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Effect of seed coating with fungicides along with polymer on seed storability of soybean (*Glycine max* L. Merril)

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Abstract
The present storage experiment was conducted at Seed Unit, University of Agricultural Sciences Raichur, Karnataka during 2016-2017 on soybean cv. JS 335 seeds were treated with different fungicides along with polymer (5 ml kg^{-1}) and were subjected for seed quality in order to know the influence of fungicides along with polymer on quality parameters were evaluated from 0 to 9 months of storage under laboratory condition, combi-fungicides carbendazim 25% + mancozeb 75% @ 3 g per kg of seed was recorded significantly higher seed quality parameters *viz*., germination (69.67 %), peak value of germination (22.36), root length (12.03 cm), shoot length (9.83 cm), seedling length (21.86 cm), seedling dry weight (111.1 mg), seedling vigour index-I (1524) and seedling vigour index-II (7747) at the end of nine months of storage period as compared to control.

Keywords: soybean, fungicides, polymer, seed quality, storage period

Introduction
Planting high quality seed is important to an efficient soybean production system. Early planting, reduced seeding rates, and drill planting all require high quality, vigorous seed to obtain optimum stands and yields. Strong seedlings grow faster than less vigorous ones, are more tolerant to adverse conditions in the seedbed, and are better able to resist diseases. Diseases affecting seed quality and yield differ in severity among cultivars, years, and locations, but the pathogens responsible are well established in most production areas. Soybean seed produced in warm, wet seasons or where rain has delayed the harvest is often of poor quality. Using fungicide seed treatments provides cheap insurance against seed borne and soil borne seed rots and against seedling blights. Although fungicide seed treatments generally increase the stand, such treatments do not always insure higher yields.

Seed ageing and deterioration of seed are irreversible, inexorable and inevitable process, but the rate of seed deterioration could be slowed down either by storing the seeds under controlled condition or by imposing seed treatment with polymer coating along with seed treatment chemicals (Duan and Burris, 1997) [4]. As the controlled condition involves the huge cost, the seed treatment remains the best alternative approach to maintain the seed quality.

However, the untreated seed germination percentage was decreased drastically when storage period increases compared to the treatments receiving fungicidal treatment with polymer coating at higher doses. This indicates that, along with the fungicides, polymer coating is also helpful in maintaining the seed quality. The rate of reduction in germination percentage from the beginning of the storage period till the end of storage was slower in seeds treated with fungicides and polymer coated seeds compared to untreated seeds. These results are in conformity with the findings of Taylor *et al.* (2001) [17], Vanangamudi *et al.* (2003) [18] and Larissa *et al.* (2004) [10] in onion, maize and bean, respectively.

Soybean seeds lose viability within 3-4 months if the storage arrangement and the condition of seed are not proper (Sajad, 1980) [12]. Types of container also regulate temperature, relative humidity and seed moisture contents. High temperature, relative humidity and moisture in the storage environment appear to be main factor involved in deterioration of seed quality. Maintenance of seed quality during storage period is important not only for crop production in the following year but also for the maintenance seeds because of their constant threat and of genetic erosion. In view of the above facts, the present research work was undertaken to evaluate the effect of different coating materials and storage container on germination and seedling vigour of stored soybean seed.

Material and Methods

The certified seeds of soybean variety JS 335 produced during *kharif* 2016-17 from the Seed Unit, Bidar. University of Agricultural Sciences, Raichur, were size graded and utilised for the study. The soybean seed coating with polymer at 5 ml per kg of seed and proper seed coating in a rotary seed treater. Almost care was taken during treatment to have uniformity in coating and the seeds were air dried under shade to bring back to its original moisture content. Then different fungicide treatments *viz*., T_0: Control, T_1: Polymer, T_2: T_1 + thiram @ 3 g/kg, T_3: T_1+ carboxine @ 2 g/kg, T_4: T_1 + carbendazim 2 g/kg, T_5: T_1 + carbendazim 25% + mancozeb 75%@ 3 g/kg, T_6: T_1 + thiram 37.5% + carboxin 37.5% @ 3 g/kg. The experiment was designed as completely randomized design concept with three replications. The fungicides along with polymer coated seeds were tested for germination percentage, root and shoot length, dry matter production, vigour index. The seed germination test was conducted as per ISTA (Anon., 2014) [2] using between paper method, the number of normal seedlings counted at the end of eight day and expressed as seed germination in percentage (%) and the peak value of germination was taken from numbers of seeds germinated were recorded on daily basis up to the day of final count (8^{th} day). The peak value is the cumulative germination percentage for each unit on its peak day divided by the number of days to reach that percentage. It was calculated by the formula suggested by Gairola *et al*. (2011) [5].

