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Effect of Packing and Storage Conditions on Physiological Loss in Weight, Diameter of the Flower, Electrolyte Leakage in Extending the Vase Life of Carnation cv. Kiro

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An experiment was carried out to study the effect of different packing and storage conditions on vase life of cut carnation cv. Kiro. The flowers packed in polypropylene at 5°C cold storage under wet condition recorded significantly the lowest physiological loss in weight (g flower^{-1}), as well as diameter of the flower (cm) with lowest electrolyte leakage (%) resulting in increased vase life of cut carnation cv. Kiro upto a period of 24.70 days.

Introduction

Carnation (*Dianthus caryophyllus* L.) belongs to the family Caryophyllaceae and native to Mediterranean region. Carnation is one among the top five cut flowers in the world and in India (Singh, 2006). The beauty of the cut flowers lies with the freshness of the flowers for longer time without post harvest losses. It is claimed that 70 per cent of the potential quality of cut flowers is pre-determined at harvest, whereas the remaining 30 per cent is influenced by post harvest factors. All along the marketing channel, there is enormous loss in value of cut flowers which could be of 50 per cent of farm value (Bhattacharjee, 1999).

Post harvest life of cut flowers also depends upon efficient packaging and storage. Appropriate packaging of cut flowers together with pulsing are helpful to ensure fresh quality of flowers. Packing is a tool for controlling flower quality in the distribution chain. Apart from preventing mechanical damage, the package serves as a barrier between the conditions inside and outside the package. It protects the flowers from unfavorable outside conditions and enables a micro-climate to develop inside the package (Lavanya *et al*., 2016). Packaging must ensure protection of flowers against flower damage, water loss and external conditions, which are detrimental to flowers in transit (Sivaswamy *et al*., 1999). Storage at low temperature under wet conditions results in low metabolic activities like respiration, transpiration and maintain high humidity and increased cell turgidity and cell enlargement there by keeping the flower quality and increased vase life (Halevy and Mayak, 1981).

Materials and Methods

The experiment was held at laboratory of Floriculture and Landscape Architecture, College of Horticulture, Dr. Y.S.R. Horticultural University, Venkataramanna gudem, West Godavari dist (A.P) during 2017-18. Experiment laid out in completely randomized design (CRD) with factorial concept. The total number of treatment combinations are as follows $T_1P_1S_1$: PVC cling film + Ambient temperature (22±2°C) (Wet storage), T_2-P_2S_1: Polyethylene (100 gauge) + Ambient temperature (22±2°C) (Wet storage), T_3-P_3S_1: Cellophane paper + Ambient temperature (22±2°C) (Wet storage), T_4-P_4S_1: Polypropylene + Ambient temperature (22±2°C) (Wet storage), T_5-P_5S_1: Control (open) + Ambient temperature (22±2°C) (Wet storage), T_6-P_1S_2: PVC cling film + Cold storage of 5°C (Wet storage), T_7-P_2S_2: Polyethylene (100 gauge) + Cold storage of 5°C (Wet storage), T_8-P_3S_2: Cellophane paper + Cold storage of 5°C (Wet storage), T_9-P_4S_2: Polypropylene + Cold storage of 5°C (Wet storage), T_{10}-P_5S_2: Control (open) + Cold storage of 5°C (Wet storage), T_{11}-P_1S_3: PVC cling film + Ambient temperature (22±2°C) (Dry storage), T_{12}-P_2S_3: Polyethylene (100 gauge) + Ambient temperature (22±2°C) (Dry storage), T_{13}-P_3S_3: Cellophane paper + Ambient temperature (22±2°C) (Dry storage), T_{14}-P_4S_3: Polypropylene + Ambient temperature (22±2°C) (Dry storage), T_{15}-P_5S_3: Control (open) + Ambient temperature (22±2°C) (Dry storage), T_{16}-P_1S_4: PVC cling film + Cold storage of 5°C (Dry storage), T_{17} -P_2S_4: Polyethylene (100 gauge) + Cold storage of 5°C (Dry storage), T_{18}-P_3S_4: Cellophane paper + Cold storage of 5°C (Dry storage), T_{19}-P_4S_4: Polypropylene + Cold storage of 5°C (Dry storage), T_{20}-P_5S_4: Control (open) + Cold storage of 5°C (Dry storage).

