INFLUENCE OF WET AND DRY COLD STORAGE AND HOLDING SOLUTIONS ON THE RESPIRATION RATE AND POST HARVEST LIFE OF CUT ROSES

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ABSTRACT

Post-harvest handling of cut rose flowers is a critical management section of floriculture that, when properly applied, influences the longevity of the flowers, thus enhancing their aesthetic value for the consumer. Wet and dry cold storage at 4^0C for 3 and 6 days periods for rose cultivars (cvs.) Golden Gate and Noblesse respectively, were identified in initial trials as being the optimum cold storage duration after harvesting which enhanced the vase life of the Golden Gate and Noblesse cut roses. Correlating the respiration rate to vase life after cold storage and during the vase life while in holding solutions was determined for both cultivars in two independent trials, that were laid out in completely randomised block designs. After subjecting the roses to the individual standardised storage treatments, they were then dipped in seven different holding solutions. Respiration rates were measured at harvest, after storage treatments, on the third day in the vases, and at senescence. Subjecting both the cut flowers to wet storage for 3 days and dry storage for 6 days at 4°C resulted in a decrease in the respiration rate when compared to that observed at harvest time. Respiration rates however increased by the third day while in holding solution and thereafter declined to lowest levels by senescence, for all the seven treatments. At senescence, the lowest respiration rate was recorded with flowers held in sucrose (3%) + 8-HQC (hydroxyquinoline citrate)) (200 ppm) followed by D-fructose (3%) + nickel chloride (300 ppm) which also gave highest vase life in case of wet storage treated Golden Gate. For dry storage treated Noblesse cut flowers held in D-fructose (3%) + nickel chloride (300 ppm), recorded lowest respiration rate and thus, resulted in maximum vase life. Regression analyses relating respiration rates with vase life revealed that vase life is inversely related to respiration rates after cold storage treatment and at senescence which could be attributed to post harvest management practices that lower respiration rates.

Key words: Cut roses, holding solutions, wet storage, dry storage, respiration rate

1.0 INTRODUCTION

Among cut flowers, rose (*Rosa hybrida)* occupies premier position in the export market. Roses are high value crops and at the same time highly perishable in nature. Owing to their tenderness and delicate nature, flowers undergo rapid deterioration in quality, which ultimately shortens their vase life. Moreover, the complex morphology of a cut flower needs special care in developing handling techniques based on the sensitivity of foliage.

According to Halevy and Mayak (1979), two distinct physiological phases have been identified in flowers, namely, bud growth and development to full opening, and maturation, senescence and wilting. One should develop handling techniques in such a way to improve opening of flowers in the first phase, and to reduce the rate of senescence at the second phase for prolonged vase life of cut flowers.

The rate of respiration has a bearing on the longevity of rose cut flowers. The standard method used throughout the flower industry to retard senescence is to reduce respiration by decreasing the storage temperature. Coorts (1973) found that flowers with the highest rates of respiration had the poorest keeping quality. He noted that the short-lived rose had a respiratory rate of 414 cc of CO_2 / kg / h, as compared to the longer lived carnation, which had a respiratory rate of 289 cc of CO_2 / kg / h. He further concluded that if a method for slowing down the respiration could be devised, the length of the flower life could be increased. Wang (1999) reported that sugar content of cut flowers of *Anthurium andraeanum* stored at 14^{0}C for 10-15 days was lower than that of flowers stored at 4^{0}C. Sugar content decreased with increasing rate of respiration. Respiration rate was lower at 4^{0}C than at 14^{0}C. Use of chemicals in holding solutions is also a simple method for lengthening the vase life of cut flowers. The efficacy of a large number of inorganic salts such as $MgSO_4$, $MnSO_4$, $Al_2(SO_4)_3$, $FeSO_4$, $NiCl_2$, $CoCl_2$, $CaCl_2$, $AlCl_3$, KCl, $MgCl_3$, KNO_3, $Ca(NO_3)_2$ and $AgNO_3$ in holding solution in lengthening the vase life of 'Raktagandha' cut roses was studied by Singh (1995). He found out that all inorganic salts lengthened the vase life of cut rose cv. Raktagandha, with $NiCl_2$ (250 ppm), $MgSO_4$ (100 ppm) and KNO_3 (500 ppm) giving the best results. The increased vase life was associated with a marked increase in water uptake, sustained fresh weight during senescence and better flower expansion. Holding solutions are vase solutions which can be retained by the wholesaler or the retailer to keep flowers until they are sold or for the consumers to use continuously in the vase. A holding solution may contain carbohydrates, germicides, growth regulators, ethylene inhibitors, mineral salts and organic acids for prolonging the life and quality of flowers (De and Bhattacharjee, 2000). Preliminary studies by Mariam (2002) identified the optimum dry storage period at 4^{0}C for Noblesse cut roses to be six (6) days; and wet storage at 4^{0}C for cultivar Golden Gate to be three (3) days. These independent periods were cultivar specific and ensured the maintenance of fresh flowers for longer periods.

