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IMPACT OF STORAGE TEMPERATURE AND PACKAGING ON SEED GERMINATION AND VIABILITY OF *Nemesia strumosa* Benth

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ABSTRACT

The seeds of *Nemesia strumosa* were packed in five different packaging (cloth bag in desiccator, plastic bin, polyethylene bag [600 gauze], cloth bag and aluminum foil pack) and stored in three storage chambers *viz*., cold storage (0-4°C and 90±2.7% RH), incubator (20-22°C and 75±1.5% RH) and ambient conditions for 18 months from May 2015 to October, 2016. The seed germination and seed viability were monitored at monthly interval from every packaging and storage chamber in three replications of 100 seed each. The seeds kept in cold storage depicted significantly higher germination (28.6%). The results revealed that seed germination remained above 90% during the initial four months of storage, which decreased gradually to 82.6% after five months in November. Maximum seed germination was recorded from aluminum foil pack (27.5%). The seed stored in cold store either in aluminum foil or desiccator showed germination upto 12 months while cloth bags gave least germination, irrespective of storage temperature. Maximum seed viability (30.5%) was recorded in cold store, followed by ambient storage (26.1%) for 18 months. The storage in desiccator maintained maximum viability (28.8%) which was at par with aluminum foil (28.4%) after 18 months of storage.

Key words: *Nemesia*, seed germination, seed storage, viability

INTRODUCTION

Nemesia is a genus comprising of 60 species of annual, perennial and sub-shrubs, mostly native to southern Africa. Amongst these, *Nemesia strumosa* Benth is a branching annual with lance-shaped entire to coarsely toothed leaves, bearing flowers from white, cream, pink, yellow, mauve and red to orange, with dark marks in the throat and the throat is coarsely hairy. *N. strumosa* is ideal for mass plantings or mixed plantings with other annual species in flower beds for landscaping. Owing to the wide variation in flower colour, this plant is generally used in rock gardens, borders, containers and window boxes. It is extensively grown as winter season annual during November to May for seed production in northern states of India.

Nemesia belongs to family Scrophulariaceae and its seeds possess remarkably complex and effective mechanism to ensure their long survival. The seeds of annual flowering crops are generally stored up to next season under ambient conditions. Many seeds remain viable till coming season; however, some seeds have complex nature being dormant requiring low chilling (Banovetz and Scheiner, 1994) or chemical treatment (Carpenter and Ostmark, 1992). Many seeds have a natural delayed action mechanism that ensures the seeds to remain viable in dormant or active state

until next growing season. Seeds are mostly stored for a short period after harvest before planting and factors like seed moisture, relative humidity of atmosphere, storage temperature, microflora and insects influence seed viability and vigour. The seed quality deteriorates with time and the rate of deterioration is dependent on the environmental conditions prevailing during storage and length of storage period. The maximum seed yield and seed viability in *Coreopsis lanceolata* was observed from June harvest and minimum from July-October harvest (Norcini *et al.,* 2004). The present study was aimed to assess the effect of various storage temperature regimes and packaging on seed viability in *Nemesia strumosa*.

MATERIALS AND METHODS

The seeds of *Nemesia strumosa* were picked manually when the pods turn brownish in April 2015 and then dried in shade, cleaned using hand winnowers and used for conducting the experiments on seed quality and storage. The seeds were kept under three storage temperatures *viz*., cold storage (0-4°C and 90±2.7% RH), incubator (20-22°C and 75±1.5% RH) and ambient storage in the Departmental laboratory. The month-wise average temperature and relative humidity (RH) under ambient conditions was as under:

Month	Temp. (°C)	RH (%)	Month	Temp. (°C)	RH (%)	Month	Temp. (°C)	RH (%)
June, 2015	36.00	39.00	Dec., 2015	14.30	68.00	June, 2016	34.5	40.70
July, 2015	30.30	74.00	Jan., 2016	12.30	80.00	July, 2016	34.1	68.50
Aug., 2015	29.90	77.00	Feb., 2016	16.00	69.00	Aug., 2016	32.0	70.00
Sept., 2015	28.70	72.00	Mar., 2016	21.30	66.00	Sept., 2016	28.5	54.50
Oct., 2015	25.10	68.00	April, 2016	28.10	42.00	Oct., 2016	30.0	51.64
Nov., 2015	19.80	64.00	May, 2016	33.3	30.10	Nov., 2016	20.5	61.40

