



**Effect of storage conditions and storage period on seed germination and viability of  
*Verbena hybrid***

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**Abstract**

*The seeds of *Verbena hybrida* were kept at three storage chambers viz., ambient storage, cold storage (0-4<sup>o</sup> C and 90 ± 2.7% RH) and incubator (20-22<sup>o</sup> C and 75 ± 1.5% RH) after packing in five different packaging (cloth bag in desiccator, poly set bin, polyethylene bag (600 gauze), cloth bag and aluminum foil pack for a period of 18 months. The cold storage resulted in highest germination (23.39%) and aluminum foil packaging gave the maximum germination (22.24%), followed by desiccator (22.18%) irrespective of storage temperature at the end of storage period. The cold store maintained the maximum seed viability (32.30%) and desiccator recorded the highest viability (28.48%). The highest viability was obtained in desiccator (36.24%) in cold store followed by aluminum foil (34.30%).*

**Key words:** *Verbena, Seed storage, Seed germination, Seed viability, packaging*

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**I. INTRODUCTION**

*Verbena hybrida* is one of the important flowering annuals grown for landscaping and seed production on commercial scale. The remarkable diversity of geographical conditions in India and adaptability of winter annuals for setting seed under these conditions are the major factors for expansion under flower seed crops. However most of the work in seasonal flowers had been done to standardize the agronomic cultural practices (Mili and Sable 2003, Verma and Arha, 2004) but meager information is available on the storage of seed (Gujar *et al.* 2001) and varies for different species (Guterman, 2000). The environmental conditions prevailing during the growing season determine the level of seed germination or dormancy and consequently affect time of seed germination and plant vigour. 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 seeking the importance of these facts in view, an attempt has been made to find out the response of verbena seed to different storage temperature and packaging to maintain minimum standard of germination maintained for a longer period.

**II. MATERIALS AND METHODS**

The present experiment was conducted at the Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana during 2013-2014. The seeds of *Verbena hybrida* were air dried and kept at three storage chambers viz., cold storage (0-4<sup>o</sup> C and 90 ± 2.7% RH), ambient storage (Appendix 1) and incubator (20-22<sup>o</sup> 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 aluminum 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-treatment. The observations on seed germination and seed viability were recorded for 18 months (June 2013 - November 2014). The seed germination (%) was determined by using towel paper method and the seed viability (%) with

2,3,5-Triphenyl-Tetrazolium Chloride (Singh *et al.* 1998) at monthly interval from every packaging and storage chambers in three replications of 100 seed each.

### III. RESULTS AND DISCUSSION

The results given in Table 1 showed that storage conditions considerably affected the seed germination of *Verbena hybrida*. The maximum germination was recorded in cold store (23.39%), which was significantly higher than ambient storage (19.65%) and incubator (18.89%) after 18 months. The seed germination declined as the storage period was increased. While analyzing the effect of storage period, the seed germination was recorded to be the highest after one month i.e., July (59.82%) followed by August (58.95%), September (55.64%), October (54.36%) and November (50.62%). As per the results of interaction between storage conditions and storage period, the cold store maintained significantly higher germination than that of in incubator and ambient conditions throughout the storage period. It was 64.40% under cold storage, 56.27% under incubator and 58.80% under ambient conditions after one month. A similar trend was also observed in the succeeding months. However, the germination was stable under all the storage conditions in initial months, but with progression of time decline was faster under ambient and incubator conditions as compared with the cold storage. 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 decline in germination with course of time 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 of poor germination under ambient and incubator storage are in line with the findings in *Kochia* as reported by Bao *et al.* 1993.

The significant differences were observed in germination of seed obtained from different packaging during storage period (Table 1). The aluminum foil (22.24%) and desiccator (22.18%) were better than other packaging at the end of storage period. The seed germination decreased significantly with increase in storage period and recorded as 59.82% after one month, 55.64% after three months, 38.18% after six months and 8.42% after nine months. The interaction effect between packaging and storage duration was also significant. It was observed that desiccator (62.67%) and polyethylene bags (61.78%) resulted in significantly higher germination after one month of storage than other packaging. After six months of storage, aluminum foil presented the maximum germination (42.67%). The results also show that all the packings maintained above 50.0% germination during initial four months, decline was more rapid in poly set bin and polyethylene bag subsequently. These results line up with the findings of Yogeeshha *et al.* (2004) in aster where laminated aluminum foil packing resulted in higher germination.