The present study was therefore conducted to further investigation, the

influence of the wet and dry storage periods at 4°C followed by treating with seven different holding solutions on the respiration rates and post harvest vase life of Golden Gate and Noblesse cut roses.

2.0 MATERIALS AND METHODS

The study was carried out during the period 2000 – 2001 in a laboratory at the divisions of Floriculture and Landscaping and Plant Physiology, Indian Agricultural Research Institute, New Delhi, India. The greenhouse grown cut roses cultivar (cv.) Golden Gate and cv. Noblesse were harvested in the morning at a stage when all the sepals were well spread and unfurled down. The flowers were brought to the laboratory in a clean bucket containing tap water. The stem ends were then re-cut to uniform length of 30 cm and the leaves removed, retaining only the four uppermost compound leaves. Golden Gate cut rose flowers were subjected to optimum wet cold storage at 4°C for three (3) days, and Noblesse cut rose flowers to dry cold storage at 4°C for six (6) days. These cold storage periods had been identified to be the optimum periods for these two cultivars in a previous experiment (Mariam, 2002). The vase life of the two cultivars was then tested in independent trials, laid out in completely randomised designs (CRD). Five roses of each variety were dipped in seven holding solution treatments, and replicated thrice. The seven holding solution treatments were: D-fructose 3% + kinetin @ 2.5 ppm (T_1); D-fructose 3% + AgNO3 @ 25 ppm (T_2); D-fructose 3% + nickel chloride @ 300 ppm (T_3); sucrose 3% +8-(HQC) @200 ppm (T_4); sucrose 2% + captan @ 200 ppm (T_5); sucrose 2% + streptomycin sulphate @ 250 ppm (T_6); tap water / control (T_7).

Respiration rates of cut rose flower buds were then measured at time of harvesting; after wet and dry cold (4°C) storage treatment periods; on the third day in vases; and at senescence, in cubic centimeters of carbon dioxide per gram dry weight per hour (cc of CO_2 / g d.w. / h). Infrared gas analyser (IRGA) model LI – 6200 was used for this purpose.

The IRGA LI – 6200 equipment consists of a CO_2 analyser, a system console and sensor housing with interchangeable chambers. The LI – 6200 CO_2 analyser is a non dispersive infra red type (NDIR) calibrated for measurement of 0 – 2000 parts per million (ppm) of carbon dioxide. Measurements were made by placing the flowers in the chambers of volume 250 ml and activating the log button on the console, when regular rise in carbon dioxide concentration is observed in the console window. The data from the measurement are automatically logged into the system memory. Data logging continues for 30 seconds, during which time the instrument records three observations. Using the data thus obtained, analyses of variance were carried out and means separated by the least significance test by use of GMAT programme. Correlation and regression analyses were done by use of Microsoft Excel program.

