80	66.64	52.72
T_3 - Cow urine (50%)	97.18	82.25	68.09	54.17
T_4 - KH_2PO_4 (2%)	125.05	109.56	95.40	81.48
T_5 - KH_2PO_4 (1%)	113.38	102.89	88.73	74.81
T_6 - KNO_3 (2%)	121.20	106.37	92.20	78.29
T_7 - KNO_3 (1%)	99.89	84.86	70.69	56.77
T_8 - $CaCl_2$ (2%)	129.23	114.55	100.38	86.46
T_9 - $CaCl_2$ (1%)	115.72	100.64	86.48	72.56
T_{10} - Neem leaf extract (50%)	81.67	67.19	53.02	39.11
S.Em±	1.94	1.75	1.48	1.13
CD at 5%	5.48	4.96	4.20	3.19
Interaction (G × T)				
$G_1 \times T_1$	97.92	83.10	69.13	54.82
$G_1 \times T_2$	95.90	80.43	66.46	52.15
$G_1 \times T_3$	97.13	82.41	68.44	54.13
$G_1 \times T_4$	124.88	109.44	95.47	81.16
$G_1 \times T_5$	113.10	106.03	92.06	77.75
$G_1 \times T_6$	120.92	106.54	92.57	78.26
$G_1 \times T_7$	99.91	84.70	70.73	56.42
$G_1 \times T_8$	129.02	114.20	100.23	85.92
$G_1 \times T_9$	115.75	100.41	86.44	72.13
$G_1 \times T_{10}$	82.16	67.30	53.33	39.02
$G_2 \times T_1$	97.24	80.86	66.63	53.48
$G_2 \times T_2$	95.40	78.62	64.39	51.24
$G_2 \times T_3$	95.59	80.54	66.31	53.16
$G_2 \times T_4$	123.65	107.63	93.40	80.25
$G_2 \times T_5$	112.24	102.84	88.61	75.46
$G_2 \times T_6$	119.74	104.62	90.39	77.24
$G_2 \times T_7$	98.02	83.13	68.90	55.75
$G_2 \times T_8$	126.70	112.47	98.24	85.09
$G_2 \times T_9$	113.62	98.72	84.49	71.34
$G_2 \times T_{10}$	78.04	64.47	50.24	37.09
$G_3 \times T_1$	100.04	85.04	70.74	56.46
$G_3 \times T_2$	98.36	83.36	69.06	54.78
$G_3 \times T_3$	98.81	83.81	69.51	55.23
$G_3 \times T_4$	126.62	111.62	97.32	83.04
$G_3 \times T_5$	114.81	99.81	85.51	71.23
$G_3 \times T_6$	122.95	107.95	93.65	79.37
$G_3 \times T_7$	101.74	86.74	72.44	58.16
$G_3 \times T_8$	131.98	116.97	102.67	88.39
$G_3 \times T_9$	117.80	102.80	88.50	74.22
$G_3 \times T_{10}$	84.80	69.80	55.50	41.22
Mean	107.83	93.21	79.05	65.65
S.Em±	3.35	3.04	2.57	1.95
CD at 5%	NS	NS	NS	NS
CV %	5.39	5.64	5.63	5.20

Table 4: Effect of seed priming treatments to different genotypes and their interaction on vigour index-I in soybean during storage

Treatments	Storage period (months)			
	Initial	4 months	8 months	12 months
Genotype (G)				
G_1 - GJS-3	2693.33	2010.84	1425.97	999.13
G_2 - JS-20-29	2646.00	1979.25	1389.86	968.84
G_3 - JS-335	2750.16	2060.71	1460.19	1021.84
S.Em±	21.40	16.95	12.64	8.890
CD at 5%	60.51	47.96	35.74	25.146
Priming treatment (T)				