Five packaging namely cloth bag kept in desiccator, plastic bin with lid, polyethylene bag (600 gauze), cloth bag and aluminum foil pack were used for a period of 18 months (from May, 2015 to October, 2016). One hundred seeds were packed individually in sachets for seed germination and 100-seed for viability in each treatment with total of 90 (storage temperature and packaging) x 18 (storage months) = 1620 small sachets for the experiment. The experiment was conducted in a completely randomized split plot design with storage temperature as main treatments, packaging as sub-treatments and storage period as sub-sub-treatment. The seed germination was assessed by towel paper method (Singh *et al.,* 1998) wherein 100 seed from each treatment were spread uniformly on wet towel paper placed in Petri-plates at 22°C in incubator and the germinated seeds were counted by following formula:

$$\text{Germination (\%)} = \frac{\text{Total number of normal seedling x 100}}{\text{Total number of seed sown}}$$

To determine the viability of nemesia seed, 100 seed per replication from each treatment were soaked in water for 24 h and split into two halves, which were subsequently treated with 2,3,5-triphenyl-tetrazolium chloride for 4 h (Singh *et al.,* 1998). The seeds which stained red on rinsing with water were considered viable. The seed viability was calculated as:

$$\text{Seed viability (\%)} = \frac{\text{Number of stained seed x 100}}{\text{Total number of seed}}$$

The analysis of data was done using computer programme CPCSI (Cheema and Singh, 1990). Wherever required the data was transformed before analysis.

RESULTS AND DISCUSSION

Seed germination

The storage temperature significantly affected seed germination (Table 1). The seeds kept in cold storage showed significantly higher germination (28.6%) as compared to ambient (25.1%) and incubator storage (25.1%). Seed germination showed decrease with prolongation of storage period, with maximum seed germination (96.3%) observed after one month's storage in July and showed gradual reduction to 82.5% in November after 5 months. The interaction between storage temperature and storage period was significant. Cold storage improved germination throughout the storage period as compared to the incubator and ambient storage. The seed germination in cold storage after 1 and 5 months was 97.6 and 87.2%, respectively; whereas the seeds exhibited germination of 84.3 and76.13% under incubator and ambient conditions, respectively, after 5 months and showed no germination after 6th month of storage. The storage of Nemesia seed at 4°C throughout storage period gave maximum germination after 6, 12 and 18 months; whereas the seed stored in incubator failed to germinate after 5 months due to high moisture content. Carpenter *et al.* (1995) reported that decrease in seed moisture content during storage improved the germination of ageratum, delphinium, impatiens, marigold, phlox and verbena. The seed of marigold deteriorated with increase in moisture content under prolonged storage and seed moisture between 3 to 6% was considered safe for long-term storage of marigold at -20°C (Singh *et al.,* 2004).

Amongst the packagings, aluminum foil- and desiccator-packed seeds showed higher germination of 27.4 and 27.0%, respectively, as compared to 24.8% in cloth bag. The interaction between storage period and packaging was significant. After one month maximum germination was recorded in aluminum foil (99.1%), followed by polyethylene bag (97.3%) and desiccator (97.0%). However, after 5 months, all the packagings maintained germination above 82% with lowest in cloth bags. These results are in line with Gujar *et al.* (2001) who reported that the seed germination of aster declined rapidly after 7 month's ambient storage and sealed polythene bags retained germination up to 12 months in refrigerator. The maximum germination in gaillardia was recorded in cold storage, followed by ambient conditions. The highest germination was obtained in desiccator kept in cold store after one year of seed storage (Dhatt and Kumar, 2010).

