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Effect of Storage Conditions, Packaging Material and Storage Period on Seed Germination and Seed Viability of *Gazania splendens* L.

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ABSTRACT The investigations were carried out with the objective to find the optimum storage conditions for Gazania seeds to increase the germination and viability of Gazania seed. The highest germination (47.94%) and viability (63.29%) was recorded in cold store after 18 months than ambient storage and incubator. Among the packaging, seed kept in desiccator gave the maximum germination (43.23%), followed by aluminium foil (41.36%) irrespective of storage temperature. The seed maintained above 92 per cent germination during the initial three months but significant decline was observed in the proceeding months, being 80.67 per cent after six months, 29.51 per cent after nine months. The cold storage resulted in the maximum seed germination (48.33%) in succeeding harvesting season (April) after nine months of storage when packed in aluminium foil. Similarly, the seeds stored in desiccator under cold store recorded the maximum viability (52.25%) after 18 months of storage. The polyethylene bag gave the maximum viability (75.67%) after nine months in April that was equivalent to desiccator and aluminium foil kept in cold store (74.67%). The highest viability was obtained in desiccator (53.67%) in cold store in next planting season viz., September.

Key words : *Gazania* seeds, packaging, viability, storage period.

Gazania (*Gazania splendens* L.) is one of the important seasonal flowers grown for landscaping and seed production on commercial scale. The remarkable diversity of geographical conditions and availability of cheap labour are the key component of area expansion under flower seed crops in India. Punjab is exporting flower seed to Holland, France, England, Germany, USA and Japan of worth Rs. 7 crore from 400 hectares of land annually [1]. The seeds of most of the seasonal flowers remain viable up to their next planting season depending on the nature of seed, physiological maturity of the seed and post - harvest storage conditions. Hence, there is need to find the optimum temperature and adequate packaging for storing seed so that minimum standard of germination may be maintained for a longer period. However most of the work in seasonal flower had been done to standardize the agronomic cultural practices [2, 3] but very meager information is available on the storage of seed [4, 5]. Therefore considering these facts, an attempt has been made to find out the response of gazania seed to different storage temperature and different packaging.

MATERIALS AND METHODS

The present experiment was conducted at the Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana during 2003-2004. The seeds of *Gazania splendens* were air dried and kept at three storage chambers viz., ambient storage, cold storage (0-4° C and 90 ± 2.7% RH) and incubator (20-22° C and 75 ± 1.5% RH). The seeds were packed in five different packaging-cloth bag in desiccator, poly set bin, polyethylene bag (600 gauze), cloth bag and aluminium foil pack. The experiment was conducted in split plot design with storage temperature as main treatments, packaging as sub treatments and storage period as sub-sub-

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treatment. The observations on seed germination and seed viability were recorded for 18 months (June 2003, November 2004).

The seed germination (%) was determined by using towel paper method and the seed viability (%) with 2,3,5-Triphenyl-Tetrazolium Chloride [6]. Seed germination and viability was recorded from every packaging and storage chambers in three replications of 100 seed each at monthly interval from June 2003 to November 2004.

RESULTS AND DISCUSSION

Storage conditions and storage period

The data presented in Table 1 show that storage conditions had significant effect on seed germination of *Gazania splendens*. The cold storage resulted in the maximum germination (47.94%), which was significantly higher than ambient (37.23%) and incubator (35.46%) storage. The effect of storage period showed non-significant difference in germination between first (92.67%) and second (92.53%) month, but significant decline was noticed in the proceeding months, where germination was 91 per cent after three months, 80.67 per cent after six months, 29.51 per cent after nine months, 10.91 per cent after 12 months, 4.78 per cent after fifteen months and 2.13 per cent after 18 months. The results of interaction between storage conditions and storage period were significant, where storage in incubator and cold store did not show any considerable differences for the first two months

Table 1. Effect of storage conditions and storage period on seed germination (%) in *Gazania spelndens*

