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Effect of Seed Coating Types and Storage Period after Coating on Seed Germination (%) and Seedling Vigour in Pigeonpea

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ABSTRACT: Biological seed coating is a new seed treatment technology in which biological agents are coated on the seed surface to control seed and soil-borne pathogens. Using a biofriendly polymer as an adjuvant, pigeonpea seed was biologically coated with *Trichoderma viride, Pseudomonas fluorescens,* Phosphorus solubilizing bacteria (PSB), and *Rhizobium* spp. The current study, titled "Studies on effectiveness of biological seed coating on seed quality parameters of Pigeonpea (*Cajanus cajan* L.), was performed at Department of Seed Science and Technology, Seed Research and Technology Centre and Agriculture Research Station, Tandur, PJTSAU, Hyderabad during the summer of 2018, Kharif of 2018, and Rabi of 2018-19 to investigate the effect of different types of seed coating and storage time after seed coating on pigeonpea seed germination (%) and seedling vigour. During the six-months storage period, the seed quality parameters were evaluated at bimonthly intervals. Six months after treatment, seed combinely inoculated with deltamethrin + *T. viride* + *P. fluorescens* + *B. subtilis* + Rhizobium + biofriendly polymer (adjuvant) showed good longevity by recording less reduction in seed germination (11%), SVI- I (776), SVI- II (12), compared to untreated control (24 %, 1012 and 22, respectively). The study's findings suggested that coating seed with biological agents, an effective chemical protectant and a biofriendly polymer as an adjuvant produced better results without affecting the seed quality.

Keywords: Pigeonpea, Biological seed coating, Biocontrol, biofriendly polymer, seed germination(%), seedling vigour.

INTRODUCTION

Pigeonpea [*Cajanus cajan* L.] is an important pulse crop rich in protein content of 15.5 - 28.8% which is almost three times to that of cereals. Keeping in view, the 68th UN General Assembly of United Nations Organization (UNO), Geneva declared 2016 as the International Year of Pulses (IYP) with the motto of "Nutritious seeds for a sustainable future" (Malvika, 2016). It's also known as arhar, redgramor tur. Pigeonpea meet a large portion of the protein needs of the country's vegetarian population. Iron, Lysine, riboflavin, thiamine, and niacin are all abundant. Pigeonpea has high protein content as well as the vital amino acids lysine, methionine, and tryptophan. Protein (20-22%), carbohydrate (57.3%), fat (1.5%) and ash (8.1%) are all present in dry pigeonpea seeds. It's protein contains two globulins- cajanin and concajanin, which constitute for 58 and 8% of the total (Saxena *et al.,* 2002). As a legume plant, pigeonpea can fix atmospheric nitrogen, restoring a significant amount of N into soil.

After chickpea, it is India's second most important pulse crop. Pigeonpea is grown on 4.78 million hectares in India, with a production of 4.43 million tonnes and a productivity of 859 kg per hectare (DES, Ministry of Agriculture, 2021). Incidence of diseases, insects, and other physiological stresses in the field are the principal constraints in reaching potential yield of the pigeonpea (Akhil Reddy *et al.,* 2020). It is known to be infected by over a hundred pathogens, the most common of which being pigeonpea wilt caused by *Fusarium udum* in India. This disease can arise during the early stages of plant development (4-6 weeks stage) and has a significant impact on yield. This disease has a significant impact on crop yield due to poor emergence in field, seedling establishment, and plant stand in the field, ultimately resulting in lower productivity and production. Wilt causes yield losses ranging from 18.86 to 54.24 percent in pigeonpea (Sharma *et al*., 2018).

Furthermore, seed performance can be improved by applying fungicides, insecticides, and other protective agents to the seed surface via coating to protect the seed from pathogens. Even though biological seed treatment is not new, the fundamental limitation is that seed treatment can only be done right before sowing. Because of their busy field operations, most farmers are skipping this crucial step of seed inoculation, resulting in poor field stand in the pulses (Jagadeesh *et al*., 2017). Beneficial microorganisms treated to seeds are an effective way to get microbial inoculum into the soil, where it will be ideally positioned to colonize seedling roots and defend against soil-borne diseases, as well as oxidative stress caused by heavy metals (Patel *et al*., 2016 and Shalini Devi *et al*., 2017). With this in consideration, the current investigation will seek to determine the technical output for implementing combined inoculation of bioagents and biofertilizers well ahead of sowing, *i.e.* during the seed processing and packing stage only. This may provide assurance to farmer that the seed is of good quality and that the seedlings are protected in the field. In this context, the purpose of this research is to determine the impact of seed coating types and storage time after coating on pigeonpea seed quality and storability.