The flowers were kept under dry and wet conditions under both cold storage at 5°C as well as ambient temperature (22±2°C) by wrapping with different packing materials till the end of vase life period. Physiological loss in weight and microbial count were observed in wet conditions. In each conical flask, six flowers were placed and considered as one replication. The treatments were replicated thrice. The individual flower stalks were placed randomly in 500 ml conical flasks containing 300 ml of distilled water under wet conditions. Observations were recorded on physiological loss in weight, diameter of the flower, vase life and electrolyte leakage.

Results and Discussion

The physiological loss in weight was significant among all the treatment combinations. Significantly the lowest physiological loss in weight (1.50 g) was recorded with flowers packed in polypropylene at cold storage (5°C) under wet condition (T_9). Cellophane packed flowers at ambient temperature (22±2°C) under dry condition (T_{13}) recorded significantly the highest physiological loss in weight (11.48 g) whereas, the remaining all other treatments recorded intermediate values. There were significant differences in physiological loss in weight during different days of vase life period. The physiological loss in weight significantly increased from 2nd day (4.78 g) to 4th day (7.09 g). Significantly the lowest physiological loss in weight was recorded on

2^{nd} day (4.78 g), whereas, the highest physiological loss in weight (7.09 g) was recorded on 4^{th} day. The interaction effect between treatments and days on physiological loss in weight was found significant. The flowers packed in polypropylene at cold storage (5°C) under wet condition (T_9) recorded significantly the minimum physiological loss in weight (0.90 g) on 2^{nd} day and 4^{th} day (2.10 g) among treatments. The minimum Physiological Loss in Weight might be due to fact that water loss mainly account for per cent physiological loss in weight. Positive effect of polypropylene accounts sufficient ventilation and creation of modified atmosphere with low temperate and high humidity, leading to a reduced concentration of oxygen there by reducing respiration. This is in accordance with Suhrita *et al.*, (2005) that the concentration of carbon dioxide would be increased as the substrate for respiration was limited which reflected the low physiological loss in weight in gladiolus.

The diameter of flower was significant among all the treatment combinations. Significantly the highest diameter (6.99 cm) was recorded with flowers packed in polypropylene at cold storage (5°C) under wet condition (T_9). Control treatment (without packing) at ambient temperature (22±2°C) under dry condition (T_{15}) recorded significantly the lowest diameter (2.54 cm) whereas, the remaining all other treatments recorded intermediate values. There were significant differences in diameter of flower during different days of vase life period. The diameter significantly decreased from 2^{nd} day (5.88 cm) to 4^{th} day (5.74 cm). Significantly the highest diameter of flower was recorded on 2^{nd} day (5.88 cm), whereas, the lowest diameter (5.74 cm) was recorded on 4^{th} day. The interaction effect between treatments and days on diameter of flower was found significant. The treatment (T_9) flowers packed in polypropylene at cold storage (5°C) under wet condition recorded significantly the highest diameter (6.86 cm) on 2^{nd} day which was onpar with (T_7) flowers packed in polyethylene (100 gauge) at cold storage (5°C) under wet condition (6.80 cm) and (T_8) flowers packed in cellophane paper at cold storage (5°C) under wet condition (6.65 cm). On 4^{th} day polypropylene packed flowers at cold storage (5°C) under wet condition (T_9) recorded the highest diameter (7.12 cm) which was onpar with (T_7) flowers packed in polyethylene (100 gauge) at cold storage (5°C) under wet condition (7.11 cm) and (T_8) flowers packed in cellophane paper at cold storage (5°C) (7.02 cm). Treatment (T_9) flowers packed in polypropylene at cold storage (5°C) under wet condition recorded the highest diameter of flower on all the days of vase life study. The data indicated that the maximum flower diameter was recorded in polypropylene packed flowers kept at cold storage (5°C) under wet condition due to enhanced water uptake leads to increased cell-turgidity and cell enlargement results in easy and more flower opening. Makhwana *et al.,* (2015) reported that polypropylene packed cold stored flowers showed 100% opening on 4^{th} and 6^{th} day of vase life in rose. Similar results were also reported by Farooq *et al.,* (2004) in rose, Namita and Singh (2006) in gladiolus, Verma *et al.,* (2006) in chrysanthemum and Patel and Singh (2009) in gerbera.

