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RESEARCH PAPER

Seed storage quality as influenced by forms of seed and containers during storage in marigold (*Tagetes erecta*)

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Abstract : Studies were conducted to know the effect of forms of seed and container on seed quality in marigold at Department of Seed Science and Technology, University of Agricultural Sciences. The treatments included two forms seed (dry flower and cleaned seed), five containers (cloth bag, single layer polythene bag with silicagel, single layer polythene bag without silicagel, double layer polythene bag with silicagel, double layer polythene bag without silicagel). The experiment was conducted in Completely Randomized Design in factorial concept in four replications stored for 10 months under ambient conditions.The results indicated that seed stored in the form of dry flower and stored in double layer polythene bag with silicagel recorded highest germination (53.25%), root length (5.13 cm), shoot length (3.98 cm), vigour index (503), seedling dry weight (4.53 mg), germination rate index (4.53) and field emergence (52.50%) with lowest electrical conductivity (0.898 dSm^{-1}) at the end of storage period compared to cleaned seeds.Irrespective of treatments, moisture content of seed stored in polythene bag with silicagel decreased gradually and maintained constant after certain period, while it remain unchanged during storage in the seeds stored in polythene bag without silicagel. However, seed moisture content fluctuated in concomitant with the prevailing atmospheric relative humidity in seed stored in cloth bag.

Key Words : Seed, Container, Storage, Marigold

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INTRODUCTION

Marigold (*Tagetes erecta*) is a commercially important flowering annual and is extensively cultivated. This flower is used for worshipping making garlands, interior decorations in ceremonial functions. It can be grown easily in varied agro-climatic conditions. Its habit of free flowering, short duration to produce marketable flowers, wide spectrum of attractive colours, shape, size and good keeping quality attracted the attention of flower growers. Besides the use of this flower as a cut flower it can be used for beautification and landscape planning. It has a great medicinal value. The leaf paste is used externally against boils and carbuncles. Leaf extract is a good remedy for ear-ache. Flower extract is considered as blood purifier, a cure of bleeding piles, and is a good remedy for eye diseases and ulcers (Bose and Yadav, 1993).

The successful establishment of the crop mainly depends upon good quality seed. Viability and vigour of the seeds is regulated by many physico-chemical factors. Seeds of marigold also loose viability and vigour in continuous storage due to several factors *viz.*, moisture content of the seed. atmospheric humidity, temperature, initial seed quality, physical and chemical composition of seed, gaseous exchange,farm of seeds, storage structure and packaging materials. Therefore, maintenance of good germinability of carry over seed till next sowing season is of vital importance to seed producers. This can be achieved by storing the seeds undercontrolled conditions of low temperature and relative humidity. But storing seed in controlled conditions

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is not feasible in developing countries like India being, costlier. Alternative methods such as storing of seeds with low moisture content in vapour proof containers, but storing the seeds at low moisture content is not always possible. However, this can be achieved by using silica gel in the vapour proof containers, which would provide extra drying required for proper storage.Keeping all these backdrops in mind, the study was conducted to know the influence of forms of seed and containers on seed quality of marigold during storage.

MATERIAL AND METHODS

The storage experiment was conducted for a period of ten months under ambient condition in the laboratory of department of Seed Science and Technology, college of Agriculture, Dharwad 580 005. The seed material of marigold variety Orange double for the present study was obtained from the Floriculture Unit, in the Department of Horticulture, University of Agricultural Sciences, Dharwad. The experiment consisted of 10 treatment combinations with two factors *viz.* forms of seeds: Dry flower storage (F_1) and cleaned seeds (F_2); Containers as second factor: cloth bag (C_1), single layer polythene bag (400 guage) with silicagel (C_2), single layer polythene bag (400 guage) without silicagel (C_3), double layer polythene bag (400 guage) with silicagel (C_4) and double layer polythene bag (400 guage) without Silicagel (C_5).Five grams of silicagel was placed in small cloth packet and was kept in polythene packet along with seed and dry flower as per the treatments and packets were immediately sealed. Experiment was laid out in Complete Randomized Design with factorial concept in four replications. Seed samples were drawn subsequently at bimonthly intervals and tested for the following seed quality parameters. The seed moisture content was calculated and expressed in per cent by using the standard procedure (ISTA, 2006).