MATERIAL AND METHODS

A. Material

Regional Agricultural Research Station, Palem, Mahabubnagar, Telangana, provided freshly harvested seeds of the Pigeonpea variety PRG - 176. The seed had a 90% initial germination rate and an 8.1% seed moisture content. The Biological Control Laboratory, Department of Agriculture, Rajendranagar, Hyderabad, provided biological agents such as *Trichoderma viride, Pseudomonas fluorescens, Rhizobium* spp, and Phosphorous Solubilizing Bacteria. Ecosense labs in Mumbai provided *Beauveria brongniartii* (Bioinsecticide). Centor India (Centor India, http://www.centoroceania.com/polymers-coatings-2/Biofriendly), Bliss Paradise Hitex, Secunderabad, Telangana provided bio-friendly polymer.

B. Methodology

T. viride, P. fluorescens, Rhizobium and Phosphorous Solubilizing Bacteria were utilised at 4 gms/kg seed for biological seed coating. 300 g pigeonpea seed was weighed separately for each treatment and deposited in a seed coating machine. To prepare the biological coating material, weigh 4 gms of adjuvant (biofriendly polymer) into the beaker, and then add 2-3 ml of distilled water and well mix. Biological substances were added to the diluted adjuvant and carefully mixed. Seed that had been uniformly coated was removed from the coating machine and dried in the shade for two hours. This treated seed was then divided into three replications of 100 gms each, packed in zip lock polythene covers and kept for storage under ambient conditions.

Seed quality and storability of biologically coated pigeonpea seed were studied.

Seed Germination (%). The laboratory test for germination was carried out according to ISTA guidelines (International Seed Testing Association, International Rules for Seed Testing, 2019) using between the paper method. Each treatment had three replications of 100 seeds each, which were uniformly placed on germination paper.

Treatment Details

Factor 1			Treatments for seed coating
	A1	:	Thiram @ 2 g/kg + Deltamethrin @ 0.04 ml/kg + Biopolymer @ 3-4 g/kg seed
	A2	:	*T. viride* @ 4 g/kg+ *P. fluorescens* @ 4 g/kg+ *B. subtilis* @ 4 g/kg + *Rhizobium* @ 4 g/kg + Deltamethrin @ 0.04 ml/kg+ Biopolymer @ 3-4 g/kg seed
	A3	:	*T. viride* @ 4 g/kg+ *P. fluorescens* @ 4 g/kg+ *B. subtilis* @ 4 g/kg + *Rhizobium* @ 4 g/kg + Bioinsecticide @ 4 g/kg+ Biopolymer @ 3-4 g/kg seed
	A4	:	Untreated seed (control)
Factor 2			Storage time after coating the seed
	B1	:	Storage of four months
	B2	:	Storage of three months
	B3	:	Storage of two months
	B4	:	Storage of one month
	B5	:	No storage
Total No. of treatments		:	20

T1	:	A1B1		**T11**	:	A3B1
T2	:	A1B2		**T12**	:	A3B2
T3	:	A1B3		**T13**	:	A3B3
T4	:	A1B4		**T14**	:	A3B4
T5	:	A1B5		**T15**	:	A3B5
T6	:	A2B1		**T16**	:	A4B1
T7	:	A2B2		**T17**	:	A4B2
T8	:	A2B3		**T18**	:	A4B3
T9	:	A2B4		**T19**	:	A4B4
T10	:	A2B5		**T20**	:	A4B5

Total No. of replications		3

The rolled paper towel was kept in the seed germinator and maintained at constant temperature of 25±0.5°C and 95% relative humidity. On sixth day evaluation of normal seedlings, abnormal seedlings, fresh ungerminated seeds and dead seeds were done. The following formula was used to compute the germination % depending on the number of normal seedlings.

