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Evaluation of different drying methods and desiccants on physical parameters of annual chrysanthemum and gerbera

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Abstract
The present experiment entitled, "Evaluation of different drying methods and desiccants on physical parameters of annual chrysanthemum and gerbera" was carried out at the laboratory of Floriculture and Landscape Architecture, Department of Horticulture, College of Agriculture, JAU, Junagadh during the year 2019-2020. The experiment was laid out in completely randomized design with factorial concept and two factors i.e. drying methods *viz.* sun drying and shade drying and desiccants *viz.* river sand (red), river sand (black), sea sand, silica gel, borax powder and replicated thrice. Sun drying was found to be the best for physical parameters such as maximum weight loss percentage, minimum moisture content percentage and maximum moisture loss percentage during drying. Shade drying resulted in minimum reduction in flower diameter. Silica gel embedding was found to be best for physical parameters such as maximum weight loss percentage, minimum moisture content percentage and maximum moisture loss percentage during drying. Sea sand embedding resulted in minimum reduction in flower diameter. Interaction effect of different drying methods and desiccants found that sun drying with silica gel found best for physical parameters and shade drying with sea sand resulted in minimum reduction in flower diameter. Hence, it can be concluded that sun drying with silica gel was found to be best for all physical parameters except for reduction in flower diameter which was found best in shade drying with sea sand of annual chrysanthemum and gerbera during drying.

Keywords: annual chrysanthemum, gerbera, drying methods, desiccants, physical parameters

Introduction

Annual chrysanthemum is a beautiful flower belongs to the Asteraceae family. It is most commonly grown as an annual (1-3 foot tall) in boarder and extensively used as a loose flower for preparing garlands and worshipping god. It has bright yellow colored disc florets surrounded with white colored ray florets.

Gerbera, commonly known as Transverse daisy, Barberton daisy or African daisy is cultivated throughout the world under wide range of climatic conditions for its attractive flowers. It is highly suitable for beds, boarders, pots and rock gardens. The wide range of colours and the attractive shapes of flowers suit very well in flower arrangement in dry flower industries.

India is one of the major exporters of dried flowers and exported to more than 65 countries. India exports around 27.67 percent of dry flower products to USA (Anon., 2019) [2]. India has exported 16,949.37 MT of floriculture products to the world for worth of Rs. 541.61 crores in 2019-20 (Anon., 2020) [3].

Virtually all the floral species can be dried, but certain consideration have to be kept in mind before selecting the material used for drying purpose. Foremost is that the material should have less moisture content and fibrous tissue. Secondly, the fluffy and open flowers are difficult to dry as they lose their shape during drying process (Kaur, 1999) [11].

In the perspective of the reviews of prior art in these directions it is obvious that although some research has been done on evaluation of the drying technique of flowers in the national and international level, but no efforts of research has been carried out on drying of annual chrysanthemum and gerbera. Hence, it is required to evaluate different drying methods and desiccants and know the best drying technique to be followed in specific climatic zone.

Keeping all these aspects in view the present study-"Evaluation of different drying methods and desiccants on physical parameters of annual chrysanthemum and gerbera" has been taken up with the three prime objectives as to evaluate the effect of different drying methods, different desiccants and interaction effect on physical parameters of annual chrysanthemum and gerbera during drying process.

Materials and Methods

The present investigation entitled "Evaluation of different drying methods and desiccants on physical parameters of annual chrysanthemum and gerbera" was carried out in at the Floriculture and Landscape Architecture Laboratory, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat), during 2020-21, which is situated at altitude of 60m above MSL and 80 kms away from the Arabian Sea coast and 21.5 ON latitude and 70.5 OE longitude. The area of Junagadh comes under the sub tropical type of climate with mild cold and dry winter and medium hot summer. The annual rainfall ranges between 800 to 900 mm in normal years and more than 1000 mm during some years.

The experiment was conducted using Completely randomized design (Factorial) the experiment comprising of twelve treatment combinations *viz.*, S_1M_1(Sun drying without desiccant), S_1M_2 (Sun drying + River sand (Red)), S_1M_3 (Sun drying + River sand (Black)), S_1M_4 (Sun drying+ Sea sand), S_1M_5 (Sun drying + Silica gel), S_1M_6 (Sun drying + Borax powder), S_2M_1(Shade drying without desiccant), S_2M_2 (Shade drying + River sand (Red)), S_2M_3 (Shade drying + River sand (Black)), S_2M_4 (Shade drying + Sea sand), S_2M_5 (Shade drying + Silica gel), S_2M_6 (Shade drying + Borax powder) replicated thrice.