The vase life of cut carnation differed significantly among the treatment combinations. The vase life period ranged from 3.05 to 24.70 days. All the treatment combinations have significantly improved vase life over control (without packing) at ambient temperature (22±2°C) under dry condition (T_{15}). Among the different treatments, flowers packed in polypropylene at cold storage (5°C) under wet condition (T_9) has recorded significantly the highest vase life (24.70 days) and the lowest vase life (3.05 days) was observed with flower kept in control (without packing) at ambient temperature (22±2°C) under dry condition (T_{15}) (Table 1–4).

Table.1 Effect of different packaging and storage conditions on physiological loss in weight (g flower^{-1}) during vase life of carnation (*Dianthus caryophyllus* L.) cv. Kiro

Treatments	Days												
	2	**4**	**Mean**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**
T_1-P_1S_1	5.98	10.70	8.34	19.50	-	-	-	-	-	-	-	-	-
T_2-P_2S_1	5.02	8.75	6.88	15.09	-	-	-	-	-	-	-	-	-
T_3-P_3S_1	5.35	9.34	7.34	17.41	-	-	-	-	-	-	-	-	-
T_4-P_4S_1	4.57	8.12	6.34	13.56	18.44	-	-	-	-	-	-	-	-
T_5-P_5S_1	6.34	11.67	9.00	-	-	-	-	-	-	-	-	-	-
T_6-P_1S_2	2.98	3.99	3.48	6.70	10.44	13.18	16.97	17.97	20.19	21.45	-	-	-
T_7-P_2S_2	1.82	2.97	2.39	7.11	8.56	11.50	15.17	16.69	18.45	19.86	21.63	22.54	-
T_8-P_3S_2	2.15	3.42	2.78	5.58	9.32	12.32	16.05	17.10	19.57	20.15	22.32	23.65	-
T_9-P_4S_2	0.90	2.10	1.50	4.09	6.35	10.27	13.23	15.21	17.29	18.56	20.12	22.09	23.18
T_{10}-P_5S_2	3.20	4.40	3.80	7.90	11.26	13.88	17.16	18.28	20.98	22.51	-	-	-
T_{11}-P_1S_3	7.96	-	3.98	-	-	-	-	-	-	-	-	-	-
T_{12}-P_2S_3	6.86	14.63	10.75	-	-	-	-	-	-	-	-	-	-
T_{13}-P_3S_3	7.20	15.76	11.48	-	-	-	-	-	-	-	-	-	-
T_{14}-P_4S_3	6.53	13.50	10.01	-	-	-	-	-	-	-	-	-	-
T_{15}-P_5S_3	9.40	-	4.70	-	-	-	-	-	-	-	-	-	-
T_{16}-P_1S_4	4.05	7.23	5.64	10.47	13.42	17.05	-	-	-	-	-	-	-
T_{17}-P_2S_4	3.77	5.92	4.84	9.20	12.50	15.42	19.08	21.40	23.12	-	-	-	-
T_{18}-P_3S_4	3.95	6.36	5.15	9.89	12.99	16.20	19.98	22.36	-	-	-	-	-
T_{19}-P_4S_4	3.46	5.20	4.33	8.13	11.94	14.57	18.19	20.73	22.46	-	-	-	-
T_{20}-P_5S_4	4.21	7.88	6.04	11.26	14.68	17.94	-	-	-	-	-	-	-
Mean	4.78	7.09											