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds planted}} \times 100$$

Seedling length (cm). Ten normal seedlings were randomly selected per replication in each treatment on 6th day of evaluation. A scale was used to measure root length from the tip of the primary root to the base of the hypocotyl, and mean root length was expressed in centimetres. The same ten normal seedlings that were used for root length measurement were also utilized to measure shoot length. The shoot length was measured from the primary leaf tip to the hypocotyl base, and the average shoot length was reported in cm.

Seedling dry weight (g). Ten normal seedlings used for shoot and root length measurements were put into butter paper bags and kept in hot air oven at 80 ± 1°C for 24 hr. The mean dry weight of the seedlings were recorded and reported in grams.

Seedling vigor index I. Seedling vigor index I was estimated using Abdul-Baki and Anderson's (1973) formula and expressed in whole number.

SVI- I = Germination (%) × Seedling length (cm)

Seedling vigor index II. Seedling vigor index II was determined as per the method suggested by Abdul-Baki and Anderson (1973) and expressed in whole number.

SVI- II = Germination (%) × Seedling dry wt. (g)

C. Statistical Analysis

The data was analyzed statistically using Panse and Sukhatma's (1985) Two Factorial (CRD) Completely Randomized Design and the standard error of difference was determined at the 5% probability level to compare the mean difference between the treatments. Before being subjected to statistical analysis, the percentage data was converted to the corresponding angular (arc sin) values.

RESULTS AND DISCUSSIONS

A. Impact of biological seed coating on pigeonpea seed germination (%)

The experiment was initiated with the untreated seed of PRG- 176 pigeonpea which showed 90 % germination. Table 1 and Fig. 1 shows the findings of the study on the effect of seed coating types and storage time after coating on seed germination. From the beginning of experiment (0MAT), the average seed germination rate was 86 %.Mean seed germination was observed to be decreased gradually from 0MAT to 6MAT (86% to 71%, respectively) with a mean reduction of 15 %. This was in accordance with the findings reported in groundnut (Balesevic *et al.,* 2010) and in soybean (Kandil *et al.,* 2013) that the germination percentage, germination index and speed of germination were decreased as the period of storage was increased.

At 0MAT, T9 treatment (*T. viride* @ 4 g/kg seed + *P. fluorescens* @ 4 g/kg seed +*B. subtilis* @ 4 g/kg seed + *Rhizobium* @ 4 g/kg seed + Deltamethrin @ 0.04 ml/kg seed + Biofriendly polymer @ 3-4 g/kg seed) recorded significantly on par germination with the seeds that were coated with insecticide + fungicide + polymer and untreated (control) seed.
At 6MAT, highest germination (%) was recorded in the seeds treated with T7 (*T. viride* @ 4 g/kg seed + *P. fluorescens* @ 4 g/kg seed + *B. subtilis* @ 4 g/kg seed + *Rhizobium* @ 4 g/kg seed+ Deltamethrin @ 0.04 ml/kg seed + Biofriendly polymer @ 3-4 g/kg seed) (79%) which was significantly on par with the seeds that are coated with insecticide + fungicide + polymer compared to untreated control.

Among the seed coatingtypes, seeds treated with insecticide + bioagents + polymer recorded lowest reduction in germination (11 %) over a storage period of six months. This is followed by the seeds coated with insecticide + fungicide + polymer (11 %) and bioagents + polymer (14 %). Highest reduction in seed germination (24 %) was recorded in the seeds of untreated control.

The similar findings of enhanced seed germination with polymer + chemical protectants compared to untreated control even after storage period were also reported with polymer + vitavax (Verma and Verma 2014) and polymer + carbendazim + thiram (Junior *et al.,* 2012a) in soybean, polymer + fungicide (Larissa *et al.,* 2004) in bean, polymer + thiram (Basavaraj *et al*., 2008) in onion and polymer + carbendazim (Geetharani and Srimathi, 2006) in chilli, polymer + fungicide + insecticide (Vanangamudi *et al.,* 2003) and polymer + fungicide (Wilson and Geneve, 2004) in maize and polymer + thiram (Manjunatha *et al.,* 2008) in chilli.