$$\text{Peak value of germination} = \frac{\text{Highest number of seeds germinated}}{\text{Number of days}}$$

The vigour index I was calculated using the formula VI I = (Mean root length + Mean shoot length) (cm) x Germination (%) as suggested by Abdul-Baki and Anderson (1973) [1]. The vigour index II was calculated using the formula VI II = Seedling dry weight (mg) x Germination (%). The data collected from the experiments were analyzed statistically by the procedure prescribed by Sundararaj *et al*. (1972). Whenever 'F' test was found significant, the critical difference (CD) values were calculated and treatment mean were compared at one per cent for lab experiment.

Result and Discussion

Seed senescence or deterioration is an irreversible and inexorable/ unavoidable process. However, the rate of seed deterioration could be slowed down either by storing the seeds under controlled conditions or by imposing certain treatments with either chemicals or any other protectants. Seed coating with polymer is one such pre-storage treatment that can be used either singly or in combination with other fungicides, pesticides to protect the seeds against pest and diseases. Duan and Burris (1997) [4] explained the possibilities of using polymers along with other chemicals to maintain the keeping quality of the seeds. The rapid deterioration of stored seed is a serious problem, particularly in the high temperature and relative humidity prevails and associated with accelerated ageing phenomenon. Since, the controlled condition involves huge cost; the polymer seed coating could be one of the best alternative approaches to maintain seed quality during storage.

In the present investigation, irrespective of the treatments, the seed quality parameters declined progressively with the increase in storage period. The germination percentage, peak value of germination, root length (cm), shoot length (cm), seedling length (cm), seedling dry weight (mg), seedling vigour index-I and seedling vigour index-II at the beginning of the storage period were 91.14 per cent, 39.60, 22.97 cm, 18.36 cm, 41.34 cm, 118.9 mg, 3777 and 10865, which declined to 64.71 per cent, 19.00, 9.68 cm, 7.67 cm, 17.34 cm, 93.1 mg, 1129 and 6050, respectively at the end of 9^{th} month of storage (Table 1-7). This decrease in seed quality during storage may be attributed to ageing effects, 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) [7]. However, the average germination was above the minimum seed certification standards (70.00 %) even after six months of storage. The polymer coat on seed acts as a physical barrier that has been reported to reduce leaching of inhibitors from the seed coverings and may restrict oxygen diffusion to the embryo (Duan and Burris, 1997) [4] and also Struve and Hopper (1996) [14] reported in cotton seeds coated with polymer recorded slower imbibitional rate, reduced the imbibitional damage, lowered the electrical conductivity values and improved the germination. These findings are in agreement with results obtained by Hunje *et al*. (1990) [8] in cowpea. The film formed around seed act as a physical barrier, which has been reported to reduce leaching of inhibitors from the seed coverings and may restrict oxygen diffusion to the embryo (Duan and Burris, 1997) [4]. The higher germination percentage can be seen in polymer coated seeds, it is due to increase in the rate of imbibition where the fine particles in the coating act as moisture attracting material to improve germination. Increase in storage period decreases in vigour index, seedling dry weight, root and shoot length was noticed irrespective of seed treatments.

The rate of reduction in germination percentage from the beginning of the storage period till the end (9^{th} month) of storage was slower in seeds treated with fungicide and polymer, compared to untreated seed. The rate of reduction in germination percentage during storage in T_5, (carbendazim 25% + mancozeb 75%) @ 3 g per kg of seed and T_0 (control) was 94.33 and 88.67 per cent from initial to 69.67 and 62.00 per cent at the end of 9^{th} month of storage period respectively. These results are in conformity with the earlier findings of Taylor *et al.* (2001) [16] in onion, Vanangamudi *et al*. (2003) [18] in maize and Larissa *et al.* (2004) [10] in bean. This increase in seed germination might be due to reduced incidence of seed-borne fungal pathogens compared to control. Similar results were also reported by Ashwini and Giri (2014) [3] in green gram.