The flowers which were used for drying were selected based on uniformity in size, shape, colour and form. Necessary observations such as flower weight and diameter were recorded before embedding. Before drying of flowers under sun and shade the desiccants were filled into plastic trays of 8 cm height, 40 cm wide and 60 cm length. The trays were filled with desiccants of required amount up to 4-5 cm from bottom. The surface was leveled by using wooden plank. Each flower was placed horizontally with face downward on the layer of desiccants. Then desiccants were carefully poured on the top of the flowers filling all the gaps and crevices in between the flowers without damaging the original petal shape. By following this method the entire flower was completely covered by the desiccants approximately around 2-3 cm above the flower. trays were kept according to the treatment combinations either under sun or under shade for drying. The flowers were removed from the embedded desiccants gently in order to take the necessary readings such as weight loss, moisture content, moisture loss and diameter of flowers and then flowers were again filled with desiccants and kept for drying according to the treatment combination.

Statistical Analysis

For judging the effect of embedded drying of different treatments, the data of different characters were recorded and statistically analyzed as per the factorial completely randomized design (FCRD). Then analyzed for treatment of comparison 'F" test was further employed to study the effect of different treatments.

Results and Discussion

The findings of the present study as well as relevant discussion have been presented under the following heads:

Weight loss percentage

$$\text{Weight loss (\%)} = \frac{(W_1 - W_2) \times 100}{W_1}$$

W_1 = Initial fresh weight of the flowers before embedding, W_2 = Weight of flowers after partial drying for specific period. (Partial flower weight was recorded daily).

The results regarding effect of weight loss percentage due to different drying methods and desiccants on annual chrysanthemum and gerbera is presented in Table 1.

Among the drying method significantly the maximum weight loss percentage (41.63, 48.59, 55.03, 61.44 and 65.21) was found in S_1 (sun drying) and it was minimum in S_2 (shade drying) in annual chrysanthemum. Whereas, significantly the maximum weight loss percentage (44.60, 51.45, 57.75, 62.27 and 67.50) was found in S_1 (sun drying) and it was minimum in S_2 (shade drying) in gerbera during 1st, 2nd, 3rd, 4th and 5th day of drying respectively. The reason for this could be due to higher temperature, higher wind velocity and lower relative humidity in open condition which induces rapid loss of moisture from the flowers when they are exposed to the sun. This in turn leads to faster rate of drying and maximum weight loss percentage from flowers. Similar findings of higher percent weight loss in china aster flowers when dried under sun during entire process of drying was reported by Meman *et al* (2006) [13].

Among the desiccants significantly the maximum weight loss percentage (45.07, 52.02, 58.52, 65.22 and 68.56) was found in (M_5) *i.e.* embedded drying with silica gel and minimum weight loss percentage (31.98, 38.09, 44.60, 50.80 and 56.66) was found in (M_6) *i.e.* embedded drying with borax powder in annual chrysanthemum. Whereas, significantly the maximum weight loss percentage (48.89, 55.70, 62.00, 66.14 and 70.34) was found in (M_5) *i.e.* embedded drying with silica gel and minimum weight loss percentage (34.11, 40.34, 46.36, 51.24 and 58.31) was found in (M_6) *i.e.* embedded drying in borax powder in gerbera during 1st, 2nd, 3rd, 4th and 5th day of drying respectively. Reason for this maximum weight loss percentage with silica gel could be its strong hygroscopic nature as it is manufactured from sodium silicate. It can absorb 40% of moisture on its own weight and thus leads to rapid removal of moisture causing weight loss. Borax is also hygroscopic but it cannot absorb moisture rapidly as that of silica gel because on absorption of moisture borax forms lumps so that there are less chances of escape of moisture from flowers leading to minimum weight loss percentage. Hence, the desiccant silica gel requires less time for drying with maximum weight loss percentage. Similar findings of maximum weight loss by silica gel embedded were reported by Dahiya *et al.* (2003) [7] in annual chrysanthemum, Meman (2006) [13] in miniature roses and gerbera, Dhatta *et al.* (2007) in rose, Khyati (2015) [12] in rose, gerbera and gomphrena and Yadlod et al. (2016) [24] in Dutch rose.