T_1 - Control	2540.14	1924.70	1340.23	908.67
T_2 - Cow urine (100%)	2444.79	1789.66	1232.84	813.45
T_3 - Cow urine (50%)	2470.43	1810.21	1257.33	845.02
T_4 - KH_2PO_4 (2%)	3103.72	2337.50	1707.03	1240.82
T_5 - KH_2PO_4 (1%)	2841.55	2109.96	1480.65	1040.15
T_6 - KNO_3 (2%)	2932.67	2209.68	1586.24	1145.96
T_7 - KNO_3 (1%)	2713.06	2004.07	1409.92	983.54
T_8 - $CaCl_2$ (2%)	3186.39	2482.60	1819.13	1311.59
T_9 - $CaCl_2$ (1%)	2924.32	2186.55	1564.27	1120.89
T_{10} - Neem leaf extract (50%)	1807.94	1314.41	855.77	555.96
S.Em±	39.06	30.96	23.07	16.23
CD at 5%	110.48	87.55	65.25	45.91
Interaction (G × T)				
$G_1 \times T_1$	2528.63	1920.23	1332.57	903.55
$G_1 \times T_2$	2456.04	1790.18	1252.03	837.81
$G_1 \times T_3$	2468.36	1804.48	1266.37	854.44
$G_1 \times T_4$	3109.68	2336.16	1725.06	1262.92
$G_1 \times T_5$	2842.79	2104.15	1461.01	1028.84
$G_1 \times T_6$	2942.47	2196.76	1594.51	1149.63
$G_1 \times T_7$	2710.82	1997.60	1409.78	985.63
$G_1 \times T_8$	3162.93	2477.49	1818.40	1308.18
$G_1 \times T_9$	2939.02	2179.04	1589.09	1141.63
$G_1 \times T_{10}$	1772.55	1302.28	810.91	518.65
$G_2 \times T_1$	2487.26	1893.13	1299.04	881.84
$G_2 \times T_2$	2409.16	1757.50	1223.57	793.79
$G_2 \times T_3$	2426.81	1780.52	1223.26	820.52
$G_2 \times T_4$	3061.85	2298.26	1699.99	1224.43
$G_2 \times T_5$	2790.48	2064.56	1429.25	989.43
$G_2 \times T_6$	2889.16	2163.12	1548.98	1125.92
$G_2 \times T_7$	2663.10	1968.62	1383.28	962.10
$G_2 \times T_8$	3110.84	2442.70	1768.87	1279.34
$G_2 \times T_9$	2887.05	2144.64	1542.49	1112.48
$G_2 \times T_{10}$	1734.32	1279.43	779.83	498.57
$G_3 \times T_1$	2604.53	1960.75	1389.08	940.60
$G_3 \times T_2$	2469.16	1821.31	1222.91	808.74
$G_3 \times T_3$	2516.10	1845.61	1282.34	860.10
$G_3 \times T_4$	3139.62	2378.07	1696.05	1235.10
$G_3 \times T_5$	2891.39	2161.16	1551.68	1102.16
$G_3 \times T_6$	2966.37	2269.15	1615.22	1162.32
$G_3 \times T_7$	2765.25	2045.98	1436.69	1002.88
$G_3 \times T_8$	3285.38	2527.61	1870.13	1347.25
$G_3 \times T_9$	2946.89	2235.98	1561.23	1108.56
$G_3 \times T_{10}$	1916.95	1361.51	976.58	650.67
Mean	2696.50	2016.93	1425.34	996.61
S.Em±	67.66	53.62	39.96	28.11
CD at 5%	NS	NS	NS	NS
CV %	4.35	4.60	4.86	4.89

Table 5: Effect of seed priming treatments to different genotypes and their interaction on vigour index-II in soybean during storage

