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Effect of seed treatment chemical on seed quality and storability in maize inbred lines and hybrids

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Abstract
The experiment was conducted at Department of Seed Science and Technology PJTSAU, Rajendranagar to investigate the "Effect of chemical seed treatment on seed quality and storability in maize inbreds lines and hybrids (*Zea may* L.)". Freshly harvested seeds were treated with the thiamethoxam seed treatment. The seeds were stored for 8 months under ambient condition and observations were recorded on seed quality parameters bimonthly up to eight months. Among chemical seed treatment, seeds treated with thiamethoxam@ 2g/ kg of seed had better seed storability and seed quality parameters such as germination test (89%), seedling vigour index-I (2282), seedling vigour index-II (65830), electrical conductivity (10.5dSm-1), and field emergence (76%) than control 84%, 2043, 47452, 12.99dSm-1, 74% respectively. This study could be concluded that the maize inbreds and hybrids treated with thiamethoxam @ 2g/ kg were stored for a longer period. However, untreated seeds recorded lower seed quality parameters.

Keywords: Maize inbred lines, hybrids, seed vigour, germination, storage periods, seed quality parameters, thiamethoxam

Introduction
Maize is one of the most important cereal crops. In most Asian countries, maize can be grown throughout the year for different purposes including sweet corn, green cobs, baby corn, and popcorn. Maize serves as a basic raw material and as an ingredient to a wide variety of industrial products such as starch, alcoholic beverages, oil, protein, food sweeteners, cosmetics, textile, pharmaceutical, gum, package, and paper industries, etc. Maize seeds are processed and converted into several required preparations like grits, flakes, and pops for human consumption (Kumar and Rai, 2006) [5].

In maize, inbred lines have been a rich source for various fundamental investigations. Inbreds constitute a wide range of genetic diversity in maize and have been widely exploited in various breeding programmes. For efficient hybrid seed production, appropriate quantities of potential seed are a prerequisite so seed multiplication has to be taken up. But due to frequent multiplication, there are the risks of drift and the cost of seed also will be increased. Besides this, inbreds are very weak and the seed is small in size and it is very difficult to produce inbred seed every year due to cross-contamination and low seed set. So, the storage of seeds is one of the important techniques to carry out breeding programmes when there is a lack of an adequate quantity of seeds. Much work has been done in maize hybrids, especially in corns but very less work in case of maize inbreds. Hence emphasis has been given to study the storage potential of maize inbreds under ambient conditions.

Throughout the growing season, a vast number of pests endanger maize production. In the soil, wireworms, cutworms, and other larvae can be a major, if not limiting, component in producing high yields. Chemical treatments are typically used to control these insects (Sekulic and rempel 2016) [13]. Many synthetic chemicals look effective, but they are not readily degradable either physically or biologically which leaves more toxic residues. Hence, the present study was taken up seed treatment with approval insecticide on storability on maize hybrids and their parental lines.

Materials and Methods
The study was carried on 16 (14lines+2 hybrids) maize inbred lines that include KML-95, KML-106, KML-109, KML-116, KML-121, PFSR3, BML-7 KML-97, KML-133, KML-134, KML-113, KML-127, KML-128 KML225, KNMH-4010131, and KNMH-4010141. Freshly harvested seeds were obtained from seed lot produced during the *Rabi* 2019-20 at Agricultural

Research Station (ARS), Karimnagar. All the seeds of inbred lines were stored under ambient conditions such as average temperature (22 ^{0}C) and relative humidity (60%). The experiment was conducted with the facilities available at the Department of Seed Science and Technology, Seed Technology Research Centre (SRTC), Rajendranagar, Hyderabad during *Kharif*, 2020 and *Rabi*, 2020-2021 under ambient conditions.
The effects of thiamethoxam on the seed quality of maize inbreds were investigated at the SRTC's Laboratory for Seed Testing in Rajendranagar, Hyderabad. The control group consisted of untreated seeds. All the seeds were treated with the insecticide thiamethoxam as per the recommended concentrations.
The seed samples drawn bimonthly up to 8 months of the storage period and were evaluated for various seed quality attributes to determine the optimum storage.
Standard germination test was conducted in the laboratory as per ISTA [4].

