Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 2496-2499
Received: 13-11-2018
Accepted: 17-12-2018

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Effect of seed treatment chemicals on storability of maize (*Zea mays* L.) Hybrids and their parental lines

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Abstract
A storage experiment was conducted to study the effect of insecticide and fungicidal as seed treatments on seed viability of single cross maize hybrids and their parental lines for ten months at National Seed Project, University of Agricultural Sciences, Bengaluru. The study comprises of two hybrids and their parental lines and treated with seed treatment insecticide and fungicide and designed in factorial CRD with three replication. The experimental results revealed that hybrids maintained significantly higher germination at the end of storage; seeds treated with Spinosad @ 0.04 ml per kg of seeds recorded significantly high values for all the seed quality traits except moisture content fluctuations. Either seed treated with insecticide (Spinosad @ 0.04 ml/kg of seed) and fungicide (Thiram @ 2 g/kg of seed) retained germination (more than MSCS) and seedling vigour up to 10 months of storage period under ambient conditions.

Keywords: Seed storage, hybrids, parental lines, storability, seed quality

Introduction
Maize occupies a vital place in Indian Agriculture. It is the third most imperative cereal in India after wheat and rice. The estimate of maize production in 2017 was 25 million tonnes from an area of 9.6 million hectares with an average productivity of 2.7 tonnes per hectare (Anon., 2017) [4]. Though, the area under maize has shown an increasing trend, with maize emerging as a competitive crop, the level of production has to be substantially raised to meet the growing demand for supply of quality seed.

Viability and vigour of the seed varied from source to source as the locality factors influenced the storability of seed. The seeds from different sources possess different quality values, physical structures and chemical composition. These factors determine the longevity of seed in the storage. Seed storage is an essential segment of seed industry. In storage, viability and vigour of the seeds is regulated by many physico-chemical factors like moisture content of the seed, atmospheric humidity, storage temperature, Initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure and packaging materials. As the seed is hygroscopic in nature, seed quality is affected by variation in moisture content, relative humidity and temperature. To combat these factors, it is better to store the seeds in moisture vapour proof containers like polythene bag, aluminium foil, tin or any sealed container to maintain the quality for longer period. Indiscriminate use of chemical and their residual toxicity causes adverse effect on seed quality. Many of synthetic chemicals look effective, but they are not readily degradable either physically or biologically which leaves more toxic residues. Hence, the feasible approach is the treatment of seeds with botanicals, which are safe, economical, eco-friendly, cheap, easily locally available and non-harmful to seeds, animals and human beings. It will be of immense use to the farming community as well as seed industry. Hence, the present study was taken up to seed treatment with eco-friendly insecticide and fungicide on storability of single maize hybrids and their parental lines.

Material and Methods
Storage study was carried out under ambient conditions at National Seed Project, University of Agricultural Sciences, and Bengaluru. The experiment consisted of twenty treatment combinations with two factors *viz*. hybrids/parental lines: SKV-50 (V_1), NAI-137 (V_2), MAI-105 (V_3), NAH-2049 (V_4) and NAH-1137 (V_5) and seed treatment with chemicals: Nimbecidine @ 5 ml/kg (T_1), Thiram @ 2 g/kg (T_2), Spinosad @ 0.04 ml/kg (T_3) and Control (untreated seeds) (T_4).

After harvest of the crop, seeds were dried to safe moisture content of 9.5 to 10.0 per cent and treated with chemicals as per the treatments and packed in polypouch bags and stored for 10 months. The bimonthly observations were recorded on seed quality parameters such as seed moisture content (%), germination (%) and seedling vigour index (Abdul-baki and Anderson, 1972) [1] were taken as per ISTA Rules (Anon., 2007) [3].

Results and Discussion

The results of the present study indicates that the moisture content of maize seeds during storage differed significantly among the hybrids and their parental lines at 10 months of storage period (Table1). Among hybrids and parental lines, female parent NAI-137 (V_2) (10.07%) recorded the lowest moisture content in contrast to hybrid NAH-1137 (V_5) recorded the highest moisture content (10.81%). The highest germination (83.50%) and seedling vigour index-I (2463) were recorded in V_4 (NAH-2049) at the end of 10 months of storage period. While, lower germination (69.83%) and seedling vigour index-I (1792) was recorded in V_3 (MAI-105) (Table 2 & 3). Similar trend was followed throughout the storage period in a decreasing order. The variation in the vigour and activity of enzymes in the storage of maize seeds was under the influence of genotype (Timoteo and Marcos-Filho, 2013) [11]. This reduction in quality in terms of viability and vigour might be due to depletion of stored food that lead to starvation of meristematic tissues and decline in synthetic activity of the embryo apart from death of the seeds due to fungal invasions and insect damage. Similar results were also observed by Basu *et al*. (2004) in maize parental lines and hybrids [6] and Anil, (2009) in maize hybrid [2].