B. Impact of biological seed coating on pigeonpea seedling vigour index-1

Table 2 and Fig 2 shows the findings of the study on the effect of seed coating types and storage time after coating on SVI- I. The average SVI- I recorded from the starting of the experiment (0MAT) was 2036. Mean SVI- I was observed to be decreased gradually from 0MAT to 6MAT (2036 to 1179, respectively) with a mean reduction of 857.

At 0MAT, seed coated with T2 (Thiram @ 2 g/kg seed + Deltamethrin @ 0.04 ml/kg seed + polymer @ 3-4 g/kg seed) recorded significantly on par SVI- I (2179) with the seeds that are coated with chemical + bioagents + biofriendly polymer. At 6MAT, highest SVI- I (1392) was recorded in the seeds treated with T7 (*T. viride* @ 4 g/kg seed + *P. fluorescens* @ 4 g/kg seed + *B. subtilis* @ 4 g/kg seed + *Rhizobium* @ 4 g/kg seed + Deltamethrin@ 0.04 ml/kg seed + polymer @ 3-4 g/kg seed) which was significantly on par with the seeds that are coated with chemicals + biofriendly polymer compared to untreated control.

Table 1: Effect of seed coating types and storage period after coating on seed germination (%) & longevity in pigeonpea seed.

Details of Treatment	Storage Period (Months)	Treatments	0MAT	2MAT	4MAT	6MAT	Decrease (6-0)	Avg
Insecticide + Fungicide + Polymer	4	T1	84 (67)	84 (67)	82 (65)	78 (62)	6.00	11
	3	T2	88 (71)	88 (70)	83 (66)	76 (61)	12.00	
	2	T3	89 (71)	86 (68)	84 (67)	77 (62)	12.00	
	1	T4	89 (71)	85 (67)	82 (65)	76 (61)	13.00	
	0	T5	88 (70)	88 (70)	84 (67)	74 (59)	14.00	
Insecticide + Bioagents + Polymer	4	T6	87 (69)	84 (67)	81 (64)	76 (61)	11.00	11
	3	T7	84 (66)	81 (64)	80 (64)	79 (63)	5.00	
	2	T8	84 (66)	82 (65)	80 (63)	74 (59)	10.00	
	1	T9	93 (75)	88 (70)	83 (66)	78 (62)	15.00	
	0	T10	87 (69)	84 (67)	81 (64)	72 (58)	15.00	
Bioagents + Polymer	4	T11	84 (67)	83 (66)	83 (65)	67 (55)	17.00	14
	3	T12	82 (65)	80 (64)	79 (63)	71 (58)	11.00	
	2	T13	84 (66)	82 (65)	79 (63)	77 (62)	7.00	
	1	T14	85 (68)	83 (66)	82 (65)	72 (58)	13.00	
	0	T15	85 (68)	83 (66)	81 (64)	64 (53)	21.00	
Untreated control	4	T16	90 (71)	87 (69)	82 (65)	66 (55)	24.00	24
	3	T17	89 (71)	86 (68)	81 (64)	70 (57)	19.00	
	2	T18	87 (69)	86 (69)	83 (66)	62 (52)	25.00	
	1	T19	87 (69)	85 (68)	82 (66)	58 (50)	29.00	
	0	T20	89 (71)	86 (68)	82 (65)	68 (56)	21.00	
Mean			**86 (69)**	**84 (67)**	**81 (65)**	**72(58)**	**14.00**	
S.D			4.155	3.303	2.767	6.877		
C.V %			4.494	3.412	3.491	4.875		
Treatment (C)		**SE (m)**	1.011	0.748	0.739	1.245		
		CD 0.05	2.889	2.138	2.113	3.559		
Period of storage after coating (S)		**SE (m)**	1.130	0.836	0.826	1.392		
		CD 0.05	3.230	2.391	2.362	3.979		
Treatment × Period of storage(C×S)		**SE (m)**	2.260	1.673	1.653	2.784		
		CD 0.05	6.461	4.782	4.725	7.959		

