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Effect of Packaging Materials and Storage Conditions on Seed Germination and Viability in Gaillardia Seeds, (*Gaillardia pulchella* Foug.)

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ABSTRACT: An experiment was carried out at, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University, Rajendranagar, Hyderabad, to assess the "Effect of packaging materials and storage conditions on seed germination and viability of gaillardia seeds (Gaillardia pulchella Foug.)". The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with twelve treatments and three replications. The treatments consist of two levels of conditions *viz*., A_1: Cold storage A_2: Ambient condition with six different packaging materials *viz*., B_1: Glass jar, B_2: Air tight plastic box, B_3: Aluminum foil, B_4: Zip lock bag, B_5: LDPE polythene bag (200 gauge), B_6: LDPE Polythene bag (400gauge). The results revealed that the treatment combination of T_3- A_1B_3- cold storage + Aluminium foil recorded maximum seed viability, (%) seed germination (%) percentage, seedling length (cm), seedling vigour index, field emergence percentage, and minimum EC, less no. of days to germination and followed by T_6- A_1B_6- cold storage + LDPE (400) gauge. While the minimum seed viability was recorded in the T_8- A_2B_2- ambient storage + Plastic box.

Keywords: Gaillardia seeds, Electric conductivity, seed germination percentage, seed viability, seedling length, seedling vigour index, field emergence percentage**.**

INTRODUCTION

Gaillardia (*Gaillardia pulchella* Foug.) is a significant flower crop that is indigenous to the central and western regions of the United States which belongs to the family Asteraceae. It is commonly called as "Blanket Flower" and "Fire wheel". Being a native of Northern America, it is found in Asia and Africa. In Telangana, it is increasingly significant as a commercial flower crop. There are 12 different species of gaillardia, which range in height from 45 to 90 cm and have solitary, single or double daisy flower heads. The vivid yellow, purple, cream yellow, or orange hues of the flowers make them conspicuous (Pal, 1989). Gaillardia flowers are frequently used in garlands and for decorative purposes. Gaillardia seeds lose viability and vigour in prolonged storage like other flower crop seeds due to number of factors like temperature, moisture content, relative humidity, packing type, storage conditions, and biotic factors. Therefore, it is crucial for growers to maintain a high percentage of seed germination till the next sowing season. This can be accomplished by keeping the seeds in a controlled environment with low temperatures and high relative humidity which may not be possible in Indian conditions as it incurs high expenditure. Seed viability will be reduced and the storage period of the seeds will be extended either by soaking or dry dressing new seeds or partially aged seeds before storage (Basu, 1993). Many crops claim that seed treatment with pesticides, desiccants, and storage containers improves the viability and vigour of seeds. However, there is a paucity of such information in flower seeds, particularly in gaillardia seed.

MATERIALS AND METHODS

The laboratory experiment is carried out at College of Horticulture, Rajendranagar, Hyderabad. The experiment was laid out in a Factorial Completely Randomized Design (FCRD)with twelve treatments and three replications. The treatments consist of two levels of conditions *viz*., A_1: Cold storage A_2: Ambient condition with six different packaging materials *viz*., B_1: Glass jar, B_2: Air tight plastic box, B_3: Aluminum foil, B_4: Zip lock bag, B_5: LDPE polythene bag (200 gauge), B_6: LDPE Polythene bag (400 gauge).

Treatments Combinations:
T_1: Cold condition + Glass jar
T_2: Cold condition + Air tight plastic box
T_3: Cold condition + Aluminium foil

T_4: Cold condition + Zip lock bag
T_5: Cold condition + LDPE bag (200 gauge)
T_6: Cold condition + LDPE bag (400 gauge)
T_7: Ambient condition + Glass jar
T_8: Ambient condition + Air tight plastic box
T_9: Ambient condition + Aluminium foil
T_{10}: Ambient condition + Zip lock bag
T_{11}: Ambient condition +LDPE bag (200 gauge)
T_{12}: Ambient condition + LDPE bag (400 gauge)

A. Germination percentage (%)
For recording germination percentage seeds were sown in Petri plates. The germination count was recorded from four days up to six days on daily basis. The emergence of shoot was considered as germination and it was converted into percentage.

$$\text{Germination percentage} = \frac{\text{number of seeds germinated}}{\text{number of seeds sown}} \times 100$$

B. Electrical conductivity of seeds (dsm^{-1})
The test is based on the leakage of solutes from the cell membrane of all the seeds into deionized distilled water. The amount of electrolyte leakage was assessed by measuring the electrical conductivity of the seed soaked water with a conductivity meter. Fifty healthy seeds were taken, and the seeds were soaked in 25 ml of distilled water at 25+1°C for 24 hrs. Then the electrical conductivity of seeds was measured by using digital EC meter at ambient conditions and expressed in dsm^{-1}.