Among seed treatments, seeds treated with spinosad @ 0.04ml per kg of seeds (T_3) recorded the highest germination (82.06%) and seedling vigour index (2357). The decline in germination percentage may be attributed to ageing effect leading to reduction of food reserves and decline in synthetic activity of embryo apart from death of seed because of fungal invasion, fluctuating temperature and relative humidity. It has been well established that seed treatment with fungicide offer better protection against storage fungi owing to fungicidal, antiaflatoxin and mycotoxin properties (Srinath, 2010 [10]; Monel *et al*., 2011 [9]; Asha, 2012 in maize [5]).

The germination percentage was found to differ significantly due to interactions of hybrids and parental lines and seed treatments (V×T) throughout the storage period. Among the interactions, significantly highest germination was recorded in V_4T_3 (NAH-2049 hybrid seeds treated with Spinosad @ 0.04ml/kg of seeds) (87.00%) and it was on par with V_5T_3 (NAH-1137 hybrid seeds treated with Thiram @ 2g/kg of seeds) (86.00%). While lowest germination was recorded in V_3T_1 (MAI-105 seeds treated with Nimbicidene @ 5ml/kg of seeds) (65.00%) at the end of ten months of storage period. The germination of both NAH-2049 and NAH-1137 hybrid seeds treated with Spinosad and Thiram were on par with each other and significantly superior over the untreated seeds of same hybrids. The superiority of the seed treatment chemical in maintaining higher germination over untreated seeds may be related to insecticidal and antifungal properties of chemical which resulted in decreased seed deterioration owing to lesser fluctuation of seed moisture content, less pest and disease (Hong and Kim, 2004 [8]; Ellis and Hong, 2007 [7]). Several studies have also indicated that seed stored in polythene bag the rate of seed deterioration would be minimal due to lesser moisture content and pest and disease activity and lesser physiological and biochemical changes (Anil, (2009) in maize hybrids [2] and Asha (2012) in maize [5].

Table 1: Influence of seed treatment on seed moisture content (%) of single cross maize hybrids and their parental lines under ambient storage condition

Treatment	Months after storage				
Variety (V)	2	4	6	8	10
V_1: SKV-50	9.60	9.79	10.00	10.15	10.36
V_2:NAI-137	9.07	9.30	9.57	9.82	10.07
V_3:MAI-105	9.52	9.73	9.95	10.14	10.29
V_4:NAH-2049	9.71	9.88	10.08	10.22	10.36
V_5:NAH-1137	10.07	10.25	10.45	10.60	10.81
S.Em±	0.02	0.03	0.03	0.03	0.05
CD (P=0.05)	0.07	0.08	0.09	0.10	0.13
Treatment (T)					
T_1:Nimbicidene @ 5ml/kg	9.59	9.78	9.99	10.13	10.31
T_2:Thiram @ 2g/kg	9.69	9.87	10.08	10.23	10.42
T_3:Spinosad @ 0.04ml/kg	9.55	9.73	9.93	10.09	10.26
T_4:Control	9.55	9.78	10.04	10.29	10.52
S.Em±	0.02	0.02	0.03	0.03	0.04
CD (P=0.05)	0.06	0.07	0.08	0.09	0.12
Interactions (VxT)					
V_1XT_1	9.64	9.79	10.02	10.16	10.33
V_1XT_2	9.69	9.86	10.06	10.21	10.46
V_1XT_3	9.55	9.74	9.94	10.09	10.28
V_1XT_4	9.52	9.76	9.98	10.14	10.36
V_2XT_1	9.10	9.34	9.55	9.71	9.91
V_2XT_2	9.25	9.43	9.65	9.81	9.99
V_2XT_3	9.04	9.24	9.45	9.63	9.85
V_2XT_4	8.90	9.19	9.64	10.14	10.51
V_3XT_1	9.49	9.69	9.93	10.11	10.27
V_3XT_2	9.59	9.79	10.02	10.19	10.32
V_3XT_3	9.44	9.64	9.87	10.01	10.14
V_3XT_4	9.57	9.78	10.00	10.25	10.43
V_4XT_1	9.72	9.88	10.07	10.16	10.28
V_4XT_2	9.80	9.95	10.17	10.33	10.48
V_4XT_3	9.64	9.82	9.99	10.13	10.28
V_4XT_4	9.70	9.87	10.09	10.24	10.40
V_5XT_1	10.02	10.20	10.39	10.50	10.74
V_5XT_2	10.12	10.29	10.48	10.64	10.83
V_5XT_3	10.06	10.23	10.43	10.58	10.76
V_5XT_4	10.06	10.27	10.50	10.67	10.90
Mean	9.59	9.79	10.01	10.18	10.38
S.Em±	0.05	0.05	0.07	0.07	0.09
CD (P=0.05)	NS	NS	NS	NS	NS

NS: Non-significant

Table 2: Influence of seed treatment on germination (%) of single cross maize hybrids and their parental lines under ambient storage condition

Treatment	Months after storage				
Variety (V)	2	4	6	8	10
V_1: SKV-50	92.42	89.92	87.17	84.33	80.33
V_2:NAI-137	89.50	86.92	84.25	81.42	77.92
V_3:MAI-105	84.50	81.50	76.25	73.83	69.83
V_4:NAH-2049	97.50	94.83	91.25	88.75	83.50
V_5:NAH-1137	94.33	91.83	89.33	86.5	81.08
S.Em±	0.54	0.38	0.4	0.42	0.31