Storage period	Storage conditions			
	Cold storage	Incubator	Ambient	Mean
July, 2003	93.20(76.19)*	93.07(75.04)	91.73(74.61)	92.67
Aug, 2003	92.60(74.88)	93.80(75.86)	91.20(73.55)	92.53
Sept, 2003	90.40(72.29)	91.93(73.73)	90.67(73.13)	91.00
Oct, 2003	82.47(65.46)	87.33(69.25)	89.33(71.50)	86.38
Nov, 2003	83.93(66.41)	84.20(66.59)	87.67(69.46)	85.27
Dec, 2003	77.20(61.68)	81.53(64.57)	83.27(66.03)	80.67
Jan, 2004	49.93(44.94)	59.53(50.59)	49.00(44.09)	52.82
Feb, 2004	32.33(34.12)	31.60(34.11)	24.20(28.65)	29.38
March, 2004	49.53(44.69)	15.20(22.88)	23.80(28.81)	29.51
April, 2004	44.07 (41.56)	0.0(0.0)	17.73(24.71)	20.60
May, 2004	3 9.60(38.56)	0.0(0.0)	16.47(23.75)	18.69
June, 2004	27.67 (31.67)	0.0(0.0)	5.07(9.92)	10.91
July, 2004	29.13(32.63)	0.0(0.0)	0.0(0.0)	9.71
Aug, 2004	22.13 (25.22)	0.0(0.0)	0.0(0.0)	7.38
Sept, 2004	18.00(22.57)	0.0(0.0)	0.0(0.0)	6.00
Oct, 2004	14.33(19.93)	0.0(0.0)	0.0(0.0)	4.78
Nov, 2004	9.93(14.35)	0.0(0.0)	0.0(0.0)	3.31
Dec, 2004	6.40(9.40)	0.0(0.0)	0.0(0.0)	2.13
Mean	47.94	35.46	37.23	

CD (P=0.05) Storage period =0.61,Storage conditions= 0.28, Storage period x Storage conditions = 1.21

*Figures in parenthesis indicate arc sine values

with 92.60-93.80 per cent germination. However, there was decline in germination during subsequent months. After 9 months, it was 49.53 per cent under cold storage, 15.20 per cent in incubator and 23.80 per cent under ambient conditions. The seeds kept in incubator and ambient conditions were not able to germinate after 9 and 13 months, respectively. It was observed that under cold storage, the loss of germination at slow rate could be due to reduced rate of metabolic activities and inactivation of enzymes required for retention of germination for longer period. Whereas with course of time decline in germination could be due to depletion of food reserve, increase in fat acidity, ultra structural changes, reduced activity of enzymes and weakening of membrane integrity. These results are in line with the findings of Banovetz and Schiener [7] and Diojode [8] who reported prolonged storage of *Coreopsis lanceolata* and *Salvia splendens* at 5 °C, respectively. The poor germination under ambient and incubator storage has been reported in *Kochia prostata* [9].

Packaging and storage period

It is evident from the data presented in Table 2 that desiccator maintained significantly higher germination (43.23%) than aluminium foil (41.36%), polyethylene bag (40.76%), cloth bag (38.85) and poly set bin (36.84%) after 18 months of storage. The effect of storage period on germination showed non-significant difference between first (92.67%) and second (92.53%) month, whereas in subsequent months decline was steady and significant. The interaction between packaging and storage period was also significant, where polyethylene bag showed maximum germination in July (97.44%) and August (96.11%). For first three months, germination remained above 90 per cent in every packaging and showed fast decline in the subsequent storage period. The effects of packing material revealed that after 18 months seeds in desiccators showed highest germination and in poly set bin lowest. The storage of seed in desiccator in cold store further enhanced the germination. The seed germination and viability is greatly influenced by adequate moisture content at a particular temperature during packaging. The higher germination and viability in desiccator might be due to strongly hygroscopic nature of calcium chloride, which absorb the excessive moisture inside the container and maintain the seed quality. These results are in line with the findings in poppy [10] and marigold [11] where laminated aluminium foil packing resulted in higher germination.

Packaging and storage conditions

The data presented in Table 3 reveal that the desiccator maintained highest count of 43.23 per cent germination, followed by 41.36 per cent in aluminium foil and 40.76 per cent in polyethylene bag. The poly set bin showed the minimum germination of 36.84 per cent after 18 months storage. The cold storage resulted in maximum germination (47.94%) with significant differences than ambient storage (37.23%) and incubator (35.46%) storage. The interaction between packaging and storage conditions was also significant; the seeds packed in aluminium foil and kept in cold store gave maximum (52.67%) germination. Whereas, under ambient conditions, desiccator and aluminium foil were the best with 41.65 per cent and 36.41 per cent count, respectively.

