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Effect of packaging materials on vase life of tuberose (*Polianthes tuberose*) cv. Shringar

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Abstract
A study was carried out to evaluate the role of packing methods on vase life of tuberose. The packing methods in which the spikes wrapped in the treatment T_1 (LDPE 100 gauge) showed the best result in terms of change in weight on 3rd day and at senescence, water uptake on 3rd day, vase life of cut spike, number of florets open at a time, percentage of open florets, however T_2 (LDPE 200 gauge) was found superior with respect of opening of fifth floret (day), withering of 5th floret (day), dry weight of cut spike at senescence, percentage of partial open florets and T_3 (Radium paper) recorded, change in weight on 6th day, water uptake on 6th day and at senescence. While the T_5 (Brown paper) was found to be best in term of percentage of unopened florets, change in reducing sugars. T_7 (Control) was found to be best in terms of change in total sugars and change in non-reducing sugars.

Keywords: packing, tuberose, spikes, LDPE, radium paper, brown paper and metal paper

Introduction
It is believed that tuberose was brought to India via Europe in 16th Tuberose (*Polianthes tuberosa* Linn.) commonly known as ‘Rajnigandha’ is a bulbous summer flowering perennial ornamental plant which belongs to the family Amaryllidaceae. It is considered to have originated in Mexico. The flowers have a funnel shaped perianth, waxy white about 25 mm long, single or double and borne in spike. ‘Single’ varieties are more fragrant than ‘Double’ type. The terminal flower spikes arising from the bulb produce flowers for a number of days. Fruit is a capsule. Tuberose inflorescence (spike) bear 10-20 pairs of florets which open acropetally. Commercially, spikes 60-90 cm long are harvested when two or three basal florets are open. The tuberose is grown on a wide range of soil and climatic conditions but it thrives and flowers best in warm and humid climate. The temperature above 40 °C reduced the size of the spike and the quality of flowers. Very low temperature and frost also damage the plants and flowers. Optimum temperate range is 20 °C to 30 °C. Tuberose is one of the potentially valuable cut flower and is an important commercial flower crop of our country. The vase life of cut flower with its keeping quality is most important and economic for tuberose growing farmers. It has been established that the post harvest behavior of flowers is an outcome of the physiological processes occurring in the leaves, stem, flower bud, the leafless peduncle connecting the bud to the stem. Mineral nutrition, foliar feeding, irrigation and growth regulator sprays were found to influence longevity and post harvest quality of cut flowers. Improvement of the keeping quality and enhancement of vase life of cut flowers is an important area of floricultural research. Although various methods have been developed to extend the vase life, however, there is a need to develop a simple technique, which may be followed right at the grower’s end. Adoption of proper post harvest treatments in cut flower is important to achieve good exportable quality. Post harvest management and value addition can increase prices of cut flowers up to 9-10 times. Packaging plays an important role in extending freshness, value addition and reducing damage. Presently, the cultivators have no standardized post harvest technology for post harvest handling of cut flowers like seasonal variation to vase life, use of floral preservatives, some harvesting operations like proper length of cut flower stem and stage of harvesting, treatment of pulsing chemicals, pre-cooling treatments, packaging methods, use of wrapping materials, packaging boxes etc. So it is great need for the farmers and flower traders to standardize the protocol for post harvest techniques for the tuberose cut flower spike.

The keeping quality and vase tuberose is one of the potentially valuable cut flower and is an important commercial flower crop of our country. The vase life of cut flower with its keeping quality is most important and economic for tuberose growing farmers, etc. The best quality of the spike is very important for marketing point of view in domestic as well as export, so there is a proper packing of cut flowers is an important factor that play important role for deciding the quality and vase life of the cut spikes. Presently, our cultivators are not aware about standard post harvest technology including packing methods and materials for extend the vase life. So it is great need to standardize the packing methods. Thus, standardization and evaluation of proper technique of packaging and storage of tuberose is vital for development of market strategy and accessibility at international market for enhancing export potential. Storage of flowers at optimum stage and quality is important for high market value. Flower quality tends to decrease after dry storage of cut flowers.