C. Seed viability
The seed viability was determined by using tetrazolium test. Fifty seeds were taken from each treatment and soaked in water for 24 hours at 25°C temperature. Then these seeds were taken out from the water and seed coat was removed with help of sharp blades and needles after removing the seed coat, the seeds were immersed in 50 ml of 1 per cent tetrazolium salt (2, 3, 5– triphenyl tetrazolium chloride) solution for three hours at 25°C for staining. The seeds were washed with water, uniformly pink stained seeds were considered as viable seeds.

D. Seedling Length (cm)
Five seedlings used for the seedling length measurement. The mean value was recorded in cm.
Seedling length = Shoot length (cm) + Root length (cm)

E. Field emergence (%)
Hundred seeds were selected at random from each treatment from three replications and were used for the field emergence studies. The seeds were sown in seed bed by providing optimum watering. Field emergence count was taken on the 14th day after sowing and the percent emergence was calculated by taking the number of seedlings which are three centimetre above the soil surface.
Field emergence (%) =

$$\frac{\text{Number of seedlings emerged on 14 th day}}{\text{Total number of seeds sown}} \times 100$$

E. Seedling vigour index
Seedling Vigour Index (SVI) was calculated as per the following formula (Abdul-Baki and Anderson 1973)
SVI = Seed germination (%) × Seedling length (cm)
Where in seedling length = Shoot length (cm) + Root length (cm).

RESULTS AND DISCUSSION

The present investigations are discussed and presented below.

A. Germination percentage (%):
During the 0, 30, 60, 90 days intervals of storage, the germination percentage varied greatly depending on the storage conditions. As they are fresh seeds there is no significant difference between the storage conditions at 0 days of storage. At 30, 60 and 90 days of storage, the maximum seed viability recorded in the cold storage conditions (A_1) (78.28 %), (77.02 %), (75.80 %) and minimum seed viability was recorded in ambient condition (A_2) (77.08 %) (75.89 %), (74.67 %) respectively and there was gradual decrease in seed viability during the storage period from 0, 30 60, and at 90 days.
The percentage of germination due to packaging materials differed significantly. At 0, 30, 60 and 90days of storage, maximum germination percentage was recorded in aluminium foil (B_3) (82.13 %), (81.15 %), (79.93 %), (78.72 %) and followed by (B_6) LDPE 400 gauge (80.35 %), (78.92 %), (77.70 %), (76.49 %) and the minimum germination percentage was recorded in air tight plastic box (B_2) (75.73 %), (75.05 %), (73.81 %), (72.59 %). There was a gradual decrease in germination percentage during the storage period from 0, 30, 60, 90 days.
The interaction effect showed non-significant effect in germination percentage in storage conditions and packaging materials during the 0, 30, 60, 90 days interval of storage period in both cold storage and ambient storage conditions. These results are similar with the research findings of Balesevic-Tubic *et al.* (2010) in soyabean, Yogeesha *et al*. (2012) in china aster and Singh *et al.* (2004) in African marigold.

B. Electrical conductivity of seeds (dsm^{-1})
The analysed data revealed that there is significant difference in electrical conductivity among the various storage conditions. At 0 days of storage as the seeds are fresh, there is no significant difference among the storage conditions. At 30, 60 and 90 days of storage, the cold storage condition recorded the lowest electrical conductivity (A_1) (0.96 dsm^{-1}), (0.99 dsm^{-1}) and (1.01 dsm^{-1}), the highest electrical conductivity in ambient storage condition (A_2) (1.08 dsm^{-1}), (1.11 dsm^{-1}) and (1.12 dsm^{-1}) respectively and there was gradual increase in electric conductivity during the storage period from 0, 30, 60, and at 90 days.
The electrical conductivity due to packaging materials differed significantly except at 0 days of storage. At 30, 60 and 90 days of storage, the lowest electrical conductivity was recorded in aluminium foil (B_3) (0.95 dsm^{-1}) (0.97 dsm^{-1}) (0.99 dsm^{-1}) and highest electrical conductivity was recorded in air tight plastic box (B_2) (1.07 dsm^{-1}), (1.09 dsm^{-1}) and (1.12 dsm^{-1}). The other treatments recorded the intermediate values and there

was gradual increase in electric conductivity during the storage period from 0, 30, 60, and at 90 days.