Storage conditions, packaging and storage period

The results of interaction between storage condition, packaging and duration showed significant differences as presented in Table 4. It showed maximum germination under cold storage in polyethylene bag (99.00%), followed by ambient storage in cloth bag (98.67%) and incubator storage in desiccator (95.67%) after one-month. After 6 months, storage in desiccator under ambient conditions gave best results with 88.00 per cent germination, whereas, after 9 months cold storage in aluminium foil gave 59.67 per cent count, which maintained consistent edge in subsequent months also. The aluminium foil packaging under cold storage resulted in the maximum seed germination (48.33%) in succeeding harvesting season (April) and desiccator kept in cold storage resulted in significantly higher germination (27.33%) in succeeding planting season (September). Even after 18 months, cold storage of *Gazania splendens*

Table 2. Effect of packaging and storage period on seed germination in *Gazania splendens*

Storage period	Packaging					
	Desiccator	Poly set bin	Poly bag	Cloth bag	Al. foil	Mean
July, 2003	93.34(75.27)*	91.00(73.23)	97.44(81.62)	90.11(73.07)	91.44(73.21)	92.67
Aug, 2003	93.33(7.21)	90.89(72.97)	96.11(79.05)	90.22(72.57)	92.11(74.03)	92.53
Sept, 2003	91.55(73.23)	89.89(71.95)	93.67(75.66)	89.11(72.00)	90.78(72.41)	91.00
Oct, 2003	88.56(70.34)	82.22(65.46)	89.22(70.89)	81.44(64.51)	90.45(72.48)	86.38
Nov, 2003	86.00(68.02)	83.33(65.94)	86.33(68.35)	84.00(66.53)	86.66(68.59)	85.27
Dec, 2003	84.00(66.59)	74.11(59.52)	83.11(65.76)	80.33(63.85)	81.78(64.75)	80.67
Jan, 2004	60.00(50.90)	55.78(48.32)	40.55(39.02)	55.33(48.08)	52.44(46.39)	52.82
Feb, 2004	45.00(42.06)	21.55(27.03)	34.67(35.90)	20.56(26.53)	25.11(29.95)	29.38
March, 2004	35.78(36.10)	21.67(27.31)	29.89(32.39)	29.00(31.77)	31.22(33.07)	29.51
April, 2004	23.11(23.94)	17.56(20.10)	19.44(21.25)	21.89(22.99)	21.00(22.18)	20.61
May, 2004	19.78(21.93)	1 6.89(19.62)	16.67(19.39)	19.11(21.22)	21.00(22.36)	18.69
June, 2004	11.89(16.37)	8.44(10.05)	10.22(14.20)	12.89(16.95)	11.11(11.75)	10.91
July, 2004	9.33(10.64)	9.78(10.92)	8.67(10.21)	10.00(11.06)	10.78(11.55)	9.71
Aug, 2004	10.9 89 (11.61)	0.0(0.0)	10.00(11.06)	5.44(7.94)	10.56(11.41)	7.38
Sept, 2004	9.11(10.50)	0.0(0.0)	6.78(8.93)	5.78(8.20)	8.33(9.99)	6.00
Oct, 2004	6.44(8.69)	0.0(0.0)	6.22(8.52)	4.11(6.83)	7.11(9.16)	4.78
Nov, 2004	5.33(7.85)	0.0(0.0)	4.67(7.31)	0.0(0.0)	6.56(8.76)	3.31
Dec, 2004	4.67(7.31)	0.0(0.0)	0.0(0.0)	0.0(0.0)	6.00(8.36)	2.13
Mean	43.23	36.84	40.76	38.85	41.36	

CD (P=0.05) Storage period = 0.61, Packaging= 0.34, Storage period x Packaging =1.45

*Figures in parenthesis indicate arc sine values

seeds in aluminium foil packing gave 18.00 per cent germination, whereas, under incubator and ambient storage seed fails to germinate after 10 and 13 months.

Seed viability

Storage conditions and storage period : The data presented in Table 5 show that storage conditions and storage period had significant effect on seed viability of *Gazania splendens*. The cold storage showed the maximum viability (63.29%), which was significantly higher than ambient (42.95%) and incubator (39.99%) storage after 18 months. The storage period showed significant effect with the highest viability after one month in July (96.36%), which decreased considerably in the following months. The viability after 6 months was 85.16 per cent, after 12 months it was 23.33 per cent and after 18 months it was 2.76 per cent. The results of interaction between storage conditions and storage period were also significant, where incubator, ambient and cold storage expressed non-significant variation in

Table 3. Effect of storage conditions and packaging material on seed germination (%) in *Gazania splendens*