The interaction effect of different drying method and desiccants regarding weight loss percentage (Table-2) showed that significantly the maximum weight loss percentage (54.03, 61.03 and 67.73) was found in interaction of (S_1M_5) *i.e.* sun drying with silica gel and minimum weight loss percentage (37.17, 44.18 and 50.28) was found in interaction of (S_2M_6) *i.e.* shade drying with borax powder during 2nd, 3rd and 4th day of drying in annual chrysanthemum. Whereas, the interaction effect of different drying method and desiccants regarding weight loss percentage showed that significantly the maximum weight loss percentage (51.84, 58.96 and 64.95) was found in interaction of (S_1M_5) *i.e.* sun drying with silica gel and minimum weight loss percentage (32.95, 39.27 and 45.15) was found in interaction of (S_2M_6) *i.e.* shade drying with borax powder during 1st, 2nd and 3rd day of drying in gerbera respectively. Reason for this may be due to the higher temperature and lower humidity during sun drying combined with highly hygroscopic property of silica gel desiccant caused the rapid absorption of moisture leading to maximum weight loss percentage. The minimum weight loss percentage was found in interaction (S_2M_6) i.e. shade drying with borax powder. Shade drying requires more time for drying and borax desiccant forms lumps on moisture absorption. Consequently there are less chances of escape of moisture. This slow down in moisture loss causes minimum weight loss percentage. These findings were in accordance with Meman (2006) [13] in china aster, Khyati (2015) [12] in rose, gerbera and gomphrena.

Table 1: Effect of different drying methods and desiccants on weight loss percentage in annual chrysanthemum and gerbera

	Annual chrysanthemum					Gerbera				
	Weight loss %					Weight loss %				
Treatments	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**
Factor A : Drying methods (S)										
S_1=Sun drying	41.63	48.59	55.03	61.44	65.21	44.60	51.45	57.75	62.27	67.50
S_2=Shade drying	39.13	45.57	52.08	58.30	62.53	40.71	46.93	53.51	58.13	63.39
S.Em±	0.27	0.27	0.28	0.27	0.25	0.25	0.24	0.25	0.29	0.35
C.D. at 5%	0.80	0.79	0.83	0.80	0.72	0.74	0.70	0.72	0.84	1.01
Factor B : Desiccants (M)										
M_1=Without media	44.26	50.94	57.59	63.94	67.10	47.61	54.48	61.22	65.08	69.44
M_2=River sand (pinkish red)	38.63	45.68	51.68	58.01	61.61	39.20	46.05	52.12	56.48	62.07
M_3=River sand (black)	39.75	46.21	52.88	58.70	62.72	40.92	47.10	53.48	57.83	63.27
M_4=Sea sand	42.59	49.55	56.06	62.55	66.57	45.19	51.47	58.61	64.42	69.25
M_5=Silica gel	45.07	52.02	58.52	65.22	68.56	48.89	55.70	62.00	66.14	70.34
M_6=Borax powder	31.98	38.09	44.60	50.80	56.66	34.11	40.34	46.36	51.24	58.31
S.Em±	0.47	0.47	0.49	0.47	0.43	0.44	0.42	0.42	0.50	0.60
C.D. at 5%	1.38	1.37	1.44	1.38	1.24	1.28	1.22	1.24	1.45	1.74
Interaction (S × M)										
S.Em±	0.67	0.66	0.70	0.67	0.60	0.62	0.59	0.60	0.70	0.85
C.D. at 5%	NS	1.94	2.04	1.95	NS	1.81	1.72	1.75	NS	NS
C.V.%	2.87	2.44	2.26	1.94	1.63	2.52	2.08	1.87	2.02	2.24

Table 2: Interaction effect of different drying methods and desiccants on weight loss percentage in annual chrysanthemum and gerbera

	Annual chrysanthemum			Gerbera		
	Weight loss %			Weight loss %		
Treatments	**2nd day**	**3rd day**	**4th day**	**1st day**	**2nd day**	**3rd day**
S_1M_1	53.70	60.00	66.39	50.20	57.52	63.70
S_1M_2	46.55	52.89	59.25	40.78	48.17	54.67
S_1M_3	47.00	54.00	59.75	43.12	49.83	55.77
S_1M_4	51.24	57.24	64.19	46.38	52.79	59.84
S_1M_5	54.03	61.03	67.73	51.84	58.96	64.95
S_1M_6	39.01	45.01	51.32	35.26	41.41	47.56
S_2M_1	48.18	55.18	61.49	45.03	51.43	58.74
S_2M_2	44.80	50.46	56.77	37.61	43.92	49.56
S_2M_3	45.42	51.75	57.65	38.72	44.36	51.18
S_2M_4	47.86	54.87	60.90	43.99	50.14	57.38
S_2M_5	50.00	56.00	62.70	45.94	52.44	59.04
S_2M_6	37.17	44.18	50.28	32.95	39.27	45.15
S.Em±	0.66	0.70	0.67	0.62	0.59	0.60
C.D. at 5%	1.94	2.04	1.95	1.81	1.72	1.75
C.V. %	2.44	2.26	1.94	2.52	2.08	1.87

Moisture content percentage

$$\text{Moisture content (\%)} = \frac{(W_2 - W_3) \times 100}{W_2}$$

W_2 = Weight of the flowers after partial drying for specific period. (Flower weight for recorded daily after specific period of drying).
W_3 = Complete dry weight of flowers.