Germination percentage :

It was determined as per ISTA rules for seed testing (ISTA, 2006). The seeds were placed in rolled paper towels. Hundred seeds of four replications were tested at a constant temperature of 25^0C. The numbers of normal seedlings were evaluated on 14th day and per cent germination was expressed on normal seedling basis.

From the standard germination test, ten normal seedlings were selected at random in each replication on final count. The shoot length was measured from collar region to the point of attachment of cotyledons and root length from the collar region to the tip of the primary root, sum of shoot and root length constitute the seedling length and mean was calculated and expressed in centimeters.

Seedling vigour index :

Seedling vigour index was computed by adopting the formula as suggested by Abdul-Baki and Anderson (1973) and expressed in whole number.

Seedling vigour index-I=Germination (%)×mean seedling length (cm)

Seed germination test was conducted as described above, daily germination counts were recorded and the only normal seedlings were considered.

Speed of germiantion :

The germination rate index was calculated by using formula suggested by Maguire (1962) :

$$\text{Speed of germination} = \frac{\text{No. of seeds germinated}}{\text{Days to first count}} + \ldots + \frac{\text{No. of seeds germinated}}{\text{Days to final count}}$$

Field emergence was calculated by sowing one hundred seeds from each treatment in four replications in the field. The emergence counts were made on 14th day after sowing and expressed in per cent.

Electrical conductivity :

To measure the electrical conductivity of the seed leachate four replicates of one hundred seeds were taken, washed with distilled water and soaked in 50 ml distilled water for 6 hours and it was measured in a digital conductivity meter (Type MCD- 287) with a cell constant of the electrode being one. The electrical conductivity of seed leachate was expressed in dSm^{-1}. The data obtained from the experiments were statistically analyzed as per Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of forms of seed on seed quality during storage :

The seed moisture content in both the forms (capitula and seeds) decreased with the advancement in storage period. The initial seed moisture content in dry flower and cleaned seed were 8.03 and 8.04 per cent, respectively. However this moisture content decreased to 7.98 per cent in dry flower and 7.42 per cent in cleaned seeds (Table 1). The decrease in the moisture content was more in case of seeds than in flowers. This may be due to the seeds embedded in extraneous material present in the dry flower which slow down the loss of moisture content in the seeds of dry flower whereas cleaned seeds were exposed directly to the rate of loss of moisture was more in cleaned seeds compared to dry flower (Murthy and Murthy, 1961; Baskin, 1979).

Among the forms of seed, dry flower storage maintained better seed quality throughout the storage period compared to cleaned seed storage. The higher germination (46.75%), field emergence (40.55%), root length (4.05cm), shoot length (3.19 cm), seedling dry weight (3.35 mg), vigour index (342) and germination rate index (11.34) with lower electrical

conductivity of see leachate (2.064 dSm^{-1}) were recorded in dry flower storage compared to the cleaned seeds at the end of storage period (Table 2, 3 and 4**)**. Cleaned seeds maintained above minimum seed certification standards up to eight months. While the seeds stored in dry flower condition maintained the viability up to nine months. The rate of decrease in germination per cent was low in dry flower storage compared to cleaned seeds. This indicates that natural ageing is inevitable, however this rate of decrease was less in dry flower compared to cleaned seeds, this means the extraneous covering (pappus) on the seeds acted as protective coating. Hence they might have maintained more germination in dry flower. These results were confirmed with findings of Beattie *et al.* (1932), Mather *et al.* (1956), Marzke *et al.* (1976) and Baskin (1979) who demonstrated beneficial effects of storing peanuts in shell form.