Packaging	Storage conditions			
	Cold storage	Incubator	Ambient	Mean
Desiccator	51.17 (46.44)*	36.87 (30.67)	41.65 (35.64)	43.23
Poly set bin	40.85 (36.22)	35.43 (29.42)	34.24 (29.76)	36.84
Poly bag	50.65 (45.95)	35.68 (29.85)	35.95 (32.45)	40.76
Cloth bag	44.35 (39.99)	34.30 (28.43)	37.91 (33.93)	38.85
Al. foil	52.67 (47.22)	35.00 (29.57)	36.41 (31.61)	41.36
Mean	47.94	35.46	37.23	

CD (P=0.05) Packaging = 0.34, Storage conditions = 0.28, Packaging x Storage conditions= 0.64

*Figures in parenthesis indicate arc sine values

initial two months presenting 95.13 to 96.67 per cent viability. The viability was above 80 per cent in all the storage conditions after seven months, but significant fall was observed in incubator and ambient temperature in the subsequent months. After 12 months of storage, cold storage showed 59.53 per cent viability compared with 10.47 per cent at ambient temperature. The temperature and moisture are the two major environmental factors that influence the seed longevity during storage. The poor germination under ambient and incubator storage has also been reported in aster [12].

Packaging and storage period

It is evident from the data presented in Table 6 that among the packaging, desiccator presented the maximum viability (52.25%) closely followed by polyethylene bags (50.13%) and aluminium foil (49.78%), while poly set bin gave minimum viability (44.51%) after 18 months of storage. The storage period showed significant effect with the highest viability after one month in July (96.36) and decreased considerably in the following months. The viability after 6 months was 85.16 per cent, after 12 months was 23.33 per cent and after 18 months was 2.76 per cent only. It is evident from the results of interaction between packaging and storage period that the cloth bag (97.67%) and polyethylene bag (97.56%) maintained significantly higher viability after one month. The highest viability after six months was recorded in desiccator (87.22%) followed by polyethylene bags (85.44%) and aluminium foil (85.89%). Even after 12 months, desiccator storage remained at top with 27.78 per cent viability.

Packaging and storage conditions

It is indicated by the data given in Table 7 that desiccator gave maximum viability (52.25%) with significant differences than polyethylene bags (50.13%), cloth bag (47.04%) and poly set bin (44.51%). Among storage conditions, cold storage resulted in the maximum viability (63.29) and the incubator minimum (39.99%) after 18 months of storage. The interaction between packaging and storage conditions was also significant, where, seed viability under cold storage was highest in desiccator (70.30%) followed by polyethylene bags (68.04%), aluminium foil (67.07%), cloth bag (59.02%) and poly set bin (52.02%).

Storage conditions, packaging and storage period

The results of interaction between storage conditions, packaging and storage period showed significant differences in seed viability (Table 8). After one month of storage seed viability of *Gazania splendens* in polyethylene bag under cold storage (99.33%), in cloth bag under ambient storage (99.00%) and cloth bag under incubator storage (98.00%) showed non-significant differences. All the packaging kept under different storage conditions maintained more than 80 per cent viability for seven months of storage. However, considerable decline was noticed under ambient and incubator storage in the following months. After 12 months, desiccator maintained the maximum viability (70.33%), followed by aluminium foil (65.33%) and polyethylene bag (63.67%) in cold store, whereas in incubator, seeds lost their viability after 9 months and in ambient conditions after 12 months. The polyethylene bag

Table 4. Effect of storage conditions, packaging and storage period on seed germination (%) in *Gazania splendens*