The results regarding effect of moisture content percentage due to different drying methods and desiccants on annual chrysanthemum and gerbera is presented in Table 3.
Among drying methods significantly the minimum moisture content percentage (55.38, 48.47, 41.56, 33.84 and 25.86) was found in S_1 (sun drying) and maximum in S_2 (shade drying) in annual chrysanthemum. Whereas, significantly the minimum moisture content percentage (61.15, 50.24, 43.95, 36.83 and 29.86) was found in S_1(sun drying) and was maximum in S_2 (shade drying) in gerbera during 1st, 2nd, 3rd, 4th and 5th day respectively. As mentioned above the weight loss percentage was found to be maximum in sun drying which means that obviously the moisture content will be reduced. The reason for this is that the high temperature and low relative humidity leads to rapid removal of moisture from flowers causing minimum moisture content in flowers. Similar findings of reduced moisture content in sun drying were found by Singh *et al.* (2003) [21] in zinnia, Meman *et al.* (2006) [13] in china aster, Khyati (2015) [12] in rose, gerbera and gomphrena.

Among the desiccants significantly the minimum moisture content percentage (50.56, 43.54, 36.91, 29.27 and 21.16) was found in (M_5) *i.e.* embedded drying with silica gel and maximum moisture content percentage (67.46, 60.48, 53.26, 44.87 and 36.62) was found in (M_6) *i.e.* embedded drying with borax powder annual chrysanthemum. Whereas, significantly the minimum moisture content percentage (57.26, 44.03, 38.93, 31.03 and 23.42) was found in (M_5) *i.e.* embedded drying with silica gel and maximum moisture content percentage (71.23, 63.96, 56.93, 50.45 and 44.20) was found in (M_6) *i.e.* embedded drying with borax powder in gerbera during 1st, 2nd, 3rd, 4th and 5th day of drying respectively. Reason will be due to the strong hygroscopic nature of silica gel which leads to rapid removal of moisture from flower tissue causing minimum moisture content in flowers. But, borax powder will not remove more moisture from flowers as that of silica gel. These findings were in accordance with Sell (1993) [19] in fresh cut flowers, Roberts (1997) [18] in cosmos, bellers of Ireland, aster, dahlia and candytuft, Dahiya *et al.* (2003) [7] in annual chrysanthemum, Desh Raj and Gupta (2003) [8] in flowers and foliage, Aravinda and Jayanthi (2004) [4] in chrysanthemum, Bhalla *et al.* (2006) [5] in chrysanthemum, Meman *et al.* (2006) [13] in china aster, Khyati (2015) [12] in rose, gerbera and gomphrena.

The interaction effect of different drying methods and desiccants regarding moisture content percentage (Table-4) showed that significantly the minimum moisture content percentage (41.87 and 35.68) was found in interaction of (S_1M_5) *i.e.* sun drying with silica gel and maximum moisture content percentage (61.28 and 53.71) was found in interaction of (S_2M_6) *i.e.* shade drying with borax powder in annual chrysanthemum. Whereas, significantly the minimum moisture content percentage (42.44 and 37.68) was found in interaction of (S_1M_5) *i.e.* sun drying with silica gel and maximum moisture content percentage (64.17 and 57.36) was found in interaction of (S_2M_6) *i.e.* shade drying with borax powder in gerbera during 2nd and 3rd day of drying respectively. Reason for this may be due higher temperature and lower humidity during sun drying combined with highly hygroscopic property of silica gel desiccant and caused the rapid removal of moisture from flowers leading to minimum moisture content percentage in flowers. The maximum moisture content percentage found in interaction (S_2M_6) *i.e.* shade drying with borax powder this may be due to fact that shade drying requires more time for removal of moisture from flowers which combined with borax cannot remove moisture as fast as silica gel. Similar results were found by Meman (2006) [13] in china aster and Khyati (2015) [12] in rose, gerbera and gomphrena.