Materials and Methods

The healthy and good appearance of spikes was used for this investigation. The trial was conducted with 7 different packing methods during the year 2017 in C.R.D. design with three replications at P.G. laboratory, Department of Floriculture and Landscape, College of Horticulture, Mandsaur (M.P.), India. The spike were packed in different packing methods viz., wrapping the spike in cut flower stem is kept in water saturated cotton then wrapped with 100 gauge LDPE (T_1), 200 gauge LDPE (T_2), radium paper (T_3), News paper (T_4), Brown paper (T_5), Metal paper (T_6) and control (T_7) in which the bunch of spikes were packed in CCBB without wrapping. The wrapped bunch of spikes were arranged in CCBB and then the boxes were kept in cooling chamber for 72 hours at 15-20 °C, which was considered as cargo (transportation) period. After storage period (72 hours), the boxes were opened carefully and the spikes from the different wrapping materials were kept in vase container as distilled water for vase life. Necessary observations were recorded during vase life period.

Results and Discussion

Change in weight on 3rd day (%), 6th day (%) and at senescence (%)

The packaging materials the maximum increase change in weight of spike on 3rd day was observed in T_1 (LDPE 100 gauge) followed by T_2 (LDPE 200 gauge). The maximum increase change in weight of spike on 6th day was recorded in T_4 (News paper) followed by T_7 (Control). The maximum change weight of spike at senescence was recorded with T_7 (Control) followed by T_4 (News paper). The minimum change in weight of spike on 3rd day was with T_6 (Metal paper) and on 6th day with T_2 (LDPE 200 gauge) and at senescence T_1 (LDPE 100 gauge). The similar results of retaining flower fresh weight were also obtained by using packaging films which developed followed by T_7 (Control).

The result may be due to modified atmosphere of high Co_2, H_2O and low O_2 within the package, which reduced respiration and transpiration during storage of gladiolus (Grover *et al*., 2006) and shipment of rose and golden rod. Similar result of low PLW %, higher fresh weight % in cut flowers with PP packaging film is well reported in gladiolus cut spikes reported that the decrease of increasing flower fresh weight may be due to increase of transpiration about of water uptake during the self life period.

Water uptake on 3rd day (ml), 6th day (ml) and at senescence (ml)

The effect of packaging materials on water uptake by the cut spike of Tuberose cv. Shringar on 3rd day (ml), 6th day and at senescence was statistically significant. The maximum water uptake by the spike on 3rd day was recorded in T_1 (LDPE 100 gauge), while on 6th day and at senescence recorded in T_3 (Radium paper). The minimum water uptake on 3rd day, 6th day and at senescence was recorded under control. The another reason may be that the maintenance of carbohydrates level in the spike leading to stomatal closure resulted for minimum loss of water. Similarly, the decreased water uptake by the stem might be mainly due to plugging of xylem vessels caused by bacteria. Similar result of low PLW %, higher water uptake in cut flowers with PP packaging film is well reported in gladiolus cut spikes (Singh *et al.,* 2007 and Grover *et al.,* 2006) and in rose flowers (Makwana, *et al.,* 2015). Temperature influences water uptake by increasing transpiration and respiration. Flowers stored at lower temperature are known to maintain water uptake as compared to those stored at higher temperatures as reported in rose.

Opening and withering of 5th floret (day)

The effect of packaging materials on opening and withering of 5th floret (day) was statistically significant. Among the packaging material the minimum days taken to opening of 5th floret (day) was recorded under T_7 (Control) followed by T_3 (Radium paper). The maximum days taken to opening of 5th floret (day) was observed in T_2 (LDPE 200 gauge) followed by T_1 (LDPE 100 gauge).

Among the packaging material the maximum days taken to withering of 5th floret (day) was recorded in T_2 (LDPE 200 gauge) followed by T_1 (LDPE 100 gauge), while the minimum days taken to withering of 5th floret (day) was recorded under control T_7 (Control) followed by T_3 (Radium paper). Goszczynska and Rudnicki, (1988) also indicated that a modified atmosphere condition within the package regulates metabolic activity in flowers that influence flower opening. Similar findings of improved floret opening due to retained fresh weight have been earlier elucidated in rose. A loss of turgidity and carbohydrates in the flower tissue might lead to flower fading and ultimately withering.