Factors	C.D at 5%	SE d			
For treatments (T)	0.189	0.095		P_1: PVC cling film	S_1: Ambient temperature (22±2°c) (Wet storage)
For days (D)	0.060	0.030		P_2: Polyethylene (100 gauge)	S_2: Cold storage of 5°C (Wet storage)
Factor(T×D)	0.267	0.134		P_3: Cellophane paper	S_3: Ambient temperature (22±2°c) (Dry storage)
*Significant at (P≤0.05)				P_4: Polypropylene	S_4: Cold storage of 5°C (Dry storage)
				P_5: Control (open)	

Table.2 Effect of different packaging and storage conditions on diameter of flower (cm) during vase life of carnation (*Dianthus caryophyllus* L.) cv. Kiro

Treatments	Days												
	2	4	Mean	6	8	10	12	14	16	18	20	22	24
T_1-P_1S_1	5.35	5.87	5.61	5.18	-	-	-	-	-	-	-	-	-
T_2-P_2S_1	5.62	6.28	5.95	5.85	5.04	-	-	-	-	-	-	-	-
T_3-P_3S_1	5.49	5.93	5.71	5.36	-	-	-	-	-	-	-	-	-
T_4-P_4S_1	5.85	6.50	6.17	5.91	5.18	-	-	-	-	-	-	-	-
T_5-P_5S_1	5.18	5.60	5.39	-	-	-	-	-	-	-	-	-	-
T_6-P_1S_2	6.19	6.75	6.53	7.00	6.59	6.03	5.56	5.24	5.12	4.73	-	-	-
T_7-P_2S_2	6.65	7.09	6.87	7.30	6.90	6.28	6.02	5.85	5.51	5.27	5.05	4.86	-
T_8-P_3S_2	6.42	7.00	6.71	7.14	6.81	6.14	5.83	5.58	5.23	5.16	4.75	4.33	-
T_9-P_4S_2	6.80	7.11	6.95	7.55	7.09	6.62	6.25	6.07	5.82	5.53	5.19	4.99	4.68
T_{10}-P_5S_2	6.02	6.50	6.26	6.90	6.32	5.88	5.41	5.02	4.88	4.65	-	-	-
T_{11}-P_1S_3	5.25	-	2.62	-	-	-	-	-	-	-	-	-	-
T_{12}-P_2S_3	5.95	4.98	5.46	-	-	-	-	-	-	-	-	-	-
T_{13}-P_3S_3	5.60	4.75	5.18	-	-	-	-	-	-	-	-	-	-
T_{14}-P_4S_3	6.22	5.79	6.01	-	-	-	-	-	-	-	-	-	-
T_{15}-P_5S_3	5.09	-	2.54	-	-	-	-	-	-	-	-	-	-
T_{16}-P_1S_4	5.42	6.76	6.09	5.35	5.12	4.64	-	-	-	-	-	-	-
T_{17}-P_2S_4	6.52	6.90	6.87	6.47	5.87	5.34	5.01	4.74	4.36	-	-	-	-
T_{18}-P_3S_4	6.18	6.89	6.53	6.09	5.63	5.14	4.79	4.35	-	-	-	-	-
T_{19}-P_4S_4	6.80	6.98	6.89	6.76	6.17	5.95	5.18	5.02	4.73	-	-	-	-
T_{20}-P_5S_4	5.08	6.85	5.96	5.00	4.94	4.15	-	-	-	-	-	-	-
Mean	5.88	5.74											

Factors	C.D at 5%	SE d			
For treatments (T)	0.180	0.090		P_1: PVC cling film	S_1: Ambient temperature (22$\pm$2^{o}c) (Wet storage)
For days (D)	0.057	0.029		P_2: Polyethylene (100 gauge)	S_2: Cold storage of 5^{o}C (Wet storage)
Factor (T×D)	0.255	0.128		P_3: Cellophane paper	S_3: Ambient temperature (22$\pm$2^{o}c) (Dry storage)
				P_4: Polypropylene	S_4: Cold storage of 5^{o}C (Dry storage)
				P_5: Control (open)	