Table 3: Effect of different drying methods and desiccants on moisture content percentage in annual chrysanthemum and gerbera

	Annual chrysanthemum					Gerbera				
	Moisture content %					Moisture content %				
Treatments	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**	**1st day**	**2nd day**	**3rd day**	**4th day**	**5th day**
Factor A : Drying methods (S)										
S_1=Sun drying	55.38	48.47	41.56	33.84	25.86	61.15	50.24	43.95	36.83	29.86
S_2=Shade drying	59.04	52.44	45.43	37.92	29.42	64.00	54.53	47.68	40.92	33.53
S.Em±	0.32	0.31	0.29	0.29	0.31	0.43	0.41	0.41	0.44	0.43
C.D. at 5%	0.94	0.89	0.85	0.84	0.91	1.24	1.20	1.19	1.27	1.26
Factor B : Desiccants (M)										
M_1=Without media	51.40	44.92	38.20	30.50	22.66	58.80	45.66	39.87	32.93	25.27
M_2=River sand (pinkish red)	61.66	54.54	47.41	39.84	31.70	64.94	56.88	49.74	43.36	35.65
M_3=River sand (black)	59.23	52.67	45.64	38.10	30.24	63.46	55.64	48.53	41.75	34.05
M_4=Sea sand	52.95	46.57	39.57	32.69	23.45	59.78	48.14	40.88	33.74	27.57
M_5=Silica gel	50.56	43.54	36.91	29.27	21.16	57.26	44.03	38.93	31.03	23.42
M_6=Borax powder	67.46	60.48	53.26	44.87	36.62	71.23	63.96	56.93	50.45	44.20
S.Em±	0.56	0.53	0.50	0.50	0.54	0.74	0.71	0.71	0.75	0.75
C.D. at 5%	1.63	1.55	1.47	1.46	1.57	2.16	2.07	2.07	2.20	2.19
Interaction (S × M)										
S.Em±	0.79	0.75	0.71	0.71	0.76	1.04	1.00	1.00	1.07	1.06
C.D. at 5%	NS	2.19	2.08	NS	NS	NS	2.93	2.93	NS	NS
C.V.%	2.40	2.58	2.83	3.41	4.78	2.89	3.32	3.79	4.75	5.79

Table 4: Interaction effect of different drying methods and desiccants on moisture content percentage in annual chrysanthemum and gerbera

	Annual chrysanthemum		Gerbera	
	Moisture content %		Moisture content %	
Treatments	**2nd day**	**3rd day**	**2nd day**	**3rd day**
S_1M_1	43.13	36.12	43.68	38.75
S_1M_2	51.45	44.50	53.83	46.41
S_1M_3	49.70	42.35	52.92	45.23
S_1M_4	44.96	37.93	44.81	39.12
S_1M_5	41.87	35.68	42.44	37.68
S_1M_6	59.68	52.80	63.74	56.50
S_2M_1	46.70	40.29	47.65	41.00
S_2M_2	57.63	50.31	59.94	53.07
S_2M_3	55.64	48.92	58.36	51.83
S_2M_4	48.18	41.21	51.46	42.65
S_2M_5	45.20	38.13	45.62	40.19
S_2M_6	61.28	53.71	64.17	57.36

S.Em±	0.75	0.71	1.00	1.00
C.D. at 5%	2.19	2.08	2.93	2.93
C.V. %	2.58	2.83	3.32	3.79

Moisture loss percentage

$$\text{Moisture loss (\%)} = \frac{(M_1-M_2)\times 100}{M_1}$$

M_1 = Initial percentage moisture content of fresh flowers. It was calculated with formula, given as $\frac{(W_1-W_3)\times 100}{W_1}$

W_1=Initial fresh weight of the flowers before embedding, W_3 = Complete dry weight of flowers.

M_2 = Percent moisture content on weight basis in the partially dried flowers and it was calculated as shown in the second observation.

The results regarding effect of moisture loss percentage due to different drying methods and desiccants on annual chrysanthemum and gerbera is presented in Table 5.

Among the drying methods significantly the maximum moisture loss percentage (34.24, 42.54, 51.46, 58.16 and 65.94) was found in S_1 (sun drying) and minimum in S_2 (shade drying) in annual chrysanthemum. Whereas, significantly the maximum moisture loss percentage (27.84, 36.90, 47.68, 56.46 and 65.21) was found in S_1 (sun drying) and minimum in S_2 (shade drying) in gerbera during 1st, 2nd, 3rd, 4th and 5th day respectively. Reason could be that during sun drying both temperature and wind velocity was higher and at high temperature, rate of moisture loss from flower tissue *i.e.* transpiration was higher due to higher transfer of heat by conduction and convention. Similar results were found by Meman et al. (2006) [13] in china aster and Khyati (2015) [12] in rose, gerbera and gomphrena.