Storage period	Cold storage					Incubator					Ambient				
	Desicc.	Poly bin	Poly bag	Cloth bag	Al foil	Desicc.	Poly bin	Poly bag	Cloth bag	Al foil	Desicc.	Poly bin	Poly bag	Cloth bag	Al foil
July, 2003	94.67 (76.6)*	96.67 (79.5)	99.00 (85.3)	84.33 (66.7)	91.33 (72.9)	95.67 (77.9)	92.00 (73.6)	95.33 (77.5)	87.33 (69.1)	95.00 (77.0)	89.67 (71.2)	84.33 (66.7)	98.00 (82.0)	98.67 (83.4)	88.00 (69.7)
Aug, 2003	94.33 (76.2)	95.33 (77.6)	97.33 (80.9)	85.00 (67.2)	91.00 (72.5)	95.33 (77.5)	93.00 (74.6)	95.33 (77.5)	89.00 (70.6)	96.33 (78.9)	90.33 (71.9)	84.33 (66.7)	95.67 (78.7)	96.67 (79.9)	89.00 (70.6)
Sept, 2003	91.00 (72.5)	94.00 (75.8)	93.00 (74.8)	82.67 (65.4)	91.33 (72.9)	94.33 (76.2)	93.00 (74.6)	93.00 (74.9)	86.67 (68.5)	92.67 (74.4)	89.33 (70.9)	82.67 (65.4)	95.00 (77.3)	98.00 (82.0)	88.33 (70.0)
Oct, 2003	85.00 (67.2)	72.33 (58.2)	88.33 (70.0)	81.00 (64.1)	85.67 (67.7)	90.00 (71.6)	86.00 (68.0)	87.67 (69.4)	83.33 (65.9)	89.67 (71.2)	90.67 (72.2)	88.33 (70.1)	91.67 (73.2)	80.00 (63.4)	96.00 (78.5)
Nov, 2003	84.33 (66.6)	81.67 (64.6)	86.67 (68.6)	80.67 (63.9)	86.33 (68.3)	86.00 (68.0)	82.00 (64.9)	83.33 (65.9)	83.33 (65.9)	86.33 (68.3)	87.67 (69.4)	86.33 (68.3)	89.00 (70.6)	88.00 (69.8)	87.33 (69.1)
Dec, 2003	83.00 (65.7)	66.67 (54.7)	83.67 (66.2)	74.00 (59.3)	78.67 (62.5)	81.00 (64.1)	78.67 (62.5)	81.67 (64.6)	82.00 (64.9)	84.33 (66.7)	88.00 (69.9)	77.00 (61.3)	84.00 (66.4)	85.00 (67.3)	82.33 (65.1)
Jan, 2004	50.33 (45.2)	49.00 (44.4)	48.33 (44.0)	44.33 (41.7)	57.67 (49.4)	72.00 (58.1)	62.67 (52.3)	55.33 (48.0)	64.33 (53.3)	43.33 (41.1)	57.67 (49.4)	55.67 (48.2)	18.00 (25.0)	57.33 (49.2)	56.33 (48.6)
Feb, 2004	49.33 (44.6)	14.00 (21.8)	44.00 (41.5)	23.33 (28.8)	31.00 (33.8)	34.00 (35.6)	36.33 (37.0)	35.33 (36.4)	27.67 (31.7)	24.67 (29.7)	51.67 (45.9)	14.33 (22.2)	24.67 (29.8)	10.67 (19.0)	19.67 (26.3)
Mar, 2004	48.67 (44.2)	34.00 (35.6)	53.33 (46.9)	52.00 (46.1)	59.67 (50.6)	15.33 (22.9)	14.00 (21.9)	15.33 (23.0)	13.67 (21.7)	17.67 (24.8)	43.33 (41.1)	17.00 (24.3)	21.00 (27.3)	21.33 (27.5)	16.33 (23.8)
April, 2004	43.00 (40.9)	39.00 (38.6)	44.00 (41.5)	46.00 (42.7)	48.33 (44.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (24.8)	26.33 (30.9)	13.67 (21.7)	14.33 (22.2)	19.67 (26.3)	14.67 (22.5)
May, 2004	35.33 (36.5)	38.00 (38.0)	38.33 (38.2)	40.67 (39.6)	45.67 (42.5)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	24.00 (29.3)	12.67 (20.8)	11.67 (19.9)	16.67 (24.1)	17.33 (24.6)
June, 2004	24.67 (29.7)	25.33 (30.2)	26.67 (31.1)	28.33 (32.1)	33.33 (35.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	11.00 (19.3)	0.0 (0.0)	4.00 (11.5)	10.33 (18.7)	0.0 (0.0)

July, 2004	28.00 (31.9)	29.33 (32.8)	26.00 (30.6)	30.00 (33.2)	32.33 (34.6)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Aug, 2004	32.67 (34.8)	0.0 (0.0)	30.00 (33.2)	16.33 (23.8)	31.67 (34.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Sept, 2004	27.33 (31.5)	0.0 (0.0)	20.33 (26.8)	17.33 (24.6)	25.00 (29.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Oct, 2004	19.33 (26.1)	0.0 (0.0)	18.67 (25.6)	2.33 (20.5)	21.33 (27.5)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Nov, 2004	16.00 (23.6)	0.0 (0.0)	14.00 (21.9)	0.0 (0.0)	19.67 (26.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Dec, 2004	14.00 (21.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	18.00 (25.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)