*Significant at ($P \leq 0.05$)

Table.3 Effect of different packaging and storage conditions on vase life (days) of carnation (*Dianthus caryophyllus* L.) cv. Kiro

Treatments	Vase life (days)
T_1-P_1S_1	6.90
T_2-P_2S_1	7.50
T_3-P_3S_1	7.22
T_4-P_4S_1	9.12
T_5-P_5S_1	5.79
T_6-P_1S_2	19.49
T_7-P_2S_2	22.81
T_8-P_3S_2	22.43
T_9-P_4S_2	24.70
T_{10}-P_5S_2	18.15
T_{11}-P_1S_3	3.75
T_{12}-P_2S_3	5.13
T_{13}-P_3S_3	4.98
T_{14}-P_4S_3	5.42
T_{15}-P_5S_3	3.05
T_{16}-P_1S_4	11.32
T_{17}-P_2S_4	17.10
T_{18}-P_3S_4	15.60
T_{19}-P_4S_4	17.80
T_{20}-P_5S_4	10.90
SE(d)	0.258
C.D at 5%	0.524

P_1: PVC cling film — S_1: Ambient temperature (22+2oc) (Wet storage)
P_2: Polyethylene (100 gauge) — S_2: Cold storage of 5oC (Wet storage)
P_3: Cellophane paper — S_3: Ambient temperature (22+2oc) (Dry storage)
P_4: Polypropylene — S_4: Cold storage of 5oC (Dry storage)
P_5: Control (open)

Table.4 Effect of different packaging and storage conditions on electrolyte leakage (%) during vase life of cut carnation (*Dianthus caryophyllus* L.) cv. Kiro

Treatments	Days												
	2	4	Mean	6	8	10	12	14	16	18	20	22	24
T_1-P_1S_1	23.49	30.89	27.19	45.38	-	-	-	-	-	-	-	-	-
T_2-P_2S_1	20.56	29.30	24.93	42.55	-	-	-	-	-	-	-	-	-
T_3-P_3S_1	21.27	30.10	25.68	43.30	-	-	-	-	-	-	-	-	-
T_4-P_4S_1	19.94	28.69	24.31	40.82	50.22	-	-	-	-	-	-	-	-
T_5-P_5S_1	23.85	31.81	27.83	-	-	-	-	-	-	-	-	-	-
T_6-P_1S_2	12.09	24.56	18.32	34.82	42.65	53.85	63.92	72.56	79.23	83.47	-	-	-
T_7-P_2S_2	10.28	22.42	16.35	32.67	41.56	52.62	62.89	71.20	78.04	82.28	89.25	92.41	-
T_8-P_3S_2	11.50	23.09	17.29	33.15	41.99	53.08	63.46	71.98	78.90	82.90	90.47	93.23	-
T_9-P_4S_2	9.11	20.03	14.57	31.20	40.23	50.17	61.15	69.52	75.45	80.13	87.14	90.26	92.05
T_{10}-P_5S_2	13.49	24.95	19.22	35.84	43.10	54.45	64.54	72.88	80.10	84.50			
T_{11}-P_1S_3	25.97	-	12.98	-	-	-	-	-	-	-	-	-	-
T_{12}-P_2S_3	24.15	34.27	29.21	-	-	-	-	-	-	-	-	-	-
T_{13}-P_3S_3	25.20	35.41	30.30	-	-	-	-	-	-	-	-	-	-
T_{14}-P_4S_3	24.10	33.52	28.81	-	-	-	-	-	-	-	-	-	-
T_{15}-P_5S_3	26.87	-	13.43	-	-	-	-	-	-	-	-	-	-
T_{16}-P_1S_4	17.42	27.53	22.47	38.12	47.07	56.70	-	-	-	-	-	-	-
T_{17}-P_2S_4	15.30	26.10	20.70	36.66	44.82	55.43	66.23	74.45	81.47	-	-	-	-
T_{18}-P_3S_4	16.73	26.92	21.82	37.69	46.47	56.02	67.44	75.10	-	-	-	-	-
T_{19}-P_4S_4	14.80	25.35	20.07	35.55	44.18	54.26	65.12	73.69	80.58	-	-	-	-
T_{20}-P_5S_4	19.20	28.11	23.65	38.98	47.45	61.12	-	-	-	-	-	-	-
Mean	18.76	25.15											