Among desiccants significantly the maximum moisture loss percentage (40.04, 48.13, 55.63, 62.76 and 67.79) was found in (M_5) *i.e.* embedded drying with silica gel and minimum moisture loss percentage (21.87, 30.45, 38.71, 44.96 and 53.08) was found in (M_6) *i.e.* embedded drying with borax powder in annual chrysanthemum. Whereas, significantly the maximum moisture loss percentage (31.28, 39.96, 52.84, 62.37 and 70.40) was found in (M_5) *i.e.* embedded drying with silica gel and minimum moisture loss percentage (20.11, 28.83, 33.93, 40.19 and 50.01) was found in (M_6) *i.e.* embedded drying in borax powder in gerbera during 1st, 2nd, 3rd, 4th and 5th days of drying respectively. Reason for this is that silica gel is known to absorb up to 40% moisture of its own weight causing maximum moisture loss from flowers. But borax will not absorb as much moisture as that of silica gel. Similar finding were found by Anon. (2001) [1] in cut flowers, Gangadharswamy (2003) [10] in rose, Dubois and Joyce (2005) in cut flowers, Meman *et al.* (2006) [13] in china aster, Nair and Singh (2011) in chrysanthemum, Wilson *et al.* (2013) in chrysanthemum, Khyati (2015) [12] in rose, gerbera and gomphrena, Yadlod *et al.* (2016) [24] in dutch rose and Chithira (2017) [6] in chrysanthemum var. marigold.

The interaction effect of different drying methods and desiccants regarding moisture loss percentage (Table-6) showed that significant maximum moisture loss percentage (58.32) was found in interaction of (S_1M_5) *i.e.* sun drying with silica gel and minimum moisture loss percentage (38.09) was found in interaction of (S_2M_6) *i.e.* shade drying with borax powder on 3rd day of drying respectively in annual chrysanthemum. Whereas, significantly the maximum moisture loss percentage of (42.35 and 54.01) was found in interaction of (S_1M_5) *i.e.* sun drying with silica gel and minimum moisture loss percentage (28.19 and 33.38) was found in interaction of (S_2M_6) *i.e.* shade drying with borax powder in gerbera during 2nd and 3rd day of drying respectively. Reason is that sun drying along with silica gel leads to rapid moisture loss due to exposure to high temperature during sun drying and higher moisture absorbing property of silica gel. The minimum moisture loss was found in shade drying with borax because room temperature was lower than outside temperature and borax absorb moisture slowly thus causing minimum moisture loss percentage. These results were in accordance with Meman (2006) [13] in china aster, Khyati (2005) [12] in rose, gerbera and gomphrena and Chithira (2017) [6] in chrysanthemum var. marigold.

Table 5: Effect of different drying methods and desiccants on moisture loss percentage in annual chrysanthemum and gerbera

	Annual chrysanthemum					Gerbera				
	Moisture loss %					Moisture loss %				
Treatments	1st day	2nd day	3rd day	4th day	5th day	1st day	2nd day	3rd day	4th day	5th day
Factor A : Drying methods (S)										
S_1=Sun drying	34.24	42.54	51.46	58.16	65.94	27.84	36.90	47.68	56.46	65.21
S_2=Shade drying	30.46	38.72	46.98	53.11	59.56	24.81	33.34	43.44	50.75	59.54
S.Em±	0.36	0.40	0.33	0.57	0.75	0.36	0.40	0.48	0.55	0.42
C.D. at 5%	1.04	1.17	0.95	1.67	2.19	1.05	1.17	1.41	1.60	1.23
Factor B : Desiccants (M)										
M_1=Without media	38.22	47.16	54.69	60.32	66.48	30.12	38.40	51.94	60.70	69.14
M_2=River sand (pinkish red)	27.69	34.59	45.08	52.13	61.27	23.46	32.47	41.39	48.61	57.72
M_3=River sand (black)	29.37	37.07	47.39	53.54	62.10	24.37	33.35	42.65	50.24	59.41
M_4=Sea sand	36.90	46.41	53.81	60.11	65.77	28.60	37.73	50.61	59.51	67.57
M_5=Silica gel	40.04	48.13	55.63	62.76	67.79	31.28	39.96	52.84	62.37	70.40
M_6=Borax powder	21.87	30.45	38.71	44.96	53.08	20.11	28.83	33.93	40.19	50.01
S.Em±	0.62	0.70	0.56	0.99	1.30	0.62	0.69	0.84	0.95	0.73
C.D. at 5%	1.80	2.03	1.65	2.89	3.80	1.82	2.02	2.45	2.78	2.12
Interaction (S × M)										
S.Em±	0.87	0.98	0.80	1.40	1.84	0.88	0.98	1.18	1.34	1.03
C.D. at 5%	NS	NS	2.33	NS	NS	NS	2.86	3.46	NS	NS
C.V.%	4.67	4.20	2.81	4.36	5.08	5.82	4.84	4.50	4.35	2.86