CD (P=0.05) Storage conditions x Packaging x Storage period = 2.72; *Figures in parenthesis indicate arc sine values

Table 5. Effect of storage conditions and storage period on seed viability (%) in

Storage period	Storage conditions			
	Cold storage	Incubator	Ambient	Mean
July, 2003	96.67 (80.02)*	96.40 (79.23)	96.00 (79.07)	96.36
Aug, 2003	95.27 (77.73)	95.13 (77.29)	95.13 (77.36)	95.18
Sept, 2003	92.73 (74.45)	93.40 (75.15)	92.67 (74.46)	92.93
Oct, 2003	87.20 (68.63)	90.27 (71.90)	91.80 (73.41)	89.76
Nov, 2003	85.67 (67.45)	86.33 (68.33)	89.00 (70.63)	87.00
Dec, 2003	84.20 (66.02)	84.53 (66.86)	86.73 (68.21)	85.16
Jan, 2004	81.20 (64.31)	82.60 (65.35)	83.40 (65.96)	82.40
Feb, 2004	80.07 (63.48)	56.60 (48.78)	49.53 (44.73)	62.07
March, 2004	75.07 (60.15)	34.53 (35.95)	33.73 (35.40)	47.78
April, 2004	70.40 (57.15)	0.0 (0.0)	24.73 (29.63)	31.71
May, 2004	63.47 (52.94)	0.0 (0.0)	19.93 (26.38)	27.80
June, 2004	59.53 (50.56)	0.0 (0.0)	10.47 (18.78)	23.33
July, 2004	50.87 (45.46)	0.0 (0.0)	0.0 (0.0)	16.96
Aug, 2004	35.07 (32.98)	0.0 (0.0)	0.0 (0.0)	11.69
Sept, 2004	31.13 (30.63)	0.0 (0.0)	0.0 (0.0)	10.38
Oct, 2004	25.93 (27.38)	0.0 (0.0)	0.0 (0.0)	8.64
Nov, 2004	16.47 (18.95)	0.0 (0.0)	0.0 (0.0)	5.49
Dec, 2004	8.27 (13.05)	0.0 (0.0)	0.0 (0.0)	2.76
Mean	63.29	39.99	42.95	

CD (P=0.05) Storage period = 0.55, Storage conditions = 0.22, Storage period x Storage conditions = 0.95; *Figures in parenthesis indicate arc sine values

Table 6. Effect of packaging and storage period on seed viability (%) in *Gazania splendens*

Storage period	Packaging					
	Desiccator	Poly set bin	Poly bag	Cloth bag	Al. foil	Mean
July, 2003	96.11(78.64)*	95.44(77.73)	97.56(81.75)	97.67(81.93)	95.00(77.13)	96.36
Aug, 2003	95.34(77.52)	94.44(76.40)	96.44(79.37)	95.78(78.29)	93.89(75.74)	95.18
Sept, 2003	91.78(73.46)	92.89(74.58)	93.89(75.76)	93.22(75.05)	92.89(74.58)	92.93
Oct, 2003	91.22 (72.10)	88.89(70.57)	90.67(72.27)	87.45(69.41)	90.56(72.22)	89.76
Nov, 2003	88.11(69.27)	86.22(68.23)	87.67(69.50)	85.11(67.35)	87.89(69.68)	87.00
Dec, 2003	87.22(67.30)	84.00(66.41)	85.44(67.60)	83.22(65.85)	85.89(67.98)	85.16
Jan, 2004	83.45(66.01)	81.89(64.80)	82.67(65.39)	81.22(64.34)	82.78(65.50)	82.40
Feb, 2004	67.89(55.69)	62.22(52.36)	61.11(51.93)	57.89(49.83)	61.22(51.83)	62.07
March, 2004	55.11(48.28)	41.89(40.17)	47.89(43.88)	47.44(43.67)	46.56(43.16)	47.78
April, 2004	37.33(32.47)	26.56(25.82)	32.56(29.45)	31.11(28.53)	31.00(28.36)	31.71
May, 2004	33.67(30.21)	19.22(21.29)	28.55(26.72)	28.44(26.82)	29.11(27.16)	27.80
June, 2004	27.78(26.03)	16.11(18.88)	23.89(23.09)	24.00(23.67)	24.89(23.90)	23.33
July, 2004	20.22(17.05)	11.44(11.95)	18.44(16.01)	15.67(14.42)	19.00(16.33)	16.96
Aug, 2004	19.33(16.53)	0.0(0.0)	15.78(14.48)	7.56(9.47)	15.78(14.48)	11.69
Sept, 2004	17.89(15.69)	0.0(0.0)	13.67(13.27)	6.44(8.69)	13.89(13.69)	10.38
Oct, 2004	13.67(13.27)	0.0(0.0)	12.67(12.68)	4.44(7.13)	12.44(12.55)	8.64
Nov, 2004	9.22(10.57)	0.0(0.0)	9.22(10.57)	0.0(0.0)	9.00(1043)	5.49
Dec, 2004	5.22(7.76)	0.0(0.0)	4.22(6.94)	0.0(0.0)	4.33(7.04)	2.76
Mean	52.25	44.51	50.13	47.04	49.78	