The other quality parameters *viz*., peak value of germination, root length (cm), shoot length (cm), seedling length (cm), dry weight of seedlings (mg) and seedling vigour index recorded at the initial storage was 43.50, 25.05 cm, 21.00 cm, 46.05 cm, 134.1 mg, 4349 and 12659 which at the end of 9^{th} month of storage was 22.36, 12.03 cm, 9.83 cm, 21.86 cm, 111.1 mg, 1524 and 7747 in T_5, (carbendazim 25% + mancozeb 75%) @ 3 g per kg of seed whereas, untreated seeds (T_0) recorded 16.76, 7.42 cm, 5.70 cm, 13.12 cm, 77.4 mg, 814 and 4803, respectively at the end of storage period. The polymer keeps the seed intact, as it acts as binding material and covers the minor cracks and aberrations on the seed coat thus blocking the fungal invasion. It may also act as a physical barrier which reduces leaching of inhibitors from seed coverings and restrict oxygen movement and thus reducing the respiration of embryo thereby reducing the ageing effect on seed (Duan and Burris, 1997) [4]. The polymer also prevents moisture content fluctuations during storage (West *et al*., 1985) [19]. The fungicide protected by polymer enhances their efficiency till the end of storage period. It forms a flexible film that adheres and protects the fungicides preventing dusting off and loss of fungicide during storage. It was due to higher percentage and better germination of seedlings in seeds coated with polymer, fungicide and insecticide as this protects fungi invasion and insect attack thereby good and better germination and subsequent higher root and shoot length. Similar results were also reported by Geetharani *et al*. (2006) [6] in chilli and Kunkur *et al*. (2007) [9] in cotton due to elongation of shoot due to proper supply of water and nutrients which were enabled by the polymers. This, in the present study is reflected by reducing the seed infection by pathogen.

The enhanced germination and quality parameters with treated seeds with fungicides and polymer coating is because of the combined favourable effects of these two chemicals. The fungicides protected the seed from deterioration by reducing the fungal invasion. The effectiveness of fungicides and polymer coating may be due to the compatibility and synergetic effect, which reduced the growth of the pathogen and favoured germination and other parameters (Omvir Singh *et al*., 1973) [11] in soybean, (Sindhan and Bose, 1981) [13] in french bean and (Sundaresh *et al.* 1987) [16] in soybean.

Table 1: Effect of seed treatment with different fungicides along with polymer on seed germination (%) during storage of soybean cv. JS 335

Treatments	**Months of storage**									
	Initial	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
T_0	88.67 (59.91)	88.33 (59.70)	86.00 (58.35)	84.50 (57.53)	81.33 (55.87)	78.00 (54.21)	75.17 (52.86)	71.70 (51.24)	66.70 (48.96)	62.00 (46.85)
T_1	89.67 (60.53)	89.33 (60.32)	87.33 (59.12)	86.00 (58.35)	81.67 (56.04)	78.33 (54.38)	75.67 (53.09)	72.53 (51.62)	68.20 (49.64)	63.00 (47.30)
T_2	90.00 (60.74)	89.33 (60.32)	87.33 (59.12)	86.33 (58.54)	83.00 (56.73)	78.67 (54.54)	76.50 (53.49)	73.07 (51.87)	68.67 (49.85)	64.00 (47.75)
T_3	90.67 (61.17)	89.67 (60.53)	88.33 (59.71)	86.67 (58.73)	83.67 (57.08)	80.67 (55.53)	77.67 (54.05)	74.33 (52.46)	69.67 (50.31)	64.33 (47.90)
T_4	91.33 (61.62)	90.33 (60.95)	88.67 (59.91)	86.67 (58.73)	84.67 (57.62)	82.33 (56.38)	78.00 (54.21)	75.37 (52.95)	70.67 (50.76)	64.67 (48.05)
T_5	94.33 (63.91)	93.67 (63.35)	92.00 (62.09)	90.00 (60.74)	88.00 (59.51)	86.67 (58.73)	82.33 (56.38)	79.37 (54.88)	74.33 (52.46)	69.67 (50.31)
T_6	93.33 (63.08)	91.67 (61.85)	89.00 (60.11)	87.50 (59.21)	85.67 (58.17)	84.00 (57.26)	80.50 (55.45)	77.00 (53.73)	70.67 (50.76)	65.33 (48.35)
Mean	91.14 (61.57)	90.33 (61.00)	88.38 (59.77)	86.81 (58.83)	84.00 (57.29)	81.24 (55.86)	77.98 (54.22)	74.77 (52.68)	69.84 (50.39)	64.71 (48.07)
S.Em±	0.16	0.13	0.10	0.07	0.08	0.09	0.06	0.05	0.03	0.03
CD at 1%	0.69	0.55	0.43	0.31	0.32	0.37	0.23	0.20	0.15	0.12