$$\text{Germination \%} = \frac{\text{Total number of normal seedlings}}{\text{The total number of seeds tested}} \times 100$$

The ten normal seedlings which were selected for measuring seedling length were kept in a butter paper, dried in a hot air oven at 130°C temperature for 24 hrs and later allowed to cool for 30 minutes and the dry weight was recorded and expressed in milligrams.
As per Abdul Baki and Anderson, (1973) [1] seedling vigour index was calculated using the formula seedling vigour I = Seedling length (cm) × Germination percentage (%).
Seedling vigour II =seedling dry matter (mg) × Germination percentage (%).

Field Emergence (%)
As per the method suggested by Shenoy *et al*. (1990) [17] field emergence potential of seed was calculated. From each treatment in three replications, 100 seeds were selected randomly and were sown in well-prepared soil at a depth of 2.0 to 2.5 cm and covered with soil. On the 7th day of sowing, field emergence count was taken and the percentage of field emergence was calculated by using the following formula.

$$\text{Field emergence (\%)} = \frac{\text{The number of seedlings emerged}}{\text{Total number of seeds tested}} \times 100$$

Electrical conductivity (dS m-1)
The method consists of soaking 50 seeds in a measured quantity of deionized water, sufficient to ensure that all seeds are completely immersed for 24 h period at room temperature. At the end of the period, the contents of the beaker are gently stirred and the stirred liquid was filtered into a beaker. The seeds were discarded. The electrical conductivity was measured in dSm-1 by inserting a cell connected to a conductivity bridge into the solution in the beakers (Mathews and Whitbread, 1968) [6].

Speed of germination
Speed of germination = N1/T1 + N2/T2 + N3/.......... Nx/Tx

where N is the number of seeds germinated at days T.
The statistical analyses were conducted by using different software packages. Analysis of variance (One-Way ANOVA) was conducted using software GenStat Release 9.1. (Rothamsted Experimental Station), after transforming the percentage data to arcsine value to homogenize the variance (Panes and Sukhatme, 1985) [8]. The critical differences (CD) were calculated at a 5 per cent probability level. The data were tested for statistical significance (*).

Results and Discussion
Most of the seed quality parameters decreased with the increase of storage period. The germination percentage at the starting and the end of the storage period was 95% and 78%, respectively (Table 1). After 8 months of storage, a significantly higher germination percentage was recorded for the genotypes when their seed treated with thiamethoxam@ 2 g/kg of seed i.e., KML-116 (89%), over control KML-116 (84%). The same pattern was recorded in all varieties. Apart from the death of seed due to fungal invasion, fluctuating temperature, relative humidity, and storage container in which seeds were stored, the decline in germination percentage with the advancement of storage period may be attributed to the ageing effect leading to depletion of stored food, resulting in starvation of meristematic tissue and decline in synthetic activity of embryo. Seed treatment with insecticide protected the seed from the effects of the above conditions, resulting in maintenance of seed viability for a longer period. The findings are consistent with those found in soybean (Thakur and Dhiman 2016) [19]. Similarly, (Padhi *et al.* 2017) [7] reported that paddy seeds treated with polymer @ 4 ml + vitavax 200 @ 2 g/kg of seed germination percentage was much greater than untreated paddy seeds after 7 months of storage. Shashibhaskar, M.S *et al.* (2019) [16], Gowda, B. *et al.* (2020) [3] also reported similar results in soybean.
The speed of germination varied significantly throughout the storage period till the end (Table 2). Regardless of seed treatment, the rate of germination decreased during the storage period. Germination rates were 2.34 and 1.93 on an average at the beginning and conclusion of the storage period, respectively. At the ending of the 8-month storage period, genotype KML-106 had a significantly higher rate of germination (2.22%) after the seed treatment with thiamethoxam @ 2 g/kg of seed than untreated seed (2.22

