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Effect of pulsing, packaging and storage on enhancing postharvest quality of gladiolus cv white prosperity

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Abstract
The present investigation was carried out at Model Floriculture Centre, GovindBallabh Pant University of Agriculture and Technology, Pantnagar; district Udham Singh Nagar, Uttarakhand. Investigation was laid out in factorial completely randomized block design (FCRD) with three replications to study the effect of three pulsing condition viz., no pulsing (P0) sucrose 20% for 12 h (P1), Sucrose 20% for 24 h (P2), seven packaging material viz., no wrapping (T0) PP-100 gauge (T1), PP-200 gauge (T2) LDPE-100 gauge (T3), LDPE-200 gauge (T4), cellophane (T5), hessian cloth (T6) and four storage durations viz., 0 day (D0), 7day (D1), 14 day (D2), and 21 day (D3) on post-harvest quality of gladiolus cv. White Prosperity spikes harvested at 4-5 florets showing colour stage. The results showed a significant effect of pulsing, packaging and storage condition on the cut spikes of gladiolus cv. White Prosperity. During storage, minimum number of florets was opened in spikes pulsed for 12 h, wrapped with cellophane and stored for 7 day. Maximum vase life (11.67 day) was recorded in spikes which were pulsed for 24 h, unwrapped and stored for 0 day duration. The diameter of second floret of the spikes pulsed for 12 h, wrapped with cellophane and stored for 14 day was 12.17 cm. The percentage opening of florets decreased with increase in storage duration and also the post-harvest quality deteriorated with increase in storage duration.

Keywords: Pulsing, packaging, storage, enhancing postharvest quality, gladiolus cv white prosperity

Introduction
Gladiolus is important bulbous ornamental crop grown commercially in several parts of world for production of cut spikes. The fascinating spikes bear a large number of florets with varying sizes and forms with smooth ruffled or crinkled tepals (Singh, 2006) [8]. Storage extends the marketing season and regulates marketing in times of glut production. Appropriate method of storing flowers offers the possibility of long term shipment (Jain *et al*., 2006) [4, 11]. Cut flower longevity depends on the carbohydrate reserves of flowers, osmotic concentrations and pressure potential of petal cells, stomatal functioning, variation in stem diameter and rigidity, differences in the number of thick walled supporting cells in the xylem elements and phloem fiber, lignification's and level of plant hormones and vulnerability of diseases and pests (Bhattacharjee, 1999) [3]. Use of packaging materials increases the vase life of flowers. Different type of packaging materials can be used to extend the shelf life of flowers viz., newspaper, butter paper, cellophane paper, plastic bags, CF Boxes, etc. which help in slow opening of florets. They reduce the amount of production of O2 and increase the production of CO_2. This mechanism checks the metabolic process of flowers which prolongs the shelf life of flowers. Low temperature helps in reducing the amount of Ethylene, which is responsible for quality improvement and increase storage life of gladiolus spikes. Cut spikes of gladiolus do not store well under refrigerated condition for long duration. The spike could also be stored under controlled atmosphere (CA) storage in poly propylene sleeves with 2% and 5% $O_2$and CO_2, respectively for about 15 days (Singh, 2006) [8]. Therefore, the proposed investigation has been planned to assess the impact of pulsing, packaging material and storage conditions on the longevity, vase life and post-harvest qualities of gladiolus cut spikes.cv. White Prosperity.

Material Methods

The experiment was carried out at Model Floriculture Center, G.B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). Experiment was laid out on commercial cultivar of gladiolus i.e., 'White Prosperity' using factorial completely randomized design (FCRD) with 3 replications. The spikes were harvested in early morning in the 3rd week of January when 4-5 florets start showing colour. Spikes were harvested from 4th leaf stage. Harvested spikes were kept in bucket with water immediately after harvesting. Spikes were brought to laboratory; leaves were removed and cut down to uniform size of 75cm length. Spikes of uniform size are then pulsed, packaged and stored as per the requirement of experiment. After weighing fresh weight and measuring length of spikes, the spikes were pulsed with 20% sucrose solution. Spikes were kept as per treatment requirement for 12 and 24 h. Spikes were packaged in packaging material *viz*., Polypropylene (PP), Low Density Polyethylene (LDPE) both 100 and 200 gauge, Cellophane and hessian cloth. Unpacked spikes served as control. After packaging the spikes were stored in vented corrugated fiber board (CFB) box at 3-4^{0}C for varying duration ranging from 0, 7, 14 and 21 days. The observations were recorded on various post-harvest attributesand data were analyzed statistically.