3.0 RESULTS AND DISCUSSION

3.1 Effect of Storage and Holding Solutions on Respiration Rates and Vase Life of 'Golden Gate' and 'Noblesse' Cut Roses

Figures 1 and 2 reveal that respiration rate of Golden Gate and Noblesse flower buds declined marginally with time in cold storage. After removal from cold storage treatment and dipping into various holding solutions in vases, the rate of respiration increased to a maximum by the third day in vases, before dropping to lowest values by senescence. The rate of respiration of wet stored Golden Gate cut roses was significantly affected by the different holding solutions in vase (Table 1). At harvest, the respiration rate of the cut roses ranged between 609 – 613 cc of CO_2 / gram dry weight / hour. After optimum wet storage at 4°C for 3 days, there was a non significant decline in the respiration rate for all treatments. This reduced rate of respiration may be due to the low temperature (4°C), wherein most of the metabolic activities of the cut flowers were minimised. Serrano *et al.* (1992) reported that cold stored (4°C) rose cut flowers cv. visa exhibited a minimum rate of respiration after the storage duration. Pritchard *et al.* (1991) also observed a slower rate of respiration after cool storage at 4°C in *Anthurium* flowers. However, on the third day (in vase) in the holding solutions, there was significant increase in the respiration rate of the cut roses, irrespective of the treatments. Maximum respiration rate was recorded with control (979.56 cc of CO_2 / g d.w. / h) followed by D-fructose (3%) + nickel chloride (300 ppm) (815.80 cc of CO_2 / g d.w. / h), At senescence, the respiration rate declined from the third day in vase irrespective of the treatments (Figure 1). The lowest respiration rate due to treatments was recorded with sucrose (3%) + 8 HQC (200 ppm) (320.40 cc of CO_2 / g d.w. / h.) followed by D-fructose (3%) + nickel chloride (300 ppm) (375.44 cc of CO_2 / g d.w. / h). These treatments, which had lowest respiration rates, also gave longer vase life.

Table 2 shows that the rate of respiration of dry stored cut rose cv. Noblesse was significantly affected by the different holding solutions in vase. At harvest, the respiration rate of the cut roses ranged from 550 – 555 cc of CO_2 / g d.w. / h, but there was no significant difference amongst the fresh cut flowers. After dry storage at 4°C for 6 days, there was a decrease in the respiration rate irrespective of treatments from harvest. On third day in vase in the holding solutions, the respiration rate increased with highest recorded in the control treatment (915 cc of CO_2 / g d.w. / h) followed by D-fructose (3%) + nickel chloride (820.07 cc of CO_2 / g d.w. / h) (Figure 2). This may be attributed to the continuous and uninterrupted development of the cut flower held in the preservative or holding solution due to the beneficial effects of nickel and 8-HQC as an ethylene inhibitor and antimicrobial nature resulting in increased holding solution uptake. At senescence, there was a decrease in the respiration rate from the third day in vase irrespective of treatments. The lowest

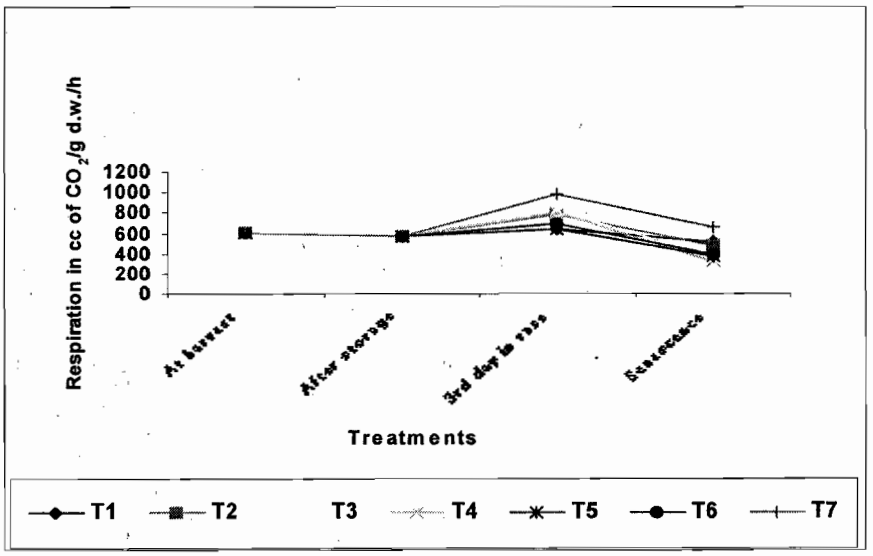

Figure 1: Rate of respiration of cut rose cv. Golden gate during the course of senescence as affected by the holding solutions and wet storage (4°C) for 3 days