Effect of containers on seed quality during storage :

Among the containers, moisture content of marigold seed gradually decreased up to sixth month and eighth month and then maintained constant in double layer polythene bag with silicagel and single layer polythene bag with silicagel. The decrease in moisture content either in single (7.95 % to 6.57 %) or double layer (7.90 % to 6.55 %) polythene bag with

Table 1 : Effect of forms of seed, containers and their interactions on moisture content (%) and electrical conductivity (dSm^{-1}) of marigold seeds during storage

Treatments	Storage period (months)									
	Moisture content (%)					Electrical conductivity (dSm^{-1})				
	2	4	6	8	10	2	4	6	8	10
Forms of seed										
F_1	7.97	7.90	7.89	7.88	7.98	0.604	0.710	0.915	1.228	2.064
F_2	7.96	7.81	7.60	7.42	7.42	0.648	0.814	0.994	1.336	2.265
S.E.±	0.004	0.007	0.006	0.006	0.009	0.002	0.001	0.004	0.006	0.004
C.D. (%)						0.007	0.005	0.014	0.022	0.015
Containers										
C_1	7.95	7.71	7.62	7.51	7.94	0.848	1.169	1.403	1.850	2.672
C_2	7.95	7.64	7.27	6.82	6.57	0.490	0.600	0.719	0.916	1.690
C_3	7.97	7.98	7.99	8.01	8.02	0.729	0.903	1.053	1.403	2.566
C_4	7.90	7.57	6.95	6.66	6.55	0.425	0.492	0.603	0.741	0.915
C_5	7.97	7.97	8.00	8.02	8.02	0.648	0.693	0.896	1.102	2.258
S.E.±	0.007	0.011	0.009	0.010	0.015	0.003	0.002	0.006	0.009	0.006
C.D.(%)	0.026	0.042	0.036	0.038	0.058	0.012	0.007	0.022	0.035	0.024
F×C interactions										
F_1C_1	7.94	7.61	7.49	7.31	7.81	0.712	0.891	1.032	1.396	2.313
F_1C_2	7.97	7.69	7.41	6.80	6.52	0.467	0.568	0.712	0.907	1.367
F_1C_3	7.97	7.98	7.98	8.03	8.01	0.696	0.803	1.231	1.894	2.428
F_1C_4	7.89	7.53	7.07	7.73	6.58	0.421	0.488	0.597	0.738	0.898
F_1C_5	7.95	7.97	7.99	8.01	8.03	0.671	0.731	0.978	1.183	2.393
F_2C_1	7.96	7.81	7.75	7.71	8.06	0.984	1.446	1.774	2.303	3.031
F_2C_2	7.92	7.58	7.13	6.83	6.62	0.513	0.631	0.726	0.926	2.013
F_2C_3	7.99	8.02	8.01	7.99	8.02	0.745	0.914	1.073	1.410	2.578
F_2C_4	7.90	7.61	6.82	6.58	6.51	0.429	0.496	0.608	0.743	0.932
F_2C_5	7.99	7.99	8.00	8.02	8.01	0.624	0.654	0.813	1.021	2.123
Mean	7.96	7.86	7.74	7.65	7.70	0.626	0.762	0.954	1.282	2.165
S.E.±	0.009	0.015	0.013	0.014	0.021	0.004	0.003	0.008	0.013	0.009
C.D.(%)	0.027	0.059	0.050	0.053	0.083	0.017	0.011	0.032	0.050	0.034

silicagel may be due to silicagel which acted as dehydrating agent and absorbed excessive moisture developed due to respiration and also impervious nature of polythene .The moisture content remained unchanged or slight fluctuation was noticed either in doublelayer polythene bag without silicagel (7.97 % to 8.02 %) or single layer polythene bag without silicagel (7.97 % to 8.02 %), which may be due to polythene layer acted as moisture proof packing (Table 1). But moisture content in seed was much fluctuated in cloth bag because of responding to the relative humidity of the atmosphere and also due to is pervious nature. These results are in conformity with the findings of Anuradha and Agarwal (1989) in tomato and carrot, Doijode (1993) and Jagadhish *et al*. (1994) in onion, Reddy and Reddy (1994) in brinjal seeds. Doijode (1996) reported that onion seed stored in laminated foil pouches with silicagel maintained initial moisture (6.5%) even after seven years.