CD (P=0.05)	1.53	1.08	1.16	1.21	0.9
Treatment (T)					
T_1:Nimbicidene @ 5ml/kg	91.40	88.67	84.60	82.13	78.20
T_2:Thiram @ 2g/kg	92.07	89.13	85.47	82.33	78.27
T_3:Spinosad @ 0.04ml/kg	92.67	90.93	88.67	86.60	82.60
T_4:Control	90.47	87.27	83.87	80.80	75.07
S.Em±	0.48	0.34	0.36	0.38	0.28
CD (P=0.05)	1.37	0.96	1.03	1.09	0.8
Interactions (VxT)					
V_1XT_1	91.33	90.00	87.33	85.67	81.67
V_1XT_2	92.67	89.33	86.33	83.00	78.67
V_1XT_3	93.00	91.33	88.67	86.67	84.00
V_1XT_4	92.67	89.00	86.33	82.00	77.00
V_2XT_1	90.00	87.33	84.33	82.67	79.67
V_2XT_2	88.67	85.67	82.00	78.00	75.00
V_2XT_3	91.33	90.00	87.33	84.33	81.00
V_2XT_4	88.00	84.67	83.33	80.67	76.00
V_3XT_1	84.00	80.00	72.00	67.67	65.00
V_3XT_2	85.00	81.67	75.67	73.00	69.33
V_3XT_3	85.67	83.67	81.33	80.00	75.00
V_3XT_4	83.33	80.67	76.00	74.67	70.00
V_4XT_1	97.33	94.67	90.67	88.67	83.67
V_4XT_2	98.33	96.00	92.67	89.67	85.67
V_4XT_3	98.00	96.33	93.00	91.00	87.00
V_4XT_4	96.33	92.33	88.67	85.67	77.67
V_5XT_1	94.33	91.33	88.67	86.00	81.00
V_5XT_2	95.67	93.00	90.67	88.00	82.67
V_5XT_3	95.33	93.33	93.00	91.00	86.00
V_5XT_4	92.00	89.67	85.00	81.00	74.67
Mean	91.65	89	85.65	82.97	78.53
S.Em±	1.07	0.75	0.81	0.85	0.63
CD (P=0.05)	NS	NS	2.31	2.43	1.80

NS: Non-significant

Table 3: Influence of seed treatment on seedling vigour index of single cross maize hybrids and their parental lines under ambient storage condition

Treatment	**Months after storage**				
Variety (V)	2	4	6	8	10
V_1: SKV-50	2814	2692	2555	2389	2190
V_2:NAI-137	2834	2722	2573	2414	2206
V_3:MAI-105	2468	2342	2129	1992	1792
V_4:NAH-2049	3226	3074	2890	2718	2463
V_5:NAH-1137	3173	3044	2886	2707	2436
S.Em±	21.76	20.91	25.38	21.55	22.00
CD (P=0.05)	62.21	59.78	72.53	61.59	62.88
Treatment (T)					
T_1:Nimbicidene @ 5ml/kg	2868	2730	2550	2406	2192
T_2:Thiram @ 2g/kg	2981	2861	2669	2488	2280
T_3:Spinosad @ 0.04ml/kg	2951	2849	2720	2575	2357
T_4:Control	2812	2659	2488	2306	2040
S.Em±	19.47	18.71	22.70	19.27	19.68
CD (P=0.05)	55.64	53.47	64.87	55.09	56.24
Interactions (VxT)					
V_1XT_1	2804	2694	2549	2417	2209
V_1XT_2	2830	2703	2564	2369	2166
V_1XT_3	2849	2755	2642	2503	2322
V_1XT_4	2774	2617	2465	2265	2064
V_2XT_1	2780	2638	2505	2373	2187
V_2XT_2	2913	2848	2638	2441	2263
V_2XT_3	2914	2823	2672	2514	2308
V_2XT_4	2730	2578	2475	2328	2068
V_3XT_1	2424	2280	1996	1833	1681
V_3XT_2	2546	2393	2149	1993	1820
V_3XT_3	2522	2414	2303	2183	1945
V_3XT_4	2382	2281	2067	1960	1719
V_4XT_1	3163	3016	2837	2709	2457
V_4XT_2	3373	3236	3005	2817	2613
V_4XT_3	3269	3157	2973	2842	2633
V_4XT_4	3100	2886	2746	2505	2148

V_5XT_1	3170	3021	2862	2699	2427
V_5XT_2	3246	3124	2987	2822	2538
V_5XT_3	3202	3099	3009	2835	2576
V_5XT_4	3074	2932	2686	2471	2203
Mean	2903	2775	2607	2444	2217
S.Em±	43.53	41.83	50.75	43.10	44.00
CD (P=0.05)	NS	NS	NS	123.18	125.75

NS: Non-significant

Conclusion

The storability maize hybrids superior over their parental lines. Between the hybrids, NAH-2049 performed better than NAH-1137. Overall results shows that seeds of maize were treated with spinosad (0.040ml/kg) and packed in ploypouch bags stored for 10 months storage period under ambient conditions maintained maximum seed quality.

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