The data presented in Table 2 show significant differences among storage treatments for germination of *Verbena hybrida*. It was observed that after one month of storage, cloth bag (69.00%) and desiccator (68.00%) in cold store showed significantly better results than other packaging and storage conditions. After three months, the germination was recorded in desiccator (66.00%) under cold storage. Whereas, after six months cloth bags kept in cold store and desiccators kept at ambient temperature showed 44.00% and 43.00% germination respectively. The storage under cold store in aluminum foil after nine and twelve months was significantly better than the other packaging and storage conditions at the end of one year. The maximum germination (30.00%) was recorded in aluminum foil under cold storage during the succeeding harvesting season in April. These results corroborate the findings of Verma *et al.* (1996) in poppy, which showed the maximum germination in aluminum foil packing. It is evident from the results of interaction that the seeds failed to germinate under ambient storage and incubator after eight months irrespective of packaging. The seed stored under cold storage presented 25 % germination after 12 months of storage in aluminium foil. While

individually analyzing the results for seed germination as affected by packaging and storage temperature, the aluminium foil resulted in significantly higher germination under all the storage temperature and the second best alternate was and cloth bags in desiccator. The results of table 3 indicating the interaction between storage temperature and packaging revealed maximum germination in aluminium foil pack kept in desiccator followed by cloth bags.

The perusal of Table 4 showed that storage conditions significantly affected the seed viability of *Verbena hybrida*. The maximum viability was recorded in cold store (32.30%), which was significantly higher than in incubator (22.04%) and ambient storage (24.28%) after 18 months. The results of interaction between storage period and storage temperature show that the maximum viability was recorded in July (72.11%) after one month, presenting significant decrease in August (69.49%), September (60.60%) and October (57.00%). The cold storage maintained considerably higher viability than incubator and ambient conditions throughout the storage period. The viability after one month was 73.60% in cold store, 72.13% in incubator and 70.60% under ambient conditions. After six months, highest viability (48.13%) was recorded under ambient conditions, however, in subsequent months it was high under cold storage. While analyzing the effect of packaging on seed viability, the maximum viability was recorded in desiccator (28.48%) followed by aluminum foil (26.48%) and polyethylene bag (26.25%) It was recorded to be minimum (24.54%) in poly set bin. The seed viability decreased considerably with increase in storage period, where it was 72.11% after one month, 60.60% after three months, 44.27% after six months and 15.82% after nine months. The interaction between packaging and storage period was also significant. The desiccator resulted in 74.11% viability after one month and 47.11% after six months showing significant difference over other packaging. The results also showed that under ambient and incubator seed packed in cloth bag presented the lowest viability. This might be due to free passage of air and increased moisture content coupled with high atmospheric temperature. This is also in agreement with the findings of Bass and Clark (1974).

The data presented in Table 5 showed significant differences among storage conditions, packaging and storage period for seed viability of *Verbena hybrida*. After one month, desiccator (77.33%) and cloth bag (74.33%) under cold store showed significantly higher viability than other packaging and storage conditions. The seed stored in desiccator and aluminum foil showed 53.33% and 50.00% viability, respectively After six months at ambient temperature. Whereas under cold store after ten months (April), maximum viability was recorded in desiccator (33.67%) and aluminum foil (31.67%), compared with 10.33% and 6.33% in respective packaging under ambient storage. These results elucidate the findings of Gujar *et al.* (2001) in aster.

It is evident from the results that the cloth bags kept in desiccators under cold store maintained the highest viability followed by aluminium foil packs and polyethylene bags after 18 months. 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. While we look at the results of interaction among storage period and packaging for every month it is revealed that cold storage retained the seed viability up to 15 months and it was 16 % in polyethylene bags. The seeds lost viability after 8 months in incubator irrespective of the packing. Whereas, higher germination in aluminum foil and can be attributed to non-permeability to moisture. The results of interaction between packaging and storage temperature show that the seed viability was maximum in desiccator under cold store followed by aluminium foil packaging in cold store (Table 6). These results line with the findings of Selvaraju and Selvaraj (1999) in marigold presenting higher germination in aluminum foil packing.