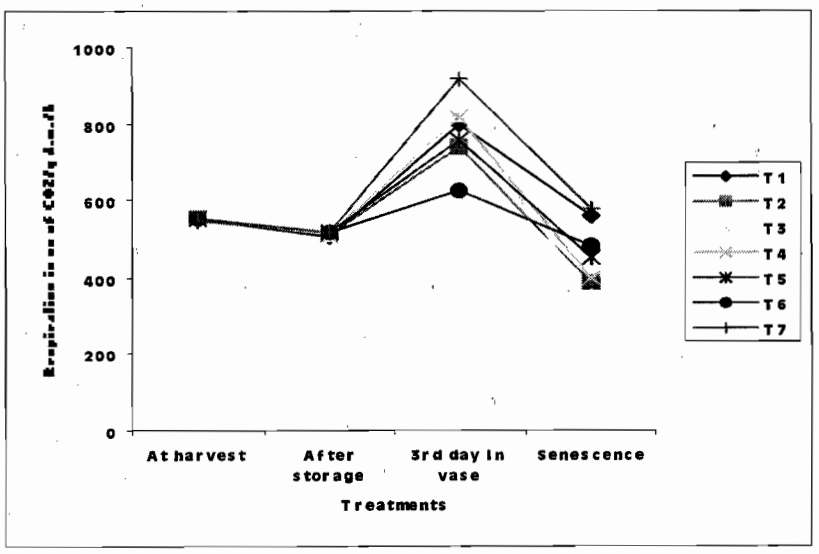

Figure 2: Rate of respiration of cut rose cv. Noblesse during the course of sencescence as affected by the holding solutions and dry storage (4°C) for six days

Table 1: Rate of respiration of cut rose cv. Golden Gate during the course of senescence as affected by the holding solutions and wet storage (4°C) for 3 days

Treatment (Holding solutions)	Rate of respiration in cc of CO_2 / g d.w. / h				
	At harvest	(3 days)	3rd day in vase	Senescence	Vase life (days)
D-fructose 3% + Kinetin 2.5 ppm	613.19	580.24	650.00	515.09	15.8
D-fructose 3% + AgNO3 25 ppm	611.83	578.19	779.96	485.65	16.8
D-fructose 3% + Nickel chloride 300 ppm	610.37	567.30	815.80	375.44	18.5
Sucrose 3% + 8-HQC 200 ppm	613.00	570.25	810.78	320.40	20.5
Sucrose 2% + Captan 200 ppm	609.68	569.45	652.19	384.23	15.3
Sucrose 2% + Streptomycin sulphate 250 ppm	609.63	571.20	700.10	389.40	17.8
Control (Tap water)	611.45	575.42	979.56	656.24	13.3
'F' test	NS	NS	**	**	**
S.Em. ±	3.33	20.02	2.89	0.97	0.07
LSD at 5%	-	-	8.77	2.94	0.20

NS -denotes non- significant

** - denotes highly significant

S.Em ± - denotes Standard error of mean differences between means

LSD - Least Significant Difference

respiration rate due to treatments was recorded with D-fructose (3%) + nickel chloride (300 ppm) (350.79 cc of CO_2 / g d.w. / h). The maximum vase life was associated with low respiration rate at senescence. Lower respiration rate at different stages of flower development being associated with longer vase life of cut roses has been reported by several investigators also (Sivasamy, 1998; Bhattacharjee and Pal, 1999; Monteiro *et al.*, 2001). Decline in respiration rate during senescence of cut flowers and increased by keeping them in the preservative solution has also been reported by de Pascale *et al.* (1998). The respiration rate of cut rose cv. Lady X and Dame de Coeur also increased in a preservative combination of 2% sucrose + 250 ppm 8-HQC + 500 ppm citric acid + 25 ppm silver nitrate (Gao and Yang, 1992).

Table 2: Rate of respiration of cut rose cv. Noblesse during the course of senescence as affected by the holding solutions and dry storage (4°C) for 6 days

Treatment (Holding solutions)	Rate of respiration in cc of CO_2 / g d.w. / h				
	At harvest	After storage (6 days)	3rd day in vase	Senescence	Vase life (days)
D-fructose 3% + Kinetin 2.5 ppm	553.85	506.69	800.03	560.35	13.0
D-fructose 3% + AgNO3 25 ppm	553.10	510.63	740.50	389.46	12.3
D-fructose 3% + Nickel chloride 300 ppm	555.64	514.25	820.07	350.79	13.5
Sucrose 3% + 8-HQC 200 ppm	552.20	512.42	812.77	399.10	12.8
Sucrose 2% + Captan 200 ppm	554.72	520.34	755.30	450.15	10.0
Sucrose 2% + Streptomycin sulphate 250 ppm	551.85	515.48	625.47	484.24	10.5
Control (Tap water)	550.35	518.90	915.00	575.27	10.5
'F' test	NS	NS	**	**	**
S.Em. ±	12.3	13.07	2.24	5.19	0.10
LSD at 5%	-	-	6.79	15.74	0.29