Result and Discussion

The number of florets opened during storage varied from minimum zero in florets stored for 0 day and maximum 5.33 in spikes unwrapped, pulsed with sucrose 20% for 24 h and stored for 21 day. Spikes wrapped with cellophane, pulsed for 12 h and stored for 7 day resulted into minimum (1.00) number of floret opening during storage. Packaging material performed significantly on influencing the number of florets opened during storage. Cellophane gave minimum (2.51) number of florets opening during storage while hessian cloth wrapped spikes resulted into maximum number of opened floret during storage. Similar findings were also reported by Murali and Reddy (1993) [7]; Bhattacharjee (1997) [2] also recommended cellophane paper wrapping to be the best material for wrapping of cut roses.Maximum vase life (11.67 day) was recorded in spikes unwrapped, pulsed for 24 h and stored for 0 day. Storage significantly reduced the vase life of spikes with increase in storage duration. LDPE-100 resulted into maximum vase life of 6.77 day. Meir *et al*. (1995) [6] reported that polythene wrapping enhance vase life. Murali and Reddy (1993) [7] concluded that pulsing with sucrose enhances vase life. Beura and Singh (2003) [3] found similar effects due to pulsing and packaging by cellophane sheet. Maximum floret size (12.33 cm) was recorded in unwrapped spikes stored for 0 day and pulsed for 12 h or 24 h followed by cellophane wrapped spikes (12.17 cm) pulsed for 12 h. Minimum floret size (9.00 cm) was recorded in hessian cloth wrapped spikes pulsed for 24 h and stored for 7 day. Similar results have been reported by Verma *et al.* (2007) [11]. Percentage opening of florets was found better when spikes pulsed for 12 h (66.46%) followed by spikes pulsed for 24 h (63.64%) and non-pulsed spikes (60.88%). Similar finding was observed by Singh and Sharma (2003) [3].

Percent opening of floret decreased with increase in storage duration. Non-stored spikes showed maximum (72.6%) percentage opening of florets followed by spikes storage for 7 day storage (63.9%). Minimum percent opening was found in 21 day storage (61.4%).Similar finding was observed by Singh and Sharma (2003) [3]. LDPE-200 when pulsed for 12 h with sucrose 20% resulted into 74.43% floret opening. While minimum was in unwrapped and non-pulsed spikes (56.38%). Unwrapped and non-stored spikes showed maximum percent opening of florets i.e., 72.61% while minimum percent opening was resulted by unwrapped spikes stored for 21 day. Similar results were found by Kumar and Singh (2004) [5] and Singh *et al*. (2005)

Table 1: Effect of pulsing, packaging and storage on number of florets opened during storage

Packaging material	Number of florets opened															
	No pulsing (P_0)					Pulsing for 12 h (P_1)					Pulsing for 24 h (P_2)					
	D_0	D_1	D_2	D_3	Mean (PXT)	D_0	D_1	D_2	D_3	Mean (PXT)	D_0	D_1	D_2	D_3	Mean (PXT)	Mean (T)
No Packaging (T_0)	0.00	1.67	3.33	5.00	3.33	0.00	1.33	3.67	-	2.50	0.00	2.67	3.67	5.33	3.89	3.33
PP100 (T_1)	-	1.67	2.33	5.00	3.00	-	3.00	2.33	-	2.67	-	2.67	3.33	4.00	3.33	3.00
PP200 (T_2)	-	1.33	3.00	4.67	3.00	-	2.00	4.33	-	3.17	-	2.33	3.00	3.33	2.89	3.02
LDPE100 (T_3)	-	2.00	2.67	4.33	3.00	-	1.67	4.33	-	3.00	-	1.67	4.33	5.00	3.67	3.20
LDPE200 (T_4)	-	1.33	3.33	4.33	3.00	-	2.33	4.33	-	3.33	-	2.00	3.33	3.67	3.00	3.10
Cellophane (T_5)	-	2.00	3.00	3.33	2.78	-	1.00	2.33	-	1.67	-	1.33	3.67	4.00	3.00	2.51
Hesian Cloth (T_6)	-	2.33	4.33	4.00	3.55	-	1.67	3.67	-	2.67	-	1.67	5.33	5.33	4.11	3.46
Mean (P×D)	0.00	1.76	3.14	4.38		0.00	1.86	3.57			0.00	2.05	3.81	4.38	3.41	
Mean (DXT)	D_0	D_1	D_2	D_3				Mean (D)	D_0	0.00			Mean (P)		P_0	2.95
No Packaging (T_0)	0.00	1.89	3.56	5.17					D_1	1.89					P_1	2.53
PP100 (T_1)	-	2.45	2.66	4.50					D_2	3.51					P_2	3.26
PP200 (T_2)	-	1.89	3.44	4.00					D_3	4.38						
LDPE100 (T_3)	-	1.78	3.78	4.67						P	T	D	P×T	T×D	P×D	P×T×D
LDPE200 (T_4)	-	1.89	3.66	4.00				CD at 5%		0.28	0.43	0.28	N S	0.74	0.48	1.28
Cellophane (T_5)	-	1.44	3.00	3.67				S.Em±		0.10	0.15	0.10	0.26	0.26	0.17	0.46
Hesian Cloth (T_6)	-	1.89	4.44	4.67												

