

Original Research Article

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Effect of Seed Treatment on Seed Quality and Storability in Wheat (*Triticum aestivum L.*) in North Western Himalayas

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A B S T R A C T

Storage experiment was conducted to study the effect of polymer, fungicides and insecticide on seed quality parameters and storability in wheat. Experimental material consisted of carry over wheat seeds (variety HPW- 155) of rabi 2017 - 18. The observations were recorded bimonthly on parameters viz; germination (%), seedling length (cm), dry weight (g), vigour index - I, vigour - II, speed of germination, field emergence (%), 100 seed weight (g) for 12 months of storage. All parameters declined with the advancement in storage period. The results showed that seeds treated with polymer + vitavax 200 @ 2 g/kg of seed, recorded higher germination percentage (95.00 %), seedling length (17.58 cm), seedling dry weight (0.0138 g), vigour index - I (1670) & vigour - II (1.311), speed of germination (19.98), 100 seed weight (5.54 g) and field emergence (87.33 %) which was at par with vitavax 200 @ 2 g/kg of seed, over untreated control (T_1). So it can be concluded that for maintain seed quality and enhancing storability, seed of wheat can either be treated with polymer @ 3 ml/kg of seed + vitavax 200 @ 2 g/kg of seed or vitavax 200 @ 2 g/kg of seed.

Keywords

Wheat, seed treatment, storability, seed quality

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Introduction

Quality seed, being the basic input in agriculture, plays an important role in realizing optimum yield and productivity of any crop. Seed with high quality and vigour will not only help in achieving optimum plant population in the field but also result in vigorous seedling, which can surpass the

initial abiotic and biotic stresses to significant extent (Jacob *et al.*, 2016). Deterioration of seed during storage is inevitable and leads to different changes at various levels viz., impairment or shift in metabolic activity, compositional changes, decline or change in enzyme activities, phenotypic, cytological changes apart from quantitative losses. Being hygroscopic in nature the viability and vigour

of seeds under storage are known to be regulated by variations in the physio-chemical factors, initial seed quality, storage structures, packaging materials (Doijode, 2000). The rate of seed deterioration can be slowed down either by storing the seeds under controlled or by treating the seeds with various seed treating chemicals. As the controlled conditions involve huge cost, seed treatment remains the best alternative approach to maintain the seed quality. From the past few decades, seed treatment technology has evolved through research innovations and has delivered several products that can be used to manipulate the performance potential of the seeds and subsequent crop (Jacob *et al.*, 2016). Seed treatment technology is being widely used for different purposes like synchronization of flowering between parental lines (Johnson *et al.*, 1999), for precision sowing (Lagoa *et al.*, 2012), for seed quality enhancement (Kumar *et al.*, 2007), delivery of nutrients (Farooq *et al.*, 2012), for early sowing in cold and wet soils (Sharratt and Gesch, 2008), delivery of growth hormones (Gevrek *et al.*, 2012), delivery of pesticides (Sherry *et al.*, 2007), delivery of bio control agents (Mastouri *et al.*, 2010), as a bioactive coating (Ziani *et al.*, 2010) and as anti-counterfeiting technology for eliminating fake seeds in the market (Guan *et al.*, 2013). Thus, with the seed treatment concept becoming a practical reality for different applications, there is now accumulating interest in multiple aspects of this technology, whereby its application can be extended to different crops that are grown and stored under different agro-climatic conditions. Among these concepts, polymer film coating has been proven to enhance the crop establishment particularly under adverse conditions.

The polymer film coat also provides protection from the stress imposed by accelerated ageing, which includes fungal invasion. The coat is thin (8 µm), simple to

apply, diffuses rapidly and non-toxic to the seedlings during germination. It improves plant stand and emergence of seeds, helps in accurate application of the chemical, reduces chemical wastage and helps to make room for all required ingredients, protectants, nutrients, plant growth promoters, hydrophobic / hydrophilic substance and oxygen suppliers etc. By encasing the seed within a thin film of biodegradable polymer, the adherence of seed treating chemicals to seed can be improved, ensures dust free handling, making treated seed both useful and environment friendly. Currently seed treating polymer are being used by seed companies along with other active ingredients such as insecticides and fungicides. This help in improving the resistance of seeds towards pest and diseases in the much warranted juvenile stage, besides improves the seedling vigour and ultimately the plant stands and yield. The polymer film also acts as physical barrier, which has been reported to reduce the leaching of inhibitors from the seed coverings and may restrict oxygen diffusion to the embryo. (Vanangamudi *et al.*, 2003).