Table 1: The effect of seed treatments on seed germination (%), root length (cm), shoot length (cm) and seedling length (cm) during storage in maize inbreds and hybrids

Genotypes	Seed germination				Root length				Shoot length				Seedling length			
	Initial		Final		Initial		Final		Initial		Final		Initial		Final	
	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C
KML-95	96	96	82	82	14.70	14.81	9.62	10.20	15.00	15.61	10.40	13.80	29.73	30.43	20.02	24.00
KML-97	96	94	83	78	15.83	15.39	11.10	10.83	15.40	15.38	14.00	13.85	31.23	30.77	25.10	24.68
KML-106	96	96	85	71	15.99	14.93	10.86	10.78	16.33	14.68	13.35	13.52	32.32	29.61	24.21	24.30
KML-109	97	97	82	74	16.06	14.42	11.16	10.97	15.32	15.10	11.22	13.51	31.37	29.52	22.37	24.48
KML-113	95	95	87	77	15.30	14.24	11.82	10.91	14.74	13.96	13.72	13.20	30.04	28.20	25.54	24.11
KML-116	95	95	89	84	14.20	14.67	10.30	10.38	16.54	14.94	11.11	13.27	30.76	29.61	21.41	23.65

KML-121	96	96	75	76	17.00	14.75	10.07	10.15	17.81	15.13	11.93	14.30	34.81	29.88	22.01	24.45
KML-127	98	97	75	73	14.90	14.89	10.77	10.36	14.32	14.02	13.57	13.23	29.25	28.91	24.33	23.60
KML-128	97	97	87	84	16.10	16.00	11.93	10.79	14.68	14.66	13.84	13.34	30.77	30.66	25.77	24.13
KML-133	98	97	87	86	16.10	15.95	11.96	10.51	18.75	15.17	14.16	13.25	34.81	31.12	26.12	23.75
KML-134	97	96	76	81	15.10	15.08	11.44	10.88	20.24	14.84	13.81	12.26	35.34	29.92	25.24	23.14
PFSR-3	95	95	83	75	13.80	14.89	9.92	9.70	16.11	14.10	10.24	13.23	29.88	28.99	20.17	22.93
KML-225	97	96	75	68	16.40	13.80	10.86	10.77	18.70	14.24	13.78	13.39	35.06	28.04	24.64	24.17
BML-7	95	93	63	61	15.10	14.19	10.30	9.80	14.70	14.71	8.67	13.13	29.84	28.90	18.96	22.93
Mean	96	96	81	77	15.47	14.86	10.87	10.50	16.33	121.53	12.41	13.38	31.80	29.61	23.28	23.88
KNMH-4010131	95	93	81	63	14.10	13.93	10.40	10.34	16.13	14.59	14.23	14.03	30.23	28.52	24.63	24.38
KNMH- 4010141	97	96	82	79	14.80	14.07	10.20	10.11	20.40	14.84	13.77	13.37	35.16	28.90	23.93	23.47
Mean	96	95	82	71	14.45	14.00	10.30	10.23	18.27	14.72	14.00	13.70	32.70	28.71	24.28	23.93
Means of inbreds and hybrids	96	95	80	75	15.34	14.75	10.79	10.47	16.57	14.74	13.61	13.41	31.91	29.49	23.40	23.88
S.E.m	1.112	1.201	1.467	1.666	0.248	0.294	0.169	0.194	0.212	0.192	0.182	0.145	0.338	0.365	0.241	24.00
S.Ed	1.572	1.699	2.074	2.357	0.352	0.416	0.239	0.275	0.301	0.271	0.258	0205	0.478	0.516	0.341	24.68
CD (0.05)	3.141	3.462	4.145	4.801	0.702	0.848	0.479	0.559	0.601	0.553	0.516	0.418	0.955	1.052	0.683	24.3

per cent). The rate of germination slowed as the storage duration extended. Chemically treated seeds showed faster germination than untreated. This could be related to seed protection against insect attacks. Sharma *et al*. (2017) [15] found that brassica seeds treated with polymer + vitavax 200 @ 2 g/kg of seed recorded highest seed germination during storage.