Table 2: Effect of pulsing, packaging and storage on vase life

Packaging material	Vase Life (in day)															
	No pulsing (P_0)					Pulsing for 12 h (P_1)					Pulsing for 24 h (P_2)					
	D_0	D_1	D_2	D_3	Mean (PXT)	D_0	D_1	D_2	D_3	Mean (PXT)	D_0	D_1	D_2	D_3	Mean (PXT)	Mean (T)
No Packaging (T_0)	8.67	8.33	8.33	3.67	6.78	9.33	8.67	5.67	-	7.17	11.67	6.33	4.67	1.67	4.22	5.92
PP100 (T_1)	-	8.67	4.33	2.67	5.22	-	9.33	6.33	-	7.83	-	6.33	5.33	3.00	4.89	5.90
PP200 (T_2)	-	8.67	4.00	3.00	5.22	-	10.00	7.00	-	8.50	-	5.67	5.67	3.67	5.00	6.14
LDPE100 (T_3)	-	8.00	4.33	4.00	5.44	-	9.00	7.00	-	8.00	-	6.67	7.33	2.33	5.44	6.21
LDPE200 (T_4)	-	8.33	7.67	3.67	6.56	-	10.00	6.33	-	8.17	-	8.00	5.67	3.33	5.67	6.77
Cellophane (T_5)	-	8.67	7.33	3.33	6.44	-	8.67	7.67	-	8.17	-	7.00	6.33	2.00	5.11	6.56
Hesian Cloth (T_6)	-	7.33	7.00	2.33	5.55	-	9.00	6.67	-	7.84	-	6.33	7.00	2.67	5.33	6.17
Mean (P×D)	8.67	8.29	6.14	3.24		9.33	9.24	6.67			11.67	6.62	6.00	2.67	5.10	
Mean (DXT)	D_0	D_1	D_2	D_3				Mean (D)	D_0	9.89			Mean (P)		P_0	6.02
No Packaging (T_0)	9.89	7.78	6.22	2.67					D_1	8.05					P_1	8.04
PP100 (T_1)	-	8.11	5.33	2.84					D_2	6.27					P_2	5.39
PP200 (T_2)	-	8.11	5.56	3.34					D_3	2.95						
LDPE100 (T_3)	-	7.89	6.22	3.17					-	P	T	D	P×T	T×D	P×D	P×T×D
LDPE200 (T_4)	-	8.78	6.56	3.50				CD at 5%		0.31	0.47	0.31	0.81	0.81	0.53	1.40
Cellophane (T_5)	-	8.11	7.11	2.67				S.Em±		0.11	0.17	0.11	0.29	0.29	0.19	0.50
Hesian Cloth (T_6)	-	7.55	6.89	2.50												