Values in parenthesis are arc sine transformed value

T_0: Control, T_1: Polymer @ 5 ml, T_2: T_1+ thiram @ 3 g/kg, T_3: T_1+ carboxin @ 2 g/kg, T_4: T_1+ carbendazim @ 2 g/kg, T_5: T_1+ (carbendazim + mancozeb) @ 3 g/kg, T_6: T_1+ (thiram + carboxin) @ 3 g/kg of seed.

Table 2: Effect of seed treatment with different fungicides along with polymer on peak value of germination during storage of soybean cv. JS 335

Treatments	**Months of storage**									
	Initial	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
T_0	36.50	34.83	34.50	33.07	32.83	30.17	28.50	26.09	22.26	16.76
T_1	37.83	36.17	36.00	34.67	34.33	31.33	29.67	27.00	23.00	17.33
T_2	38.17	36.50	36.17	35.37	35.00	31.83	30.17	26.63	22.29	16.29
T_3	38.83	37.17	37.00	35.90	35.50	32.67	31.00	28.26	24.43	18.93
T_4	40.50	39.15	38.16	37.25	36.70	33.80	32.18	29.39	25.69	20.37
T_5	43.50	42.97	42.03	40.67	39.83	37.83	36.17	33.03	28.53	22.36
T_6	41.83	40.57	39.33	38.38	37.83	34.83	33.17	30.29	26.45	20.95
Mean	39.60	38.19	37.60	36.47	36.00	33.21	31.55	28.67	24.66	19.00
S.Em±	0.29	0.29	0.28	0.27	0.26	0.24	0.23	0.21	0.18	0.14
CD at 1%	1.22	1.20	1.16	1.12	1.11	1.02	0.97	0.88	0.75	0.57

T_0: Control, T_1: Polymer @ 5 ml, T_2: T_1+ thiram @ 3 g/kg, T_3: T_1+ carboxin @ 2 g/kg, T_4: T_1+ carbendazim @ 2 g/kg, T_5: T_1+ (carbendazim + mancozeb) @ 3 g/kg, T_6: T_1+ (thiram + carboxin) @ 3 g/kg of seed.

Table 3: Effect of seed treatment with different fungicides along with polymer on root length (cm) during storage of soybean cv. JS 335

Treatments	**Months of storage**									
	Initial	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
T_0	21.00	20.28	19.78	18.47	16.47	14.92	13.92	11.92	9.67	7.42
T_1	22.18	21.50	21.00	19.58	17.65	16.17	14.80	13.30	11.05	8.61
T_2	22.50	22.01	21.51	20.33	19.58	19.28	16.28	15.03	12.78	9.25
T_3	22.67	22.22	21.72	20.35	19.70	19.58	16.35	15.10	12.85	9.74
T_4	23.09	22.92	22.42	21.57	20.57	19.70	17.67	16.02	13.77	10.20
T_5	25.05	24.77	24.27	23.38	22.12	21.20	19.95	18.40	16.15	12.03
T_6	24.32	23.85	23.45	22.42	21.25	20.33	18.54	16.75	14.50	10.50
Mean	22.97	22.51	22.02	20.87	19.62	18.74	16.79	15.22	12.97	9.68
S.Em±	0.17	0.16	0.17	0.15	0.14	0.14	0.12	0.11	0.10	0.07
CD at 1%	0.71	0.69	0.71	0.64	0.60	0.58	0.51	0.47	0.41	0.30

T_0: Control, T_1: Polymer @ 5 ml, T_2: T_1+ thiram @ 3 g/kg, T_3: T_1+ carboxin @ 2 g/kg, T_4: T_1+ carbendazim @ 2 g/kg, T_5: T_1+ (carbendazim + mancozeb) @ 3 g/kg, T_6: T_1+ (thiram + carboxin) @ 3 g/kg of seed.