Table 1: Effect of storage temperature, packaging and storage period on seed germination (%) *Nemesia strumosa*

Storage months**	Cold storage	Incubator	Ambient	Desiccator	PolyBin	Poly bags	Cloth bag	Al. foil	Mean
June, 2015	97.6 (82.0)	94.2 (78.3)	97.0 (80.3)	97.0 (80.9)	93.6 (76.8)	97.3 (81.3)	94.4 (76.9)	99.1 (85.2)	96.3
July, 2015	97.6 (82.5)	93.5 (77.3)	96.3 (79.1)	96.2 (79.0)	93.3 (77.0)	97.3 (81.8)	93.6 (75.9)	98.5 (84.3)	95.8
Aug, 2015	96.0 (79.1)	91.9 (74.4)	93.6 (76.2)	94.6 (76.8)	93.6 (77.0)	94.4 (77.0)	88.7 (70.5)	97.7 (81.5)	93.8
Sept, 2015	91.2 (73.0)	88.7 (73.6)	89.5 (71.5)	88.6 (70.3)	89.6 (73.7)	88.6 (72.7)	87.7 (69.6)	94.3 (76.4)	89.8
Oct, 2015	87.2 (69.4)	84.3 (69.9)	76.1 (61.2)	82.5 (65.4)	86.2 (70.7)	86.3 (70.8)	75.1 (60.4)	82.6 (66.2)	82.5
Nov, 2015	14.4 (21.8)	0.0 (0.0)	0.0 (0.0)	8.2 (9.92)	3.1 (5.9)	3.5 (6.35)	2.7 (5.5)	6.3 (8.61)	4.8
Dec, 2015	9.7 (14.2)	0.0 (0.0)	0.0 (0.0)	6.6 (8.85)	0.0 (0.0)	4.3 (7.04)	0.0 (0.0)	5.2 (7.77)	3.2
Jan, 2016	4.8 (10.9)	0.0 (0.0)	0.0 (0.0)	4.1 (6.85)	0.0 (0.0)	1.1 (3.50)	1.0 (3.3)	1.8 (4.57)	1.6
Feb, 2016	4.4 (10.4)	0.0 (0.0)	0.0 (0.0)	3.7 (6.56)	0.0 (0.0)	0.7 (2.91)	1.1 (3.5)	1.6 (4.30)	1.4
Mar 2016	4.4 (10.7)	0.0 (0.0)	0.0 (0.0)	1.6 (4.29)	0.0 (0.0)	2.7 (5.59)	1.1 (3.5)	1.7 (4.44)	1.4
April, 2016	4.6 (9.57)	0.0 (0.0)	0.0 (0.0)	2.8 (5.70)	0.0 (0.0)	1.8 (4.54)	0.0 (0.0)	2.8 (5.70)	1.5
May, 2016	1.8 (4.93)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	1.1 (3.5)	2.0 (4.71)	0.6
June, 2016	0.0 (0.0)	0.0 (0.0)	0.0 (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	28.56	25.16	25.15	27.02	25.54	26.59	24.83	27.46	-

$CD_{0.05}$: Storage period (SP) = 0.28, Storage temperature (ST) = 0.15, Packaging (P) = 0.16, SP x ST = 0.63; SP x P = 0.71

*Figures in parenthesis indicate arc sine values; Al. foil = Aluminum foil

**No seed germination in all the treatments was observed from June, 2016 onwards till the end of experiment i.e. Nov., 2016 and the data was included in statistical analysis

The interaction between storage temperature, packaging and storage period revealed significant variation in the seed germination of nemesia (Table 2). Ambient and incubator storage showed maximum germination (99.3%) after one month in both aluminum foil and desiccator. Polyethylene bag, aluminum foil and poly set bin under cold storage showed >98% germination upto 3 months. The results showed that aluminum foil under incubator and ambient conditions maintained the same germination level after 3 months of storage; whereas seed stored in aluminum foil and desiccator under cold storage depicted germination upto 12 months. The maximum germination (8.3%) was observed in polyethylene bag kept in cold storage after 10 months. The results revealed that the superiority of low temperature storage in desiccators is due to moisture absorption by calcium chloride and secondly the seed stored in sealed aluminum foil resulted in proper maintenance of food reserves which stimulated seed germination. The germination in cloth bags and poly bin decreased significantly due to increase in moisture content with increase in relative humidity from the surrounding environment. But moisture content in seed was much fluctuated in cloth bag in response to changes in the relative humidity of atmosphere. These results corroborate with those Verma *et al*. (1996) in poppy who found decline in seed germination in cloth bags and paper bags as compared to polythene bags after 18 months of storage. Polyethylene bag (700 gauge) were reported as the adequate packaging for maintaining maximum seed viability in case