The root length and shoot length varied significantly with seed treatment (Table 1). The average seedling length recorded at the initial to final month of storage was 15.09 to 10.63cm and 15.64cm to 13.01cm, respectively. After 8 months of storage, the seed treatment with thiamethoxam @ 2 g/kg had considerably greater root length and shoot length in genotypes i.e., KML-133 and KNMH-40101131(11.95cm and 14.23cm) than the control (10.51cm and 14.03 cm). Similar results were reported by Padhi *et al*. 2017 [7] in paddy.

The seedling length varied significantly with seed treatment (Table 1). The average seedling length recorded at the initial and final months of storage was 30.69cm and 23.64 cm, respectively. After 8 months of storage, seed treatment with thiamethoxam @ 2 g/kg of seed had considerably greater seedling length i.e., KML-131(26.12cm) than the control (23.76 cm). Results are in conformity with Padhi *et al.* 2017 [7] in paddy. Patel *et al.* (2017) [9] and Gowda *et al.* (2020) [3] reported that soybean seeds when treated with Mancozeb @ 2 g/kg of seeds resulted in significantly higher seedling length as compared to control during 2 years of the storage period. The decrease in seedling length could be attributable to age-related germination failure and toxic metabolite synthesis, both of which could have hampered seedling growth.

The ultimate expression of physiological vigour is seedling dry matter development. Reserve metabolites, enzyme activity, and growth regulators all play a role in this physiological event. Seedling dry weight showed almost identical tendencies. Regardless of seed treatments, the dry weight of seedlings decreased from the first to the last month of storage (Table 2). In the beginning and at the end of the storage period, the dry weight of 10 seedlings was 895.52 mg and 619.75 mg, respectively. After 8 months of storage, seedling dry weight (mg) of the genotype i.e., KML-97 (796.3 mg) was considerably higher than the control (608.3 mg) after seed treatment with thiamethoxam@ 2 g/kg of seed. It suggests that seed treatment has a good effect and may be useful for better seed storage. These findings are consistent with Thakur and Dhiman's (2016) [19] in soybean.

The totality of seed performance, or computed vigour index, has been regarded as a good measure to measure the quality of seed lots. Irrespective of seed treatments, the vigour of stored seed rapidly declined as the storage period advanced. The average seedling vigour index-I and II at the start and end of storage decreased from 2941 to 1847 and 85903 to 48486, respectively. The decline in vigour index could be caused by a decrease in germination, seedling length, and seedling dry weight. Throughout the storage period, the seedling vigour indices - I and II fluctuated considerably. After 8 months of storage, seedling vigour indices -I and II were considerably greater in the seeds treated with thiamethoxam@ 2 g/kg of seed i.e., KML-131 and KML-97(2282 and 65830, respectively) when compared to untreated (2043 and 47452) at the end of the storage period of 8months. Similar results were reported by Patel *et al.* (2017) [9] in soybean and Gowda *et al.* (2020) [3] in soybean, Sharma and Dhiman 2017 [14] in paddy.

Table 2: The effect of seed treatments on seedling dry weight (mg), field emergence (%), radicle emergence (%) and speed of germination during storage in maize inbreds and hybrids.