Treatments	**Storage period (months)**			
	Initial	**4 months**	**8 months**	**12 months**
Genotype (G)				
G_1 - GJS-3	9941.50	7582.15	5512.83	3988.21
G_2 - JS-20-29	9653.55	7372.91	5295.67	3840.29
G_3 - JS-335	10201.56	7795.21	5649.40	4068.03
S.Em±	111.08	90.63	67.09	48.48
CD at 5%	314.17	256.34	189.77	137.12
Priming treatment (T)				
T_1 - Control	9048.97	6731.55	4749.41	3309.25
T_2 - Cow urine (100%)	8747.60	6442.61	4504.03	3102.63
T_3 - Cow urine (50%)	8836.18	6585.07	4626.23	3207.43
T_4 - KH_2PO_4 (2%)	12083.14	9396.09	7024.35	5287.82
T_5 - KH_2PO_4 (1%)	10532.88	8437.65	6198.76	4572.34
T_6 - KNO_3 (2%)	11472.67	8912.36	6608.45	4927.05
T_7 - KNO_3 (1%)	9286.43	6966.48	4947.42	3477.36
T_8 - $CaCl_2$ (2%)	12583.13	9908.27	7467.55	5676.70
T_9 - $CaCl_2$ (1%)	10936.93	8417.76	6184.09	4554.93
T_{10} - Neem leaf extract (50%)	5794.10	4036.38	2549.39	1539.58

S.Em±	202.80	165.47	122.49	88.51
CD at 5%	573.59	468.02	346.46	250.34
Interaction (G × T)				
$G_1 \times T_1$	9015.83	6709.89	4738.23	3296.14
$G_1 \times T_2$	8728.15	6408.98	4564.87	3144.09
$G_1 \times T_3$	8861.27	6584.80	4666.72	3235.88
$G_1 \times T_4$	12113.13	9375.78	7116.02	5367.82
$G_1 \times T_5$	10519.18	8660.49	6347.24	4705.98
$G_1 \times T_6$	11477.94	8906.07	6652.10	4965.91
$G_1 \times T_7$	9312.32	6935.11	4948.88	3473.15
$G_1 \times T_8$	12589.96	9850.26	7428.92	5645.36
$G_1 \times T_9$	10980.13	8387.51	6254.40	4613.22
$G_1 \times T_{10}$	5817.09	4002.61	2410.89	1434.51
$G_2 \times T_1$	8845.49	6509.44	4530.74	3160.88
$G_2 \times T_2$	8545.40	6217.55	4365.47	3019.77
$G_2 \times T_3$	8582.64	6386.68	4462.33	3105.71
$G_2 \times T_4$	11825.24	9164.81	6886.36	5205.31
$G_2 \times T_5$	10289.59	8349.77	6040.43	4473.14
$G_2 \times T_6$	11205.26	8693.08	6423.96	4803.82
$G_2 \times T_7$	9004.18	6765.00	4766.35	3361.61
$G_2 \times T_8$	12191.90	9643.54	7202.91	5482.93
$G_2 \times T_9$	10626.18	8197.84	6047.27	4473.37
$G_2 \times T_{10}$	5419.64	3801.40	2230.95	1316.38
$G_3 \times T_1$	9285.60	6975.33	4979.28	3470.73
$G_3 \times T_2$	8969.24	6701.30	4581.74	3144.04
$G_3 \times T_3$	9064.64	6783.75	4749.64	3280.69
$G_3 \times T_4$	12311.05	9647.68	7070.66	5290.32
$G_3 \times T_5$	10789.88	8302.68	6208.60	4537.89
$G_3 \times T_6$	11734.82	9137.94	6749.30	5011.41
$G_3 \times T_7$	9542.79	7199.33	5127.02	3597.33
$G_3 \times T_8$	12967.53	10231.01	7770.82	5901.82
$G_3 \times T_9$	11204.47	8667.95	6250.61	4578.19
$G_3 \times T_{10}$	6145.57	4305.14	3006.33	1867.84
Mean	9932.20	7583.42	5485.97	3965.51
S.Em±	351.25	286.60	212.17	153.30
CD at 5%	NS	NS	NS	NS
CV %	6.13	6.55	6.70	6.70

Table 6: Effect of seed priming treatments to different genotypes and their interaction on seed electrical conductivity (µS/cm/seed) in soybean during storage