In north western Himalayas region, the information on storability of carryover wheat seeds is inadequate and the quality of wheat seed deteriorates mainly due to storage of untreated seed, storage conditions and the packaging materials used for storage of seed. So the present study was conducted to study the effect of seed treatment on seed quality and storability in wheat.

Materials and Methods

The current study was conducted at the Department of Seed Science and Technology, CSKHPKV Palampur. Experimental material consisted of carry over wheat seed (variety HPW -155) of rabi 2017 - 18. The experiment was conducted under a completely randomized design (CRD) and each treatment

was replicated three times (Table 1). Seeds are stored in high density polyethylene bags (HDPE). The seed quality parameters were evaluated at bimonthly interval for twelve months from December 2018 to December 2019. The seeds were drawn at random from each treatment bag replication - wise. Germination test was conducted using 100 seeds in four replications by adopting blotter paper method as described by ISTA procedures (Anonymous 1999). Seeds were incubated in germinator at a temperature $25\pm1^{\circ}\text{C}$ and RH of 90 percent. Normal germinated seeds were counted on 4th and 8th day after incubation and total germination percentage was calculated using the formula at the end of test period:

$$\text{Germination (\%)} = \left(\frac{\text{Number of normal germinated seeds}}{\text{Total number of seeds}} \right) \times 100$$

Speed of germination was determined on the basis of daily germination count and was calculated by the following formula.

$$\text{Speed of germination} = \frac{n_1}{d_1} + \frac{n_2}{d_2} + \frac{n_3}{d_3} + \dots$$

Where,

n - number of germinated seeds, d - number of days.

Ten normal seedlings on 8th day of germination test were selected randomly from each replication of the treatment for measuring the seedling length and the average was worked out in centimeters. The same ten normal seedlings were then used for measurement of seedling dry weight. The seedlings were put butter paper bag and placed in hot air oven at 80°C for 24 hours. The dry weight of the seedlings was recorded and expressed in grams per seedling. The seedling vigour index - I and vigour index - II were

calculated by adopting the method suggested by Abdul Baki and Anderson (1973).

SVI - I = Germination (%) \times Seedling length (cm), and

SVI - II = Germination (%) \times Seedling dry weight (g)

Field emergence count was taken on the 14th day after sowing and the emergence percentage was calculated taking into account the number of seedlings emerging above the soil surface. Moisture content of seeds was recorded in percentage using a moisture meter (Non – Destructive PM 600).

The laboratory data was statistically analyzed using software OPSTAT (Sheoran *et al.*, 1998). The data on germination (%) and field emergence (%) were transformed into arc sine root percentage and transformed data were used for statistical analysis.

Results and Discussion

Most of seed quality parameters declined with the advancement of storage period. Mean germination percentage (final count) in the beginning and end of storage period was 96.30 and 92.2., respectively (Table 2). The reduction in seed germination over time could also be due to the reduction in enzyme activity within the seed. Initially significantly highest germination percentage was recorded in T₆ - (98.66 %) which was at par with T₅ - (98.00%), followed by T₈ - (96.66%) which was at par with T₇ - (96.66%), T₁₀ - (96.66 %), T₃ - flowable thiram (Royal flow 40 SC) @ 2.4 ml/kg (96.00%), followed by T₂ - (95.33%) which was at par with T₉ - (95.00%) and T₄ - (95.00 %) as while lowest was recorded in T₁ - control (95.00 %). The same pattern was recorded till six months. At 8th month the trend varied and significantly highest germination (%) was recorded for T₆ -

(95.67 %) which was at par with T₅ - (95.00 %), followed by T₈ - (94.33 %) compared to T₁ - control (91.00 %). The same pattern was recorded till the end of storage period. At the end of storage, significantly highest germination percentage was recorded for T₆ - (95.00 %) which was at par with T₅ - (94.33 %) while lowest was recorded in T₁ - control (89.00%). The higher germination percentage was recorded in seeds treated with fungicides is due to increase in rate of imbibitions where the fine particles in the treatment act as moisture attracting material to improve germination. The polymer treatment on seeds acts as a physical barrier that has been reported to reduce leaching of inhibitors from the seed covering and may restrict oxygen diffusion to the embryo (Duan and Burris 1997). The results are in accordance with the finding of Parihar *et al.*, (2019) in okra who reported that seed coated with polymer @ 3 ml/kg of seed + vitavax 200 @ 2 g/kg of seeds showed significantly higher germination over untreated control at the end of one year of storage. Similarly, radish seed treated with polymer @ 3 ml/kg of seed+ vitavax 200 @ 2 g/kg of seed also recorded significantly higher germination percentage over untreated control after 12 months of storage (Kotia 2020).