#### IV. CONCLUSION

It is concluded that the cold storage of verbena seed was significantly better to maintain germination and viability for longer period especially up to the next planting season, which falls in September to October in north Indian plains. The seed packed in aluminum foil and desiccator gave the maximum viability and germination irrespective of storage temperature.

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**Table1- Effect of storage conditions, packaging and storage period on seed germination (%) in *Verbena hybrida*.**

Storage period	Storage conditions			Mean	Packaging					Mean
	Cold storage	Incubator	Ambient		Desiccator	Plastic bin	Poly. bag	Cloth bag	Al. foil	
July, 2013	64.40 (56.67)*	56.27 (49.51)	58.80 (52.33)	59.82	62.67 (56.40)*	58.67 (52.80)	61.78 (55.60)	57.89 (51.55)	58.11 (52.29)	59.82
Aug, 2013	63.60 (55.96)	55.87 (49.16)	57.40 (51.08)	58.95	61.78 (55.60)	58.78 (52.90)	59.89 (53.30)	56.67 (50.43)	57.67 (51.32)	58.95
Sept, 2013	59.40 (52.27)	54.40 (47.87)	53.13 (47.28)	55.64	60.56 (54.50)	56.00 (50.40)	55.00 (48.95)	53.00 (47.17)	53.67 (47.76)	55.64
Oct, 2013	56.40 (49.63)	53.53 (47.10)	53.13 (47.28)	54.36	59.67 (53.61)	53.00 (47.70)	53.00 (47.17)	52.78 (46.97)	53.33 (47.46)	54.36
Nov, 2013	53.80 (47.34)	51.67 (45.98)	46.40 (41.89)	50.62	59.55 (53.59)	48.67 (43.16)	47.00 (41.83)	48.67 (43.31)	49.22 (44.29)	50.62
Dec, 2013	39.20 (34.49)	33.33 (29.66)	42.00 (37.80)	38.18	38.00 (34.20)	35.22 (31.23)	37.00 (32.93)	38.00 (33.82)	42.67 (37.97)	38.18
Jan, 2014	25.27 (22.49)	17.47 (15.37)	23.60 (21.00)	22.11	24.33 (21.89)	20.11 (18.09)	24.44 (21.75)	16.67 (14.83)	25.00 (22.5)	22.11
Feb, 2014	18.20 (16.19)	13.40 (11.79)	10.07 (8.96)	13.89	17.00 (15.30)	12.67 (11.40)	11.33 (10.08)	8.78 (7.81)	19.67 (17.50)	13.89
Mar 2014	14.60 (12.84)	4.07 (3.58)	6.60 (5.87)	8.42	10.22 (9.19)	8.33 (7.49)	5.56 (4.94)	4.00 (3.56)	14.00 (12.46)	8.42
April, 2014	11.33 (9.97)	0.0 (0.00)	2.60 (2.31)	4.64	3.78 (3.40)	0.00 (0.00)	5.11 (4.54)	4.33 (3.85)	10.00 (9.00)	4.64
May, 2014	8.87 (7.80)	0.0 (0.00)	0.00 (0.00)	2.96	1.78 (1.60)	0.00 (0.00)	0.00 (0.00)	4.33 (3.85)	8.67 (7.71)	2.96
June, 2014	5.93 (5.22)	0.00 (0.00)	0.00 (0.00)	1.98	0.00 (0.00)	0.78 (0.70)	0.00 (0.00)	0.78 (0.69)	8.33 (7.41)	1.98
July, 2014	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0
Aug, 2014	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0
Sept, 2014	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0	0.0 (0.0)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0
Oct, 2014	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0
Nov, 2014	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0
Dec, 2014	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.0
Mean	23.39	18.89	19.65	-	22.18	19.57	20.01	19.22	22.24	-

CD (P=0.05) Storage period = 0.55, Storage conditions = 0.21, Storage period x Storage conditions = 0.91, Packaging = 0.26, Storage period x Packaging = 1.13 \* Figures in parenthesis indicate arc sine values

**Table 2 - Interaction effect of storage conditions, packaging and storage period on seed germination (%) in *Verbena hybrida***