Table 6: Interaction effect of different drying methods and desiccants on moisture loss percentage in annual chrysanthemum and gerbera

	Annual chrysanthemum	Gerbera	
	Moisture loss %	Moisture loss %	
Treatments	3rd day	2nd day	3rd day
S_1M_1	57.49	41.49	53.05
S_1M_2	47.61	33.11	45.95
S_1M_3	48.90	34.36	46.15
S_1M_4	57.12	40.61	52.44
S_1M_5	58.32	42.35	54.01
S_1M_6	39.32	29.48	34.47
S_2M_1	51.90	35.31	50.84
S_2M_2	42.54	31.82	36.82
S_2M_3	45.89	32.34	39.14
S_2M_4	50.51	34.85	48.77
S_2M_5	52.93	37.56	51.67
S_2M_6	38.09	28.19	33.38
S.Em±	0.80	0.98	1.18
C.D. at 5%	2.33	2.86	3.46
C.V. %	2.81	4.84	4.50

Reduction in flower diameter

Decrease in flower diameter = D_1-D_2

D_1 = Maximum diameter of the fresh flower and D_2 = Partially dried flower size in cm.

The results regarding effect of reduction in flower diameter due to different drying methods and desiccants on annual chrysanthemum and gerbera is presented in Table 7.

Among drying methods significantly the minimum reduction in flower diameter (0.50, 0.58, 0.66, 0.68 and 0.71) was found in S_2 (shade drying) and maximum in S_1 (sun drying) in annual chrysanthemum. Whereas, significantly the minimum reduction in flower diameter (0.60, 0.65, 0.70, 0.73 and 0.76) was found in S_2 (shade drying) and maximum in S_1 (sun drying) in gerbera during 1st, 2nd, 3rd, 4th and 5th day respectively. Reason for this is that minimum moisture loss during shade drying caused less shrinkage of cell thus leading to minimum reduction in flower diameter. Whereas, maximum moisture loss from flowers during sun drying caused shrinkage of petals thus causing maximum reduction in flower diameter. The findings are in accordance with Shruthi (2010) [20] in Dutch rose and Khyati (2015) [12] in rose, gerbera and gomphrena.

Among desiccants significantly the minimum reduction in flower diameter (0.40, 0.48, 0.54, 0.56 and 0.58) was found in (M_4) *i.e.* embedded drying with sea sand and maximum reduction in flower diameter (0.81, 0.87, 0.94, 0.98 and 1.01) was found in (M_1) *i.e.* without desiccant in annual chrysanthemum. Whereas, significantly the minimum reduction in flower diameter (0.53, 0.57, 0.61, 0.65 and 0.67) was found in (M_4) *i.e.* embedded drying with sea sand and maximum reduction in flower diameter (0.82, 0.88, 0.95, 0.99 and 1.04) was found in (M_1) *i.e.* without desiccant in gerbera during 1st, 2nd, 3rd, 4th and 5th days of drying respectively. Reason for this is that sea sand does not react with the water vapor released during the process of drying and it allows the water vapor to escape into the atmosphere freely thus causing minimum reduction in flower diameter. Whereas, maximum reduction in flower diameter was found in without desiccant due to the fact that uneven petal shrinkage occurs when exposed to direct sun because there is no pressure of desiccant on flowers. The findings of minimum reduction in flower diameter with sea sand were in accordance with Sujatha *et al.* (2001) [22] in gerbera, Nirmala *et al.* (2008) [16] in carnation and Khyati (2015) [12] in rose, gerbera and gomphrena.