The speed of germination varied significantly throughout the storage period till the end. Irrespective of different seed treatments, the speed of germination continued to decrease from initial to last month of the storage. On an average, the speed of germination in the beginning and end of the storage period was 20.65 and 18.83, respectively (Table 2). Initially higher speed of germination was recorded in T₆ - (21.42) which was at par with T₅ - (21.40), followed by T₈ - (20.49) which was at par with T₇ - (20.49), T₁₀ - (20.48) and T₃ - (20.47), followed by T₂ - (20.45), which was at par with T₉ - (20.45), and T₄ - (20.45) as compared to T₁ - untreated control (20.45). The same pattern was recorded till six months

of storage and after 8th month, significantly higher speed of germination was recorded for T₆ - (21.00) which was at par with T₅ - (20.98), followed by T₈ - (19.95) as compared to T₁ - control (19.50). The same pattern was recorded till end of storage period and significantly higher speed of germination was recorded in T₆ - (19.98) which was at par with T₅ - (19.96) over T₁ - control (18.10). Speed of germination decreased with the increase in storage period. The reduction in speed of germination of seeds might be due to restricted oxygen supply to the embryo and retention of water soluble germination inhibitors. Similar findings were reported by Padhi *et al.*, (2017) and Sharma *et al.*, (2017) in paddy, who studied the effect of polymer @ 4ml + vitavax 200 @ 2 g/kg of seed and recorded significantly higher speed of germination over untreated control after one year of storage.

Irrespective of different seed treatments, the seedling length (cm) decreased with the advancement in the storage period. Average seedling length recorded at the beginning and the end of storage period was 18.93 cm and 16.94 cm, respectively (Table 3). The decline in seedling length may be attributed to age induced decline in germination, the damage caused by accumulation of toxic metabolites which might have hindered the seedling growth. Initially significantly highest seedling length was recorded for T₆ - (18.99 cm) which was at par with T₅ - (18.98 cm), followed by T₈ - (18.95 cm) which was at par with T₇ - (18.94 cm), T₁₀ - (18.94 cm), T₃ - (18.92 cm), followed by T₂ - (18.91 cm) which was at par with T₉ - (18.90 cm), and T₄ - (18.90 cm) as compared to T₁ - control (18.90 cm). The similar pattern was recorded till 6th month of storage.

At 8th month the trend varied and significantly highest seedling length was recorded for T₆ - (18.32 cm) which was at par with T₅ - (18.30

cm), followed by T₈ - (18.26 cm), T₇ - (18.22 cm), while the lowest was recorded in T₁ - control (15.12 cm). It may be due to proper supply of water, nutrients and due to induction of photosynthesis and synthesis of alpha - amylase, protease and other hydrolytic enzymes which appear to induce the activity of gluconeogenic enzymes during early stage of seed germination causing higher seedling length (Huang *et al.*, 2021). Roopashree *et al.*, (2018) and Parihar *et al.*, (2019) in soybean and okra seeds reported the similar results. They recorded that seeds treated with polymer and vitavax had resulted in significantly higher seedling length as compared to untreated control after 12 months of storage.

Almost similar trends were recorded for seedling dry weight (g). Seedling dry weight decreased from initial to last month of the storage. On an average, dry weight per seedling at the beginning and end of storage period was 0.0167g and 0.0125 g, respectively (Table 3). In the initial month of storage, significantly maximum seedling dry weight (g) was recorded for T₆ - (0.0173 g) which was at par with T₅ - (0.0171 g), followed by T₈ - (0.0169 g) which was at par with T₇ - (0.0167 g), T₁₀ - (0.0167 g), T₃ - (0.0167 g), followed by T₂ - (0.0165 g) which was at par with T₉ -

(0.0165 g), T₄ - (0.0165 g) while the lowest was recorded in T₁ - control (0.0164 g). The same pattern was recorded till six months of storage.