Among the containers, germination percentage and field emergence was influenced throughout the storage period. The germination percentage and field emergence was higher in double layer polythene bag with silicagel (51.50% and 50.25 %) followed by single layer polythene bag with silica gel (46.50% and 40.88 %) and it was lowest in cloth bag (31.25% and 26.25%) (Table 2). This could be attributed to slower rate of deterioration in double layer and single layer polythene bag with silica gel due to silicagel maintain the lower relative

Table 2: Effect of forms of seed, containers and their interactions on germination (%) and field emergence (%) of marigold seeds during storage

Treatments	Storage period (months)									
	Germination (%)					Field emergence (%)				
	2	4	6	8	10	2	4	6	8	10
Forms of seed										
F_1	73.90	70.00	64.35	56.05	46.75	68.60	64.05	57.95	50.65	40.55
F_2	70.70	65.90	57.55	50.60	38.10	64.45	60.00	51.80	44.90	32.80
S.E±	0.221	0.210	0.260	0.275	0.269	0.176	0.200	0.304	0.299	0.214
C.D. (P=0.01)	0.864	0.824	1.021	1.077	1.054	0.689	0.783	1.191	1.172	0.838
Containers										
C_1	70.13	64.13	53.13	44.50	31.25	64.75	59.00	46.50	39.00	26.25
C_2	72.88	70.13	65.25	57.88	46.50	69.13	61.88	58.63	52.00	40.88
C_3	71.25	66.13	58.13	49.50	37.25	65.25	60.50	51.38	44.38	32.00
C_4	74.88	72.25	68.50	63.25	51.50	69.50	66.13	62.13	57.63	50.25
C_5	72.38	67.13	59.75	51.50	39.25	66.50	62.63	54.63	45.75	33.25
S.E±	0.349	0.333	0.412	0.434	0.425	0.278	0.316	0.481	0.473	0.338
C.D. (P=0.01)	1.367	1.303	1.614	1.702	1.667	1.09	1.239	1.884	1.853	1.325
F×C interactions										
F_1C_1	71.75	66.75	60.25	51.25	41.00	67.25	61.25	54.75	46.75	35.75
F_1C_2	74.25	71.00	68.75	59.25	48.25	69.50	63.50	61.50	52.75	42.50
F_1C_3	73.25	68.75	59.75	51.75	42.25	67.75	62.75	52.50	46.50	36.75
F_1C_4	76.00	74.25	69.75	63.25	53.25	68.75	64.75	60.75	56.75	52.50
F_1C_5	74.25	69.25	63.25	54.75	44.75	68.25	65.25	57.50	48.75	38.50
F_2C_1	68.50	61.50	46.00	37.75	21.50	62.25	56.75	40.50	31.50	16.75
F_2C_2	71.50	69.25	61.75	56.50	44.75	68.75	60.25	55.75	51.25	39.25
F_2C_3	69.25	63.50	56.50	47.75	32.25	62.75	58.25	50.25	42.25	27.25
F_2C_4	73.75	70.25	67.25	63.25	49.75	70.25	67.50	63.50	58.50	49.50
F_2C_5	70.50	65.00	56.25	48.25	33.75	64.75	60.00	51.75	42.75	28.75
Mean	72.30	67.95	60.95	53.33	42.43	67.03	62.03	54.88	47.78	36.68
S.E.±	0.493	0.47	0.582	0.614	0.601	0.393	0.447	0.680	0.669	0.478
C.D. (P=0.01)	1.93	1.843	2.283	2.407	2.357	1.54	1.752	2.664	2.621	1.874

humidity inside the package and further, the polythene layer acting as a better moisture barrier. Whereas, in cloth bag due to decreased metabolic process and products of metabolism developing and multiplication of microflora causing seed deterioration as reported by Likhachev (1984). Similar results were also reported by Doijode (1990) and Padma and Reddy (2000) in onion.