Numbers of florets open at a time

The effect of packaging materials on number of florets open at a time was statistically significant. The maximum number of florets open at a time was recorded in T_1 (LDPE 100 gauge), followed by T_2 (LDPE 200 gauge). The minimum number of florets open at a time was recorded in the T_7 (Control) followed by T_3 (Radium paper). These results found similar with the report of Meir *et al*., (1995) in gladiolus, they observed that MA (Modified Atmosphere) packaging may reduced floret metabolism, there by reducing carbohydrate consumption as the respiratory substrate and improved floret opening. This may be due to reducing the solution viscosity and the microorganism growth (Alvarez *et al.,* Van Doorn and Peirik) *via* flowering the pH of solution.

Percentage of open florets on 3rd day of vase

The effect of packaging materials on percentage of open florets on 3rd day of vase was statistically significant. Among the packaging materials the maximum percentage of open florets was observed in T_1 (LDPE 100 gauge) followed by T_4 (News paper), while the minimum percentage of open florets on 3rd day of vase was recorded in T_7 (Control) and T_2 (LDPE 200 gauge) followed by T_6 (Metal paper). The opening of florets in tuberose spikes is directly related to the normal metabolic activities mainly respiration and carbohydrate content in cut spikes. The conditions which control the metabolic activities like transpiration and water uptake were maintained in those cut spikes which were wrapped in polyethylene and stored for minimum duration in storage and ultimately it maintained higher floret opening in tuberose cut spikes. Improved percent of floret opening with TDZ along with sucrose was earlier observed in tuberose, in gladiolus (Singh and Jegadheesan, 2003) and in iris.

Percentage of partial opened florets on 3rd of vase

The maximum percentage of partial open florets was observed in T_2 (LDPE 200 gauge) and T_5 (Brown paper) followed by T_6 (Metal paper). The minimum percentage of partial open florets on 3rd day of vase was recorded in T_7 (Control) followed by T_3 (Radium paper). The result may be due to modified atmosphere created in polyethylene sheet retained maximum water and maintained higher level of CO_2 concentration, which reduced floret metabolism and improved floret opening. These results found similar with the report of Meir *et al*., (1995) in gladiolus, they observed that MA (Modified Atmosphere) packaging may reduced floret metabolism, thereby reducing carbohydrate consumption as the respiratory substrate and improved floret opening.

Percentage of unopened florets on 3rd day of vase

The minimum percentage of unopened florets on 3rd day of vase was recorded in T_5 (Brown paper) followed by T_2 (LDPE 200 gauge). The maximum percentage of unopened florets was observed in T_7 (Control) followed by T_3 (Radium paper). The result Prolonged storage leads to desiccation and unopening of florets and depletion of stored carbohydrates and water loss which increase with increase in duration. Considerable improvement in cv. double indicating that carbohydrate stress may account for poor opening of bud in this cultivar. Nowak and Rudnicki, (1990) reported that many immature buds require exogenous supply of sucrose for the opening.

Dry weight of cut spike at senescence

The maximum dry weight of cut spike at senescence was observed in T_2 (LDPE 200 gauge) followed by T_1 (LDPE 100 gauge). The minimum dry weight of cut spike at senescence was recorded in T_5 (Brown paper) followed by T_4 (News paper).

Vase life of cut spike (days)

The maximum vase life of cut spike (days) was recorded in T_1 (LDPE 100 gauge) followed by T_2 (LDPE 200 gauge), while the minimum vase life of cut spike (days) was recorded in the T_7 (Control) followed by T_4 (News paper). The result may be due to modified atmosphere, which increased the CO2 concentration as well as humidity and slow down the transpiration inside the package leading to slow down the respiration process. Furthermore, it might have higher turgidity and freshness, contains more amount of carbohydrates and energy because of reduced permeability of polyethylene sheet. The polyethylene reduced the permeability to moisture and air, thereby reducing the weight loss probably due to a reduction in the moisture loss, respiration and cell division processes. Thus, water balance in spike was increased. Higher water balance is associated with gain in fresh weight and it seems to be the most important aspect in extension of longevity of cut flower. These results were in accordance with observations made by Madaiha and Reddy, (1994) and Michael, (1996) in tuberose, Khan *et al*., (2003) [5] in gladiolus.