At 8th month the trend varied and significantly maximum dry weight (g) was recorded for T₆ - (0.0156 g) which was at par with T₅ - (0.0154 g), followed by T₈ - (0.0152 g), T₇ - (0.151 g) as compared to T₁ - control (0.0134 g). The same pattern was recorded till end of storage period. At the end of storage, significantly maximum dry weight (g) was recorded for T₆ - (0.0138 g) which was at par with T₅ - (0.0136 g) while the lowest was recorded in T₁ - control (0.0109 g). The dry matter production of seedling is the ultimate manifestation of physiological vigour. This is a physiological phenomenon influenced by reserve metabolites, enzyme activities and growth regulators (Geetha and Bhaskharan 2020).

These results are in the conformity with finding of Sharma *et al.*, (2017) who observed significantly higher seedling dry weight in maize seeds treated with polymer @ 3ml/kg of seed + vitavax 200 @ 2 g/kg of seed over untreated seeds at end of one year of storage period.

Table.1 Details of different seed treatment employed in study

T ₁	Control (Untreated seeds)
T ₂	Polymer coating (Polykote @ 3 ml/kg) of seed, diluted with 5 ml of water)
T ₃	Flowable thiram (Royal flow 40SC) @ 2.4 ml/kg
T ₄	Polymer + flowable thiram (Royal flow 40 SC) @ 2.4 ml/kg seed
T ₅	Vitavax 200 (containing thiram 37.5% and carboxil 37.5%) @ 2 g/kg seed
T ₆	Polymer + vitavax 200 (containing thiram, 37.5% and carboxil, 37.5%) @ 2 g/kg of seed
T ₇	Imidacloprid (Gaucho) @ 4 ml/kg seed
T ₈	Polymer + flowable thiram (Gaucho) @ 4 ml/kg seed
T ₉	Polymer + flowable thiram (Royal flow 40 SC) @ 2.4 ml/kg seed + imidacloprid (Gaucho) @ 4 ml/kg seed
T ₁₀	Polymer + vitavax 200 (containing thiram, 37.5% and carboxil, 37.5%) @ 2 g/kg of seed + imidacloprid (Gaucho) @ 4 ml/kg seed.

Table.2 Effect of different seed treatment on germination (%) and speed of germination

Treatments	Months after storage													
	Germination (%)						Speed of germination							
	Initial	2	4	6	8	10	12	Initial	2	4	6	8	10	12
T₁	95.00 (77.04)	93.66 (75.40)	93.00 (74.63)	93.00 (74.63)	91.00 (72.51)	90.00 (71.54)	89.00 (70.60)	20.45	20.40	20.34	20.20	19.50	19.00	18.10
	95.33 (77.50)	94.33 (76.21)	93.66 (75.40)	93.33 (75.02)	92.33 (73.90)	91.66 (73.20)	91.33 (72.86)		20.45	20.42	20.35	20.22	19.85	19.2
T₃	96.00 (78.43)	94.66 (76.62)	94.33 (76.21)	94.00 (75.79)	93.33 (75.02)	92.66 (74.27)	92.00 (73.54)	20.47	20.43	20.37	20.23	19.87	19.4	18.50
	95.00 (77.04)	94.00 (75.79)	93.33 (75.02)	93.00 (74.63)	92.00 (73.54)	91.33 (72.86)	91.00 (72.51)		20.45	20.41	20.35	20.21	19.83	19.18
T₅	98.00 (81.83)	96.00 (78.49)	96.00 (78.43)	95.66 (77.97)	95.00 (77.04)	94.33 (76.21)	94.33 (76.21)	21.4	21.33	21.23	21.13	20.98	20.48	19.96
	98.66 (83.43)	97.00 (79.99)	97.00 (79.99)	96.66 (79.47)	95.67 (77.97)	95.00 (77.05)	95.00 (77.05)		21.42	21.35	21.25	21.15	21.00	20.5
T₇	96.66 (79.47)	95.33 (77.51)	95.00 (77.05)	94.33 (76.21)	94.00 (75.79)	93.33 (75.02)	93.00 (74.63)	20.49	20.44	20.38	20.25	19.93	19.58	18.93
	96.66 (79.47)	95.66 (76.97)	95.33 (77.51)	95.00 (77.04)	94.33 (76.21)	93.66 (75.40)	93.33 (75.02)		20.49	20.45	20.39	20.26	19.95	19.6
T₉	95.00 (77.04)	94.33 (76.21)	93.33 (75.02)	93.33 (75.02)	92.00 (73.54)	91.66 (73.20)	91.33 (72.86)	20.45	20.41	20.35	20.21	19.84	19.19	18.42
	96.66 (79.47)	95.33 (77.51)	94.66 (76.63)	94.33 (76.21)	93.33 (75.02)	92.67 (74.27)	92.33 (73.90)		20.48	20.43	20.38	20.24	19.90	19.44
Mean	96.30 (78.87)	95.03 (77.08)	94.56 (76.48)	94.26 (76.10)	93.30 (74.96)	92.63 (74.21)	92.27 (73.82)	20.65	20.60	20.54	20.41	20.06	19.56	18.83
SE (m±)	0.408	0.415	0.445	0.337	0.286	0.33	0.263		0.008	0.007	0.01	0.012	0.008	0.007
CD (5%)	1.21	1.23	1.33	1	0.85	0.98	0.78	0.023	0.022	0.031	0.035	0.022	0.021	0.02