Table 2: Interaction among storage temperature, packaging and storage period on seed germination (%) in *Nemesia strumosa*

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
June,	95.6	98.3	99.0	96.3	99.0	99.3	85.6	97.0	90.0	99.3	96.0	97.0	96.0	97.0	99.0
2015	(77.9)	(82.6)	(85.3)	(78.9)	(85.3)	(86.1)	(67.7)	(80.1)	(71.5)	(86.1)	(78.4)	(80.1)	(78.5)	(80.1)	(84.2)
July,	95.6	98.6	99.3	95.6	98.6	97.6	84.6	97.3	88.6	99.3	95.3	96.6	95.3	96.6	97.6
	(78.0)	(84.5)	(87.2)	(77.8)	(84.5)	(81.5)	(66.9)	(80.7)	(70.3)	(87.2)	(77.5)	(79.6)	(77.5)	(79.6)	(81.2)
Aug.	94.3	98.6	97.6	91.6	97.6	96.0	85.3	90.3	89.6	98.3	93.6	97.0	95.3	85.0	97.3
	(76.2)	(83.4)	(81.5)	(73.2)	(81.2)	(78.7)	(67.5)	(72.0)	(71.2)	(82.6)	(75.5)	(80.1)	(77.5)	(67.2)	(80.7)
Sept.,	90.0	90.6	91.3	88.0	96.0	88.6	83.0	88.6	90.0	93.3	87.3	95.3	86.0	85.3	93.6
	(71.6)	(72.3)	(73.0)	(69.7)	(78.7)	(70.3)	(65.6)	(70.3)	(71.6)	(75.0)	(69.1)	(77.5)	(68.0)	(67.5)	(75.5)
Oct.,	87.3	88.3	91.3	77.6	91.6	83.0	82.0	85.0	84.6	87.00	77.3	88.3	82.6	63.0	69.3
	(69.1)	(70.0)	(72.9)	(61.8)	(73.3)	(65.6)	(64.8)	(67.0)	(66.9)	(68.8)	(61.6)	(70.0)	(65.4)	(52.5)	(56.3)
Nov.,	24.6	9.3	10.6	8.3	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(29.8)	(17.8)	(19.0)	(16.7)	(25.8)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Dec.,	20.0	0.0	13.0	0.0	15.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(26.5)	(0.0)	(21.1)	(0.0)	(23.3)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Jan.,	12.3	0.0	3.3	3.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	(20.5)	(0.0)	(10.4)	(9.9)	(13.7)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Feb.,	11.3	0.0	2.3	3.33	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(19.7)	(0.0)	(8.7)	(10.5)	(12.9)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Mar.	5.0	0.0	8.3	3.33	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(12.9)	(0.0)	(16.7)	(10.5)	(13.3)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
April	8.6	0.0	5.6	0.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(17.1)	(0.0)	(13.6)	(0.0)	(17.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
May	0.0	0.0	0.0	3.33	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)	(10.5)	(14.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)

$CD_{0.05}$: Storage conditions x Packaging x Storage period = 1.43

Desi = Dessicator; A. foil = Aluminum foil

* The figures in parenthesis indicate arc sine values

**No seed germination in all the treatments was observed from May, 2016 onwards till the end of experiment i.e. Nov., 2016 and the data was included in analysis

of marigold upto 8 months (Selvaraju and Selvaraj, 1999). Our results are in line with Tejaswani *et al*. (2014) in marigold who found that polythene bag with silica gel and single layer polythene bag with silica gel maintained constant germination after six months.