Among the interactions, there is no significant difference in electrical conductivity due to storage conditions and packaging materials during storage intervals of 0, 30, 60, and 90 days in both cold storage and ambient storage conditions. The results are similar with the research findings of Szemruch *et al.* (2015) in sunflower seeds, Vieira *et al.* (2004).

C. Seed viability

The data on seed viability revealed significant difference between two different storage conditions. At 0 days, there was no significant difference in cold conditions. At 30, 60 and 90 days of storage, the maximum seed viability was recorded in cold storage condition A_1 (79.51 %), (77.41 %), (75.24 %) and minimum seed viability was recorded in ambient condition A_2 (78.47 %) (76.43 %), (74.11 %) respectively and there was gradual decrease in seed viability during the storage period from 0, 30, 60, and at 90 days.

The impact of packaging materials on seed viability was also significant for storage intervals of 0, 30, 60, and 90 days. At 0, 30, 60 and 90 days of storage, maximum seed viability was recorded in aluminium foil (B_3) (85.26 %), (81.98 %), (79.86 %), (77.59 %) and followed by (B_6) LDPE 400 gauge (84.10 %), (80.41 %), (78.78 %), (76.70 %) and the minimum seed viability was recorded in air tight plastic box (B2) (76.97 %), (76.56%), (74.73 %), (72.44 %). There was a gradual decrease in seed viability during the storage period from 0, 30, 60, 90 days.

The interaction effect on seed viability due to storage conditions and packaging materials is non- significant during storage intervals of 0, 30, 60, and 90 days in both cold storage and ambient storage conditions. The results are similar with the findings of Dhatt (2010) in gaillardia, in marigold by Selvaraju and Selvaraj (1999), by Dhatt (2016) in Pansy, and in cluster bean by Doijode (1989); Bharathi (2002) in gaillardia and Hunje (2002) in chilli and Gnyandev *et al.* (2014) in China aster.

D. Seedling Length (cm)

The length of the seedlings showed significant difference between the storage conditions. The length of the seedling was observed non-significant in both cold and ambient conditions as the seeds are freshly harvested at 0 days of storage. At 30, 60, 90 days of storage the maximum seedling length was observed in cold storage (A_1) (16.25 cm), (15.63 cm), (14.86 cm) whereas the minimum seedling length was recorded in ambient storage (A_2) (15.95 cm), (15.23 cm), (14.36 cm) respectively.

Seedling length due to various packaging materials differed significantly. At the 0, 30, 60, 90 days of storage the maximum seedling length was recorded in aluminium foil (B_3) (17.97 cm), (17.60 cm), (17.00 cm), (16.41 cm), which is followed by LDPE 400 gauge (B_6) (17.37 cm), (16.71 cm), (16.57 cm), (15.58 cm) and the minimum seedling length was reported in plastic box (B_2) (16.61 cm), (15.00 cm), (14.00 cm), (13.08 cm) respectively.

The interaction effect had shown non-significant difference with respect to seedling length due to storage conditions and packing materials during storage intervals of 0, 30, 60, and 90 days in both cold storage and ambient storage conditions. The results are similar with the findings of Ellis *et al.* (1991); Yogeesha *et al.* (2012) in China aster.

E. Field emergence (%)

The data on field emergence percentage revealed that there is significant difference among storage conditions. In both the cold and ambient conditions there was no significant difference was reported as they were fresh seeds at the 0 days of storage. At the 30, 60, 90 days storage interval the maximum field emergence percentage was recorded in cold storage (A_1) (67.27 %), (66.10 %), (65.79 %) and the minimum field emergence percentage was recorded in ambient storage (A_2) (66.31 %), (65.15 %), (63.96 %) respectively.

Field emergence percentage showed significant variations depending on the packaging during intervals of 0, 30, 60, and 90 days of storage. At the 0, 30, 60, 90 days of storage the maximum field emergence percentage was recorded in aluminium foil (B_3) (70.04 %), (68.40 %), (67.42 %), (66.67 %), followed by LDPE 400 gauge (B_6) (69.48 %), (67.78 %), (66.74 %), (65.99 %) and the minimum field emergence percentage was reported in plastic box (B_2) (66.88 %), (65.55 %) (64.12 %), (63.38 %) respectively.

Regarding, the field emergence percentage interaction effect due to storage conditions and packing materials during storage intervals of 0, 30, 60, and 90 days in both cold storage and ambient storage conditions is non- significant. The results are similar with the findings of Dhatt (2009) in *Gazania splendens* L., Yogeesha *et al.* (2012) in China aster.