Figure in parentheses indicated arc sine value

Table.3 Effect of different seed treatments on seedling length (cm) and seedling dry weight (g) in wheat during storage

Treatments	Months after storage							Seedling dry weight (g)						
	Initial	2	4	6	8	10	12	Initial	2	4	6	8	10	12
T ₁	18.90	18.87	18.84	18.74	17.60	16.90	15.12	0.0164	0.0162	0.0156	0.0154	0.0134	0.0123	0.0109
T ₂	18.91	18.88	18.85	18.75	17.89	17.56	16.86	0.0165	0.0163	0.0158	0.0156	0.0142	0.0131	0.0120
T ₃	18.92	18.89	18.86	18.77	17.95	17.63	16.93	0.0167	0.0164	0.0160	0.0158	0.0145	0.0135	0.0124
T ₄	18.90	18.87	18.84	18.74	17.85	17.53	16.83	0.0165	0.0163	0.0156	0.0154	0.0141	0.0129	0.0118
T ₅	18.98	18.94	18.90	18.84	18.30	17.90	17.55	0.0171	0.0170	0.0167	0.0163	0.0154	0.0146	0.0136
T ₆	18.99	18.95	18.93	18.86	18.32	17.94	17.58	0.0173	0.0171	0.0169	0.0166	0.0156	0.0147	0.0138
T ₇	18.94	18.91	18.88	18.79	18.22	17.78	17.32	0.0167	0.0166	0.0162	0.0160	0.0151	0.0141	0.0130
T ₈	18.95	18.91	18.89	18.80	18.26	17.82	17.37	0.0169	0.0167	0.0164	0.0161	0.0152	0.0143	0.0132
T ₉	18.90	18.87	18.85	18.74	17.87	17.55	16.85	0.0165	0.0163	0.0157	0.0155	0.0142	0.0131	0.0119
T ₁₀	18.94	18.90	18.88	18.78	18.00	17.70	17.00	0.0167	0.0166	0.0161	0.0159	0.0148	0.0139	0.0127
Mean	18.93	18.90	18.87	18.78	18.02	17.63	16.94	0.0167	0.0166	0.0161	0.0159	0.0147	0.0137	0.0125
SE (m)	0.010	0.009	0.010	0.011	0.016	0.021	0.022	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
CD (5%)	0.031	0.026	0.031	0.031	0.045	0.062	0.064	0.0002	0.0003	0.0004	0.0004	0.0002	0.0002	0.0002

Table.4 Effect of different seed treatments on field emergence (%) in wheat during storage