Table 3: Effect of seed treatment with different fungicides along with polymer on shoot length (cm) during storage of soybean cv. JS 335

Treatments	Months of storage									
	Initial	1	2	3	4	5	6	7	8	9
T_0	16.00	15.20	14.83	13.50	12.17	10.83	9.53	8.70	7.70	5.70
T_1	16.83	16.03	15.67	14.33	13.00	11.67	10.45	9.62	8.62	6.04
T_2	17.17	16.37	16.00	14.67	13.33	12.00	11.48	10.15	8.98	6.65
T_3	17.83	17.03	16.67	15.33	14.00	12.67	12.07	10.74	9.57	7.24
T_4	19.32	18.43	18.27	17.22	16.27	14.33	12.54	11.54	10.70	9.04
T_5	21.00	20.40	20.17	19.27	18.63	17.17	15.06	13.93	12.56	9.83
T_6	20.39	19.52	19.24	18.19	17.47	15.49	13.07	12.07	11.10	9.16
Mean	18.36	17.57	17.26	16.07	14.98	13.45	12.03	10.96	9.89	7.67
S.Em±	0.14	0.10	0.12	0.12	0.11	0.10	0.09	0.08	0.07	0.06
CD at 1%	0.59	0.43	0.53	0.49	0.46	0.42	0.37	0.34	0.31	0.24

T_0: Control, T_1: Polymer @ 5 ml, T_2: T_1+ thiram @ 3 g/kg, T_3: T_1+ carboxin @ 2 g/kg, T_4: T_1+ carbendazim @ 2 g/kg, T_5: T_1+ (carbendazim + mancozeb) @ 3 g/kg, T_6: T_1+ (thiram + carboxin) @ 3 g/kg of seed.

Table 4: Effect of seed treatment with different fungicides along with polymer on seedling length (cm) during storage of soybean cv. JS 335

Treatments	Months of storage									
	Initial	1	2	3	4	5	6	7	8	9
T_0	37.00	35.48	34.61	31.97	28.64	25.75	23.45	20.62	17.37	13.12
T_1	39.01	37.54	36.67	33.91	30.65	27.84	25.25	22.92	19.67	14.65
T_2	39.67	38.38	37.51	35.00	32.91	31.28	27.76	25.18	21.76	15.90
T_3	40.50	39.25	38.39	35.68	33.70	32.25	28.42	25.84	22.42	16.98
T_4	42.41	41.35	40.69	38.79	36.84	34.03	30.21	27.56	24.47	19.23
T_5	46.05	45.17	44.44	42.65	40.75	38.37	35.01	32.33	28.71	21.86
T_6	44.71	43.37	42.69	40.61	38.72	35.82	31.61	28.82	25.60	19.66
Mean	41.34	40.08	39.28	36.94	34.60	32.19	28.82	26.18	22.86	17.34
S.Em±	0.28	0.21	0.22	0.27	0.25	0.23	0.21	0.19	0.17	0.13
CD at 1%	1.19	0.89	0.94	1.13	1.06	0.99	0.89	0.81	0.71	0.54

T_0: Control, T_1: Polymer @ 5 ml, T_2: T_1+ thiram @ 3 g/kg, T_3: T_1+ carboxin @ 2 g/kg, T_4: T_1+ carbendazim @ 2 g/kg, T_5: T_1+ (carbendazim + mancozeb) @ 3 g/kg, T_6: T_1+ (thiram + carboxin) @ 3 g/kg of seed.

Table 5: Effect of seed treatment with different fungicides along with polymer on seedling dry weight (mg) during storage of soybean cv. JS 335

Treatments	Months of storage									
	Initial	1	2	3	4	5	6	7	8	9
T_0	108.5	107.0	105.0	102.0	98.9	95.4	91.4	87.4	82.4	77.4
T_1	110.9	109.4	107.6	105.4	103.1	100.5	97.8	94.1	90.0	85.9
T_2	115.8	114.3	112.5	110.4	108.0	105.5	102.7	99.1	95.5	91.8
T_3	117.6	116.1	114.4	112.3	109.9	107.4	104.6	101.2	97.7	94.2
T_4	120.3	118.8	117.1	115.0	112.6	109.1	105.6	102.8	98.5	94.1
T_5	134.1	132.6	130.8	128.7	126.3	123.8	120.9	117.7	114.4	111.1
T_6	125.3	124.3	122.9	120.9	118.5	113.0	108.9	106.0	101.5	97.0
Mean	118.9	117.5	115.8	113.5	111.0	107.8	104.6	101.2	97.1	93.1
S.Em±	0.87	0.86	0.84	0.83	0.81	0.79	0.76	0.74	0.71	0.68
CD at 1%	3.65	3.61	3.55	3.48	3.41	3.31	3.22	3.11	2.99	2.87