F. Seedling vigour index

The data on seedling vigour index revealed significant difference among storage conditions. At 0 days of storage, non-significant was observed in the seedling vigour index in both the cold and ambient condition as they were fresh seeds. At the 30, 60, 90 days storage interval the maximum seedling vigour index was recorded in cold storage (A_1) (1274.06), (1206.52), (1128.42) and the minimum seedling vigour index was recorded in ambient storage (A_2) (1231.07), (1163.80), (1074.85) respectively.

Seedling vigour index showed significant effect due to packaging materials during 0, 30, 60, and 90 days of storage. At the 0, 30, 60, 90 days of storage the maximum seedling vigour index was recorded in aluminium foil (B_3) (1454.15), (1428.32), (1359.38), (1291.95), followed by LDPE 400 gauge (B_6) (1366.55), (1319.24), (1284.28), (1192.08) and the minimum seedling vigour index was reported in plastic box (B_2) (1256.39), (1126.14) (1033.44), (949.65) respectively.

Regarding, the seedling vigour index, the interaction effect showed non-significant effect due to storage conditions and packing materials during storage intervals of 0, 30, 60, and 90 days in both cold storage and ambient storage conditions. The results are similar with the findings of Kumar (2014) in marigold seeds which are stored in double layered polythene bag, Tripathi & Lawande (2014) in Agrifound Dark Red onion seeds which are stored in aluminum foil.

Table 1: Effect of packaging materials and storage conditions on germination percentage of Gaillardia seeds (*Gaillardia pulchella*).

	0 days of storage				30 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	76.90	76.60	**76.75^{de}**	**B_1**	76.65	75.53	**76.09^{de}**
B_2	76.26	75.20	**75.73^{e}**	**B_2**	75.23	74.87	**75.05^{e}**
B_3	83.19	81.07	**82.13^{a}**	**B_3**	81.98	80.32	**81.15^{a}**
B_4	78.70	77.80	**78.25^{cd}**	**B_4**	77.92	76.56	**77.24^{cd}**
B_5	79.20	78.50	**78.85^{bc}**	**B_5**	78.32	76.96	**77.64^{bc}**
B_6	80.80	79.90	**80.35^{b}**	**B_6**	79.60	78.24	**78.92^{b}**
MEAN	**79.17^{A}**	**78.17^{B}**		**MEAN**	**78.28^{A}**	**77.08^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.51**	**0.88**	**1.25**	**SEm±**	**0.43**	**0.74**	**1.05**
CD at 5%	**NS**	**2.58**	**NS**	**CD at 5%**	**1.25**	**2.17**	**NS**

	60 days of storage				90 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	75.33	74.37	**74.85^{de}**	**B_1**	74.12	73.15	**73.63^{cd}**
B_2	73.91	73.71	**73.81^{e}**	**B_2**	72.70	72.49	**72.59^{d}**
B_3	80.76	79.10	**79.93^{a}**	**B_3**	79.55	77.89	**78.72^{a}**
B_4	76.61	75.40	**76.00^{cd}**	**B_4**	75.39	74.18	**74.78^{c}**
B_5	77.11	75.74	**76.42^{bc}**	**B_5**	75.89	74.53	**75.21^{bc}**
B_6	78.38	77.03	**77.70^{b}**	**B_6**	77.17	75.81	**76.49^{b}**
MEAN	**77.02^{A}**	**75.89^{B}**		**MEAN**	**75.80^{A}**	**74.67^{B}**	
		B	**A*B**		**A**	**B**	**A*B**
SEm±	**0.39**	**0.67**	**0.95**	**SEm±**	**0.52**	**0.91**	**1.28**
CD at 5%	**1.13**	**1.97**	**NS**	**CD at 5%**	**1.53**	**2.65**	**NS**

Table 2: Effect of packaging materials and storage conditions on electric conductivity (dsm^{-1}) of Gaillardia seeds (*Gaillardia pulchella*).

	0 days of storage				30 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	0.93	0.96	**0.94^{b}**	**B_1**	0.99	1.12	**1.06^{bc}**
B_2	0.94	0.95	**0.95^{b}**	**B_2**	1.01	1.13	**1.07^{c}**
B_3	0.89	0.91	**0.90^{a}**	**B_3**	0.91	0.98	**0.95^{a}**
B_4	0.95	0.97	**0.96^{b}**	**B_4**	0.98	1.10	**1.04^{cd}**
B_5	0.94	0.94	**0.94^{b}**	**B_5**	0.96	1.09	**1.03^{bc}**
B_6	0.91	0.95	**0.92^{b}**	**B_6**	0.93	1.04	**0.99^{ab}**
MEAN	**0.94^{A}**	**0.96^{B}**		**MEAN**	**0.96^{A}**	**1.08^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.006**	**0.010**	**0.014**	**SEm±**	**0.008**	**0.013**	**0.019**
CD at 5%	**NS**	**NS**	**NS**	**CD at 5%**	**0.023**	**0.039**	**NS**