Root and shoot length (5.08 and 3.90 cm), germination rate index (4.34) and vigour index (453) were higher in double layer polythene bag with silica gel followed by single layer polythene bag with silica gel and it was lower in cloth bag (3.33 cm, 2.54 cm, 2.28 and 206, respectively) (Table 3 and 4). This was probably because of lower relative humidity of air maintained within the packet due to silicagel and polythene bag acting as a better moisture barrier in single or double layer polythene bag with silicagel. Whereas in cloth bag moisture content was fluctuating with ambient relative humidity and thereby promoting deterioration of seed (Bass and Clark, 1974). These results are in confirmation with results of Vijaykumar *et al.* (1991), who reported that onion seed stored in polythene bag showed significantly higher root and shoot length, seedling dry weight and vigour index. Similarly results obtained are in agreement with Saxena *et al.* (1987) in onion, Dhyani *et al.* (1991) in bellpaper and Verma *et al.* (1991) in tomato.

The electrical conductivity of seed leachate was lower in double layer polythene bag with silicagel (0.915 dSm^{-1}) followed by single layer polythene bag with silicagel (1.690 dSm^{-1}) at the end of storage period (Table 1). This might be due to lower seed metabolites leaching from seed because of

Table 3 : Effect of forms of seed, containers and their interactions on root length (cm) and shoot length (cm) of marigold seeds during storage

Treatments	Storage period(months)									
	Root length (cm)					Shoot length (cm)				
	2	4	6	8	10	2	4	6	8	10
Forms of seed										
F_1	6.15	5.65	5.35	4.90	4.05	5.26	4.77	4.48	4.07	3.19
F_2	6.13	5.58	5.25	4.80	3.99	5.19	4.68	4.40	3.98	3.17
S.E.±	0.005	0.006	0.004	0.010	0.004	0.010	0.009	0.008	0.013	0.005
C.D. (P=0.01)	0.018	0.023	0.017	0.038	0.017	0.041	0.035	0.031	0.049	0.02
Containers										
C_1	5.99	5.25	4.80	4.22	3.33	5.15	4.40	4.03	3.41	2.54
C_2	6.22	5.76	5.46	5.04	4.22	5.32	4.93	4.71	4.33	3.47
C_3	6.10	5.47	5.20	4.69	3.79	5.12	4.44	4.12	3.70	2.68
C_4	6.26	6.04	5.90	5.56	5.08	5.32	5.12	4.92	4.40	3.90
C_5	6.14	5.57	5.17	4.75	3.72	5.19	4.74	4.44	4.03	3.00
S.E.±	0.007	0.009	0.007	0.015	0.007	0.016	0.014	0.012	0.020	0.008
C.D. (P=0.01)	0.029	0.036	0.027	0.061	0.027	0.064	0.055	0.049	0.078	0.031
F×C interactions										
F_1C_1	6.07	5.48	5.03	4.57	3.58	5.18	4.54	4.18	3.63	2.69
F_1C_2	6.20	5.84	5.58	5.18	4.51	5.32	4.98	4.78	4.43	3.65
F_1C_3	6.08	5.47	5.31	4.70	3.68	5.22	4.62	4.26	3.89	2.86
F_1C_4	6.27	6.06	5.96	5.61	5.13	5.35	5.20	5.03	4.59	3.98
F_2C_5	6.13	5.63	5.23	4.84	3.76	5.24	4.78	4.53	4.10	3.01
F_2C_1	5.89	5.02	4.56	3.86	3.08	5.08	4.27	3.87	3.19	2.38
F_2C_2	6.23	5.68	5.34	4.90	3.93	5.32	4.89	4.63	4.23	3.28
F_2C_3	6.13	5.47	5.12	4.68	3.87	5.06	4.27	3.97	3.51	2.49
F_2C_4	6.24	6.01	5.83	5.50	5.03	5.31	5.03	4.73	4.29	3.82
F_2C_5	6.16	5.51	5.02	4.65	3.67	5.13	4.69	4.34	3.96	2.98
Mean	6.14	5.62	5.30	4.85	4.02	5.22	4.73	4.44	4.03	3.18
S.E.±	0.011	0.013	0.010	0.022	0.010	0.023	0.020	0.018	0.028	0.011
C.D. (P=0.01)	0.041	0.051	0.038	0.086	0.038	0.019	0.078	0.069	0.111	0.044