Treatments	Months after storage						
	Initial	2	4	6	8	10	12
T₁	91.33 (72.85)	89.33 (70.91)	87.33 (69.12)	86.00 (68.03)	80.33 (63.65)	78.33 (62.33)	76.00 (60.64)
T₂	91.33 (72.85)	89.66 (71.22)	88.00 (69.71)	86.66 (68.55)	85.33 (67.45)	83.33 (65.88)	81.00 (64.13)
T₃	92.33 (73.90)	90.33 (71.86)	88.33 (70.00)	87.33 (69.12)	86.33 (68.27)	84.33 (66.65)	82.33 (65.12)
T₄	91.33 (72.85)	89.33 (70.91)	87.66 (69.41)	86.33 (68.27)	84.66 (66.92)	82.66 (65.37)	80.33 (63.65)
T₆	93.66 (75.40)	93.00 (74.62)	91.33 (72.85)	90.00 (71.55)	89.00 (70.60)	87.66 (69.41)	86.66 (68.55)
T₅	94.33 (76.21)	94.00 (75.82)	93.00 (74.65)	91.00 (72.51)	89.33 (70.91)	88.33 (70.00)	87.33 (69.12)
T₇	92.66 (74.26)	91.33 (72.85)	89.33 (70.91)	88.66 (70.30)	87.66 (69.70)	86.00 (68.00)	84.33 (66.65)
T₈	92.66 (74.26)	91.33 (72.85)	89.33 (70.91)	89.00 (70.65)	88.66 (70.30)	86.33 (68.27)	85.00 (67.18)
T₉	91.33 (72.85)	89.66 (71.22)	88.00 (70.00)	86.66 (68.55)	85.00 (67.18)	83.00 (65.62)	80.66 (63.89)
T₁₀	92.66 (74.26)	91.00 (72.53)	89.00 (70.61)	88.33 (70.00)	87.33 (69.12)	85.33 (67.45)	83.33 (65.88)
Mean	92.36 (73.92)	90.90 (72.41)	89.13 (70.72)	88.00 (69.70)	86.40 (68.33)	84.53 (66.81)	82.70 (65.39)
SE(m)	0.363	0.394	0.402	0.533	0.234	0.240	0.256
CD (5%)	1.080	1.170	1.190	1.680	0.696	0.714	0.760

Figure in parentheses indicates arc sine value

Table.5 Effect of different seed treatments on 100 seed weight (g) in wheat during storage

Treatments	Initial	Months after storage					
		2	4	6	8	10	12
T ₁	5.40	5.27	5.20	5.30	5.34	5.22	5.30
T ₂	5.41	5.29	5.23	5.32	5.36	5.25	5.32
T ₃	5.42	5.30	5.34	5.34	5.39	5.28	5.35
T ₄	5.43	5.34	5.39	5.38	5.40	5.33	5.35
T ₅	5.50	5.44	5.41	5.45	5.48	5.37	5.42
T ₆	5.52	5.48	5.43	5.49	5.51	5.41	5.44
T ₇	5.45	5.37	5.40	5.40	5.42	5.35	5.37
T ₈	5.48	5.40	5.41	5.42	5.44	5.35	5.40
T ₉	5.55	5.52	5.50	5.54	5.56	5.45	5.50
T ₁₀	5.58	5.56	5.53	5.56	5.58	5.48	5.53
Mean	5.47	5.40	5.38	5.42	5.45	5.35	5.40
SE (m)	0.004	0.004	0.004	0.004	0.004	0.005	0.004
CD (5%)	0.011	0.011	0.013	0.012	0.012	0.014	0.012

Fig.1 Effect of different seed treatments on vigour index - I during storage in wheat