Storage period	Cold storage					Incubator					Ambient				
	Desi.	Poly bin	Poly bag	Cloth Bag	A.foil	Desi.	Poly Bin	Poly bag	Cloth bag	A.foil	Desi.	Poly bin	Poly bag	Cloth bag	A.foil
July, 2013	68.00 (55.5)*	63.00 (52.5)	62.00 (51.9)	69.00 (56.1)	60.00 (50.2)	61.00 (51.0)	57.00 (47.1)	60.00 (50.2)	53.67 (47.1)	49.67 (44.8)	59.00 (49.2)	56.00 (46.2)	63.33 (52.7)	51.00 (42.8)	64.67 (53.5)
Aug, 2013	66.33 (54.5)	64.33 (53.3)	59.33 (50.4)	68.00 (55.4)	60.00 (50.2)	60.00 (51.0)	57.00 (47.1)	59.00 (49.4)	54.00 (47.3)	49.33 (44.6)	59.00 (49.2)	55.00 (46.2)	61.33 (51.5)	48.00 (40.3)	63.67 (52.9)
Sept, 2013	66.00 (54.0)	58.00 (49.4)	56.00 (46.9)	59.00 (47.9)	58.00 (48.5)	57.00 (48.4)	56.00 (46.5)	58.00 (48.1)	53.00 (46.6)	48.00 (43.3)	58.67 (48.9)	54.00 (45.4)	51.00 (42.8)	47.00 (39.1)	55.00 (45.5)
Oct, 2013	65.00 (53.2)	51.00 (41.9)	53.00 (43.9)	56.00 (45.4)	57.00 (47.9)	56.00 (47.8)	54.00 (44.6)	55.00 (45.6)	54.67 (47.9)	48.00 (43.3)	58.00 (48.3)	54.00 (45.4)	51.00 (42.8)	47.67 (39.6)	55.00 (45.5)
Nov, 2013	65.00 (53.2)	51.00 (41.9)	51.00 (42.3)	51.00 (41.4)	51.00 (42.3)	55.33 (44.5.6)	51.00 (41.8)	51.00 (41.8)	53.00 (46.5)	48.00 (43.3)	58.33 (49.8)	44.00 (37.0)	39.00 (32.8)	42.00 (35.3)	48.67 (39.8)
Dec, 2013	41.00 (33.4)	25.00 (20.6)	41.00 (34.0)	44.00 (36.7)	45.00 (37.3)	30.00 (24.9)	39.67 (32.5)	31.00 (25.3)	31.00 (26.9)	35.00 (31.5)	43.00 (35.8)	41.00 (33.4)	39.00 (32.8)	39.00 (32.8)	48.00 (39.3)
Jan, 2014	28.00 (22.8)	24.00 (20.1)	6.33 (4.9)	33.00 (26.7)	35.00 (29.0)	20.00 (16.6)	15.33 (12.3)	29.00 (23.8)	12.00 (17.4)	11.00 (9.9)	25.00 (20.8)	21.00 (17.4)	38.00 (31.5)	5.00 (4.2)	29.00 (23.8)
Feb, 2014	22.00 (17.8)	19.00 (16.2)	3.00 (2.5)	13.00 (10.5)	34.00 (28.4)	19.00 (16.3)	9.00 (7.4)	17.00 (14.1)	12.00 (10.4)	10.00 (9.0)	10.00 (8.3)	10.00 (8.3)	14.00 (11.8)	1.33 (1.1)	15.00 (12.3)
Mar 2014	10.33 (8.7)	14.00 (11.9)	3.67 (3.0)	12.00 (9.8)	33.00 (27.4)	20.33 (16.9)	0.00 (0.0)	0.00 (0.0)	0.00 (10.4)	0.00 (0.0)	0.00 (0.0)	11.00 (9.1)	13.00 (9.2)	0.00 (0.0)	9.00 (7.4)
April, 2014	11.33 (8.9)	0.0 (0.0)	2.33 (1.9)	13.00 (10.5)	30.00 (24.9)	0.0 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	13.00 (9.2)	0.00 (0.0)	0.00 (0.0)
May, 2014	5.33 (4.31)	0.0 (0.0)	0.00 (0.0)	13.00 (10.5)	26.00 (21.6)	0.0 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
June, 2014	0.00 (0.0)	0.0 (0.0)	0.00 (0.0)	2.33 (1.9)	25.00 (20.7)	0.00 (0.0)	0.00 (0.0)	0.00 (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)
July, 2014	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (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)
Aug, 2014	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (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)
Sept, 2014	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (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)
Oct, 2014	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Nov, 2014	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)
Dec, 2014	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)	0.00 (0.0)