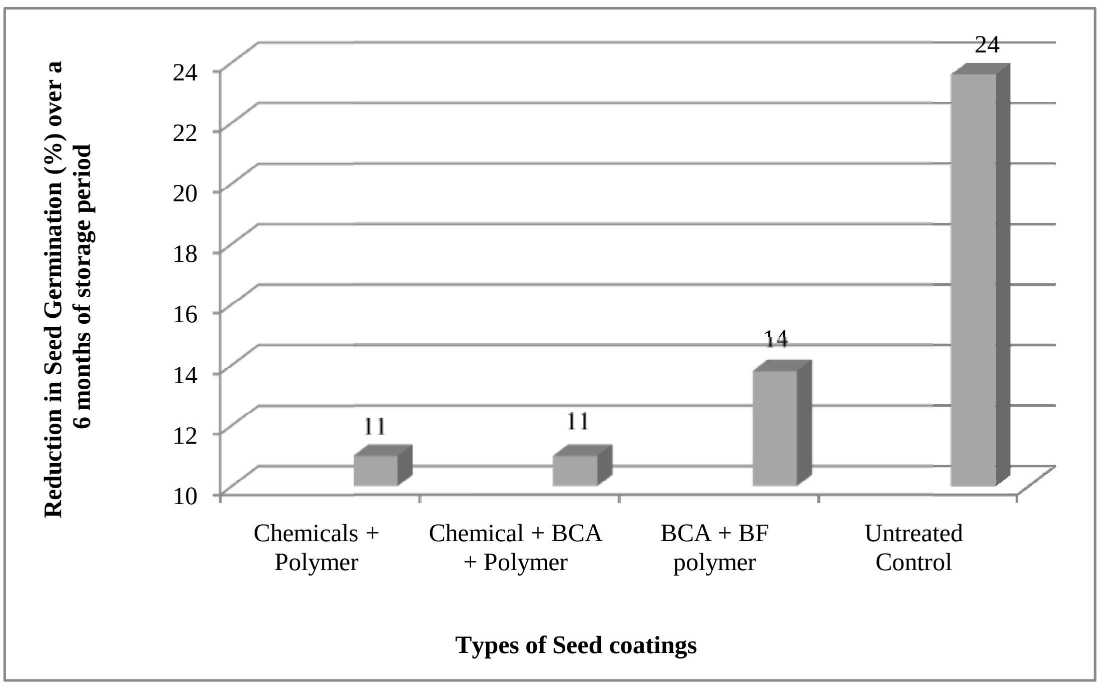

Fig. 1. Impact of seed coating materials on seed germination and longevity in pigeonpea.

Table 2: Effect of seed coating types and storage period after coating on seedling vigour index I& longevity in pigeonpea seed.

Details of Treatment	Storage Period (Months)	Treatments	0MAT	2MAT	4MAT	6MAT	Decrease (6-0)	Avg
Insecticide +Fungicide + Polymer	**4**	**T1**	2065	1743	1493	1192	873	828
	3	**T2**	2179	2018	1698	1326	848	
	2	**T3**	2066	1787	1752	1264	802	
	1	**T4**	2144	1845	1670	1273	871	
	0	**T5**	2020	2091	1724	1272	748	
Insecticide + Bioagents + Polymer	**4**	**T6**	1864	1801	1664	1250	614	776
	3	**T7**	1992	1819	1712	1392	600	
	2	**T8**	2058	1749	1567	1255	803	
	1	**T9**	2148	1981	1528	1199	949	
	0	**T10**	2056	1894	1472	1138	918	
Bioagents + Polymer	**4**	**T11**	1934	1810	1535	1048	886	808
	3	**T12**	1919	1809	1367	1053	866	
	2	**T13**	1857	1686	1564	1339	518	
	1	**T14**	1965	1783	1595	1225	740	
	0	**T15**	2122	1743	1619	1092	1030	
Untreated control	**4**	**T16**	2174	1936	1607	1079	1100	1012
	3	**T17**	2133	1812	1538	1105	1028	
	2	**T18**	2101	1811	1513	968	1133	
	1	**T19**	2020	1771	1622	986	1034	
	0	**T20**	1895	1727	1520	1130	765	
Mean			**2036**	**1831**	**1588**	**1179**	**857**	
S.D			143.56	132.74	129.61	148.53		
C.V %			4.792	4.276	4.443	3.699		
Treatment (C)		**SE (m)**	32.028	26.594	27.477	28.008		
		CD 0.05	91.544	76.013	78.537	80.054		
Period of storage after coating (S)		**SE (m)**	35.808	29.733	30.720	31.314		
		CD 0.05	102.34	84.985	87.807	89.503		
Treatment × Period of storage(C×S)		**SE (m)**	71.617	59.466	61.441	62.628		
		CD 0.05	204.69	169.97	175.61	179.00		