	60 days of storage				90 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	1.02	1.15	**1.08^{bc}**	**B_1**	1.04	1.17	**1.10^{de}**
B_2	1.04	1.15	**1.09^{c}**	**B_2**	1.06	1.18	**1.12^{e}**
B_3	0.94	1.07	**0.97^{a}**	**B_3**	0.96	1.03	**0.99^{a}**
B_4	1.01	1.13	**1.06^{b}**	**B_4**	1.03	1.15	**1.09^{cd}**
B_5	0.98	1.12	**1.05^{bc}**	**B_5**	1.00	1.14	**1.07^{bc}**
B_6	0.96	1.06	**1.01^{b}**	**B_6**	0.98	1.09	**1.03^{ab}**
MEAN	**0.99^{A}**	**1.11^{B}**		**MEAN**	**1.01^{A}**	**1.12^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.006**	**0.010**	**0.015**	**SEm±**	**0.006**	**0.010**	**0.014**
CD at 5%	**0.018**	**0.030**	**NS**	**CD at 5%**	**0.017**	**0.030**	**NS**

Table 3: Effect of packaging materials and storage conditions on seed viability Gaillardia seeds (*Gaillardia pulchella*).

	0 days of storage				30 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	78.60	79.10	**78.85^{d}**	**B_1**	77.95	76.79	**77.37^{e}**
B_2	77.00	76.95	**76.97^{e}**	**B_2**	76.96	76.17	**76.56^{e}**
B_3	85.53	85.00	**85.26^{a}**	**B_3**	82.48	81.48	**81.98^{a}**
B_4	82.19	80.00	**81.09^{c}**	**B_4**	78.59	77.63	**78.11^{d}**
B_5	84.40	82.10	**83.25^{b}**	**B_5**	79.56	78.64	**79.10^{c}**
B_6	84.60	83.60	**84.10^{ab}**	**B_6**	80.92	79.90	**80.41^{b}**
MEAN	**81.28^{A}**	**80.44^{B}**		**MEAN**	**79.51^{A}**	**78.47^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.45**	**0.78**	**1.11**	**SEm±**	**0.03**	**0.06**	**0.09**
CD at 5%	**NS**	**2.30**	**NS**	**CD at 5%**	**0.11**	**0.19**	**NS**

	60 days of storage				90 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	75.66	74.77	**75.21^{c}**	**B_1**	73.43	72.45	**72.94^{c}**
B_2	75.21	74.25	**74.73^{c}**	**B_2**	72.96	71.92	**72.44^{c}**
B_3	80.26	79.46	**79.86^{a}**	**B_3**	78.04	77.14	**77.59^{a}**
B_4	76.30	75.61	**75.95^{bc}**	**B_4**	74.08	73.29	**73.68^{bc}**
B_5	77.34	76.62	**76.98^{b}**	**B_5**	75.12	74.30	**74.71^{b}**
B_6	79.68	77.88	**78.78^{ab}**	**B_6**	77.84	75.56	**76.70^{ab}**
MEAN	**77.41^{A}**	**76.43^{B}**		**MEAN**	**75.24^{A}**	**74.11^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.39**	**0.68**	**0.97**	**SEm±**	**0.40**	**0.70**	**1.01**
CD at 5%	**1.16**	**2.01**	**NS**	**CD at 5%**	**1.19**	**2.06**	**NS**

Table 4: Effect of packaging materials and storage conditions on seedling length of the seedlings (cm) of Gaillardia seeds (*Gaillardia pulchella*).

	0 days of storage				30 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	16.73	16.82	**16.77^{d}**	**B_1**	15.61	15.26	**15.43^{cd}**
B_2	16.66	16.55	**16.61^{de}**	**B_2**	15.26	14.75	**15.00^{d}**
B_3	18.08	17.87	**17.97^{a}**	**B_3**	17.70	17.50	**17.60^{a}**
B_4	16.87	16.81	**16.84^{cd}**	**B_4**	15.86	15.63	**15.74^{cd}**
B_5	17.26	17.03	**17.15^{c}**	**B_5**	16.22	16.05	**16.13^{c}**
B_6	17.49	17.25	**17.37^{b}**	**B_6**	16.86	16.57	**16.71^{b}**
MEAN	**17.18^{A}**	**17.05^{B}**		**MEAN**	**16.25^{A}**	**15.95^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.10**	**0.18**	**0.26**	**SEm±**	**0.10**	**0.18**	**0.25**
CD at 5%	**NS**	**0.54**	**NS**	**CD at 5%**	**0.30**	**0.52**	**NS**