Seed viability

The storage temperature and storage period significantly affected seed viability of *N. strumosa* (Table 3 and 4). The cold storage resulted in maximum viability (30.5%) as compared to ambient (26.0%) and incubator (25.9%) after 18 months. The results indicated that seed viability declined with the progression of storage period with maximum viability (96.7%) recorded after 1 month, which showed a linear decrease to 87.0% after 5 months of storage. The interactions between storage temperature and storage period were also significant. The cold storage gave significantly higher viability than incubator and ambient conditions throughout the period. The seeds stored under cold storage depicted viability for longer period than ambient and incubator. After 5 months of storage cold storage and incubator showed viability > 89%.

Table 3: Effect of storage temperature, packaging and storage period on seed viability (%) in *Nemesia strumosa*

Storage period	Cold storage	Incubator	Ambient	Mean	Desiccator	Poly Bin	Poly bags	Cloth bag	Aluminum foil	Mean
June, 2015	97.7 (81.4)	96.1 (79.3)	96.4 (79.1)	96.7	97.1 (80.5)	96.7 (79.9)	96.8 (79.9)	94.7 (77.1)	98.2 (82.3)	96.7
July	97.6 (81.5)	94.6 (77.2)	96.1 (78.7)	96.1	95.8 (78.3)	95.6 (76.0)	97.8 (81.7)	94.3 (76.5)	97.0 (80.2)	96.1
Aug.	96.0 (78.6)	92.2 (74.3)	93.2 (75.4)	93.8	94.8 (77.0)	93.4 (75.2)	94.0 (76.2)	89.7 (71.5)	96.8 (79.8)	93.8
Sept.	90.4 (72.1)	90.6 (72.3)	89.1 (71.0)	90.0	88.6 (70.3)	93.4 (75.1)	87.6 (69.4)	87.3 (69.1)	93.3 (75.0)	90.0
Oct.	89.1 (71.2)	92.3 (75.2)	79.2 (63.3)	87.0	87.3 (69.3)	93.0 (75.1)	92.3 (74.7)	78.3 (62.5)	84.4 (67.8)	87.0
Nov.	19.4 (25.7)	0.0 (0.0)	8.9 (15.4)	9.4	15.2 (18.7)	5.1 (7.6)	8.7 (14.1)	5.6 (11.2)	12.5 (16.9)	9.4
Dec.	16.0 (23.2)	0.0 (0.0)	6.5 (13.1)	7.5	12.3 (16.5)	3.6 (6.4)	8.0 (13.3)	4.6 (10.0)	8.8 (14.1)	7.5
Jan., 2016	9.4 (15.8)	0.0 (0.0)	0.0 (0.0)	3.1	6.6 (8.8)	0.0 (0.0)	2.7 (5.5)	2.6 (5.4)	3.6 (6.4)	3.1
Feb.	8.4 (15.2)	0.0 (0.0)	0.0 (0.0)	2.8	5.8 (8.2)	0.0 (0.0)	2.2 (5.5)	2.5 (5.3)	3.4 (6.2)	2.8
March	7.9 (14.3)	0.0 (0.0)	0.0 (0.0)	2.6	4.7 (7.4)	0.0 (0.0)	2.7 (5.4)	2.1 (4.8)	3.4 (6.2)	2.6
April	6.4 (12.7)	0.0 (0.0)	0.0 (0.0)	2.1	3.6 (6.4)	0.0 (0.0)	2.6 (4.9)	1.3 (3.8)	3.1 (5.9)	2.1
May	5.2 (11.7)	0.0 (0.0)	0.0 (0.0)	1.7	3.2 (6.0)	0.0 (0.0)	1.6 (4.3)	1.4 (4.0)	2.4 (5.2)	1.7
June	3.0 (9.7)	0.0 (0.0)	0.0 (0.0)	1.0	1.8 (4.5)	0.0 (0.0)	0.0 (3.3)	1.1 (3.5)	2.1 (4.8)	1.0
July	2.8 (6.7)	0.0 (0.0)	0.0 (0.0)	0.9	1.4 (4.0)	0.0 (0.0)	1.0 (0.0)	1.2 (3.6)	1.1 (3.5)	0.9
Aug.	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	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	30.55	25.92	26.09	-	28.83	26.73	27.70	25.96	28.37	-