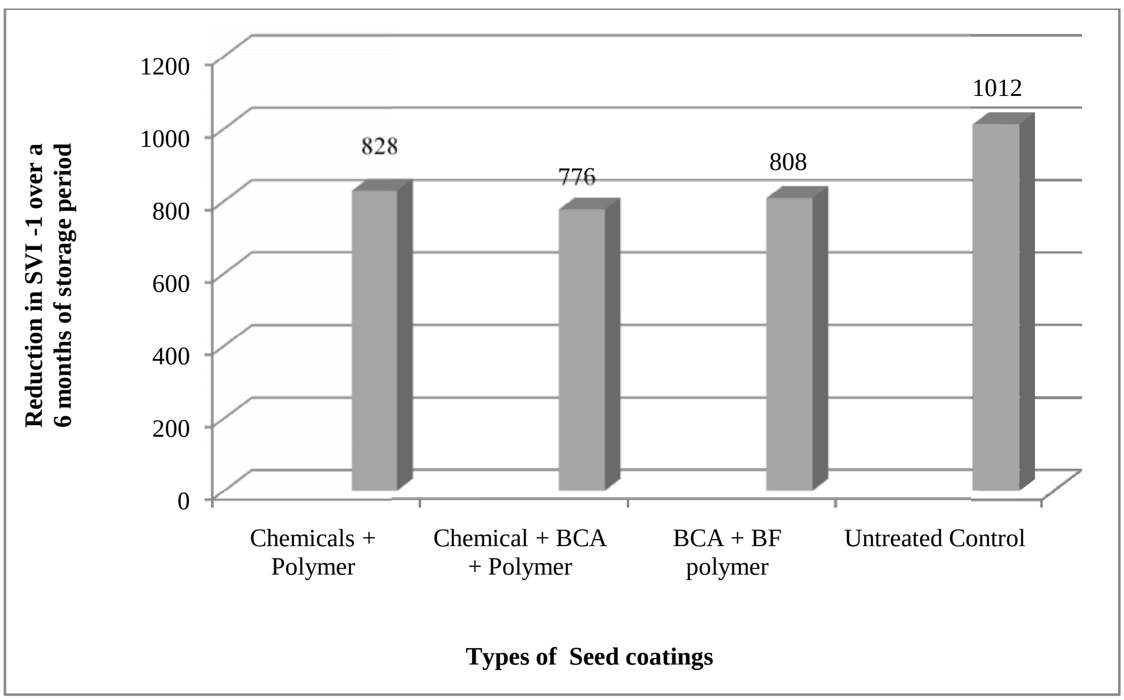

Fig. 2. Impact of seed coating materials on SVI-I and longevity in pigeonpea.

Among the seed coatingtypes, seeds treated with chemical+ bioagents + polymer recorded lowest reduction (776) in SVI- I over a period of six months storage. This is followed by the seeds treated with bioagents + polymer (808) and chemicals+ polymer (828). Highest reduction (1012) in SVI- I was recorded in the seeds of control.

These findings of enhanced SVI- 1 with biological agents are in accordance with (Asaduzzaman *et al.* 2010) who have given that seed coating with *T. harzianum*IMI -3924332 gave the highest SVI-1 in chilli, with *T. viride and T. harzianum*(Mukhtar *et al.*, 2012) in chilli and in peas with *T. viride* (Windham *et al.*, 1986). Similar findings of the enhanced SVI- I with biological agents + chemical protectants were also reported in okra and sunflower with *T.harzianum* + *Rhizobium* + polymer (Chaubey *et al.*, 2014) and in rice with *P. fluorescens* + thiram (Jeevalatha, 2004).

C. Impact of biological seed coating on pigeonpea seedling vigour index-2

Table 3 and Fig. 3 shows the findings of the study on the effect of seed coating types and storage time after coating on SVI-II. The average SVI- II recorded from the starting of the experiment (0MAT) was 75. Mean SVI- II was observed to be decreased gradually from 0MAT to 6MAT (75 to 60, respectively) with a mean reduction of 15.