Genotypes	Seedling dry weight				Field emergence				Radicle emergence				Speed of germination			
	Initial		Final		Initial		Final		Initial		Final		Initial		Final	
	T	C	T	C	T	C	T	C	T	C	T	C	T	C	T	C
KML-95	903.0	906.3	694.7	638.3	96	96	69	63	96	91	75	75	3.13	3.13	2.02	2.02
KML-97	940.0	939.0	796.3	608.3	90	90	71	68	93	92	77	74	2.93	2.89	1.94	1.92
KML-106	886.7	940.6	541.3	534.6	92	91	73	65	94	94	75	74	2.89	2.95	2.22	2.22
KML-109	903.0	905.3	720.7	548.6	97	97	75	70	93	93	81	81	2.67	2.67	2.00	1.97
KML-113	947.7	829.0	751.7	555.0	95	95	71	65	93	92	83	83	2.32	2.26	1.89	1.89
KML-116	906.3	906.3	622.7	515.3	93	93	69	67	92	92	78	76	2.31	2.31	1.84	1.96
KML-121	939.0	947.6	548.3	631.0	85	88	73	67	93	93	79	76	2.02	2.03	1.89	1.93
KML-127	837.7	800.6	750.3	518.0	92	89	69	65	90	90	79	78	2.03	1.97	1.98	1.96
KML-128	910.0	903.0	616.0	505.0	95	95	75	74	93	93	79	76	2.30	2.29	2.09	2.09
KML-133	936.7	934.6	648.3	646.0	86	85	76	73	95	94	77	77	2.20	2.18	2.01	1.99
KML-134	893.3	877.6	720.3	492.3	94	93	75	74	93	93	73	73	2.32	2.29	1.99	1.99
PFSR-3	934.0	934.0	681.0	627.0	95	95	71	67	90	91	78	78	2.15	2.15	1.89	1.85

KML-225	853.0	846.0	730.0	407.0	93	93	69	64	90	90	80	79	2.02	2.01	1.88	1.82
BML-7	942.7	833.0	676.7	589.0	93	93	61	57	87	88	71	67	1.91	1.91	1.26	1.39
Mean	909.5	893.1	678.5	558.2	93	92	71	67	92	92	78	76	2.37	2.36	1.92	1.93
KNMH-4010131	854.0	824.3	681.3	534.0	94	94	71	69	90	90	78	78	2.05	2.04	1.91	1.90
KNMH- 4010141	874.7	867.3	731.3	571.3	98	98	84	72	93	90	82	81	2.35	2.33	1.95	1.93
Mean	864.4	845.8	706.3	552.7	96	96	78	71	91	90	80	79	2.20	2.19	1.93	1.92
Means of inbreds and hybrids	903.8	887.1	681.9	557.5	93	92	72	67	92	91	77	76	2.35	2.33	1.93	1.93
S.E.m	23.064	23.904	14.393	13.497	1.166	1.772	0.872	1.269	1.112	1.199	1.467	0.942	0.036	0.034	0.026	0.026
S.Ed	32.617	33.806	20.355	19.087	1.649	2.505	1.233	1.795	1.572	1.670	2.074	1.333	0.051	0.048	0.038	0.037
CD (0.05)	65.161	68.862	40.664	38.881	3.296	5.104	2.463	3.656	3.141	3.454	4.145	2.715	0.103	0.099	0.075	0.075

Table 3: The effect of seed treatments on electrical conductivity, seedling vigour index-I and seedling vigour index-II during storage in maize inbreds and hybrids.