NS - denotes non-significant

** - denotes highly significant

S.Em ± - denotes Standard error of mean differences between means

LSD - Least Significant Difference

3.2 Relationships of Respiration Rates of Cut roses at Harvest and Senescence

When respiration rates were related with the vase lives of both the cultivars, it was evident from figures 3, 4, 5 and 6 that respiration rates declined with increasing vase life. It is evident from Figure 4 that the vase life of Golden Gate cut rose (which had been subjected to wet storage at 4°C for three days treatment) was highly but negatively correlated (R = -0.8414) to respiration rates measured at senescence. This compares with relatively lower coefficient of -0.4405, for the Noblesse cut rose which had been subjected to dry storage at 4°C for 6 days. Therefore, vase life is inversely related to respiration rates after cold storage treatment.

Correlation of respiration rates to vase life was highest (R = -0.7755) for cultivar 'Noblesse' when respiration measurements were taken after removal of the cut roses from the cold storage treatments (Figure 5). The confidence of predicting vase life for Noblesse cut rose from the respiration rates were much higher at 76.9 and 60.1 % (Figure 5), from the quadratic and linear functions, as compared to only 24.4 and 22.1 % (Figure 3), respectively, for the cultivar Golden Gate.

This implies that we can be able to confidently predict vase life for Noblesse from respiration rates taken after cold (4°C) dry storage for 6 days. Whereas, for Golden Gate subjected to cold (4°C) wet storage for 3 days only, the confidence is very low, ranging between 22.1 to 24.3 % only. The relationship of respiration to vase life was however strongest (0.7508 to 0.708) at senescence for Golden Gate (Figure 4), as compared to 0.2265 and 0.194 for Noblesse (Figure 6), respectively. The low respiration rates at senescence would be due to death of plant tissues, a stage at which plant metabolic activities are nearing to nil. Kaltaler and Steponkus (1976) reported that decline in respiration during senescence was not due to substrate limitations, but the inability of the mitochondria to utilise the substrate.

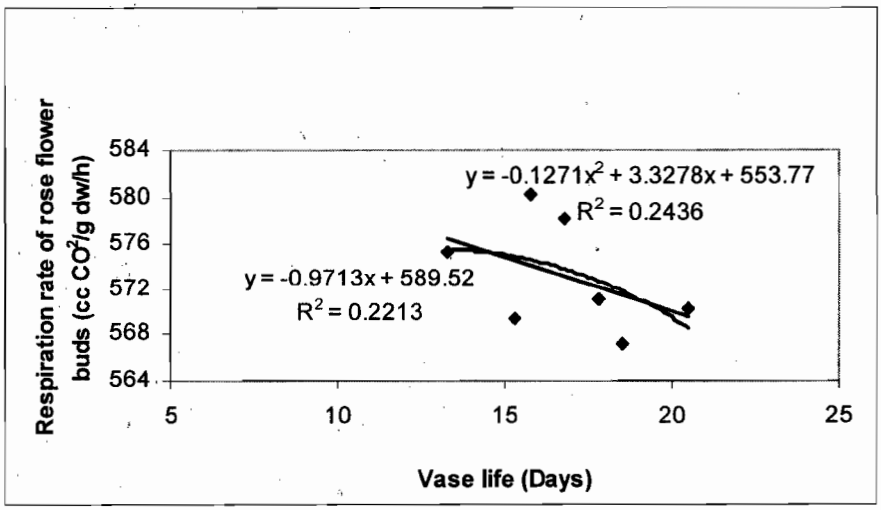

Figure 3: Relationship pf Golden Gate rose flower buds respiration after 3 days wet storage at 4^0C