CD (P=0.05) Storage conditions x Packaging x Storage period = 2.04. \* Figures in parenthesis indicate arc sine values

**Table 4 - Effect of storage conditions, packaging and storage period on seed viability (%) in *Verbena hybrida*.**

Storage period	Storage conditions			Mean	Packaging					Mean
	Cold storage	Incubator	Ambient		Desiccator	Plastic bin	Poly. bag	Cloth bag	Al. foil	
July, 2013	73.60 (59.09)*	72.13 (58.12)	70.60 (57.14)	72.11	74.11 (59.42)*	71.78 (57.89)	70.78 (57.26)	72.33 (58.26)	71.56 (57.75)	72.11
Aug, 2013	70.40 (57.06)	68.67 (55.95)	69.40 (56.40)	69.49	71.89 (58.01)	69.00 (56.15)	69.22 (56.29)	68.89 (56.08)	68.44 (55.81)	69.49
Sept, 2013	62.87 (52.51)	62.00 (51.92)	56.94 (48.97)	60.60	65.56 (54.15)	59.56 (50.49)	58.44 (49.85)	59.22 (50.30)	60.22 (50.88)	60.60
Oct, 2013	56.27 (48.59)	59.27 (50.32)	55.47 (48.12)	57.00	60.89 (51.27)	56.67 (48.82)	55.00 (47.86)	55.67 (48.24)	56.78 (48.88)	57.00
Nov, 2013	54.87 (47.78)	54.60 (47.62)	50.60 (45.32)	53.35	59.66 (50.55)	51.78 (46.00)	50.33 (45.17)	53.00 (46.70)	52.00 (46.12)	53.35
Dec, 2013	45.93 (42.65)	38.73 (38.45)	48.13 (43.91)	44.27	47.11 (43.32)	45.11 (42.17)	41.56 (40.09)	42.67 (40.75)	44.89 (42.03)	44.27
Jan, 2014	35.60 (36.59)	20.13 (26.59)	31.80 (34.29)	29.18	31.67 (34.14)	28.00 (31.78)	28.11 (31.83)	28.22 (31.80)	29.89 (32.90)	29.18
Feb, 2014	31.93 (34.34)	17.26 (24.52)	19.13 (25.86)	22.78	25.67 (30.17)	21.33 (27.36)	23.00 (28.54)	20.11 (26.38)	23.78 (28.74)	22.78
Mar 2014	29.73 (32.99)	3.87 (7.24)	13.87 (21.62)	15.82	18.67 (25.00)	11.56 (15.95)	16.00 (19.52)	14.22 (18.06)	18.67 (24.56)	15.82
April, 2014	27.60 (31.61)	0.0 (0.0)	10.46 (18.38)	12.69	14.67 (18.06)	9.33 (13.91)	14.89 (18.77)	11.89 (16.31)	12.67 (16.25)	12.69
May, 2014	25.00 (29.92)	0.0 (0.0)	6.20 (11.07)	10.40	12.11 (15.96)	6.33 (8.61)	13.00 (17.37)	11.33 (15.81)	9.22 (10.57)	10.40
June, 2014	24.40 (29.51)	0.0 (0.0)	4.40 (9.28)	9.60	10.89 (14.71)	6.11 (8.44)	12.22 (16.53)	9.55 (14.40)	9.22 (10.57)	9.60
July, 2014	21.33 (27.23)	0.0 (0.0)	0.0 (0.0)	7.11	8.56 (10.14)	5.22 (7.77)	8.78 (10.29)	4.11 (6.83)	8.89 (10.36)	7.11
Aug, 2014	14.66 (20.12)	0.0 (0.0)	0.0 (0.0)	4.89	8.11 (9.85)	0.0 (0.0)	5.78 (8.20)	3.78 (6.55)	6.78 (8.93)	4.89
Sept, 2014	7.20 (12.07)	0.0 (0.0)	0.0 (0.0)	2.40	3.00 (5.81)	0.0 (0.0)	5.33 (7.85)	0.0 (0.0)	3.67 (6.45)	2.40
Oct, 2014	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, 2014	0.0 (0.00)	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
Dec, 2014	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
Mean	32.30	22.04	24.28		28.48	24.54	26.25	25.28	26.48	