$CD_{0.05}$: Storage period (SP) = 0.31, Storage temperature (ST) = 0.12, SP x ST = 0.54, Packaging (P) = 0.14, SP x P = 0.62

*Figures in parenthesis indicate arc sine values

**No seed germination in all the treatments was observed from August, 2016 onwards till the end of experiment i.e. Nov., 2016 and the data was included in analysis

The seeds maintained in desiccator recorded maximum viability (28.8%), closely followed by aluminum foil (28.3%), polyethylene bag (27.7%) and poly set bin (26.7%). The minimum viability was found in seeds kept in cloth bag (25.9%). Among the storage temperature, highest viability (30.5%) was observed in seeds kept under cold storage and lowest in incubator (25.9%), which was at par with the ambient storage (26.0%) after 18 months of storage. The lower germination in seeds in polyethylene bags may be due to lower membrane integrity under improper storage temperature resulting in cytoplasm membrane destruction and soluble-matters exudation during uptake. Similar results were obtained for seeds stored for 6 months in pearl pet jars with silica gel. Likewise, seeds stored in cloth bags without desiccants maintained lower germination due to high moisture content (11.53%) as compared to polythene bags with silica gel or zeolite beads (Nethra *et al.,* 2016).

Seed viability of *Nemesia* showed significant difference in packaging under different storage temperature during 18 months of seed storage. After one month, the seed viability was >91%, irrespective of packaging. After 3 months, poly set bin in cold store showed 98.6% count, which was at par with polyethylene bag, aluminum foil and desiccator under cold store and aluminum foil under incubator and ambient conditions. After 6 months, highest viability (31%) was found in desiccator under cold storage, whereas seeds failed to germinate in all the packaging under incubator storage.

Table 4: Interaction among storage temperature, packaging and storage period on seed viability (%) in *Nemesia strumosa*

Storage period	Cold storage					Incubator					Ambient				
	Desi.	Poly bin	Poly bag	Cloth Bag	Al foil	Desi.	Poly Bin	Poly bag	Cloth bag	Al foil	Desi.	Poly bin	Poly bag	Cloth bag	Al foil
June, 2015	97.6 (81.2)	98.6 (83.3)	98.0 (81.8)	96.3 (78.9)	98.0 (81.8)	98.6 (83.3)	95.3 (77.5)	97.0 (80.0)	91.0 (72.5)	98.6 (83.3)	95.0 (77.0)	96.3 (78.9)	95.6 (77.9)	97.0 (80.0)	98.0 (81.8)
July	95.6 (77.9)	99.0 (84.2)	99.0 (84.3)	96.6 (79.4)	98.0 (81.8)	97.0 (80.0)	90.6 (72.2)	97.3 (80.6)	90.3 (71.8)	98.0 (81.8)	95.0 (77.0)	97.3 (80.6)	97.3 (80.6)	96.0 (78.4)	95.0 (77.0)
Aug.	96.3 (78.9)	98.6 (80.6)	97.6 (80.0)	92.6 (74.3)	96.6 (79.4)	96.0 (78.4)	86.6 (68.6)	89.6 (71.2)	91.3 (72.8)	97.3 (80.6)	92.3 (73.9)	96.3 (78.9)	95.3 (77.5)	85.3 (67.4)	96.6 (79.4)
Sept.	90.3 (71.8)	91.3 (72.8)	88.6 (70.3)	87.3 (69.1)	94.6 (76.6)	88.3 (70.0)	94.3 (76.2)	88.3 (70.0)	89.0 (70.6)	93.3 (75.0)	87.3 (69.1)	94.6 (76.6)	86.0 (68.0)	85.6 (67.7)	92.0 (73.5)
Oct.	88.3 (70.0)	90.3 (70.8)	94.6 (76.6)	79.0 (62.7)	93.3 (75.0)	92.0 (73.5)	97.6 (81.2)	97.3 (80.6)	86.6 (68.6)	91.0 (72.5)	81.6 (64.6)	91.0 (72.5)	85.0 (67.2)	69.3 (56.3)	69.0 (56.1)
Nov.	31.0 (33.8)	15.3 (23.0)	16.0 (23.6)	10.3 (18.7)	24.6 (29.8)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	14.6 (22.5)	0.0 (0.0)	10.3 (18.7)	6.6 (14.9)	13.0 (21.1)
Dec.	27.0 (31.3)	11.0 (19.4)	16.0 (23.6)	9.3 (17.8)	16.6 (24.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	10.0 (18.4)	0.0 (0.0)	8.0 (16.4)	4.6 (12.5)	10.0 (18.4)
Jan., 2016	20.0 (26.5)	0.0 (0.0)	8.3 (16.8)	8.0 (16.4)	11.0 (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)
Feb.	17.6 (24.8)	0.0 (0.0)	6.6 (16.8)	7.6 (16.1)	10.3 (18.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
March	14.3 (22.2)	0.0 (0.0)	8.3 (16.4)	6.3 (14.6)	10.3 (18.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
April	11.0 (19.4)	0.0 (0.0)	8.0 (14.9)	4.00 (11.5)	9.3 (17.8)	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)
May	9.6 (18.1)	0.0 (0.0)	5.0 (12.9)	4.3 (12.0)	7.3 (15.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
June	5.6 (13.8)	0.0 (0.0)	0.0 (9.9)	3.3 (10.5)	6.3 (14.6)	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)
July	4.3 (12.0)	0.0 (0.0)	3.00 (0.0)	3.6 (11.0)	3.3 (10.5)	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)
Aug.	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
$CD_{0.05}$	Storage conditions x Packaging x Storage period = 1.21														