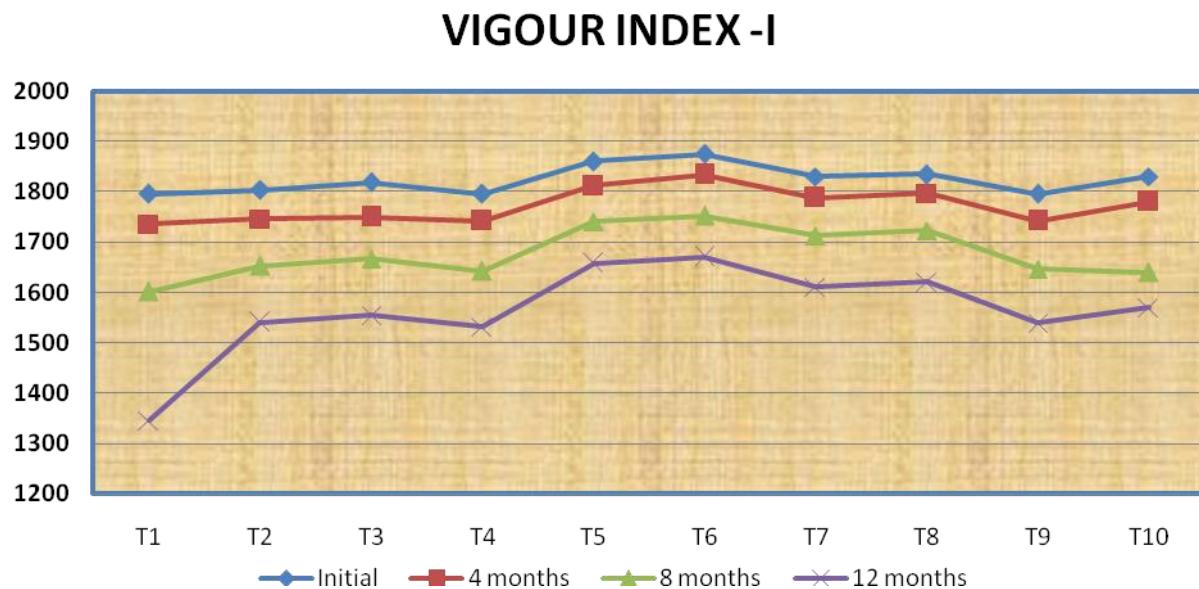
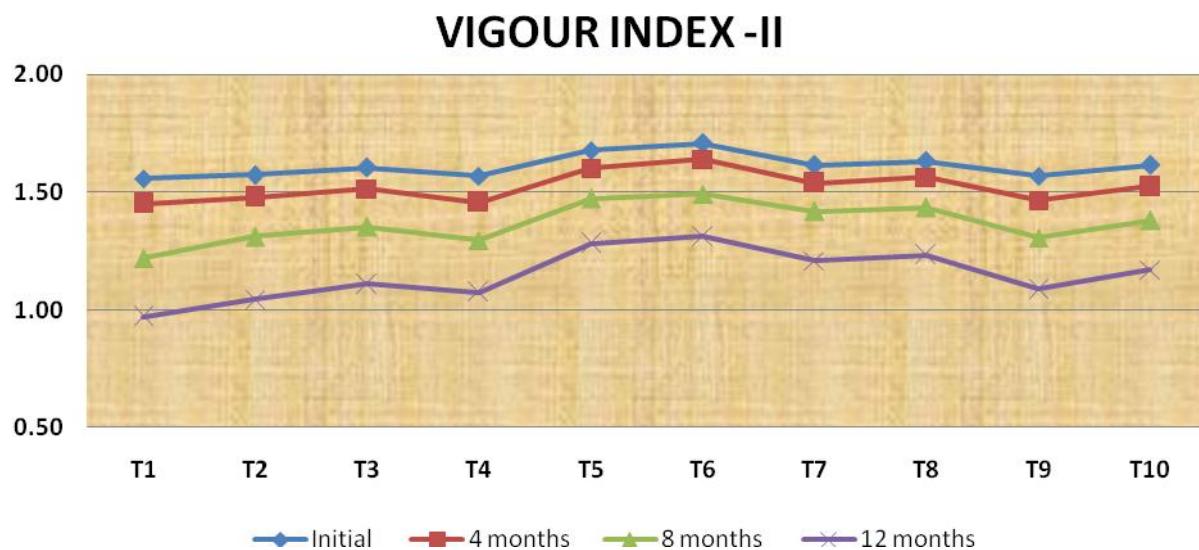


Fig.2 Effect of different seed treatments on vigour index – II during storage in wheat



The computed vigour index, which is the totality of seed performance, has been regarded as a good index to measure the quality of seed lots. Irrespective of seed treatments, the vigour of the stored seed decreased with advancement in the storage period. Mean seedling vigour index - I and II

recorded at the beginning and end of storage was 1824 to 1564 and 1.612 to 1.149, respectively (Figure 1 and 2). The decrease in vigour index may be due to decline in germination, decrease in seedling length and seedling dry weight. In initial months of

indices – I and II were recorded in treatment T₆ - (1874 and 1.707) which were at par with T₅ - (1860 and 1.678), followed by T₈ - (1834 and 1.633) which was at par with T₇ - (1830 and 1.615). The same pattern was recorded till six months of storage.

At 8th month the trend varied and significantly highest vigour indices - I & II were recorded in treatment T₆ - (1753 and 1.492) which was at par with T₅ - (1741 and 1.474), followed by T₈ - (1723 and 1.434).