Treatments	**Storage period (months)**			
	Initial	**4 months**	**8 months**	**12 months**
Genotype (G)				
G_1 - GJS-3	1793.47	1884.27	2105.60	2420.74
G_2 - JS-20-29	2136.46	2365.71	2552.04	2761.91
G_3 - JS-335	1629.28	1682.91	1875.80	2094.01
S.Em±	9.78	11.60	15.37	17.63
CD at 5%	27.65	32.80	43.47	49.85
Priming treatment (T)				
T_1 - Control	2151.15	2208.03	2426.09	2619.10
T_2 - Cow urine (100%)	4022.70	4123.56	4267.55	4522.65
T_3 - Cow urine (50%)	2318.59	2576.59	2740.10	3306.54
T_4 - KH_2PO_4 (2%)	1186.15	1253.80	1456.68	1652.43
T_5 - KH_2PO_4 (1%)	1687.59	1865.69	2097.65	2306.10
T_6 - KNO_3 (2%)	1378.04	1536.58	1755.65	1957.99
T_7 - KNO_3 (1%)	1845.92	2078.59	2325.77	2525.65
T_8 - $CaCl_2$ (2%)	751.48	855.69	939.76	1147.65
T_9 - $CaCl_2$ (1%)	1439.26	1637.14	1838.20	2054.54
T_{10} - Neem leaf extract (50%)	1676.97	1741.47	1930.65	2162.88
S.Em±	17.85	21.17	28.06	32.18
CD at 5%	50.49	59.89	79.36	91.02
Interaction (G × T)				
$G_1 \times T_1$	2003.09	2025.15	2162.09	2370.32
$G_1 \times T_2$	3493.81	3758.93	3884.10	4111.54
$G_1 \times T_3$	2120.99	2155.81	2210.77	3428.54
$G_1 \times T_4$	871.92	1095.46	1140.80	1306.87
$G_1 \times T_5$	1488.04	1592.36	1805.54	2002.10
$G_1 \times T_6$	1499.09	1824.03	2111.99	2267.43

$G_1 \times T_7$	1969.51	2581.47	2892.43	3116.54
$G_1 \times T_8$	642.92	651.70	777.54	1008.21
$G_1 \times T_9$	1335.07	1559.81	1793.65	2047.32
$G_1 \times T_{10}$	1945.50	2117.47	2322.43	2548.54
$G_2 \times T_1$	2400.75	2415.48	2663.43	2883.99
$G_2 \times T_2$	4307.75	4347.81	4502.10	4737.21
$G_2 \times T_3$	2535.45	3111.14	3335.10	3581.54
$G_2 \times T_4$	1515.41	2048.25	2241.46	2453.87
$G_2 \times T_5$	2135.54	2443.69	2633.54	2851.43
$G_2 \times T_6$	1926.77	2195.70	2351.32	2567.43
$G_2 \times T_7$	2179.31	2350.81	2581.77	2730.21
$G_2 \times T_8$	1088.90	1495.58	1550.88	1718.87
$G_2 \times T_9$	1586.24	1738.81	1943.98	2164.32
$G_2 \times T_{10}$	1553.81	1638.46	1716.76	1930.21
$G_3 \times T_1$	2017.61	2212.48	2452.76	2602.99
$G_3 \times T_2$	4179.97	4263.47	4416.44	4719.21
$G_3 \times T_3$	2299.33	2462.81	2674.43	2909.54
$G_3 \times T_4$	590.03	708.25	803.65	1039.10
$G_3 \times T_5$	1439.19	1561.03	1853.88	2064.77
$G_3 \times T_6$	841.25	902.23	1033.13	1196.54
$G_3 \times T_7$	1288.96	1303.47	1503.10	1730.21
$G_3 \times T_8$	428.58	490.88	513.83	715.87
$G_3 \times T_9$	1396.46	1612.81	1776.98	1951.98
$G_3 \times T_{10}$	1446.95	1553.14	1752.76	2009.88
Mean	1853.07	1977.63	2177.81	2425.55
S.Em±	30.92	36.67	48.60	55.74
CD at 5%	87.45	103.73	137.45	157.64
CV %	2.89	3.21	3.86	3.98

4. Conclusion

On the basis of these observations, it may be concluded that soybean seeds positively responded to treatments of priming. Calcium chloride primed seeds, however, showed better performance than the other treatments. There are variations between soybean genotypes in response to priming. The highest benefit of priming can be obtained from seeds primed with $CaCl_2$ (2%) treatment.

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