*The figures in parenthesis indicate arc sine values

** No seed germination in all the treatments was observed from August, 2016 onwards till the end of experiment i.e. Nov., 2016 and the data was included in analysis

In present study the seed viability was significantly higher under cold storage as compared to incubator and ambient storage. There were non-significant differences among different treatments during the initial 3 months. After 6 months, seed stored in desiccators showed seed viability below the standard germination percentage, whereas seed stored at ambient temperature and incubator failed to germinate. Similarly, Bita Oskouei and Sheidaie (2013) found seed germination and electrical conductivity in canola was not affected due to packaging during first 3 months but the decline of germination ability at standard germination test was observed after 6 months storage. Further, the best storage conditions for seeds were 3- and 4-layers paper bags presenting germination ability above standard after 9 months storage. These findings were parallel to the work done in marigold, where seed stored in double layer polythene bag recorded higher seed quality parameters in terms of germination, root length, shoot length and vigour index (Tejashwi, *et al*., 2014). The poor germination in cloth bags may be attributed to the temperature increasing effects and the relation of temperature and relative humidity at storage period. Hence high temperatures cause increase in the velocity of some enzyme and hydraulic reactions which accelerate seed deterioration. Higher germination and viability in this study in aluminum foil and polyethylene bag can be attributed to the non-permeability to moisture in that packaging. This is in accordance with the universal "rule of thumb" by Harrington that the seeds loose half of their storage life with every 5°C increase in storage temperature between 0 and 50°C and halved with every 1% increase in seed moisture between 5 and 14% (Harrington, 1972). Below 5% the speed of aging may increase and above 14% the storage fungi destroy the capacity of seed for germination. Similar results have also reported by Agha *et al*. (2004) considering that the temperature increased up to 45ºC and relative humidity increased to 85% at propylene caused increase in temperature and respiration thus affected seed vigour.

Conclusion: The seed germination and viability of *Nemsia* can be best maintained by packing seed in aluminum foil or in cloth bags kept in desiccator containing calcium chloride under ambient conditions up to 6 months. The cold storage chamber (0-4°C and 90±2.7% RH) up was found to be the best for maintaining maximum germination up to 12 months.

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