Genotypes	Electrical conductivity				Seed vigour- II				Seed vigour -I			
	Final		Initial		Final		Initial		Final		Initial	
	T	C	T	C	T	C	T	C	T	C	T	C
KML-95	6.99	5.63	18.23	13.15	86661	86982	56971	52773	2822	2921	1641	1984
KML-97	6.81	8.13	13.52	13.77	90239	88279	65830	47452	2998	2892	2075	1925
KML-106	6.68	5.37	11.50	14.24	85005	90286	45851	38157	3104	2843	2050	1732
KML-109	6.23	7.07	17.50	14.56	87270	87517	58753	40751	3033	2854	1834	1811
KML-113	8.08	8.17	16.15	18.33	90329	78488	65138	42841	2864	2669	2213	1866
KML-116	9.74	7.23	15.30	17.83	85809	85809	55641	43293	2911	2803	1912	1986
KML-121	6.45	6.23	14.07	15.04	90197	90909	40963	47979	3341	2867	1643	1858
KML-127	8.57	8.68	11.96	14.50	82091	77928	56013	37638	2867	2814	1818	1715
KML-128	7.70	8.16	17.66	19.77	88559	87303	53375	42425	2995	2964	2234	2026
KML-133	5.04	5.09	10.50	12.99	91793	90965	56614	55571	3412	3029	2282	2043
KML-134	5.76	5.99	11.52	12.67	86975	84823	54781	36419	3440	2891	1918	1715
PFSR-3	8.64	9.24	15.76	16.43	89039	89039	56715	47243	2850	2629	1680	1727
KML-225	8.93	10.73	15.60	20.04	82451	81174	54521	27680	3390	2691	1839	1643
BML-7	12.39	11.59	16.68	20.12	89869	77735	42351	36166	2845	2698	1187	1406
Mean	7.72	7.67	14.71	15.96	87592	85517	54537	42599	3062	2826	1880	1817
KNMH-4010131	5.22	5.32	11.11	11.13	80828	76756	55391	33776	2862	2661	2003	1544
KNMH- 4010141	6.69	6.95	13.04	13.06	84547	83264	59947	44883	3399	2775	1963	1846
Mean	5.96	6.14	12.08	12.10	82688	80010	57669	39330	3131	2718	1983	1695
Means of inbreds and hybrids	7.49	7.47	14.38	15.48	86979	84828	54928	42438	3071	2921	1893	1813
S.Em	0.219	0.198	0.233	0.243	2163.294	2169.526	1274.408	1387.660	39.946	43.369	35.110	37.826
S.Ed	0.311	0.280	0.329	0.344	3059.359	3068.173	1802.285	1962.448	56.493	61.333	49.653	53.495
CD (0.05)	0.621	0.571	0.658	0.701	6111.77	6249.682	3600.480	3997.386	112.851	124.932	99.194	108.966

The field emergence decreases gradually with advancement of storage period. On average, the field emergence recorded at the starting and end of the storage period was 92.66% and 69.47%, respectively (Table 2). This could be caused by a drop in germination, seedling vigour, seed ageing, seed degeneration, and seed viability over a period. After 8 months of storage, genotypes after seed treatment with thiamethoxam@ 2 g/k had significantly higher field emergence of i.e., KML-133 (76.00%), over untreated control (74%). This could be due to seed protection from microbes following the seed treatment, which improves seedling establishment in the field. The findings for field emergence are identical to those in cotton (Rathinavel 2015) [11], where cotton seeds coated with polymer @ 3 ml/kg + Thiram @ 2.5 g/kg+ Super red @ 5 ml/kg + Cruiser @ 5 g/kg of seeds resulted in significantly highest field emergence as compared to control at the end of 26 months of storage period. Results were also in conformity with Prasher *et al* (2020) [10]. Sattigeri (2019) [12] in rice, Gowda *et al.* (2020) [3] in soybean.

The electrical conductivity of seed leachates is used to quantify seed deterioration. Irrespective of seed treatment, the electrical conductivity continued to increase from initial to final months of storage period (7.48 to14.92) (Table 3). An increase in electrical conductivity may be attributed to a higher incidence of fungi that caused a loss of membrane integrity. The electrical conductivity varied significantly with seed treatment throughout the storage period. After eight months of storage, significantly low electrical conductivity was recorded in the seed treated with thiamethoxam @ 2 g/kg of seed i.e., KML-131(105 m mho/cm/g) over untreated (12.99m mho/cm/g). The polymer covering keeps the seeds intact and covers the seed coat's fissures and aberrations, decreasing electrolyte leaching. The findings are consistent with those of Gowda *et al.* (2020) [3] in soybean.

Conclusion

The study revealed that the seed quality parameters declined progressively with the increase in storage period irrespective of seed treatment, but the reduction percentage was less in treated seed compared to untreated seed. The results have shown that seeds treated with thiamethoxam@ 2 g/kg of seed showed significant superiority for most of the seed quality parameters over control during the storage. It can be concluded that for enhancing seed longevity and to maintain seed quality during storage, the seeds of maize inbreds can be treated with thiamethoxam @2 g/kg of seed as treated seeds allows for controlled germination and vigour expression as well as storage potential by reducing the rate of germination loss over time.