	60 days of storage				90 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	14.75	14.17	**14.46^{e}**	**B_1**	13.98	13.27	**13.63^{e}**
B_2	14.29	13.71	**14.00^{e}**	**B_2**	13.50	12.66	**13.08^{f}**
B_3	17.17	16.84	**17.00^{a}**	**B_3**	16.60	16.22	**16.41^{a}**
B_4	15.45	14.83	**15.14^{d}**	**B_4**	14.27	13.97	**14.12^{d}**
B_5	15.91	15.49	**15.70^{c}**	**B_5**	15.00	14.69	**14.84^{c}**
B_6	16.26	16.88	**16.57^{b}**	**B_6**	15.79	15.38	**15.58^{b}**
MEAN	**15.63^{A}**	**15.32^{B}**		**MEAN**	**14.86^{A}**	**14.36^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.09**	**0.16**	**0.23**	**SEm±**	**0.09**	**0.10**	**0.23**
CD at 5%	**0.27**	**0.47**	**NS**	**CD at 5%**	**0.27**	**0.48**	**NS**

Table 5: Effect of packaging materials and storage conditions on field emergence percentage of Gaillardia seeds (*Gaillardia pulchella*).

	0 days of storage				30 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	67.10	66.98	**67.04^{c}**	**B_1**	66.12	65.78	**65.95^{c}**
B_2	66.94	66.82	**66.88^{c}**	**B_2**	65.96	65.15	**65.55^{c}**
B_3	70.10	69.98	**70.04^{a}**	**B_3**	69.12	67.68	**68.40^{a}**
B_4	67.57	67.45	**67.51^{c}**	**B_4**	66.59	66.02	**66.31^{c}**
B_5	68.25	68.13	**68.19^{bc}**	**B_5**	67.27	66.23	**66.75^{bc}**
B_6	69.54	69.42	**69.48^{ab}**	**B_6**	68.56	67.01	**67.78^{ab}**
MEAN	**68.25^{A}**	**68.13^{B}**		**MEAN**	**67.27^{A}**	**66.31^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.47**	**0.82**	**1.16**	**SEm±**	**0.34**	**0.58**	**0.83**
CD at 5%	**NS**	**2.40**	**NS**	**CD at 5%**	**0.99**	**1.71**	**NS**

	60 days of storage				90 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	64.68	64.56	**64.62^{c}**	**B_1**	64.37	63.38	**63.87^{cd}**
B_2	64.32	63.93	**64.12^{c}**	**B_2**	64.01	62.75	**63.38^{d}**
B_3	68.14	66.70	**67.42^{a}**	**B_3**	67.83	65.52	**66.67^{a}**
B_4	65.61	64.80	**65.21^{c}**	**B_4**	65.30	63.62	**64.46^{cd}**
B_5	66.29	65.01	**65.65^{bc}**	**B_5**	65.98	63.83	**64.90^{bc}**
B_6	67.58	65.89	**66.74^{ab}**	**B_6**	67.27	64.71	**65.99^{ab}**
MEAN	**66.10^{A}**	**65.15^{B}**		**MEAN**	**65.79^{A}**	**63.96^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**0.40**	**0.69**	**0.98**	**SEm±**	**0.36**	**0.62**	**0.88**
CD at 5%	**1.17**	**2.02**	**NS**	**CD at 5%**	**1.05**	**1.82**	**NS**

Table 6: Effect of packaging materials and storage conditions on seedling vigour index (Root length + Shoot length × Germination percentage) of Gaillardia seeds (*Gaillardia pulchella*).

	0 days of storage				30 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	1280.34	1279.12	**1279.73^{e}**	**B_1**	1196.88	1148.50	**1172.69^{e}**
B_2	1260.45	1252.34	**1256.39^{f}**	**B_2**	1148.25	1104.03	**1126.14^{f}**
B_3	1455.65	1452.65	**1454.15^{a}**	**B_3**	1451.04	1405.60	**1428.32^{a}**
B_4	1290.12	1289.23	**1289.67^{d}**	**B_4**	1235.81	1196.63	**1216.22^{d}**
B_5	1322.34	1315.87	**1319.10^{c}**	**B_5**	1270.35	1235.20	**1252.77c**
B_6	1372.98	1360.12	**1366.55^{b}**	**B_6**	1342.05	1296.43	**1319.24^{b}**
MEAN	**1330.31^{A}**	**1324.88^{B}**		**MEAN**	**1274.06^{A}**	**1231.07^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**6.45**	**11.17**	**15.80**	**SEm±**	**8.02**	**13.89**	**19.64**
CD at 5%	**NS**	**32.62**	**NS**	**CD at 5%**	**23.40**	**40.54**	**NS**