Table 4 : Effect of forms of seed, containers and their interactions on seedling vigour index and germination rate index of marigold seeds during storage

Treatments	Storage period(months)									
	Seedling vigour index					Germination rate index				
	2	4	6	8	10	2	4	6	8	10
Forms of seed										
F_1	843	731	634	506	342	11.86	11.12	8.99	6.73	3.35
F_2	801	678	559	455	292	11.69	10.74	8.59	6.38	3.31
S.E.±	2.02	2.36	2.19	2.10	2.03	0.010	0.010	0.010	0.011	0.011
C.D. (P=0.01)	7.92	9.23	8.56	8.23	7.94	0.038	0.040	0.039	0.042	0.044
Containers										
C_1	781	624	469	361	206	11.36	10.38	7.29	5.05	2.28
C_2	841	749	663	542	357	11.86	11.09	9.23	7.17	3.86
C_3	800	653	546	414	236	11.81	10.93	8.56	6.12	3.04
C_4	868	790	741	630	453	12.05	11.19	9.70	7.42	4.34
C_5	820	692	572	452	310	11.82	11.07	9.21	7.03	3.14
S.E.±	3.19	3.72	3.46	3.32	3.20	0.015	0.016	0.016	0.017	0.018
C.D. (P=0.01)	12.52	14.60	13.54	13.02	12.55	0.060	0.063	0.062	0.066	0.070
F×C interactions										
F_1C_1	824	689	550	424	265	11.81	10.89	8.18	5.92	2.93
F_1C_2	726	749	640	543	365	11.93	10.94	9.29	7.21	4.08
F_1C_3	811	674	577	440	268	11.64	10.93	8.61	6.18	3.02
F_1C_4	878	823	743	657	503	11.97	11.01	9.76	7.43	4.53
F_2C_5	844	721	617	489	303	11.91	11.18	9.41	7.03	3.09
F_2C_1	751	571	420	298	147	11.04	10.12	7.83	5.17	2.69
F_2C_2	858	750	685	542	348	11.78	11.24	9.16	7.13	3.64
F_2C_3	775	618	514	687	203	11.81	10.93	8.51	6.06	3.06
F_2C_4	857	791	737	603	433	12.12	11.36	9.63	7.41	4.14
F_2C_5	796	663	527	415	224	11.72	10.96	9.01	7.03	3.18
Mean	806	705	597	480	317	11.78	10.93	8.80	6.56	3.33
S.E.±	4.52	5.27	4.89	4.70	4.53	0.021	0.023	0.022	0.024	0.025
C.D. (P=0.01)	17.71	20.64	19.15	18.41	17.75	0.084	0.089	0.087	0.093	0.098

higher membrane integrity. This is because of lower relative humidity. This is because of lower relative humidity maintained inside the packet due to silicagel and vapour proofing nature.

Interaction effect :

Among the interaction of forms of seed and containers, the highest seed quality parameters *viz.*, germination, field emergence, root length, shoot length, seedling dry weight, germination rate index, vigour index with lowest electrical conductivity of seed leachate and moisture content in dry flower stored in double layer polythene bag with silica gel followed by dry flower stored in single layer polythene bag with silica gel at the end of storage period.

Based on results, it may be concluded that for long term storage of marigold seed at a moisture content of 8 per cent can be stored with 5 g of silicagel in double layer polythene bag or seed should be dried to 6.5 per cent moisture content and stored in the form of dry flower and packed in moisture proof container *i.e.* double layer polythene bag (400 gauge) for maintaining maximum viability and vigour of seed during storage.

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