Factors	C.D at 5%	SE d		P_1: PVC cling film	S_1: Ambient temperature (22$\pm$2^{o}c) (Wet storage)
For treatments (T)	0.709	0.356		P_2: Polyethylene (100 gauge)	S_2: Cold storage of 5^{o}C (Wet storage)
For days (D)	0.224	0.112		P_3: Cellophane paper	S_3: Ambient temperature (22$\pm$2^{o}c) (Dry storage)
Factor(T×D)	1.003	0.503		P_4: Polypropylene	S_4: Cold storage of 5^{o}C (Dry storage)
*Significant at ($P \leq 0.05$)				P_5: Control (open)	

Termination of vase life for many cut flowers is characterised by wilting. Generally, wilting is caused by an imbalance between water uptake by flowering stems and water loss *via* transpiration from their leaves and other organs unless despite their stem being held in water continuously (Halevy and Mayak, 1981; Doorn and Stead, 1997). It is logical that the most important components of cold storage technique which might adversely affect quality are water loss during dry storage, low temperature injury, continued ageing during the time at low temperature. The water status of the flower was assumed to be an important determinant of flower quality after cold storage (Halevy and Mayak, 1974). Maximum vase life was observed in polypropylene packed flowers at cold storage (5°C) under wet condition due to cumulative effect of polypropylene packing under cold storage that enhanced water uptake, fresh weight, reduced transpirational loss of water, better water balance, minimum physiological loss in weight resulted extended vase life upto (24.7 days). These results were supported by Jain *et al.,* (2007) in rose, Patel and Dhaduk (2010), Mazumder *et al.,* (2014) in tuberose, Cevallos and Reid (2001) in Iris and carnation, Sankar and Bhattacharjee (2003) in rose, Sashikala and Singh (2003), Namita and Singh (2006) in gladiolus and Lavanya *et al.*, 2016 in jasmine.

The electrolyte leakage was significant among all the treatment combinations. Significantly the lowest electrolyte leakage (12.98 %) was recorded with flowers packed in polypropylene at cold storage (5°C) under wet condition (T_9). Control treatment (without packing) at ambient temperature (22±2°C) under dry condition (T_{15}) recorded significantly the highest electrolyte leakage (30.30 %) whereas, the remaining all other treatments recorded intermediate values. There were significant differences in electrolyte leakage during different days of vase life period. The electrolyte leakage significantly increased from 2nd day (18.76 %) to 4th day (25.15 %). Significantly the lowest electrolyte leakage was recorded on 2nd day (18.76 %), whereas, the highest electrolyte leakage (25.15 %) was recorded on 4th day. The interaction effect between treatments and days on electrolyte leakage was found significant. The flowers packed in polypropylene at cold storage (5°C) under wet condition (T_9) recorded significantly the lowest electrolyte leakage (9.11 %) on 2nd day and on 4th day (20.03 %) among the treatments. It is evident from the data that lowest electrolyte leakage was observed in polypropylene packed flowers at cold storage (5°C) under wet conditions might be due to beneficial effect of polypropylene packing for reducing the electrolyte leakage may be due to modified atmosphere for flowers supported by slow down the respiration, transpiration and floret metabolism under low temperature effect. The electrolyte leakage increased at a constant level through vase life period. This might be due to senescence is accompanied by dramatic increase in electrolyte leakage of many molecules including pigments, amino acids, sugars, K^+ and total electrolytes (Feragher, 1986 and Paulin, 1986). The results were in accordance with Gast (2000) in gladiolus, Regan, (2008) in rose and Ahmed *et al.,* (2013) in hydrangea.

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