CD (P=0.05) Storage period = 0.78, Storage conditions= 0.21, Storage period x Storage conditions = 0.92  
 Packaging = 0.29,  
 Storage period x Packaging =1.24 \* Figures in parenthesis indicate arc sine values

**Table 5- Interaction effect of storage conditions, packaging and storage period on seed viability (%) in *Verbena hybrida***

Storage period	Cold storage					Incubator					Ambient				
	Desi.	Poly bin	Poly bag	Cloth Bag	A.foil	Desi.	Poly bin	Poly bag	Cloth bag	A.foil	Desi.	Poly bin	Poly bag	Cloth bag	A.foil
July, 2013	77.33 (61.6)*	72.33 (58.2)	70.67 (57.2)	74.33 (59.6)	73.33 (58.9)	74.00 (59.3)	72.67 (58.5)	72.00 (58.0)	71.33 (57.6)	70.67 (57.2)	71.00 (57.4)	70.33 (56.9)	69.67 (56.6)	71.33 (57.6)	70.67 (57.2)
Aug, 2013	77.00 (61.3)	69.00 (56.1)	70.00 (56.8)	69.00 (56.1)	67.00 (54.9)	70.00 (56.8)	69.00 (56.2)	68.00 (55.5)	68.00 (55.5)	68.33 (55.7)	68.67 (55.9)	69.00 (56.1)	69.67 (56.6)	69.67 (56.6)	70.00 (56.8)
Sept, 2013	74.33 (59.5)	59.33 (50.4)	58.33 (49.8)	60.67 (51.1)	61.67 (51.7)	64.67 (53.5)	61.67 (51.7)	62.33 (52.1)	60.00 (50.7)	61.33 (51.5)	57.67 (49.4)	57.67 (49.4)	54.67 (47.7)	57.00 (49.0)	57.67 (49.3)
Oct, 2013	61.67 (51.7)	55.00 (47.9)	54.67 (47.7)	52.33 (46.3)	57.67 (49.4)	62.33 (52.1)	60.33 (50.9)	58.67 (49.9)	58.67 (49.9)	56.33 (48.6)	58.67 (49.9)	54.67 (47.7)	51.67 (45.9)	56.00 (48.4)	56.33 (48.6)
Nov, 2013	60.33 (50.9)	53.67 (47.1)	54.33 (47.5)	52.67 (46.5)	53.33 (46.9)	59.33 (50.4)	53.33 (46.9)	54.00 (47.3)	55.00 (47.8)	51.33 (45.7)	59.33 (50.4)	48.33 (44.1)	42.67 (40.8)	51.33 (45.7)	51.33 (45.7)
Dec, 2013	46.00 (42.7)	45.67 (42.5)	45.00 (42.1)	46.00 (42.7)	47.00 (43.3)	42.00 (40.4)	42.67 (40.8)	35.00 (36.2)	36.33 (37.0)	37.67 (37.8)	53.33 (46.9)	47.00 (43.3)	44.67 (41.9)	45.67 (42.5)	50.00 (44.9)
Jan, 2014	37.67 (37.8)	30.33 (33.4)	35.67 (36.5)	35.67 (36.6)	38.67 (38.4)	24.33 (29.5)	19.67 (26.3)	20.33 (26.7)	17.00 (24.3)	19.33 (26.0)	33.00 (35.1)	34.00 (36.3)	28.33 (32.1)	32.00 (34.4)	31.67 (34.2)
Feb, 2014	36.67 (37.2)	28.00 (31.9)	28.33 (32.1)	29.00 (32.6)	37.67 (37.8)	18.33 (25.3)	18.00 (25.1)	18.33 (25.3)	15.33 (23.0)	16.33 (23.8)	22.00 (27.9)	18.00 (25.1)	22.33 (28.1)	16.00 (23.5)	17.33 (24.6)
Mar 2014	30.67 (33.6)	25.67 (30.4)	27.00 (31.3)	29.33 (32.8)	36.00 (36.8)	9.67 (18.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	9.67 (18.1)	15.67 (23.3)	9.00 (17.3)	21.00 (27.3)	13.33 (21.4)	10.33 (18.7)
April, 2014	33.67 (35.4)	22.67 (28.4)	24.67 (29.8)	25.33 (30.2)	31.67 (34.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	10.33 (18.7)	5.33 (13.3)	20.00 (26.5)	10.33 (18.7)	6.33 (14.5)
May, 2014	29.67 (32.9)	19.00 (25.8)	23.67 (29.1)	25.00 (29.9)	27.67 (31.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	6.67 (14.9)	0.0 (0.0)	15.33 (23.0)	9.00 (17.4)	0.0 (0.0)
June, 2014	28.33 (32.1)	18.33 (25.3)	26.33 (30.9)	21.33 (27.5)	27.67 (31.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	4.33 (11.9)	0.0 (0.0)	10.33 (18.7)	7.33 (15.7)	0.0 (0.0)
July, 2014	25.67 (30.4)	15.67 (23.3)	26.33 (30.9)	12.33 (20.5)	26.67 (31.1)	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)
Aug, 2014	24.33 (29.5)	0.0 (0.0)	17.33 (24.6)	11.33 (19.7)	20.33 (26.8)	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, 2014	9.00 (17.4)	0.0 (0.0)	16.00 (23.6)	0.0 (0.0)	11.00 (19.4)	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)
Oct, 2014	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)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Nov, 2014	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)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Dec, 2014	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)	0.0 (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 = 2.07 \* Figures in parenthesis indicate arc sine values