Table 3: Effect of pulsing, packaging and storage on diameter of 2nd floret

Packaging material	Diameter of second floret (in cm)															
	No pulsing (P_0)					Pulsing for 12 h (P_1)					Pulsing for 24 h (P_2)					
	D_0	D_1	D_2	D_3	Mean (PXT)	D_0	D_1	D_2	D_3	Mean (PXT)	D_0	D_1	D_2	D_3	Mean (PXT)	Mean (T)
No Packaging (T_0)	9.83	10.50	10.67	10.33	10.50	12.33	11.00	9.50	-	10.25	12.33	10.67	11.33	10.17	10.72	10.52
PP100 (T_1)	-	11.33	10.83	10.67	10.94	-	11.33	10.83	-	11.08	-	10.67	11.33	10.50	10.83	10.95
PP200 (T_2)	-	10.67	10.00	10.50	10.39	-	10.17	10.67	-	10.42	-	11.17	10.50	10.50	10.72	10.50
LDPE100 (T_3)	-	10.67	10.50	10.50	10.56	-	10.83	10.83	-	10.83	-	10.83	11.67	11.00	11.17	10.82
LDPE200 (T_4)	-	10.33	10.33	10.33	10.33	-	10.67	11.00	-	10.84	-	11.50	10.17	10.17	10.61	10.57
Cellophane (T_5)	-	10.50	11.67	11.00	11.06	-	11.00	12.17	-	11.59	-	11.00	11.50	11.00	11.17	11.25
Hesian Cloth (T_6)	-	10.83	10.33	10.50	10.55	-	11.17	11.00	-	11.09	-	9.00	11.17	9.67	9.95	10.53
Mean (P×D)	9.83	10.69	10.62	10.55		12.33	10.88	10.86			12.33	10.69	11.10	10.43	10.74	
Mean (DXT)	D_0	D_1	D_2	D_3				Mean (D)	D0	11.50			Mean (P)		P0	10.58
No Packaging (T_0)	11.50	10.72	10.50	10.25					D1	10.75					P1	10.97
PP100 (T_1)	-	11.11	11.00	10.59					D2	10.86					P2	10.81
PP200 (T_2)	-	10.67	10.39	10.50					D3	10.49						
LDPE100 (T_3)	-	10.78	11.00	10.75						P	T	D	P×T	T×D	P×D	P×T×D
LDPE200 (T_4)	-	10.83	10.50	10.25				CD at 5%		0.24	0.36	0.24	N S	N S	0.41	1.08
Cellophane (T_5)	-	10.83	11.78	11.00				S.Em±		0.08	0.13	0.08	0.22	0.22	0.15	0.39
Hesian Cloth (T_6)	-	10.33	10.83	10.09												

Table 4: Effect of pulsing, packaging and storage on percentage opening of florets

Packaging material	Percentage opening of floret															
	No pulsing (P_0)					Pulsing for 12 h (P_1)					Pulsing for 24 h (P_2)					
	D_0	D_1	D_2	D_3	Mean (PXT)	D_0	D_1	D_2	D_3	Mean (PXT)	D_0	D_1	D_2	D_3	Mean (PXT)	Mean (T)
No Packaging(T0)	77.50	57.97	58.22	52.96	56.38	70.31	64.71	68.26	-	66.49	70.13	69.49	59.72	59.72	62.98	61.38
PP100 (T1)	-	55.88	59.08	56.55	57.17	-	68.94	59.95	-	64.45	-	65.44	59.84	68.75	64.68	61.60
PP200 (T2)	-	56.09	62.65	59.19	59.31	-	70.14	59.70	-	64.92	-	66.05	68.34	67.36	67.25	63.38
LDPE100 (T3)	-	62.50	62.28	64.09	62.96	-	70.59	60.78	-	65.69	-	68.06	52.96	62.23	61.08	63.21
LDPE200 (T4)	-	66.89	56.65	57.65	60.40	-	70.36	78.49	-	74.43	-	53.73	66.67	59.27	59.89	64.45
Cellophane (T5)	-	62.75	67.71	65.97	65.48	-	54.30	66.02	-	60.16	-	57.65	63.40	65.97	62.34	62.94
Hesian Cloth (T6)	-	57.35	64.79	54.58	58.91	-	69.10	65.32	-	67.21	-	72.94	57.52	64.80	65.09	63.25
Mean (P×D)	77.50	59.92	61.63	58.71		70.31	66.88	65.50			70.13	64.77	61.21	64.01	63.33	
Mean (DXT)	D_0	D_1	D_2	D_3				Mean (D)	D0	72.65			Mean (P)		P_0	60.88
No Packaging (T_0)	72.65	64.06	62.07	56.34					D1	63.85					P_1	66.46
PP100 (T_1)	-	63.42	59.62	62.65					D2	62.78					P_2	63.64
PP200 (T_2)	-	64.09	63.56	63.28					D3	61.36						
LDPE100 (T_3)	-	67.05	58.67	63.16						P	T	D	P×T	T×D	P×D	P×T×D
LDPE200 (T_4)	-	63.66	67.27	58.46				CD at 5%		2.734	n s	2.734	6.280	6.280	4.111	n s
Cellophane (T_5)	-	58.23	65.71	65.97				S.Em±		0.848	1.295	0.848	2.244	2.244	1.469	3.886
Hesian Cloth (T_6)	-	66.46	62.54	59.69												

Conclusion

On the basis of above results, it can be concluded that gladiolus spikes are significantly influenced due to pulsing, packaging and storage. Spikes wrapped with cellophane gave promising results when stored at 40ºC. Twelve hour pulsing was considered good for most of the characters. Cellophane wrapping may be recommended with 12 h pulsing and storage for 7 day as best combination for keeping the post harvest quality of spikes.

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