	60 days of storage				90 days of storage		
Treatment	**A_1**	**A_2**	**MEAN**	**Treatment**	**A_1**	**A_2**	**MEAN**
B_1	1111.26	1053.83	**1082.55^{e}**	**B_1**	1036.19	970.70	**1003.44^{e}**
B_2	1056.31	1010.56	**1033.44^{f}**	**B_2**	981.46	917.85	**949.65^{f}**
B_3	1386.65	1332.12	**1359.38^{a}**	**B_3**	1320.53	1263.37	**1291.95^{a}**
B_4	1183.62	1118.19	**1150.91^{d}**	**B_4**	1075.83	1036.37	**1056.10^{d}**
B_5	1226.82	1173.97	**1200.39^{c}**	**B_5**	1138.35	1094.84	**1116.59^{c}**
B_6	1274.45	1294.10	**1284.28^{b}**	**B_6**	1218.19	1165.98	**1192.08^{b}**
MEAN	**1206.52^{A}**	**1163.80^{B}**		**MEAN**	**1128.42^{A}**	**1074.85^{B}**	
	A	**B**	**A*B**		**A**	**B**	**A*B**
SEm±	**7.44**	**12.89**	**18.24**	**SEm±**	**6.53**	**11.32**	**16.01**
CD at 5%	**21.73**	**37.64**	**NS**	**CD at 5%**	**19.08**	**33.05**	**NS**

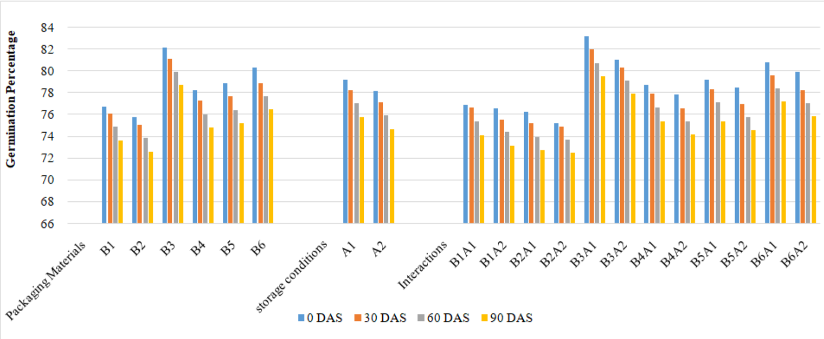

Fig. 1.

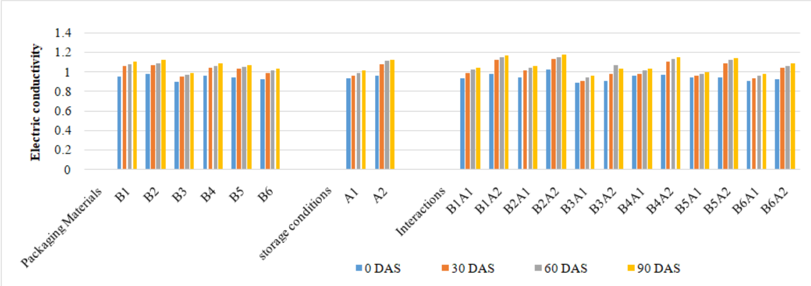

Fig. 2.

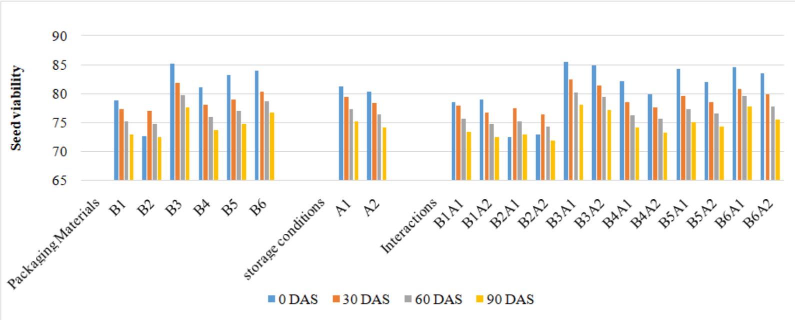

Fig. 3.