**Table 3 -Effect of storage conditions and packaging on seed germination (%) in Verbena hybrid**

Packaging	Storage conditions			
	Cold storage	Incubator	Ambient	Mean
Desiccator	24.91(19.92)*	21.04(16.83)	20.61(16.48)	22.18
Poly set bin	20.65(16.52)	18.33(14.66)	19.22(16.13)	19.57
Poly bag	18.76(15.00)	20.00(16.20)	21.26(17.01)	20.01
Cloth bag	24.07(19.25)	17.96(14.36)	15.61(12.48)	19.22
Al. foil	28.56(22.84)	16.61(13.28)	21.56(17.24)	22.24
Mean	23.39	18.89	19.65	

CD (P=0.05) Packaging = 0.26, Storage conditions= 0.21, Packaging x Storage conditions = 0.48

\* Figures in parenthesis indicate arc sine values

**Table 6 - Effect of storage conditions and packaging on seed viability (%) in Verbena hybrid**

Packaging	Storage conditions			
	Cold storage	Incubator	Ambient	Mean
Desiccator	36.24(34.13)*	23.59(21.41)	22.59(24.55)	28.48
Poly set bin	28.59(27.82)	22.07(19.80)	22.96(23.08)	24.54
Poly bag	32.13(31.65)	21.59(19.51)	25.02(25.30)	26.25
Cloth bag	30.24(29.57)	21.20(19.23)	24.39(24.25)	25.28
Al. foil	34.30(32.95)	21.72(20.26)	23.43(25.05)	26.48
Mean	32.30	22.04	24.28	

CD (P=0.05) Packing = 0.29, Storage conditions= 0.21 , Packing x Storage conditions= 0.49

\* Figures in parenthesis indicate arc sine values

#### Appendix I : Meteorological Data - Ambient conditions

Month	Maximum temp. (°C)	Minimum temp. (°C)	Rainfall (mm)
June, 2013	35.6	27.2	296.4
July, 2013	35.0	27.7	110.2
August, 2013	33.0	26.4	252.1
September, 2013	33.0	23.5	25.3
October, 2013	31.4	20.2	36.2
November, 2013	25.9	10.2	4.6
December, 2013	20.0	7.4	13.2
January, 2014	17.5	7.0	55.5
February, 2014	19.4	8.2	36.7
March, 2014	27.6	13.2	35.6
April, 2014	32.7	16.6	1.0
May, 2014	37.6	22.8	26.2
June, 2014	40.6	27.1	30.2
July, 2014	35.5	27.9	154.2
August, 2014	34.1	26.9	89.6
September, 2014	31.3	23.4	160.8
October, 2014	31.2	18.9	69.0
November, 2014	26.9	10.9	0.0
December, 2014	17.8	7.0	42.2