References

1. Abdul Baki AA, Anderson JD. Vigour deterioration in

soybean by multiple criteria. Crop Science 1973;13:630-633.
2. Anonymous. International rules for seed testing. *Seed Science and Technology*. 2007;29:1-348.
3. Gowda B, Hiremath U, Kumara V, Matti SC. Effect of seed treatment with fungicides on seed quality of soybean (*Glycine max* L.) during storage. IJCS, 2020;8(1):420-424.
4. ISTA. International rules for seed testing. Seed Science and Technology 1985;13:299-355.
5. Kumar G, Rai P. Partial genome elimination through micronuclei in soybean (*Glycine max*). National Academy Science Letters, 2006;29(11-12):417-421.
6. Mathews J, Whitbread R. Factors influencing pre-emergence maturity in peas exudates. Plant Pathology 1968;17:11-17.
7. Padhi SK, Behera S, Mishra SP, Padhiary AK, Nayak B. Effect of seed coating materials on seed quality during storage of paddy. Journal of Pharmacognosy and Phytochemistry 2017;6(6):1263-1279.
8. Panse VG, Sukhatme PV. Statistical methods for agricultural workers 2nd edition., I.C.A.R., New Delhi, 1985, 381.
9. Patel JB, Jyoti S, Babariya CA, Rathod RR, Bhatiya VJ. Effect of different storage conditions and seed treatments on seed viability in soybean (*Glycine max* (L.)Merr.). Journal of Applied and Natural Science 2017;9(1):245-252.
10. Prasher A, Dhiman KC, Kanwar R, Thakur A. Effect of different seed coating treatments on the longevity of okra [*Abelmoschus esculentus* (L). Moench] seeds. Himachal Journal of Agricultural Research, 2020;46(1):44-55.
11. Rathinavel K. Extension of shelf life of cotton (*Gossypium hirsutum* L.) seeds through polymer coating under ambient storage conditions. Indian Journal of Agricultural Research 2015;49:447-451.
12. Sattigeri B, Parashivamurthy SR, Harish MS. Effect of seed treatment chemicals on seed quality and storability in rice (Oryza sativa L.) hybrid KRH-4. Journal of Pharmacognosy and Phytochemistry 2020;9(1):123-125.
13. Sekulic G, Rempel CB. Evaluating the role of seed treatments in canola/oilseed rape production: integrated pest management, pollinator health, and biodiversity 2016.
14. Sharma A, Dhiman KC. Effect of seed coating on seed quality and storability of rice (Oryza sativa L.). Himachal Journal of Agricultural Research 2017;43:102-111.
15. Sharma A, Thakur S, Kumar V, Kesavan AK, Thukral AK, Bhardwaj R. 24-epibrassinolide stimulates imidacloprid detoxification by modulating the gene expression of Brassica juncea L. BMC plant biology 2017;17(1):1-10.
16. Shashibhaskar MS, Prasad SR, Puttaramanaik KT, Pandurangegowda RG, Narayanaswamy S. Effect of seed treatment chemicals on storability of maize (*Zea mays L.*) Hybrids and their parental lines. Journal of Pharmacognosy and Phytochemistry 2019;*8*(1):2496-2499.
17. Shenoy VV, Dadlani M, Seshu DV. Association of laboratory assessed parameters with field emergence in rice: The nonanoic acid stress as a seed vigour test. Seed Research 1990;18:60-68.
18. Sisman C, Delibas L. Storing sunflower seed and quality losses during storage. Journal of Central European Agriculture. 2004;4:239-250.
19. Thakur S, Dhiman KC. Effect of seed coating with synthetic polymer and additives on storability of soybean seeds under the mid-hill condition of Himachal Pradesh. Himachal Journal of Agricultural Research 2016;42:22-28.