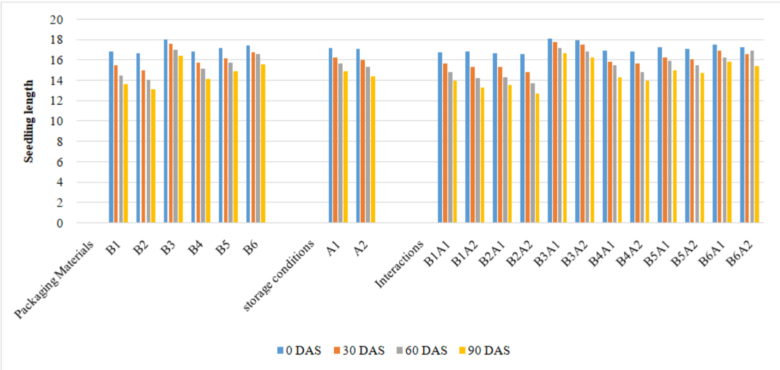

Fig. 4.

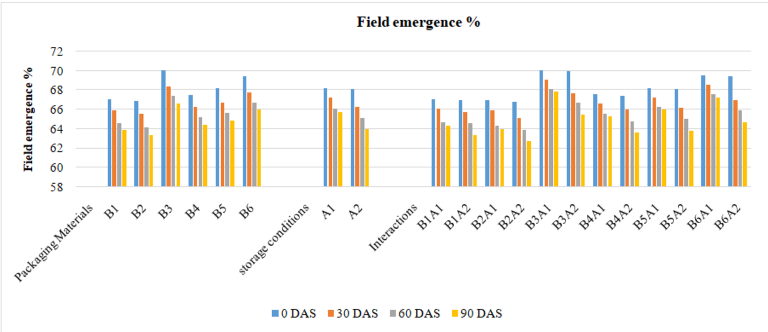

Fig. 5.

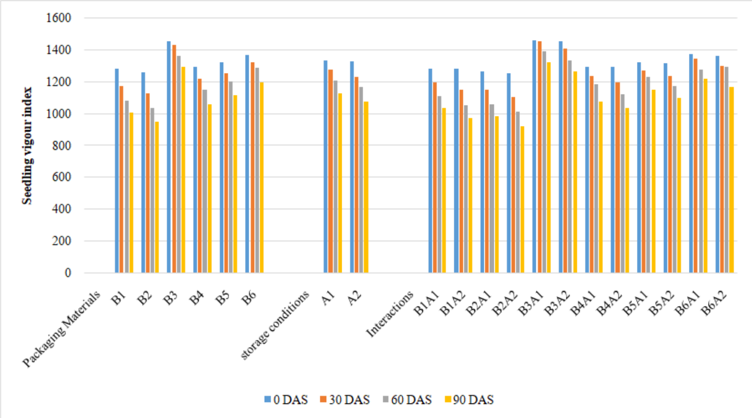

Fig. 6.

CONCLUSIONS

It can be concluded from the present investigation that among the two storage conditions, cold condition (A_1) and ambient condition (A_2) the best results were observed in cold condition (A_1) in seed viability (81.28 %, 75.24 %), electrical conductivity (0.94 dsm^{-1}, 1.01 dsm^{-1}), germination percentage (79.17%, 75.80 %), seedling length (17.18 cm, 14.86 cm), field emergence (68.25 %, 65.79 %), seedling vigour index (1330.31, 1128.42) at 0 days and 90 days of storage respectively.

Among the different packaging materials the maximum results were observed in the aluminum foil (B_3) in seed viability (85.26 %, 77.59 %), electrical conductivity (0.90 dsm^{-1}, 0.99 dsm^{-1}), germination percentage (82.13 %, 78.72 %), seedling length (17.97 cm, 16.41 cm), field emergence (70.04 %, 66.67 %), seedling vigour index (1454.15, 1291.95) at 0 days and 90 days of storage respectively. The minimum results were observed in the air tight plastic box (B_2) in seed viability (76.97 %, 72.44 %), electrical conductivity (0.95 dsm^{-1}, 1.12 dsm^{-1}), germination percentage (75.73 %, 72.59 %), seedling length (16.61 cm, 13.08 cm), field emergence (66.88 %, 63.38 %), seedling vigour index (1256.39, 949.65) at 0 days and 90 days of storage respectively.

Among the interactions the effect of seed physiological parameters and seedling parameters due to storage conditions and packaging materials differed non-significantly.

FUTURE SCOPE

— To study the influence of storage conditions and packaging materials in other flower crops where in the seed loses viability with in short duration.

— To study the influence of storage conditions and packaging materials in gaillardia seeds of different age group seeds so as to know the viability and percentage of germination.

— To study the influence of cold storage conditions at different temperatures on the viability of gaillardia seeds.

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