At 0MAT, seed coated with T9 (*T. viride* @ 4 g/kg seed + *P. fluorescens* @ 4 g/kg seed + *B. subtilis* @ 4 g/kg seed + *Rhizobium* @ 4 g/kg seed + Deltamethrin @ 0.04 ml/kg seed + polymer @ 3-4 g/kg seed) recorded significantly on par SVI- II (81) with the seeds that are coated with chemicals + biofriendly polymer. At 6MAT, highest SVI- II (67) was recorded in the seeds treated with T6 (*T. viride* @ 4 g/kg seed + *P. fluorescens* @ 4 g/kg seed+ *B. subtilis* @ 4 g/kg seed + *Rhizobium* @ 4 g/kg seed + Deltamethrin @ 0.04 ml/kg seed + polymer @ 3-4 g/kg seed) which was significantly on par with the seeds that are coated with chemicals + biofriendly polymer compared to untreated control.

Among the seed coatingtypes, seeds treated with chemical+ bioagents + polymer recorded lowest reduction in SVI- II (12) over a storage period of six months. This is followed by the seeds treated with chemicals+ polymer (13) and bioagents + polymer (15). Highest reduction (22) in SVI- IIwas recorded in seeds of untreated control.

Table 3: Effect of seed coating types and storage period after coating on seedling vigour index II& longevity in pigeonpea seed.

Details of Treatment	Storage Period (Months)	Treatments	0MAT	2MAT	4MAT	6MAT	Decrease (6-0)	Avg
Insecticide + Fungicide + Polymer	4	T1	69	72	67	65	4	13
	3	T2	75	77	69	60	15	
	2	T3	78	74	66	66	12	
	1	T4	79	72	68	62	17	
	0	T5	79	72	72	63	16	
Insecticide + Bioagents + Polymer	4	T6	77	74	71	67	10	12
	3	T7	76	74	69	65	11	
	2	T8	71	71	73	64	7	
	1	T9	81	76	75	64	17	
	0	T10	75	73	67	62	13	
Bioagents + Polymer	4	T11	74	72	71	56	18	15
	3	T12	72	71	70	58	14	
	2	T13	72	71	69	66	6	
	1	T14	77	71	68	61	16	
	0	T15	77	73	72	55	22	
Untreated control	4	T16	79	76	69	54	25	22
	3	T17	73	70	69	58	15	
	2	T18	74	75	71	48	25	
	1	T19	73	72	70	45	28	
	0	T20	75	75	68	56	19	
Mean			**75**	**73**	**70**	**60**	**15**	
S.D			3.914	2.992	3.273	6.208		
C.V %			3.978	3.745	4.020	4.278		
Treatment (C)		**SE (m)**	0.773	0.708	0.723	0.657		
		CD 0.05	2.211	2.023	2.068	1.880		
Period of storage after coating (S)		**SE (m)**	0.865	0.791	0.808	0.735		
		CD 0.05	2.473	2.262	2.312	2.102		
Treatment × Period of storage(C×S)		**SE (m)**	1.730	1.583	1.617	1.470		
		CD 0.05	4.946	4.525	4.624	4.204		