Change in total sugars (%), Change in reducing sugars (%) and Change in Non-reducing sugars (%)

The effect of packaging materials on change in total sugars (%) was statistically significant and non-significant with change in reducing sugars (%) and change in reducing sugars (%). The maximum change in total sugars was recorded in T_7 (Control) followed by T_5 (Brown paper), while the minimum change in total sugars was recorded in the T_1 (LDPE 100 gauge) followed by T_3 (Radium paper). The maximum change in reducing sugars was recorded in T_5 (Brown paper) followed by T_7 (Control), while the minimum change in reducing sugars was recorded in the T_1 (LDPE 100 gauge) followed by T_2 (LDPE 200 gauge). The maximum change in non-reducing sugars was recorded in T_7 (Control) followed by T_1 (LDPE 100 gauge), while the minimum change in reducing sugars was recorded in the T_5 (Brown paper) followed by T_3 (Radium paper). This finding is in agreement with the observations made in cut rose.

Table 1: Effect of packaging's materials of on vase life tuberose

Treatment	Change in weight (%)			Water uptake (ml)			Opening of 5th floret (day)	Withering of 5th floret (day)	Number of florets open at a time
	3rd day (%)	6th day (%)	Senescence (%)	3rd day	6th day	Senescence			
T_1 – LDPE 100 gauge	21.74	4.70	-15.42	18.93	24.38	33.53	3.13	5.60	2.93
T_2 - LDPE 200 gauge	19.14	0.04	-37.53	15.00	25.67	37.33	3.60	6.13	2.87
T_3 - Radium paper	11.03	6.54	-26.33	14.37	26.80	39.47	2.67	5.27	2.40
T_4 - News paper	15.35	-7.99	-38.96	11.40	17.47	35.67	2.67	4.67	2.53
T_5 - Brown paper	13.33	-6.63	-28.04	18.77	19.34	34.33	2.93	5.13	2.47
T_6 – Metal paper	2.25	-2.07	-35.33	16.83	17.33	34.67	2.73	5.33	2.47
T_7 - Control	13.31	-7.01	-44.83	8.27	11.87	21.93	2.60	4.60	1.93
S.EM.±	0.25	2.30	1.61	1.23	0.44	1.30	0.08	0.24	0.18
C.D. at 5%	0.75	6.97	4.89	3.74	1.34	3.93	0.25	0.72	0.56

Table 2: Effect of packaging's material of on vase life tuberose

Treatment	Percentage of open, partial, unopened florets on 3rd day of vase			Dry weight (g) of cut spike at senescence	Vase life (days)	Change in sugars (%)		
	Open florets (%)	Partial open florets (%)	Unopened florets (%)			Total sugars (%)	Reducing sugars	Non-reducing sugars (%)
T_1 – LDPE 100 gauge	10.67	10.33	79.00	3.86	13.33	0.74	0.54	0.20
T_2 - LDPE 200 gauge	8.67	15.33	76.00	4.46	13.00	0.97	0.83	0.14
T_3 - Radium paper	10.00	9.33	80.67	3.28	12.40	0.91	0.83	0.08
T_4 - News paper	10.33	12.00	77.33	2.87	9.27	1.02	0.93	0.09
T_5 - Brown paper	10.00	15.33	74.67	2.64	9.47	1.46	1.46	0.00
T_6 – Metal paper	9.67	13.33	77.00	3.51	11.60	1.11	0.95	0.16
T_7 - Control	8.67	8.67	82.67	3.29	9.00	1.52	1.31	0.21
S.EM.±	0.47	0.49	1.16	0.22	0.75	0.18	0.20	0.05
C.D. at 5%	1.43	1.48	3.52	0.67	2.28	0.55	0.62	0.14

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