Same pattern was recorded till 12th months of storage and significantly higher vigour indices - I and II were recorded in T₆ - (1670 and 1.311) which was at par with T₅ - (1658 and 1.283) as compared to T₁ - control (1346 and 0.970) after 12 months of storage. Higher vigour index in polymer + vitavax 200 (T₆) may be due to more germination, seedling length and no infection and infestation by storage fungi and insects, respectively. The polymer treatment provides protection from the stress imposed by accelerated ageing. Similar results were reported by Sharma and Dhiman (2017) & Parihar *et al.*, (2019) in paddy and okra seeds. They reported that seeds treated with polymer and vitavax had resulted in higher seedling vigour Index-I as compared to untreated control after 12 months of storage.

The field emergence declined with advancing storage period due to different seed treatments. Mean field emergence recorded at the beginning and end of storage period was 92.36% and 82.70%, respectively (Table 4).

Initially significantly highest field emergence (%) was recorded for T₆ - (94.33 %) which was at par with T₅ - (93.66%), followed by T₈ - (92.66 %) which was at par with T₇ - (92.66%), T₁₀ - (92.66%), T₃ - (92.33%), followed by T₂ - (91.33%), T₉ - (91.33%), and T₄ - (91.33%) while the lowest was recorded in T₁ - control (91.33%). The same pattern was observed till six months

At the 8th month the trend varied and significantly highest field emergence (%) was recorded for T₆ - (89.33%), which was at par with T₅ - (89.00 %) followed by T₈ - (88.66 %), T₇ - (87.66%), T₁₀ - (87.33 %), T₃ - (86.33 %), T₂ - (85.33 %), T₉ - (85.00 %), T₄ - (84.66 %) as compared to T₁ - control (80.33 %). Same pattern was recorded till the end of storage period and significantly highest field emergence was recorded for T₆ - (87.33%) which was at par with T₅ - (86.66 %) as compared to T₁ - control (76.00%). Seed treated with polymer and fungicides showed significantly higher field emergence over control. This could be due to protection of seeds by the chemicals and polymers against micro-organism, which in turn help in better establishment of seedling. The polymer and fungicide treatment keep seed intact, as it acts as binding material. It covers the minor cracks and aberration on the seed coat (Rao *et al.*, 2017). The results recorded for field emergence are similar to the finding in radish (Kotia *et al.*, 2020) where it was observed that radish seed treated with polymer @ 3 ml/kg + vitavax @ 2 g/kg resulted in significantly higher field emergence as compared to untreated control after 12 months of storage period.

The 100 seed weight (g) increased and decreased gradually during the storage period as per fluctuations in the prevalent temperature and humidity. On an average, 100 seed weight recorded at the beginning and the end of storage period was 5.47 and 5.40 g, respectively (Table 5). Initially highest 100 seed weight was recorded for treatment T₁₀ - (5.58 g), followed by T₉ - (5.55 g), T₆ - (5.52 g), T₅ - (5.50 g), T₈ - (5.48 g), T₇ - (5.45 g), T₄ - (5.43 g), T₃ - (5.42 g) and T₂ - (5.41 g) over T₁ - untreated control (5.40 g).

The similar pattern was recorded at the end of storage period. The highest 100 seed weight (g) was observed for T₁₀ - (5.53 g), followed

by T₉ - (5.50 g) as compared to T₁ - untreated control (5.30 g). Similar findings were reported in chickpea (Sushma 2013). The chickpea seeds treated with polymer @ 10 ml/kg and Deltamethrin 2.8 EC @ 0.4 ml/kg of seed + Vitavax @ 2 g/kg of seeds recorded significantly higher 100 seed weight as compared to untreated seeds after 4 months' storage period.

The study revealed that seed quality parameters declined with the advancement in storage period. The results have shown that seeds treated with polymer @ 3 ml/kg of seed + vitavax 200 @ 2 g/kg of seeds (T₆) and vitavax 200 @ 2 g/kg of seeds (T₅) recorded significantly superiority over control (T₁) for most of seed quality parameters during storage. Thus it can be concluded that for enhancing storability and to maintain the seed quality during storage, the seeds of wheat can either be treated with polymer coating @ 3 ml/kg of seed + vitavax 200 @ 2 g/kg of seed or vitavax 200 @ 2 g/kg of seed.

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