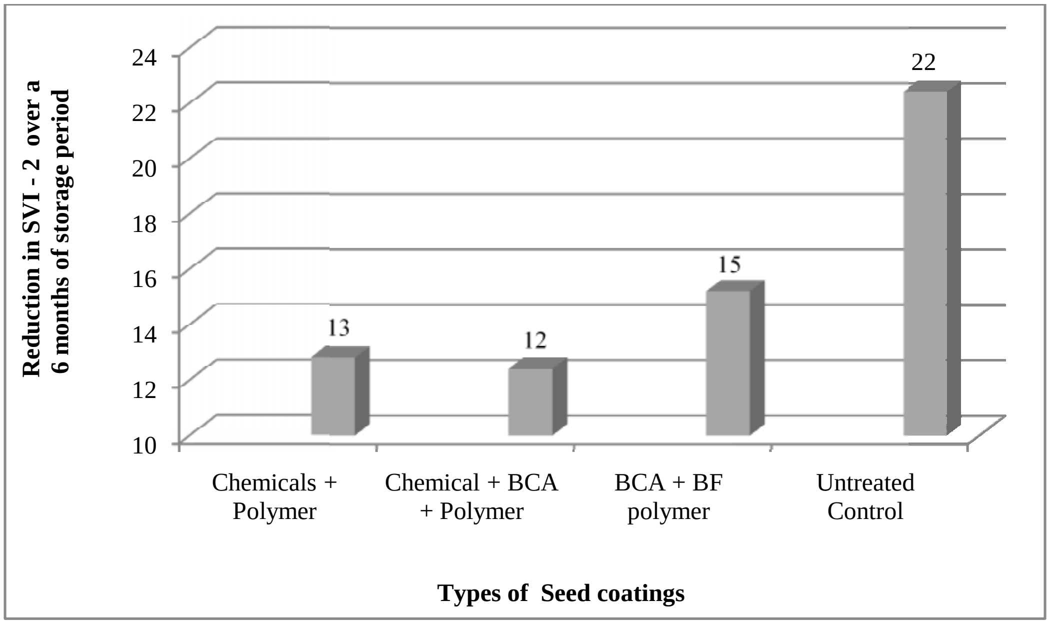

Fig. 3. Impact of seed coating materials on SVI- II and longevity in pigeonpea.

The results of high SVI- II with chemical protectants + polymer compared to untreated control even after storage period were also reported with thiram + polymer (Baig, 2005, Kunkur, 2005 and Kaushik *et al.*, 2014) in soybean, cotton and maize, thiram + polymer (Basavaraj *et al.*, 2008) in onion, vitavax + polymer (Verma and Verma, 2014) in soybean, carbendazim + polymer (Geetharani and Srimathi 2006) in chilli and fungicide + insecticide + polymer (Vanangamudi *et al.*, 2003) in maize.

These findings of the enhanced SVI- II with biological agents are in accordance with (Moussa *et al*., 2013) who have given that coating seed with *P. fluorescence* + *B. subtilis* gave the highest SVI- II in wheat, with *T. viride and T. harzianum* (Mukhtar *et al.*, 2012) in soybean, with *P. fluorescens* (Moeinzadeh *et al*., 2010) in sunflower, with *T. harzianum* IMI -3924332 (Asaduzzaman *et al.*, 2010) in chilli.

CONCLUSION

Seed quality parameters were gradually decreased with the increase in storage period from initial month to 6MAT in pigeonpea. With regard to type of seed coatings, seeds coated with deltamethrin (insecticide) @ 0.04 ml kg^{-1}seed + *T. viride* @ 4 g/kg seed + *P. fluorescens* @ 4 g/kg seed + *B. subtilis* @ 4 g/kg seed + *Rhizobium* @ 4 g/kg seed + biofriendly polymer (adjuvant) @ 4 g/kg seed showed good longevity by recording less reduction in seed germination (11%), SVI- I (776), SVI- II (12), compared to untreated control (24 %, 1012 and 22, respectively). Period of storage after seed coating showed a significant effect on seed quality parameters. Seeds coated 4 months before with insecticide (deltamethrin @ 0.04 g kg^{-1} seed) + bioagents (*T. viride* @ 4 g kg^{-1} seed + *P. fluorescens* @ 4 g kg^{-1} seed + *B. subtilis* @ 4 g kg^{-1} seed + *Rhizobium* @ 4 g kg^{-1} seed) + biofriendly polymer (@ 4 g kg^{-1} seed) showed better longevity by recording more SVI I (1250) and SVI II (67) at 6 months after storage and it showed no significant effect on other seed quality parameters. With regard to, period of storage after seed coating, the seeds coated 3 months back with deltamethrin + bioagents + biofriendly polymer recorded more SVI- I (1392) and SVI- II (65) after 6 months of storage. Treatment, T7 (deltamethrin + 4 bioagents + biofriendly polymer recorded good seed quality and longevity after 6 months storage by showing more germination (79%), more SVI- I (1392) and SVI- II (65) compared to its counterpart (T17) of untreated control (70%, 1105 and 58 respectively).

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