T_0: Control, T_1: Polymer @ 5 ml, T_2: T_1+ thiram @ 3 g/kg, T_3: T_1+ carboxin @ 2 g/kg, T_4: T_1+ carbendazim @ 2 g/kg, T_5: T_1+ (carbendazim + mancozeb) @ 3 g/kg, T_6: T_1+ (thiram + carboxin) @ 3 g/kg of seed.

Table 6: Effect of seed treatment with different fungicides along with polymer on seedling vigour index-I during storage of soybean cv. JS 335

Treatments	Months of storage									
	Initial	1	2	3	4	5	6	7	8	9
T_0	3285	3138	2981	2705	2332	2011	1765	1480	1160	814
T_1	3503	3357	3206	2920	2506	2183	1913	1665	1343	924
T_2	3575	3433	3279	3025	2735	2464	2127	1842	1496	1019
T_3	3675	3523	3394	3095	2822	2603	2209	1922	1563	1093
T_4	3877	3739	3611	3365	3121	2804	2358	2079	1731	1245
T_5	4349	4235	4093	3841	3589	3328	2885	2568	2136	1524
T_6	4176	3979	3803	3556	3319	3012	2546	2221	1810	1285
Mean	3777	3629	3481	3215	2918	2629	2258	1968	1606	1129
S.Em±	26.90	21.17	22.81	24.20	23.38	22.28	18.95	17.26	14.79	10.71
CD at 1%	113	89	96	102	98	94	80	73	62	45

T_0: Control, T_1: Polymer @ 5 ml, T_2: T_1+ thiram @ 3 g/kg, T_3: T_1+ carboxin @ 2 g/kg, T_4: T_1+ carbendazim @ 2 g/kg, T_5: T_1+ (carbendazim + mancozeb) @ 3 g/kg, T_6: T_1+ (thiram + carboxin) @ 3 g/kg of seed.

Table 7: Effect of seed treatment with different fungicides along with polymer on seedling vigour index-II during storage of soybean cv. JS 335

Treatments	Months of storage									
	Initial	1	2	3	4	5	6	7	8	9
T_0	9631	9462	9040	8628	8051	7448	6877	6272	5501	4803
T_1	9957	9785	9413	9079	8428	7886	7406	6837	6147	5418
T_2	10432	10220	9838	9542	8977	8310	7867	7253	6564	5883
T_3	10676	10423	10114	9739	9203	8670	8131	7528	6811	6063
T_4	10998	10742	10389	9971	9540	8987	8248	7756	6964	6091
T_5	12659	12429	12046	11594	11127	10740	9965	9351	8512	7747
T_6	11702	11403	10949	10588	10163	9501	8773	8166	7179	6345
Mean	10865	10638	10256	9877	9356	8792	8181	7595	6811	6050
S.Em±	78.78	77.34	74.66	72.25	69.30	66.64	62.20	58.58	53.81	49.77
CD at 1%	332	326	314	304	292	281	262	247	227	210

T_0: Control, T_1: Polymer @ 5 ml, T_2: T_1+ thiram @ 3 g/kg, T_3: T_1+ carboxin @ 2 g/kg, T_4: T_1+ carbendazim @ 2 g/kg, T_5: T_1+ (carbendazim + mancozeb) @ 3 g/kg, T_6: T_1+ (thiram + carboxin) @ 3 g/kg of seed.

Conclusion

In conclusion, the higher germination percentage, root length, shoot length, seedling vigour index, dry matter, were recorded in the seeds treated with carbendazim 25% + mancozeb 75% @ 3 g per kg of seed with polymer @ 5 ml per kg of seed (T_5) recorded significantly higher seed quality parameters as compared to control. The enhanced germination and quality parameters with treated seeds with fungicides and polymer coating is because of the combined favourable effects of these two chemicals. The fungicides protected the seed deterioration by reducing the fungal invasion. The effectiveness of fungicides and polymer coating may be due to the compatibility and synergetic effect, which reduced the growth of the pathogen and favoured germination and other parameters.

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