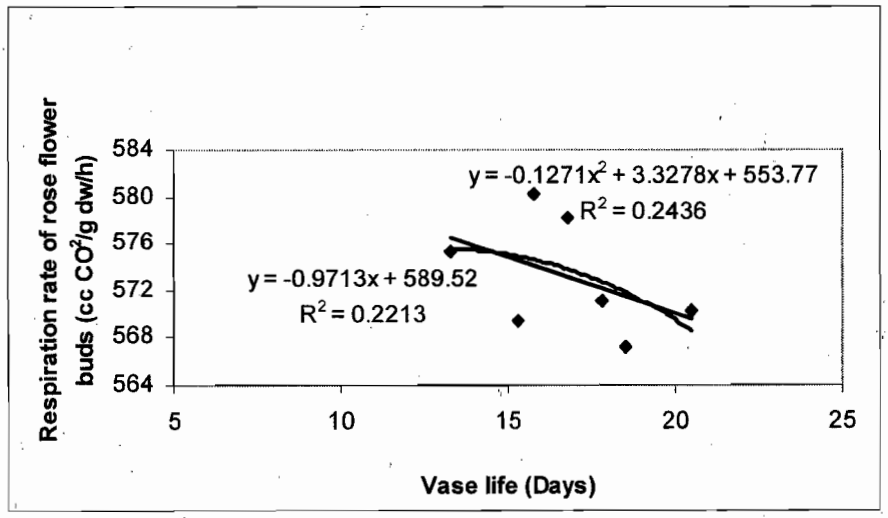

Figure 4: Relationship of Golden Gate flower buds respiration at senescence while being held in various holding solutions

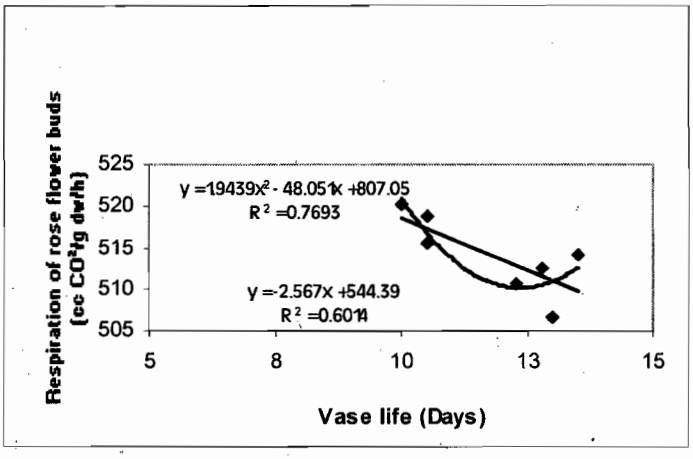

Figure 5: Relationship of Noblesse rose flower buds respiration after 6 days dry storage at 4⁰C with vase life

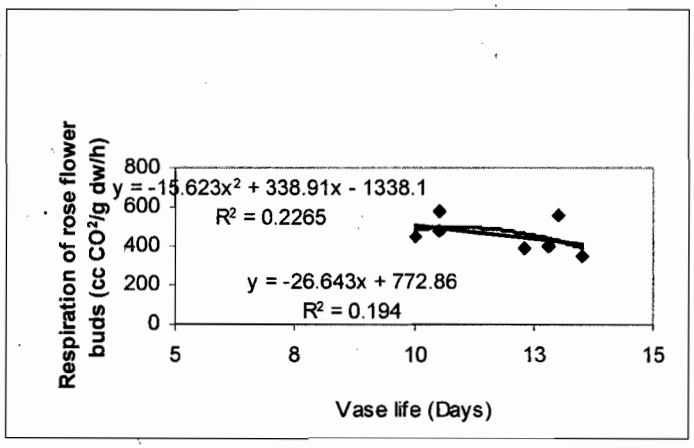

Figure 6: Relationship of Noblesse buds respiration at senescence while being held in various holding solutions with vase life

4.0 CONCLUSION AND RECOMMENDATIONS

On the third day in vase, there was a significant difference in the respiration rate when the cut roses were held in different holding solutions with the highest respiration rates recorded in untreated control, followed by D-fructose (3%) + nickel chloride (300 ppm) and sucrose (3%) + 8-HQC (200 ppm).

(i) By senescence, there was a further decrease in respiration rate. Lower respiration rate at senescence was associated with longer vase life.

(ii) Regression analyses relating respiration rates with vase life revealed that longer vase life of cut roses was associated with lower respiration rates; which could be attributed to post harvest management practices that lower the respiration rates.

(iii) Vase life is inversely related to respiration rates after cold storage treatment. The functions describing this relationship can be used for predictive purposes, especially for the Noblesse cut rose subjected to dry storage for six days at 4^0C.

(iv) Efforts to standardise optimum post-harvest practices that lower respiration rates at critical stages in storage for various cut rose cultivars need to be identified.

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