CD (P=0.05) Storage period = 0.55, Packaging = 0.31, Storage period x Packaging =1.32; *Figures in parenthesis indicate arc sine value

kept in cold store maintained the highest count in succeeding harvesting season (75.67%) in April and desiccator in cold store showed significantly higher viability (53.67%) in next planting season (September). Whereas, in aluminium foil and polyethylene bag it can be attributed to non-permeability to moisture.

In cloth bag free passage of air increased the moisture content and in coupling with high atmospheric temperature, it lowered the germination and viability under ambient and incubator storage. These results corroborate the findings of Yogeesha *et al.* [12] where sealed storage of aster (*Callistephus chinenesis*) at 5° C and –4° C retained viability up to nine and sixteen years respectively.

The observations on seed germination and viability percentage revealed that higher germination and viability was maintained under cold storage than ambient and incubator storage. Under cold storage, the loss of germination at slow rate could be due to reduced rate of

Table 7. Effect of storage conditions and packaging on seed viability (%) in *Gazania splendens*

Packaging	Storage conditions			
	Cold storage	Incu-bator	Ambient	Mean
Desiccator	70.30 (57.94)*	40.65 (33.23)	45.81 (38.47)	52.25
Poly set bin	52.02 (43.23)	39.80 (32.46)	41.72 (35.84)	44.51
Poly bag	68.04 (57.47)	39.98 (32.75)	42.37 (36.56)	50.13
Cloth bag	59.02 (49.51)	39.54 (32.46)	42.56 (37.10)	47.04
Al. foil	67.07 (56.10)	39.98 (32.67)	42.30 (36.48)	49.78
Mean	63.29	39.99	42.95	48.70

CD (P=0.05) Packaging = 0.31, Storage conditions = 0.22, Packaging x Storage conditions= 0.50; *Figures in parenthesis indicate arc sine values

metabolic activities and inactivation of enzymes required for retention of germination for longer period. Whereas with course of time decline in germination could be due to depletion of food reserve, increase in fat acidity, ultra structural changes, and reduced activity of enzymes and weakening of membrane integrity.

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Table 8. Effect of storage conditions, packaging and storage period on seed viability (%) in *Gazania splendens*