The interaction effect of different drying methods and desiccants regarding reduction in flower diameter (Table-8) showed that minimum reduction in flower diameter (0.44 and 0.46) was found in interaction of (S_2M_4) *i.e.* shade drying with sea sand and maximum reduction in flower diameter (0.94 and 0.98) was found in interaction of (S_1M_1) *i.e.* sun drying without desiccant during 2nd and 3rd day of drying respectively in annual chrysanthemum. Whereas, significantly the minimum reduction in flower diameter (0.51 and 0.54) was found in treatment combination of (S_2M_4) *i.e.* shade drying with sea sand and maximum reduction in flower diameter (0.98 and 1.02) was found in interaction of (S_1M_1) *i.e.* sun drying without desiccant in gerbera during 3rd and 4th day of drying respectively. Reason for minimum reduction in flower diameter under shade drying with seas sand is because there is less temperature inside room which causes less moisture loss in shade drying combined with desiccant sea sand which will not react with water vapor released during drying causing minimum reduction in flower diameter. Whereas, sun drying without desiccant causes maximum reduction in diameter because due to direct exposure to high temperature without embedding with desiccant causes uneven shrinkage of petals and hence diameter gets reduced.

Conclusion

The evaluation of different drying methods and desiccants was conducted in order to find out the effect of drying method, desiccants and their interaction on physical parameters of annual chrysanthemum and gerbera and we found out that sun drying along with silica gel as a desiccants was found best for all the physical parameters *viz.*, weight loss percentage, moisture content percentage, moisture loss percentage except for reduction in flower diameter which was found best in shade drying with sea sand.

Author contributions

VR hypothesized the experiment; CS carried out the trial and recorded observations under the guidance of VR; CS performed the statistical analysis and wrote the manuscript.

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Table 7: Effect of different drying methods and desiccants on reduction in flower diameter in annual chrysanthemum and gerbera

	Annual chrysanthemum					Gerbera				
	Reduction in flower diameter					Reduction in flower diameter				
Treatments	1st day	2nd day	3rd day	4th day	5th day	1st day	2nd day	3rd day	4th day	5th day
Factor A : Drying methods (S)										
S_1=Sun drying	0.64	0.69	0.77	0.80	0.83	0.70	0.76	0.80	0.85	0.88
S_2=Shade drying	0.50	0.58	0.66	0.68	0.71	0.60	0.65	0.70	0.73	0.76
S.Em±	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C.D. at 5%	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03
Factor B : Desiccants (M)										
M_1=Without media	0.81	0.87	0.94	0.98	1.01	0.82	0.88	0.95	0.99	1.04
M_2=River sand (pinkish red)	0.44	0.50	0.59	0.61	0.64	0.57	0.62	0.65	0.70	0.72
M_3=River sand (black)	0.49	0.57	0.65	0.68	0.70	0.59	0.64	0.67	0.71	0.74
M_4=Sea sand	0.40	0.48	0.54	0.56	0.58	0.53	0.57	0.61	0.65	0.67
M_5=Silica gel	0.71	0.79	0.87	0.91	0.93	0.76	0.82	0.86	0.91	0.93
M_6=Borax powder	0.55	0.61	0.71	0.73	0.75	0.65	0.71	0.75	0.80	0.82
S.Em±	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.02
C.D. at 5%	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.04	0.04
Interaction (S × M)										
S.Em±	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
C.D. at 5%	NS	0.06	0.05	NS	NS	NS	NS	0.06	0.06	NS
C.V.%	7.16	5.33	4.33	4.83	5.18	5.09	4.36	4.59	4.19	4.52

Table 8: Interaction effect of different drying methods and desiccants on reduction in flower diameter in annual chrysanthemum and gerbera

	Annual chrysanthemum		Gerbera	
	Reduction in flower diameter		Reduction in flower diameter	
Treatments	2nd day	3rd day	3rd day	4th day
S_1M_1	0.94	0.98	0.98	1.02
S_1M_2	0.54	0.63	0.70	0.75
S_1M_3	0.59	0.69	0.72	0.76
S_1M_4	0.53	0.62	0.71	0.75
S_1M_5	0.86	0.92	0.90	0.95
S_1M_6	0.69	0.80	0.79	0.84
S_2M_1	0.80	0.90	0.91	0.96
S_2M_2	0.46	0.54	0.60	0.64
S_2M_3	0.54	0.61	0.62	0.66
S_2M_4	0.44	0.46	0.51	0.54
S_2M_5	0.72	0.82	0.83	0.86
S_2M_6	0.52	0.62	0.70	0.75
S.Em±	0.02	0.02	0.02	0.02
C.D. at 5%	0.06	0.05	0.06	0.06
C.V. %	5.33	4.33	4.59	4.19

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