Storage period	Cold storage					Incubator					Ambient				
	Desicc.	Poly bin	Poly bag	Cloth bag	Al foil	Desicc.	Poly bin	Poly bag	Cloth bag	Al foil	Desicc.	Poly bin	Poly bag	Cloth bag	Al foil
July, 2003	96.33 (78.9)*	96.67 (79.5)	99.33 (86.1)	96.00 (78.4)	95.00 (77.1)	96.67 (79.5)	95.33 (77.5)	96.67 (79.6)	98.00 (82.0)	95.33 (77.5)	95.33 (77.5)	94.33 (76.2)	96.67 (79.5)	99.00 (85.3)	94.67 (76.8)
Aug, 2003	95.67 (77.9)	95.33 (77.5)	98.33 (82.6)	94.00 (75.8)	93.00 (74.7)	95.67 (77.9)	94.33 (76.3)	95.67 (77.9)	96.00 (78.4)	94.00 (75.8)	94.67 (76.6)	93.67 (75.4)	95.33 (77.5)	97.33 (80.6)	94.67 (76.7)
Sept, 2003	91.33 (72.8)	94.67 (76.6)	94.00 (75.9)	92.33 (73.9)	91.33 (72.9)	94.67 (76.6)	92.67 (74.3)	94.00 (75.8)	92.67 (74.4)	93.00 (74.6)	89.33 (70.9)	91.33 (72.8)	93.67 (75.5)	94.67 (76.8)	94.33 (76.2)
Oct, 2003	89.00 (68.4)	86.67 (68.6)	88.67 (70.3)	83.67 (66.1)	88.00 (69.7)	92.67 (74.4)	91.00 (72.5)	90.67 (72.2)	87.00 (68.8)	90.00 (71.5)	92.00 (73.6)	89.00 (70.6)	92.67 (74.3)	91.67 (73.2)	93.67 (75.4)
Nov, 2003	88.00 (67.3)	85.00 (67.2)	87.00 (68.9)	83.00 (65.7)	85.33 (67.5)	87.33 (69.2)	85.67 (67.8)	86.00 (68.0)	84.33 (66.7)	88.33 (70.0)	89.00 (70.6)	88.00 (69.7)	90.00 (71.5)	88.00 (69.7)	90.00 (71.5)
Dec, 2003	88.00 (67.3)	83.33 (65.9)	85.67 (67.7)	80.67 (63.9)	83.33 (65.9)	84.67 (66.9)	83.33 (65.9)	83.33 (65.9)	83.67 (66.2)	87.67 (69.4)	89.00 (70.6)	85.33 (67.5)	87.33 (69.2)	85.33 (67.5)	86.67 (68.6)
Jan, 2004	83.00 (65.6)	81.67 (64.6)	82.33 (65.1)	78.67 (62.5)	80.33 (63.6)	81.67 (64.6)	82.00 (64.9)	82.67 (65.4)	81.67 (64.7)	85.00 (67.2)	85.67 (67.7)	82.00 (64.9)	83.00 (65.6)	83.33 (65.9)	83.00 (65.7)
Feb, 2004	80.00 (63.4)	79.00 (62.7)	83.00 (65.6)	78.33 (62.2)	80.00 (63.4)	60.67 (51.1)	59.00 (50.2)	53.00 (46.7)	54.00 (47.3)	56.33 (48.6)	63.00 (52.5)	48.67 (44.2)	47.33 (43.4)	41.33 (39.9)	47.33 (43.4)
Mar, 2004	79.67 (63.2)	63.67 (52.9)	75.67 (60.4)	77.67 (61.8)	78.67 (62.5)	37.67 (37.8)	33.00 (35.0)	37.67 (37.8)	34.33 (35.8)	30.00 (33.2)	48.00 (43.8)	29.00 (32.6)	30.33 (33.4)	30.33 (33.4)	31.00 (33.8)
April, 2004	74.67 (59.8)	56.67 (48.8)	75.67 (60.4)	70.33 (56.9)	74.67 (59.8)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	37.33 (37.6)	23.00 (28.6)	22.00 (27.9)	23.00 (28.6)	18.33 (25.3)
May, 2004	72.67 (58.5)	41.00 (39.8)	69.33 (56.3)	65.33 (53.9)	69.00 (56.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	28.33 (32.1)	16.67 (24.1)	16.33 (23.8)	20.00 (26.5)	18.33 (25.3)
June, 2004	70.33 (56.9)	38.33 (38.2)	63.67 (52.9)	60.00 (50.7)	65.33 (53.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	13.00 (21.1)	10.00 (18.4)	8.00 (16.4)	12.00 (20.2)	9.33 (17.8)
July, 2004	60.67 (51.1)	34.33 (35.8)	55.33 (48.0)	47.00 (43.3)	57.00 (49.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Aug, 2004	58.00 (49.6)	0.0 (0.0)	47.33 (43.4)	22.67 (28.4)	47.33 (43.4)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)

Sept, 2004 (47.1)	53.67 (0.0)	0.0 (39.8)	41.00 (26.0)	19.33 (40.2)	41.67 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0
Oct, 2004 (39.8)	41.00 (0.0)	0.0 (38.0)	38.00 (21.4)	13.33 (37.6)	37.33 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0
Nov, 2004 (31.7)	27.67 (0.0)	0.0 (31.7)	27.67 (0.0)	0.0 (31.3)	27.00 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0
Dec, 2004 (31.7)	15.67 (0.0)	0.0 (31.7)	12.67 (0.0)	0.0 (31.3)	13.00 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0

CD (P=0.05) Storage conditions x Packaging x Storage period = 2.13; *Figures in parenthesis indicate arc sine values